17th Global Symposium for Regulators (Nassau, 2017)

Living in a World of Digital Opportunities

Reports and Papers

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GLOBAL ICT REGULATORY OUTLOOK 2017

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

Over past decades the world has witnessed a digital revolution that is ushering in huge change. The rate of that change continues to accelerate challenging our governments and institutions to keep pace. The ICT regulatory landscape too is evolving and at an ever-increasing pace. This report measures and monitors changes taking place in the telecommunication/ICT market itself as well as in the regulatory environment. It identifies and analyses seven *market trends* and seven *regulatory trends* and takes an informed view on future regulatory direction. The report builds on extensive data captured in the *ICT Regulatory Tracker*.

Of the many findings featured in this report, one stands out as particularly significant. It is this: the move towards a more open, collaborative regulatory approach, together with the role played by the ICT regulator in orchestrating this, will be critically important in delivering on the rich promise of the digital economy – to the benefit not only of consumers and businesses but to the 3.9 billion people who remain unconnected to the Internet.

SEVEN MAJOR TRENDS MOVING ICT MARKETS

1

ICTs move centre-stage as the digital economy gains momentum.

With the rise of the Internet and mobile communications, ICTs increasingly power the global economy, rendering some markets obsolete and enabling the emergence of others. New efficiencies and opportunities trigger important developments in industry and science – hardly any area of economy and society is untouched. And yet, the global picture remains mixed: while mobile has grown hugely, large populations still have no access to the Internet. This looks set to change as a growing swathe of urban young in developing countries make new demands for future connectivity.

2

Mobile – the engine for expanded local access to the Internet.

By 2017, three-quarters of all global Internet use will be via mobile and much of that growth will come in low and middle-income countries. Significant gaps in penetration remain with more than half the world's population yet to be connected to mobile broadband. Mobile virtual network operators have taken up this challenge, successfully targeting under-served market niches and optimizing network coverage to grow subscriber bases. While fixed connectivity leverages ICT for increased productivity, outreach and efficiency, mobile is set to transform economic sectors across the board.

3

ICTs are less visible but more prevalent.

As ICT moves into each area of our daily lives, cloud computing is the catalyst and enabler of important technological advances. The cloud transforms people's data into an increasingly valuable by-product: today's data trails produced by users using multiple ICTs are massive and growing, generating 'big data'. A new culture of 'dealing in data' is beginning to take root.

4

ICTs are enabling and disrupting industries.

ICT focus has shifted towards building platforms which integrate technologies, networks and devices powering new capabilities and services. 5G mobile broadband is being conceptually enhanced and is now poised to take the integration of communication protocols, devices and applications to the next level. Close-to universal coverage of ICT networks, especially mobile, paves the way for the connecting together of machines and objects, a major trend over the coming years.

5

The rise of the app economy.

The app economy is transforming economic and social activities and opening up channels of innovation, productivity and communication. Technology design deployed by disruptive app companies reduces transaction costs while allowing for increasing economies of scale. The outlook for both network operators and over-the-top providers is bright as they benefit from a virtuous cycle: as the ICT sector outgrows all others, innovation continues to power ahead creating yet more opportunity.

6

Market concentration and consolidation.

The past decade has seen ICT in constant flux – new players, services and delivery platforms have stretched boundaries and changed market dynamics. Led by innovation, digitization and automation, new competitors have gate-crashed markets around the world. In 2016, high-profile mergers and acquisitions swept the ICT landscape, featuring a wide range of market players and deals, from fibre to cloud to artificial intelligence. In some cases, players from the extended ICT sector are opting for strategic partnerships or 'coopetition'.

7

Cyber threats have grown in scope and scale.

Massive digitization in consumer and corporate life has brought increased risk. The level of threat has grown as the tools in the hands of criminals and terrorists have become more sophisticated. Though cyber readiness has become paramount for building secure ICT networks and services, not all countries are prepared.

SEVEN MAJOR TRENDS

THAT CHARACTERIZE THE REGULATORY LANDSCAPE

1

Collaboration – fast-tracking the promise of the digital economy.

With the growing economic confidence of ICTs and related markets has come a new regulatory assertiveness embodied in the G5 collaborative regulation approach. Increasingly, ICT regulators are teaming with regulators from other sectors to address multi-sector issues. Equipped with this collaborative, problem-solving attitude, regulators are better harnessing and maintaining buoyant growth. Key questions for today's regulators include: how to collaborate and with whom? What are we regulating and how?

2

Regulatory landscape continuing to see rapid and fundamental change.

The ICT sector cannot remain narrowly focused on its own players and issues – simply because convergence has blurred boundaries and complicated the rules of the game. The pace of regulation in the ICT sector is faster than in most other industries today, with transformation happening all the time.

3

More regulation being adopted; many countries expand scope of regulatory policies.

From 2007 to 2015, ICT regulation is characterized both by the volume of change and the increasing pace at which it is adopted. No fewer than 52 regulators are now in the G4 category. Fifty-five per cent of countries have moved one generation up the ICT ladder of regulation while 15 per cent have leaped generations in only nine years. In contrast, one-quarter of countries have seen no regulatory movement since 2007.

4

Regulation as an equalizer.

Regulation ensures that all market players – from start-ups to national incumbents to multinational corporations – benefit from a level playing field. Competition is essential today in spurring innovation, diversifying services on offer and improving consumer experience in ICT markets. The regulation of that competition continues to trigger a massive opening up of ICT markets, from basic telephony services to mobile broadband.

5

Focus moves to monitoring and enforcement.

The scope of monitoring and enforcement continues to widen. In 2015-16, challenging issues – including taxation of players without national physical points of presence and the poor quality of information being shared over social media – have sparked passionate global debate. These issues underline the need for more effective monitoring and enforcement of regulation.

6

One model does not fit all – convergence and divergence in complex, fast-moving landscape.

A single ICT regulatory model that fits all does not exist. Points of convergence are emerging however, driven by factors such as efficiency, extended access to networks, affordability and quality of service. New issues are constantly emerging, posing challenges for regulators. Some challenges require collective action from the international community while others will disrupt the market order.

7

Regulators are standing up to challenges, reinventing the rules.

Expectations of ICT regulation have grown. No fewer than 43 countries now conduct a Regulatory Impact Assessment before regulatory decisions are made. Incentive regulation is sometimes included to encourage investment, especially in infrastructure. Ex ante Regulatory Impact Assessment and evidence-based decision-making have become mainstream.

www.itu.int/go/tracker

The data behind the Outlook 2017 was captured through the

ICT REGULATORY TRACKER,

an evidence-based tool which covers 186 countries and economies over the period 2007 – 2015.

Leveraging a large amount of historic regulatory data, the tool is devised to help decision-makers and regulators more fully understand the ever-changing terrain of ICT regulation.



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THE ECONOMIC COST OF IPR INFRINGEMENT IN THE SMARTPHONES SECTOR



February 2017

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THE ECONOMIC COST OF IPR INFRINGEMENT IN THE SMARTPHONES SECTOR

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1. FOREWORD

THE ECONOMIC COST OF IPR INFRINGEMENT IN THE SMARTPHONES SECTOR

The European Observatory on infringements of Intellectual Property Rights (the Observatory) was created to improve the understanding of the role of Intellectual Property and of the negative consequences of Intellectual Property Rights (IPR) infringements. It was transferred from the Commission to EUIPO in 2012 by Regulation 386/2012.

The International Telecommunication Union (ITU) is the United Nations specialised agency for Information and Communication Technologies (ICTs), with responsibilities that include among others the allocation of global radio spectrum and satellite orbits, the development of technical standards that ensure networks and technologies seamlessly interconnect, and efforts to improve access to ICTs to underserved communities worldwide. The goal is to bring the benefits of modern communication technologies to people everywhere in an efficient, safe, easy and affordable manner.

In a study carried out in collaboration with the European Patent Office[1], the EUIPO, acting through the Observatory, estimated that approximately 42% of total economic activity and 28% of all employment in the EU is directly generated by IPR-intensive industries, with a further 10% of jobs in the EU arising from purchases of goods and services from other industries by IPR-intensive industries.

Another study[2] compared economic performance of European companies that own IPRs with those that do not, finding that IPRs owners' revenue per employee is 28% higher on average than for non-owners, with a particularly strong effect for Small and Medium-Sized Enterprises (SMEs). Although only 9% of SMEs own registered IPRs, those that do have almost 32% more revenue per employee than those that do not.

Perceptions and behaviours of European citizens regarding Intellectual Property and counterfeiting and piracy[3] were also assessed as part of an EU-wide survey. This survey revealed that although citizens recognise the value of IP in principle, they also tend to justify infringements at individual level in certain cases.

The Observatory is seeking to complete the picture by assessing the economic impact of counterfeiting and piracy.

In 2016, EUIPO and ITU signed an agreement to collaborate in the publication of a study on the economic impact of intellectual property rights (IPR) infringement in smartphones. The present report is the result of that agreement.

1 - "Intellectual Property Rights intensive industries and economic performance in the European Union", EUIPO/EPO, October 2016.

2 - "Intellectual Property Rights and firm performance in Europe: an economic analysis", June 2015.

3 - "European citizens and intellectual property: perception, awareness and behaviour", November 2013, updated report 2017 (forthcoming).

This exercise is challenging from a methodological point of view, as it attempts to shed light on a phenomenon that by its very nature is not directly observable. To pave the way towards quantification of the scope, scale and impact of IPR infringements, as identified in its mandate, the Observatory has developed a step by step approach to evaluate the negative impact of counterfeiting and its consequences for legitimate businesses, governments and consumers, and ultimately for society as a whole.

Several IPR intensive industries whose products are known or thought to be subject to counterfeiting have been selected. Previous studies have examined the following sectors: cosmetics & personal care; clothing, footwear and accessories; sports goods; toys & games; jewellery & watches; handbags & luggage; recorded music; spirits & wine; medicines; and pesticides.

The sectorial studies published to date estimate the impact of counterfeit goods in the EU marketplace. This eleventh study, covering the smartphone sector, is published in collaboration with ITU, a UN agency with a global focus. Therefore, while it uses a similar methodology to that applied in previous sectorial studies it is not limited to EU countries. Due to the need to include a wider set of countries and to the special nature of the sector, different data sources and adjustments of the methodology were required.

2. EXECUTIVE SUMMARY

THE ECONOMIC COST OF IPR INFRINGEMENT IN THE SMARTPHONES SECTOR

2.1. Methodology and data

The study aims to estimate the scale of the economic impact of counterfeiting in the legitimate sector. The starting point of this analysis is the number of smartphones sold in 86 countries based on point-of-sale tracking of consumers' purchases. Expected sales are estimated based on new smartphones connections and expected replacement of devices. Subsequently, the difference between expected and actual sales estimated for each country is analysed using statistical methods. This difference can be partly explained by socio-economic factors such as per capita GDP or mobile broadband services prices. In addition, factors related to counterfeiting are considered, such as the legal and regulatory environment[4].

The methodology is explained in detail in section 5.

2.2. Main findings

It is estimated that in 2015, 14 million smartphones fewer were sold by the legitimate industry across the EU than would have been the case in the absence of counterfeiting. This translates to approximately **4.2 billion EUR lost due to the presence of counterfeit smartphones in the EU marketplace**, corresponding to **8.3% of the sector's sales.**

Worldwide, the effect of counterfeiting on smartphone sales is estimated at 184 million units, valued at **45.3 billion EUR or 12.9% of total sales.**

Region[5]-level estimates of lost sales expressed both as a percentage of sales and in euros, are shown in the table below along with the confidence intervals.

4 - The Worldwide Governance Indicator of Government Effectiveness from the World Bank is used in this study. This indicator captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.

5 - The countries included in each region are shown in Table 4.

TABLE 1: LOST SALES DUE TO COUNTERFEITING OF SMARTPHONES BY REGION AND CONFIDENCE INTERVALS (2015)

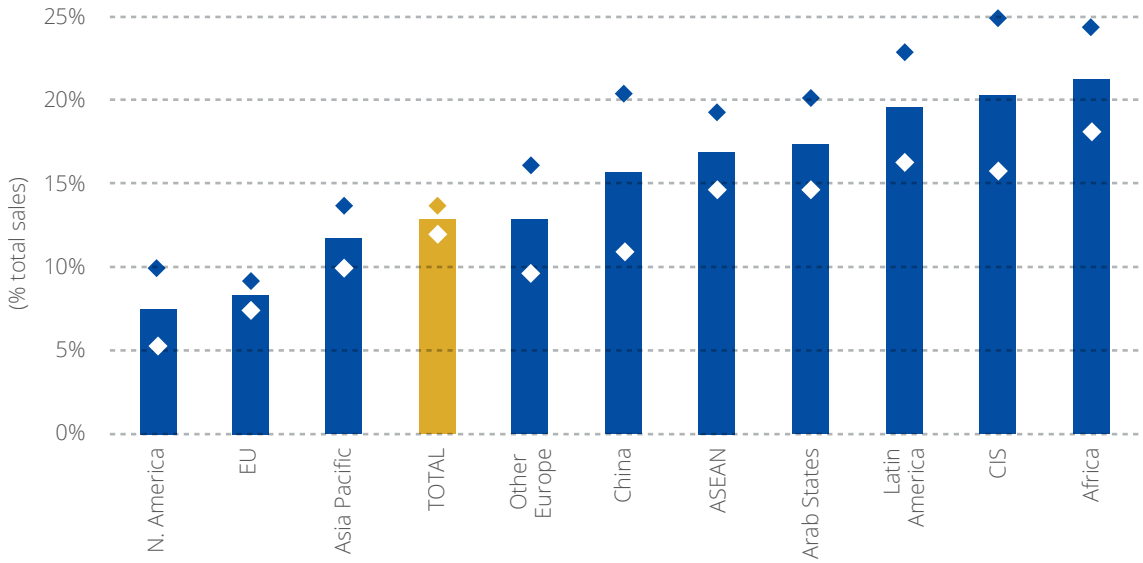
	Lost sales (million EUR)	Lost (%)	Upper	Lower
European Union*	4,212.2	8.3%	9.1%	7.4%
Other European Countries	1,207.0	12.9%	16.1%	9.7%
CIS**	1,122.9	20.3%	25.0%	15.7%
Asia-Pacific***	7,166.6	11.8%	13.7%	10.0%
ASEAN****	2,674.9	16.9%	19.3%	14.6%
Arab States	1,975.7	17.4%	20.2%	14.6%
Africa	1,024.9	21.3%	24.4%	18.2%
Latin America	4,706.5	19.6%	22.9%	16.2%
North America	4,927.2	7.6%	9.9%	5.3%
China	16,335.8	15.6%	20.4%	10.9%
TOTAL	**45,353.8**	**12.9%**	**13.7%**	**12.0%**

*EU28 except Malta and Bulgaria
**CIS Commonwealth of Independent States
*** Asia-Pacific region except China and ASEAN countries
**** ASEAN Association of Southeast Asian Nations
Source: EUIPO calculations

The resulting estimates of lost sales due to counterfeit smartphones in each region are shown in the figure below. The bar indicates the impact of counterfeiting on the legitimate sector's sales, expressed as a percentage of sales, while the diamonds indicate the 95% confidence interval of that estimate[6].

6 - The 95% confidence interval is a statistical calculation which means that there is a 95% probability that the true figure lies between the lower and upper bounds of that interval. For example, for the EU as a whole, the estimated percentage of lost sales is 8.3%, with a 95% probability that the true percentage lies between 7.4% and 9.1%.

FIGURE 1: LOST SALES DUE TO COUNTERFEITING OF SMARTPHONES BY REGION (2015)

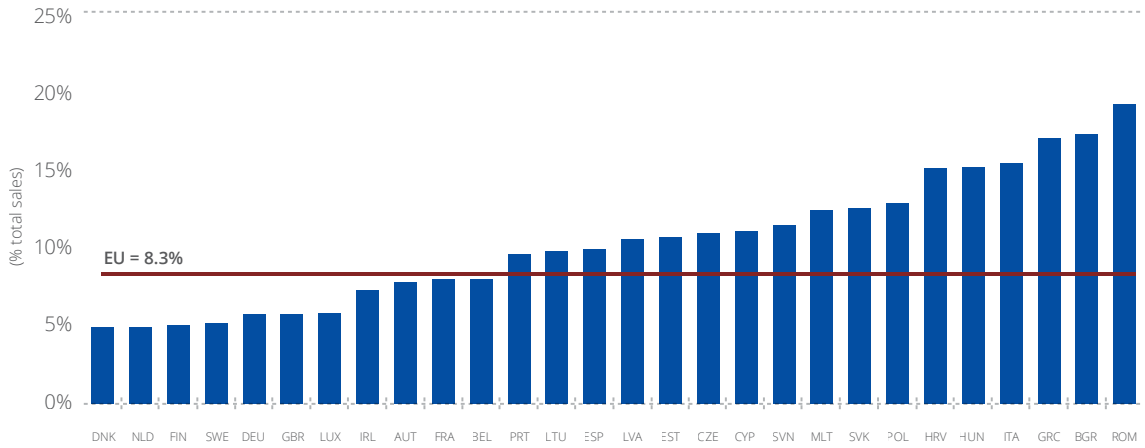


Source: EUIPO calculations

Lost sales in China account for 36% of worldwide lost sales. Lost sales in absolute terms in North America and Latin America are quite similar although in relative terms the losses in Latin America are almost three times higher. North America and the EU are the two regions with the lowest relative impact of counterfeiting on sales, both below 10%.

Among the EU Member States, 11 are below the EU average of 8.3%. The country least affected by counterfeiting in relative terms is Denmark (4.9%), while Romania is the country most affected (19.1%). In absolute terms, the impact is greatest in Italy, with lost sales due to counterfeiting estimated by 885 million EUR; followed by UK at 660 million EUR, Germany (564 million EUR), Spain (386 million EUR) and France (380 million EUR). The five biggest EU Member States account for 2.9 billion EUR lost due to counterfeiting, nearly 70% of total lost sales in the EU.

FIGURE 2: LOST SALES DUE TO COUNTERFEITING OF SMARTPHONES IN EU MEMBER STATES (2015)[7]



Source: EUIPO calculations

Country-level estimates of lost sales expressed as a percentage of total sales are shown in the table below.

7 - International Standards Organizations (ISO) country codes are used throughout this report. See: http://wits.worldbank.org/wits/wits/witshelp/Content/Codes/Country_Codes.htm

TABLE 2: LOST SALES DUE TO COUNTERFEITING OF SMARTPHONES IN EU MEMBER STATES (2015)

Code	Country	Lost sales (%)
AUT	AUSTRIA	7.7
BEL	BELGIUM	8.0
BGR	BULGARIA	17.2
CYP	CYPRUS	11.0
CZE	CZECH REPUBLIC	10.9
DEU	GERMANY	5.7
DNK	DENMARK	4.9
EST	ESTONIA	10.6
GRC	GREECE	16.9
ESP	SPAIN	10.0
FIN	FINLAND	5.1
FRA	FRANCE	8.0
HRV	CROATIA	15.0
HUN	HUNGARY	15.1
IRL	IRELAND	7.3
ITA	ITALY	15.4
LTU	LITHUANIA	9.8
LUX	LUXEMBOURG	5.8
LVA	LATVIA	10.6
MLT	MALTA	12.4
NLD	NETHERLANDS	5.0
POL	POLAND	12.8
PRT	PORTUGAL	9.5
ROM	ROMANIA	19.1
SWE	SWEDEN	5.2
SVK	SLOVAK REPUBLIC	12.5
SVN	SLOVENIA	11.5
GBR	UNITED KINGDOM	5.7
EU	**EUROPEAN UNION**	**8.3**

2.3. Non-economic impacts of counterfeit smartphones

This report focuses on the economic consequences of counterfeit smartphones. However, there are a number of other impacts in areas such as health and safety, environmental damage, network quality, cyber-security and privacy. A recent report by the ITU singles out the following *non-economic* effects of counterfeit mobile devices[8]:

8 - "Counterfeit ICT equipment", ITU Technical Report, December 2015.

- lowering the quality of service of mobile telecommunication services, thus impacting the experience of consumers and businesses;
- creating a safety hazard for consumers due to use of defective or inadequate components or materials;
- raising cybersecurity-related threats;
- jeopardizing consumer privacy;
- impairing the safety of digital transactions;
- hurting the most financially vulnerable consumers by failing to provide any warranties to the consumer and otherwise violating consumer law requirements;
- creating risks to the environment and consumer health due to the use of hazardous substances in the manufacturing of these devices.

Many of these impacts are particularly serious in regions such as Africa where many consumers rely on their smartphones to an even greater extent than consumers in Europe or North America. The smartphone is often the only way to access the internet, and the main source of banking services (the M-PESA mobile banking service in Kenya being a well-known example). Any malware or other security breach that can be found in counterfeit devices has serious consequences in this context.

Counterfeit products, because of their poor assembly and use of poor quality components, contain hazardous substances that are banned in many countries under the restriction of hazardous substances (RoHS) or national equivalent legislation. This poses risks to both health and safety of the users and to the environment.

While the non-economic impacts outlined in this sub-section are beyond the scope of this report, they are clearly of significant societal importance and must be kept in mind when considering the phenomenon of counterfeit smartphones.

3. INTRODUCTION

A major problem which has hindered the effective enforcement of Intellectual Property Rights (IPR) in the EU is related to a lack of knowledge in relation to the precise scope, scale and impact of IPR infringements. Many attempts to quantify the scale of counterfeiting and its consequences for businesses, consumers and society as a whole have suffered from the absence of a consensual and consistent methodology for collecting and analysing data on counterfeiting and piracy across various sectors. Different approaches have been used, such as surveys, mystery shopping or monitoring of online activities, making it all the more difficult to aggregate results for the whole economy. The very nature of the phenomenon under investigation makes it extremely challenging to quantify reliably, as obtaining comprehensive data for a hidden and secretive activity is by necessity difficult.

These challenges have in turn hindered the tasks of those involved in enforcing IP rights and in charge of establishing precise priorities, programmes and targets for enforcement, as they limit the possibilities to design more focused policies as well as evidence-based public awareness campaigns.

To help overcome these challenges while taking fully into account of methodological constraints, the Observatory developed a specific approach that has so far been applied to the Cosmetics and Personal Care; Clothing, Footwear and Accessories; Sports Goods; Games and Toys; Jewellery and Watches; Handbags and Luggage; Recorded Music; Wine and Spirits; Pharmaceutical; and Pesticides sectors. In the present report the Observatory focuses its attention on the smartphones sector.

The increasing role that mobile devices, specifically smartphones, are playing in communication services, applications and e-services (m-payments, m-agriculture, m-learning and many others) have raised the importance of such devices, and made them essential. The number of mobile phones, which started out as simple voice communication terminals, has steadily increased around the world, evolving towards smartphones in many cases. While this has created economic and social and opportunities for people around the world, it has also raised concerns regarding trust and security of such devices, in particular with policy makers and National ICT Regulatory Authorities (NRAs). When equipment is not fully trustworthy, the quality of service of communication can be affected, personal information may be misused or irrecoverable, and health and security harmed.

3.1. The global market for smartphones

Based on GfK data[9] **1.3 billion smartphones were sold in 2015 globally, meaning that 1 in 6 people in the world have purchased a smartphone** that year, roughly equal to the entire population of China or India.

China, with 20% of the World population and a smartphones penetration of 65 connections per 100 inhabitants[10] is the leading market with 30% of smartphones sold accounting for 385 million units. The Asia - Pacific area[11], with 29% of the total population and a smartphones penetration ratio of 25, registers 221 million smartphones sold in 2015, 17% of total sales; North America has the highest penetration ratio at 78 connections per 100 inhabitants and sales are estimated at 190 million units; and the EU[12], with a penetration of 76, registered more than 150 million units sold[13].

The value of the devices sold in 2015 is 352 billion EUR, hence the average nonsubsidized price[14] of smartphones sold in all countries is 275 EUR. The value of devices sold in China is 105 billion EUR with an average price of 272 EUR per unit. The nine African countries included in this study and the CIS countries show the lowest average prices of 156 and 154 EUR per unit and sales values around 5 billion EUR. In North America total sales amount to 65 billion EUR with an average price of 340 EUR and in EU countries total sales are 51 billion EUR at an average price of 333 EUR. Finally, the average price in the rest of Europe is 439 EUR per unit, resulting in a market value of 9 billion EUR. The table below shows sales and average prices by region.

The figures in this report refer to sales of new smartphones. In some regions, particularly in low-income countries, there is an important market for second-hand and refurbished smartphones. In the refurbished market there is a further potential for IPR infringement, for example when the outer shell of a genuine branded smartphone is combined with non-original components. In principle, the effect of this type of infringement is captured by the methodology used in this study, but in the absence of reliable data it is not feasible to quantify its impact separately. Such quantification could be the subject of a future study.

9 - GfK Retail & Technology GmbH is a German market research institute: http://www.gfk.com/about-gfk/about-gfk/. The data on smartphones used in this report cover more than 90 countries representing 94% of the World population. Only Africa has a lower coverage including 56% of the population in the region, with Ethiopia, Democratic Republic of the Congo and Sudan the most populous missing countries. The data and methodology used in this report are described in Section 5.

10 - Penetration ratio is defined in this report as the number of smartphone connections per 100 inhabitants in contrast with other definitions using subscriptions per 100 inhabitants. The term 'connections' defines wireless accounts and corresponds to the number of SIM cards. This term is different from unique subscribers.

11 - The Asia-Pacific region, as defined in this report, does not include China or the ASEAN countries. Table 4 shows the countries included in each region.

12 - The data for the EU is based on 26 Member States, as data for Malta and Bulgaria was not available.

13 - List of countries included in each region are shown in Section 4.

14 - Nonsubsidized (or unsubsidized) price of a phone is the full price of the device, covering the actual cost paid to the phone manufacturer including taxes such as VAT. This price is comparable among countries and in time, in contrast to the subsidized price often part of a contract for voice and data services, conditional on the acceptance of restricting the device during a period of time to one particular operator. The difference between real cost and the price paid by the consumer is the subsidy paid by carriers.

TABLE 3: SALES AND PRICES OF SMARTPHONES BY REGION (2015)

	Total sales (million EUR)	Total sales (million units)	Average price
European Union*	50,801	152	333
Other European Countries	9,361	21	439
Commonwealth of Independent States (CIS)	5,519	36	154
Asia – Pacific**	60,697	221	275
Assoc. Southeast Asian Nations (ASEAN)	15,789	86	183
Arab States	11,358	48	238
Africa	4,814	31	156
Latin America	24,055	108	222
North America	64,975	191	340
China	104,570	385	272
TOTAL	**351,939**	**1,280**	**275**

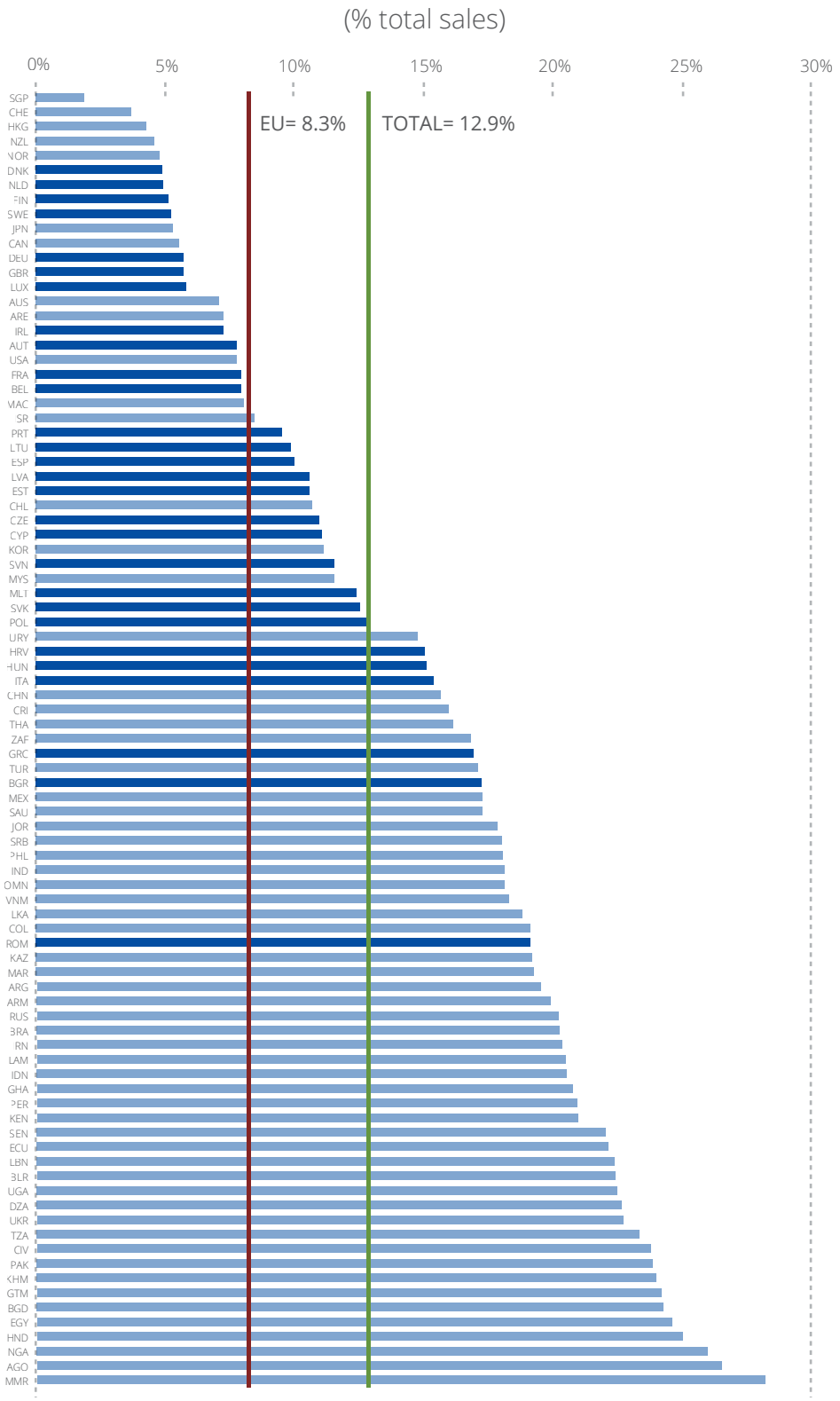
* EU28 except Malta and Bulgaria
**Asia-Pacific region except China and ASEAN countries
Source: EUIPO analysis based on market research data by GfK

4. COUNTRY LEVEL RESULTS

THE ECONOMIC COST OF IPR INFRINGEMENT IN THE SMARTPHONES SECTOR

The resulting estimates of the lost sales due to counterfeit smartphones for all countries analysed are shown in the figure below. For each country, the bar indicates the impact of counterfeiting on the legitimate sector's sales, expressed as a percentage of sales in year 2015. The vertical lines represent the average effect in all countries and in the 26 EU Member States included in the study.

FIGURE 3: LOST SALES DUE TO COUNTERFEITING OF SMARTPHONES BY COUNTRY (2015)



Country-level estimates of losses due to counterfeiting expressed as a percentage of sales, are shown in the tables below along with the average ratios for the regions considered, calculated as the average of the countries in each region, weighted by sales in EUR:

TABLE 4: LOST SALES DUE TO COUNTERFEITING OF SMARTPHONES BY COUNTRY AND REGION (2015)

Code	Region/country	Lost sales (%)
EU	EUROPEAN UNION	8.3
DNK	DENMARK	4.9
NLD	NETHERLANDS	5.0
FIN	FINLAND	5.1
SWE	SWEDEN	5.2
DEU	GERMANY	5.7
GBR	UNITED KINGDOM	5.7
LUX	LUXEMBOURG	5.8
IRL	IRELAND	7.3
AUT	AUSTRIA	7.7
FRA	FRANCE	8.0
BEL	BELGIUM	8.0
PRT	PORTUGAL	9.5
LTU	LITHUANIA	9.8
ESP	SPAIN	10.0
LVA	LATVIA	10.6
EST	ESTONIA	10.6
CZE	CZECH REPUBLIC	10.9
CYP	CYPRUS	11.0
SVN	SLOVENIA	11.5
MLT	MALTA	12.4
SVK	SLOVAK REPUBLIC	12.5
POL	POLAND	12.8
HRV	CROATIA	15.0
HUN	HUNGARY	15.1
ITA	ITALY	15.4
GRC	GREECE	16.9
BGR	BULGARIA	17.2
ROM	ROMANIA	19.1

Code	Region/country	Lost sales (%)
EUR	OTHER EUROPEAN COUNTRIES	12.9
CHE	SWITZERLAND	3.7
NOR	NORWAY	4.8
ISR	ISRAEL	8.5
TUR	TURKEY	17.1
SRB	SERBIA	18.0
CIS	CIS COUNTRIES**	20.3
KAZ	KAZAKHSTAN	19.2
ARM	ARMENIA	19.8
RUS	RUSSIAN FEDERATION	20.2
BLR	BELARUS	22.4
UKR	UKRAINE	22.7
NOA	NORTH AMERICA	7.6
CAN	CANADA	5.5
USA	UNITED STATES	7.8
LA	LATIN AMERICA	19.6
CHL	CHILE	10.7
URY	URUGUAY	14.7
CRI	COSTA RICA	16.0
MEX	MEXICO	17.2
COL	COLOMBIA	19.1
ARG	ARGENTINA	19.5
BRA	BRAZIL	20.2
LAM	OTHER LATIN AMERICAN	20.5
PER	PERU	20.9
ECU	ECUADOR	22.1
GTM	GUATEMALA	24.2
HND	HONDURAS	25.0

Code	Region/country	Lost sales (%)
CHN	CHINA	15.6
ASP	ASIAN AND PACIFIC COUNTRIES	11.8
HKG	HONG KONG SAR, CHINA	4.3
NZL	NEW ZEALAND	4.6
JPN	JAPAN	5.3
AUS	AUSTRALIA	7.1
MAC	MACAO SAR, CHINA	8.0
KOR	KOREA, REP.	11.1
IND	INDIA	18.1
LKA	SRI LANKA	18.7
IRN	IRAN, ISLAMIC REP.	20.3
PAK	PAKISTAN	23.8
BGD	BANGLADESH	24.3
ASEAN	ASEAN COUNTRIES*	16.9
SGP	SINGAPORE	1.9
MYS	MALAYSIA	11.6
THA	THAILAND	16.1
PHL	PHILIPPINES	18.0
VNM	VIETNAM	18.2
IDN	INDONESIA	20.5
KHM	CAMBODIA	24.0
MMR	MYANMAR	28.1

Code	Region/country	Lost sales (%)
ARB	ARAB STATES	17.4
ARE	UNITED ARAB EMIRATES	7.2
SAU	SAUDI ARABIA	17.2
JOR	JORDAN	17.8
OMN	OMAN	18.1
MAR	MOROCCO	19.3
LBN	LEBANON	22.4
DZA	ALGERIA	22.6
EGY	EGYPT, ARAB REP.	24.5
AFR	AFRICA	21.3
ZAF	SOUTH AFRICA	16.8
GHA	GHANA	20.7
KEN	KENYA	21.0
SEN	SENEGAL	22.1
UGA	UGANDA	22.4
TZA	TANZANIA	23.3
CIV	CÔTE D'IVOIRE	23.7
NGA	NIGERIA	26.0
AGO	ANGOLA	26.4

* ASEAN Association of Southeast Asian Nations
**CIS = Commonwealth of Independent States
Source: EUIPO calculations

The biggest relative impact of counterfeiting is observed in Myanmar where 28% of sales are lost due to counterfeit smartphones. Lost sales due to counterfeiting are above 20% in a total of 26 countries, mostly in Africa (8) and Latin America (6).

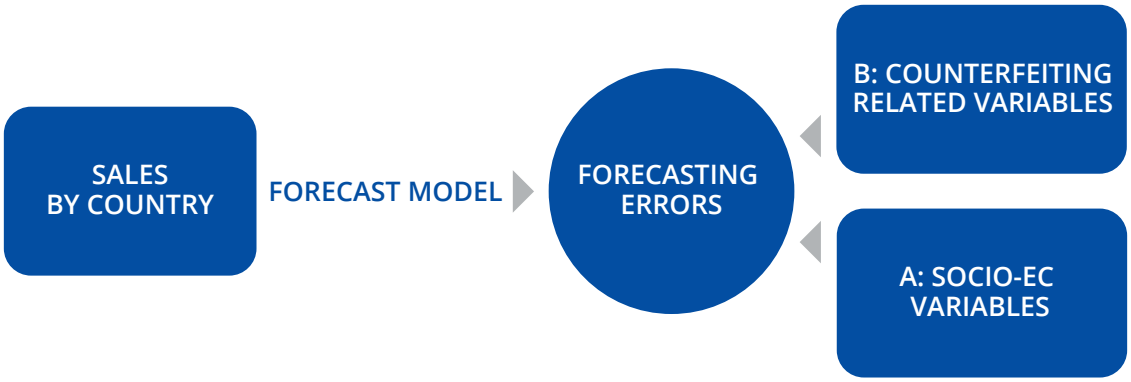
At the other extreme, lost sales due to counterfeiting in Singapore are estimated to be less than 2% of total sales. Another 26 countries have lost sales below 10%, including US and Canada and 14 EU Member States.

5. METHODOLOGY

THE ECONOMIC COST OF IPR INFRINGEMENT IN THE SMARTPHONES SECTOR

The methodology builds on an adaptation of a methodology developed for the European Commission[15] so that it can be used on a sectorial level rather than on a firm level which proved very difficult to apply in practice.

The methodology used for the estimation of the economic effects of counterfeiting is depicted in the following figure:



The first stage is comprised of the compilation of actual sales of smartphones and the development of a forecasting model of sales in each country.

5.1. First stage: real versus expected sales

Data on sales of smartphones in units and value in USD and EUR were purchased from GfK[16]. The database includes quarterly data for the period 2013-2015 of consumer purchases based on point-of-sale (POS) tracking of 86 countries. The POS tracking split sales into different retail channels (technical superstores, operators, other telecommunication specialists, direct sales, etc.) to ensure an appropriate coverage of different distribution channels. When POS data is compared to the total market, which is estimated based on inputs such as annual shipments from vendors to the country and information from third parties (e.g. associations), a coverage gap remains. This coverage gap is usually caused by missing distribution channels, as GfK ensures complete coverage of the channels present in its data by applying extrapolation factors for missing retailers within a channel. To calculate total market sales, the missing channels are extrapolated to reach 100% coverage and this is the value used for this study.

15 - RAND (2012): *Measuring IPR infringements in the internal market.* Report prepared for the European Commission. RAND proposed to analyse ex-post the forecast errors on the level of individual companies, using company-specific explanatory variables. However, attempts at implementing the methodology in this manner were not successful, mainly due to the fact that most companies are not able or willing to provide the required data on past budgeted and actual sales revenues. Therefore, the methodology has been modified to allow its use on sector-level data which can be obtained from public sources.

16 - http://www.gfk.com/solutions/point-of-sales-tracking/point-of-sales-tracking/

The coverage of total sales based on POS data is an average of 83% of total units sold in 2015. Ten countries have a coverage ratio below 50% and 20 countries between 50 and 70%. Among large countries France (55%) and India (43%) show the lowest coverage ratio based on POS.

North American sales are estimated based on proprietary market modelling and consumer research rather than POS data so that sales for United States and Canada are not included separately but as a total for North America. The totals for Mexico, Panama and other Latin America countries[17] are also estimated based on modelling and presented jointly as 'rest of Latin America'.

Finally, values in USD and EUR are based on nonsubsidized retail pricing including taxes such as VAT. Prices at country level can be estimated based on sales in units and EUR and provide the basic information to transform lost sales in units into lost sales in EUR.

Expected sales in units are estimated based on a methodology developed for the ITU[18] by Telecom Advisory Services, an international consulting firm specialising in providing advisory services to telecommunications and technology companies, governments and international organisations. The methodology estimates the number of smartphones sold based on the new connections and new smartphones resulting from replacing obsolete devices. The number of replaced smartphones was calculated based on a replacement factor determined a priori based on the market characteristics of each country. This methodology has been modified to consider different smartphones replacement factors in countries with different characteristics such as the development level in ICT (Information and Communication Technology) as well as the relationship between real sales and smartphones connections in previous years.

The analysis is based on data published by the GSMA Association[19] on the number of smartphone mobile connections[20]. In the present report the number of smartphone SIM connections is used, as opposed to unique mobile subscribers. Therefore, multiple connections of a single subscriber correspond to multiple devices and this is why this measure is appropriate here, although in other studies market penetration is defined based on unique subscribers.

Expected sales are estimated as the yearly increase of smartphone connections (new smartphone users as well as feature phone users who have migrated to a smartphone while keeping the same SIM card) added to the smartphones replaced from previous year (replacing obsolete smartphones). The second term is a replacement factor which depends on the propensity of users to replace their old smartphone with a new one in any given year. This factor differs from country to country.

17 - Bolivia, Cuba, Dominican Republic, El Salvador, Haiti, Nicaragua, Paraguay, Puerto Rico, Trinidad y Tobago and Venezuela are also included in this aggregate, in addition to a number of smaller territories with less than one million inhabitants.

18 - "Methodology for estimating smartphones and feature phones worldwide annual shipments", unpublished manuscript http://www.teleadvs.com/

19 - https://www.gsmaintelligence.com/

20 - The term "connections" defines wireless accounts and equals the number of SIM cards. This term is different from unique subscribers.

Expected sales of country i in year t is calculated based on the following equation:

$$\hat{S}_{it} = (C_{it} - C_{it-1}) + \alpha_i * C_{it-1} \qquad (1)$$

Where $\hat{S}_{it}$ is the number of smartphones expected to be sold in country i and year t and C_{it} is the number of smartphones connections in country i and year t. The coefficient α_i depends on the country i and is estimated based on the relationship between real sales and connections in previous years and represents the share of old smartphones replaced each year.

Therefore, for estimating expected sales in each country, the total number of connections in the current and previous year are needed as well as the value of the coefficient α_i specific to country i.

Prior to the estimation of the α coefficients, a quality check of the connections data has been done to control the influence of outliers. An Intervention Analysis done with the TRAMO software automatic procedure revealed some additive outliers and short term temporary changes. In the end, fewer than 2% of the observations have been imputed as a consequence.

In the subsequent step, countries are grouped based on similar characteristics so that in each group a different α coefficient will be applied. The determination of the countries included in each group is based on a cluster analysis that uses the value of the ICT Development Index (IDI) for year 2014 published by ITU in the publication Measuring the Information Society[21]. This index measures the development in ICT access, use and skills based on 11 quantitative indicators. Four clusters have been initially identified based on hierarchical clusters and single linkages. In each group, countries with similar levels of development in information and communication technology (ICT) are included:

21 - http://www.itu.int/en/ITU-D/Statistics/Pages/publications/mis2015.aspx

- Low value of IDI: 18 countries with IDI below 4
- Medium value of IDI: 17 countries with IDI between 4 and 5.58
- Medium-high value of IDI:28 countries with IDI between 5.90 and 7.32
- High value of IDI:24 countries with IDI above 7.6

Afterwards, new smartphones connections (C_t-C_{t-1}) and real sales (S_t) collected by GfK as explained before, are compared for all countries in the years 2013 and 2014. As a result of this comparison and the cluster analysis, the final classification of countries is as follows:

Cluster 0: This group includes 14 countries with low IDI values, 6 countries with medium IDI values and 2 with medium-high values. Smartphones sales in these countries in 2015 account for 9.5% of total units sold world-wide, and sales are lower than new connections in every country.

Expected sales of smartphones in these 22 countries and also in the aggregate Rest of Latin America are estimated to be equal to the increase of smartphones connections as demand is driven by new buyers since the penetration ratio is still low.

Algeria	Armenia	Bangladesh
Cambodia	Cote d'Ivoire	Ecuador
Ghana	Guatemala	Honduras
Indonesia	Morocco	Myanmar
Nigeria	Philippines	Rest of Latin America
Romania	Senegal	Serbia
Sri Lanka	Tanzania	Thailand
Uganda	Ukraine	

Cluster 10: Nine countries with medium and medium-high values of IDI presented in the table below register sales slightly above the needs for new connections so expected sales include the new connections and the renewal of 10% of the stock of smartphones each year.

Cyprus	Greece	Iran
Israel	Latvia	Russia
Turkey	Uruguay	Vietnam

Sales of smartphones in the nine countries listed above account for 5.7% of total units sold world-wide in 2015.

Cluster50: Four countries with medium-high values of IDI and eight countries with high values of IDI show a very high replacement factor and so expected sales are estimated as new connections plus 50% of current smartphones. Sales in those mature markets are driven by renewal of devices as demand for new connections is declining due to market saturation. These twelve countries account for 24.8% of smartphones sold in the world in 2015.

Canada	Chile	Germany
Hong Kong	Ireland	Jordan
Lebanon	Saudi Arabia	South Korea
Spain	United Kingdom	United States

Cluster25: The remaining 42 countries cover 60% of the smartphones sold world-wide in 2015 and expected sales are estimated as new connections plus 25% of older smartphones. This group of countries is considered as the base for comparison purposes.

Angola	Argentina	Australia	Austria
Belarus	Belgium	Brazil	China
Colombia	Costa Rica	Croatia	Czech Republic
Denmark	Egypt	Estonia	Finland
France	Hungary	India	Italy
Japan	Kazakhstan	Kenya	Lithuania
Luxembourg	Macau	Malaysia	Netherlands
New Zealand	Norway	Oman	Pakistan
Peru	Poland	Portugal	Slovakia
Slovenia	Singapore	South Africa	Sweden
Switzerland	U. Arab Emirates		

The presence of several highly developed countries in the last group (18 EU Member States as well as Australia, Japan, New Zealand, Norway and Singapore) is explained by lower replacement factors found in those countries, compared with the 12 countries included in cluster50.

The α coefficient (replacement factor) estimated for all 86 countries is 21% and can be understood as an average period of "obsolescence" of four years and nine months.

Finally, equation 1 is used to estimate expected sales in 2015 based on smartphones connections in 2015 and 2014 and different α coefficients: 0; 0.10; 0.25; and 0.50 depending on the cluster in which each country is included.

The forecast error is the difference between expected and real sales and for the purposes of comparability is expressed as a proportion of actual sales, as shown in the following equation:

$$q_{it}^{*} = \frac{\widehat{S_{it}} - S_{it}}{S_{it}} \qquad (2)$$

where S_{it} is the number of units sold in country i and year t (2015) and $\hat{S}_{it}$ is the number of units expected to be sold in that year, as calculated in the previous step.

The relative error q^{*}_{it} measures the extent to which the model has predicted a higher or lower value (as a share of actual sales) versus the actual level of sales, expressed in units.

The errors are presented in the table below. It is evident that these errors exhibit a large degree of variability. They are presented ordered by cluster to consider the fact that for each group of countries expected sales were estimated applying different α coefficients. The highest errors are registered in the first group of countries (Cluster 0), meaning that even though sales are estimated based on the increase of smartphones connections without including any replacement for older devices, in those countries expected sales are on average much higher than real sales.

TABLE 5: RELATIVE FORECAST ERRORS (2015)

Country	Code	CLUSTER	ERRORS
ARMENIA	ARM	Cluster 0	0.3383
BANGLADESH	BGD	Cluster 0	0.6829
CÔTE D'IVOIRE	CIV	Cluster 0	1.2145
ALGERIA	DZA	Cluster 0	0.5180
ECUADOR	ECU	Cluster 0	-1.4372
GHANA	GHA	Cluster 0	0.6481
GUATEMALA	GTM	Cluster 0	0.7112
HONDURAS	HND	Cluster 0	1.2708
INDONESIA	IDN	Cluster 0	0.1750
CAMBODIA	KHM	Cluster 0	1.4425
OTHER LATIN AMERICAN	LAM	Cluster 0	0.3481
SRI LANKA	LKA	Cluster 0	1.2956

Country	Code	CLUSTER	ERRORS
MOROCCO	MAR	Cluster 0	-0.0690
MYANMAR	MMR	Cluster 0	2.6903
NIGERIA	NGA	Cluster 0	0.5253
PHILIPPINES	PHL	Cluster 0	0.2816
ROMANIA	ROM	Cluster 0	0.0954
SENEGAL	SEN	Cluster 0	2.7354
SERBIA	SRB	Cluster 0	0.2974
THAILAND	THA	Cluster 0	-0.5551
TANZANIA	TZA	Cluster 0	1.6593
UGANDA	UGA	Cluster 0	0.2436
UKRAINE	UKR	Cluster 0	1.1774
CYPRUS	CYP	Cluster 10	0.0162
GREECE	GRC	Cluster 10	-0.0489
IRAN, ISLAMIC REP.	IRN	Cluster 10	0.4017
ISRAEL	ISR	Cluster 10	-0.2896
LATVIA	LVA	Cluster 10	-0.1403
RUSSIAN FEDERATION	RUS	Cluster 10	0.2036
TURKEY	TUR	Cluster 10	-0.0453
URUGUAY	URY	Cluster 10	-0.3469
VIETNAM	VNM	Cluster 10	-0.0999
ANGOLA	AGO	Cluster 25	0.0133
CHINA	CHN	Cluster 25	-0.1704
COLOMBIA	COL	Cluster 25	-0.1313
EGYPT, ARAB REP.	EGY	Cluster 25	0.2392
INDIA	IND	Cluster 25	0.0152
KENYA	KEN	Cluster 25	-0.2493
PAKISTAN	PAK	Cluster 25	0.1806
PERU	PER	Cluster 25	0.0475
SOUTH AFRICA	ZAF	Cluster 25	0.1665
UNITED ARAB EMIRATES	ARE	Cluster 25	-0.2725
ARGENTINA	ARG	Cluster 25	0.3422

Country	Code	CLUSTER	ERRORS
BELARUS	BLR	Cluster 25	0.1287
BRAZIL	BRA	Cluster 25	0.1929
COSTA RICA	CRI	Cluster 25	0.0286
CZECH REPUBLIC	CZE	Cluster 25	0.0849
CROATIA	HRV	Cluster 25	-0.0008
HUNGARY	HUN	Cluster 25	0.0113
ITALY	ITA	Cluster 25	-0.1481
KAZAKHSTAN	KAZ	Cluster 25	0.2781
LITHUANIA	LTU	Cluster 25	0.4351
MALAYSIA	MYS	Cluster 25	0.3885
OMAN	OMN	Cluster 25	-0.0145
POLAND	POL	Cluster 25	0.1545
PORTUGAL	PRT	Cluster 25	-0.2662
SLOVAK REPUBLIC	SVK	Cluster 25	-0.1306
SLOVENIA	SVN	Cluster 25	0.0358
AUSTRALIA	AUS	Cluster 25	-0.0626
AUSTRIA	AUT	Cluster 25	0.1442
BELGIUM	BEL	Cluster 25	-0.0866
SWITZERLAND	CHE	Cluster 25	-0.2600
DENMARK	DNK	Cluster 25	-0.0664
ESTONIA	EST	Cluster 25	0.2278
FINLAND	FIN	Cluster 25	-0.0635
FRANCE	FRA	Cluster 25	-0.2867
JAPAN	JPN	Cluster 25	0.0437
LUXEMBOURG	LUX	Cluster 25	0.0703
MACAO SAR, CHINA	MAC	Cluster 25	0.1909
NETHERLANDS	NLD	Cluster 25	-0.3063
NORWAY	NOR	Cluster 25	-0.3469
NEW ZEALAND	NZL	Cluster 25	-0.1065
SINGAPORE	SGP	Cluster 25	-0.0601
SWEDEN	SWE	Cluster 25	-0.2458

Country	Code	CLUSTER	ERRORS
CHILE	CHL	Cluster 50	-0.2830
GERMANY	DEU	Cluster 50	0.5957
SPAIN	ESP	Cluster 50	0.1736
UNITED KINGDOM	GBR	Cluster 50	0.2229
HONG KONG SAR, CHINA	HKG	Cluster 50	-0.1359
IRELAND	IRL	Cluster 50	-0.0796
JORDAN	JOR	Cluster 50	-0.3125
KOREA, REP.	KOR	Cluster 50	0.0762
LEBANON	LBN	Cluster 50	-0.2227
NORTH AMERICA	NOA	Cluster 50	-0.2237
SAUDI ARABIA	SAU	Cluster 50	0.0414

Source: EUIPO calculations

However, the errors are not interesting in themselves. The purpose of this study is not to produce a "good" forecast of smartphones sold but rather to generate a set of relative errors which can then be quantitatively analysed to construct estimates of counterfeiting. Forecasts for 2015 are produced based on connections and the relationship between sales and connections in the previous two years, which ensures that they are comparable and "unpolluted" by a priori knowledge of factors influencing changes in demand.

The second part of the estimation process seeks to determine to what extent these forecast errors can be explained by economic variables and by variables related to counterfeiting.

5.2. The second stage econometric model

Counterfeiting might be one of a number of factors impacting on the level of sales of smartphones, but there are, as outlined earlier, a series of other economic factors which can explain the differential, such as variables related to the economic capacity of households (e.g. broadband services prices or per capita GDP) or any other driver of consumption expenditure.

Having accounted for the influence of economic variables on the sales differential, an attempt is made to assess the extent to which counterfeiting variables, or relevant proxies, can explain the propensity to purchase counterfeit smartphones. These variables might include measures of consumers and market characteristics, as well as the evolution of a country´s legal environment.

Combining the economic and counterfeiting variables allows for the specification of an econometric model whose aim is to explain the aggregated differential between expected and real sales. The model is specified in the following format:

$$q_i^* = \partial * X_i + \beta * Z_i + \varepsilon_i \qquad (3)$$

where X_i is a matrix of explanatory variables unrelated to counterfeiting and Z_i a matrix of variables related to counterfeiting. Finally, ε_i is the remaining error.

Socio-economic variables considered to have explanatory power, unrelated to counterfeiting, include:

1. GDP per capita and GDP growth expressed in Purchased Power Parity (PPP);
2. Exchange rate of the US dollar vs. local currencies;
3. Mobile broadband services prices (ITU) expressed in PPP as well as a share of per capita Gross National Income (GNI).

Variables thought to be **related to counterfeiting** include:

1. Corruption Perception Index (CPI);
2. Intellectual Property Right Index;
3. Worldwide Governance Indicators (World Bank) covering Government Effectiveness, Regulatory Quality, Rule of Law and Control of Corruption (level and growth);
4. World Development Indicators (WB) related to ICT imports, customs and tourism.

Variables considered to be drivers of counterfeiting are related to the market and institutional characteristics of each country.

The Corruption Perception Index (CPI) is published by Transparency International and measures how corrupt public sectors are seen to be by the public in each country. In this study the updated index is used with reference year 2015.

The Intellectual Property (IP) Rights Index used is published by Property Rights Alliance and measures the strength of protection accorded to IP. The 2016 index is used in this study.

The Worldwide Governance Indicators reflect the perception of government effectiveness, regulatory quality, rule of law and corruption. They are published annually and range from 2.5

for favourable aspects of governance to -2.5 for poor performance. For computational reasons, the indicators have been re-scaled to avoid negative values so that 0 correspond to better performance and higher values indicate a worse situation. These indicators are considered as potential proxies for the perceived risk of buying or selling counterfeit goods.

The rationale behind these variables is that in countries where governance and rule of law are perceived to be weak there is a higher likelihood of consumption of a product to be illicit than in countries with good governance, strong rule of law and low corruption.

World Development Indicators include besides ICT imports and tourism indicators, the burden of customs procedures and logistics performance indexes including the ability to track and trace consignments and the efficiency of the customs clearance process and quality.

For the aggregated regions of North America and the rest of Latin America the indicators are obtained as a weighted average using population as weight with the exception of the GDP variables which use the GDP values by country as weights.

Altogether, 24 different explanatory variables were tested and different econometric techniques were applied in order to select a model with robust econometric results and a clear interpretation.

Some of the variables considered in the modelling process are correlated with each other. High correlation coefficients between explanatory variables (referred to as multicollinearity) are a common problem in econometric analysis. If correlated explanatory variables are included in the model, the estimated coefficients for these variables could be mistakenly considered as insignificant (small t-statistics), although possessing a high overall significance for the model as measured by the F-test. This situation can pose problems when trying to interpret the meaning and significance of parameter estimates and when testing the significance of other variables in the model specification.

For instance, Worldwide Governance Indicators and CPI are highly correlated. Therefore only those variables with the greatest explanatory power are included in the model in order to avoid the problems described above.

The final model is estimated using Two Steps Least Squares (2SLS) to solve problems of heteroscedasticity (confirmed with Breusch-Pagan test) as stability of variance of estimated residuals is a requirement for an acceptable accuracy in the coefficients estimation. Variation Inflation Factor (VIF) test, residuals plots and Information Criteria such as Akaike and Bayesian were also used to select the preferred model[22].

22 - All results of the diagnostic tests are available on request.

Based on residuals analysis, two countries were excluded in the final model (Ecuador and Senegal) as they are considered outliers. The final model was estimated using 80 observations due to lack of explanatory variables for Argentina, Iran and Myanmar.

Variable	Coefficient	Standard Error	t Statistic	95% Confidence interval	
				Lower	Upper
Constant	-0.2451	0.0188	-13.03 ***	-0.2826	-0.2076
Cluster0	0.3505	0.0475	7.39 ***	0.2559	0.4450
Cluster10	-0.0840	0.0147	-5.72 ***	-0.1132	-0.0547
Cluster50	-0.0155	0.0335	-0.46	-0.0822	0.0512
Prices pc GNI	0.0728	0.0122	5.95 ***	0.0484	0.0972
GDP pc PPP	0.0017	0.0004	4.14 ***	0.0009	0.0026
WB Index: Government Effectiveness	0.0753	0.0117	6.42 ***	0.0519	0.0986

R-square = 84.85%

F statistic = 122.85 ***

*** significant at 99% confidence level

The econometric model explains 85% of total variance of the stage 1 forecast errors. The model uses a combination of two economic variables and one counterfeiting related variable besides three dummy variables. For each variable the first column shows the estimated coefficient, the second column shows the standard error, while the third column indicates the statistical significance of the parameter estimates.

The model estimated includes two explanatory variables not related to counterfeiting (mobile broadband services prices as a share of per capita GNI and per capita GDP expressed in PPP) and **one explanatory variable related to counterfeiting: the WB index on Government Effectiveness**[23].

The coefficient estimated for the counterfeiting related variable is positive, so that a higher value of the index in a particular country (which corresponds to poorer regulation) is related to bigger forecast errors.

23 - This indicator captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.

Three dummy variables are included to allow for different average errors in the clusters built in the 1st step, with Cluster25 as the base. The estimated coefficients capture the effect of omitted variables that are common to each group of countries. The positive sign of the Cluster0 coefficient reflects a higher value of errors in the 23 countries of this group for which expected sales are estimated to be equal to new connections and are on average above real sales. It is not clear which factors explain the positive sign of Cluster0 coefficient but one of them could be sales not included in the GfK data, such as second-hand and refurbished devices and the presence of shared devices prevalent in some developing countries[24].

Based on the coefficient estimated for the counterfeiting-related variable presented above, the impact of counterfeiting is estimated via the following relationship:

$$F_i^* = \hat{\beta} * Z_i$$

Where F^*_i represents the sales lost due to counterfeiting in country *i* (expressed as the fraction of the sector's actual sales) and Z_i is the value the World Bank Index in that country. $\hat{\beta}$ is the estimated coefficient from the table at the beginning of this section with value 0.0753.

Based on the estimation of units lost due to counterfeiting, smartphones prices by country are applied to obtain lost sales in EUR by region. The average prices by region shown in the table in section 3.1 hide big differences among countries within each region. The two regions with lowest prices, CIS and African countries, are also the most homogeneous with a difference between countries with higher and lower smartphones prices of 78 and 85 EUR. The EU, ASEAN and other European countries register differences of more than 300 EUR between the most expensive and the cheapest country. But the most diverse region is Asia - Pacific including the country with lowest prices (Bangladesh) and the one with the highest average price in 2015 (Japan), with a spread of 479 EUR.

24 - Alternative models have been estimated using additional explanatory variables related to counterfeiting such as CPI and IPRI but the Variation Inflation Factor (VIF) test confirms the presence of severe multicollinearity in those models. The coefficient of the WB Index in different models is always significant with 99% of confidence level ranging from 0.0654 to 0.1014 providing a good indication of its stability.

6. CONCLUSIONS AND PERSPECTIVES

The studies aiming to quantify the scale and impact of IPR infringements in cosmetics and perfumes, clothing and footwear, sports goods, toys and games, jewellery and watches, handbags and luggage, recorded music, spirits and wine, pharmaceuticals, pesticides and now smartphones have provided coherent estimates of the size of the problem of counterfeiting for legitimate businesses. These studies have used a common methodology and demonstrated the benefits of working in cooperation with stakeholders to take advantage of their knowledge of market conditions, while relying on official, reputable sources for the analysis.

The eleven sectorial studies published to date will be followed in the coming months by other similar studies covering additional sectors, applying the same methodology and combining it with knowledge from industry, depending on availability of data.

In parallel, the Observatory has carried out a joint study with the Organization for Economic Cooperation and Development (OECD) to estimate the value of counterfeit and pirated goods in international trade. That study, published in April 2016, estimated the value of international trade of counterfeit goods in 2013 at 338 billion EUR (USD 461 billion) globally, corresponding to 2.5% of world trade. The corresponding figures for the EU were 85 billion EUR (USD 116 billion), representing 5% of EU's imports from the rest of the world.

Taken together, these studies complement each other and provide a complete and objective picture of the impact of IPR infringements in Europe and beyond, in order to help policy makers develop effective enforcement policies.

ITU is addressing the growing problem of counterfeited telecommunication/ICT equipment and devices, which is adversely affecting all stakeholders in the ICT field (vendors, governments, operators and consumers)[25]. The ITU-T Study Group 11 (Q8/11) on *Guidelines for implementations of signalling and protocols, and for addressing counterfeited ICT devices* is working on this issue together with other ITU study groups as well as with regional and international bodies concerned with counterfeiting. A *Technical Report on Counterfeit ICT Equipment* was published in December 2015 addressing the nature of the issues related to the counterfeiting of ICT equipment and devices, a review of the international conventions covering this type of infringement of IPR and the activities of organizations in the enforcement of these rights. This report also provides a description of a variety of means to combat the trade in ICT counterfeit products, and a description of national and regional initiatives to combat the counterfeiting of mobile devices.

25 - ITU Activities to combat counterfeit ICT Equipment - http://www.itu.int/en/ITU-T/studygroups/2013-2016/11/Pages/counterfeit.aspx

ITU has also initiated the development of a normative Recommendation on *"Framework for solution to combat counterfeit ICT Devices"* to describe a reference framework and requirements to be considered when deploying anti-counterfeiting solutions.

Finally, ITU is working with OECD on a case study on trade in counterfeit ICT goods, building on the joint EUIPO-OECD 2016 study on trade in counterfeit goods. The aim of the case study is to improve decision-makers' understanding of the nature and scale of the trade in counterfeit goods in the ICT sector. The study will be published in the first half of 2017.

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THE ECONOMIC COST OF IPR INFRINGEMENT IN THE SMARTPHONES SECTOR



REGULATORY AND MARKET ENVIRONMENT

Maximising Availability OF INTERNATIONAL CONNECTIVITY IN DEVELOPING COUNTRIES: STRATEGIES TO ENSURE GLOBAL DIGITAL INCLUSION



Telecommunication Development Sector

Maximising availability of international connectivity in developing countries: Strategies to ensure global digital inclusion

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1 Introduction and background

The United Nations General Assembly in its resolution entitled *The Future We Want* provided that "…the goal of sustainable development is to ensure the promotion of an economically, socially and environmentally sustainable future for the planet and for present and future generations. Sustainable development emphasizes a holistic, equitable and far-sighted approach in decision-making at all levels. It rests on integration and a balanced consideration of social, economic and environmental goals and objectives in both public and private decision-making. It emphasizes intra-generational and intergenerational equity".[1]

The achievement of the 17 Sustainable Development Goals (SDGs)[2] adopted in 2015 will rely heavily on the digital ecosystem since there is an ever-expanding variety of services and applications depending on the realization of a truly connected and networked society, in which ICTs can fulfil their potential. Although telecommunication networks and ICTs have already become a vital part of the daily lives of anyone with a reliable Internet connection, many people have yet to take full advantage of the ICT revolution. This especially applies to those living in developing countries and particularly people in the lower-income countries and those in post-conflict or post-natural disaster situations. About 3.2 billion people are now online, representing 43.4 per cent of the global population. While more than 7 billion people now have access to voice services, over 70 per cent of those living in the least developed countries (LDCs) still cannot afford a basic Internet connection, and less than half the people in the world regularly use the Internet[3].

The causes of the lack of connectivity are many. Limited local network infrastructure is often a constraint. In 2015, there were still an estimated 350 million people out of reach of a mobile network. Although 89 per cent of the world's urban population is now covered by a 3G network, only 29 per cent of the 3.4 billion people living in rural areas have 3G coverage. There may also be more basic issues, such as low-income levels or lack of electricity. However ensuring the availability of low-cost reliable international links can often be a particularly difficult problem to solve. International connections are often relatively costly. Some countries are land-locked, unable to reach the global backbones without the additional cost of traversing their neighbours. Small island nations isolated by large stretches of ocean may have difficulties recovering the cost of the necessary infrastructure. In some countries, governments have not stepped in to build demand for ICT services, or the policy and regulatory environment may constrain investment in local and international infrastructure, especially when there is an absence of neutral platforms where stakeholders can meet and exchange information.

Furthermore, many countries may lack experience in the wide range of technical and economic fields required, such as in laying of cables in deep waters and setting up satellite earth stations, to the business and ownership strategies of the large consortia of operators and investors that finance international projects. These and many other aspects of international network deployment and operation must work seamlessly together to ensure that there is sufficient demand for and supply of international connectivity.

Strategies for ensuring that all citizens, wherever they may be, have access to the best possible international infrastructure is therefore an important public policy priority that will also assist in reaching the WSIS targets and SDGs.

This report aims to build awareness of the challenges and strategies for improving international connectivity, and to consider some potential options for promoting increased local, regional and global collaboration to further this objective. In this respect, the report aims to inform the international development community as well as national policy makers, industry and civil society groups.

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1 The Future we want: final document of the Rio+20 Conference (E/20, 13/69, para. 6).

2 Transforming our world: the 2030 Agenda for Sustainable Development. United Nations Resolution A/RES/70/1: www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E

3 www.itu.int/en/mediacentre/pages/default.aspx

Supported by data from case studies that were carried out to provide on the ground experience in international connectivity, the report discusses the technical, economic and policy or regulatory constraints that can prevent the maximal use of international communications infrastructure. It also considers the opportunities, strategies and policies that can assist countries (particularly developing countries) to address these constraints, as well as identifying the institutions that could contribute to efforts to improve the international connectivity environment.

In addition, the report puts forward a detailed set of international connectivity strategy building blocks, providing a framework to address all the elements required for optimal international connectivity ecosystems (see Section 8).

2 The dynamics of international capacity provision in developing countries

2.1 The Global context

With the explosive growth in the use of broadband, the bandwidth demands of users have increased tremendously, resulting in soaring international capacity requirements. In 2014, it was estimated that international capacity use was growing at about 44 per cent annually (Figure 1)[4]. Reflecting greater pent-up demand, the fastest growth rates occurred in emerging markets, where Africa, Asia, and the Middle East have had annual growth of about 50 per cent between 2010 and 2014.

There were about 400 international carrier networks in 2014[5] providing 221 Tbit/s of international capacity, and this is projected to increase to 900 Tbit/s by 2020. Similarly, Cisco estimated that in 2013, submarine cables carried 51 Exabytes of data per month, which was projected to increase to 132 Exabytes by 2017[6]. According to McKinsey[7], the amount of cross-border bandwidth in use has grown 45 times since 2005 and is projected to increase by an additional nine times by 2020, as flows of information, searches, communication, video, transactions, and intra-company traffic continues to surge. With the expected growth in the Internet of Things (IoT), along with more widespread migration of broadcast and video content distribution channels to broadband, further bandwidth demand increases are expected.

These trends serve to highlight the importance of putting in place national strategies to ensure that there is sufficient and affordable local and international capacity not only for the current levels of use, but also for the higher levels of use expected in the future, when many more people and billions of additional devices will have affordable high-speed broadband links.

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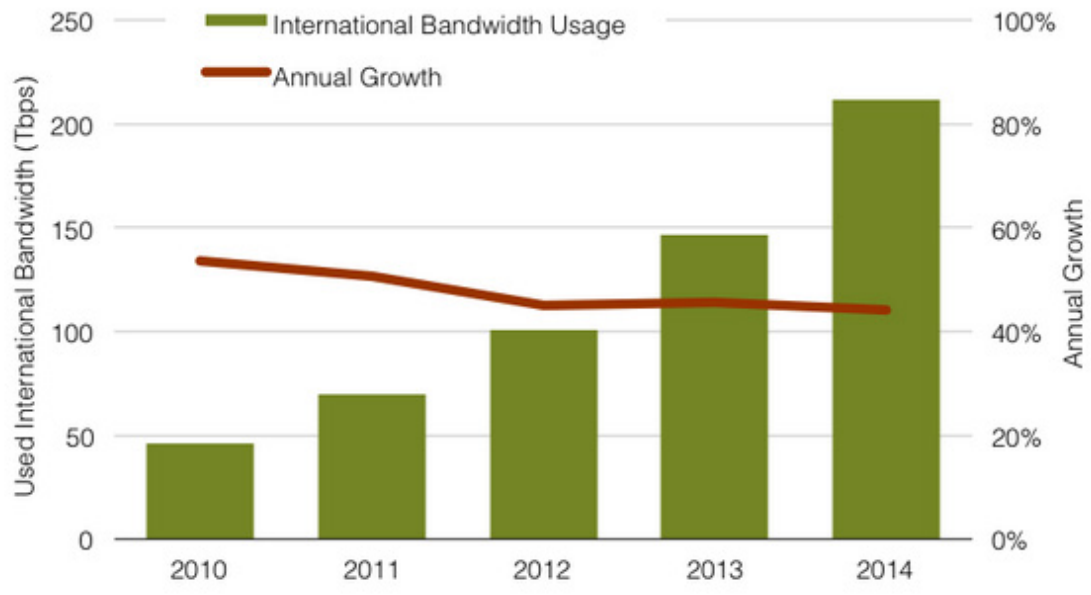
4 www.telegeography.com/page_attachments/products/website/research-services/global-bandwidth-research-service/0005/9474/gb15-exec-sum.pdf

5 These networks are being mapped by ITU: www.itu.int/itu-d/tnd-map-public

6 www.slideshare.net/jokosuryana90/international-bw-and-data-market

7 www.mckinsey.com/business-functions/mckinsey-digital/our-insights/digital-globalization-the-new-era-of-global-flows

Figure 1: Worldwide international bandwidth use and growth 2010-2014



Source: Telegeography

2.2 International capacity costs

Prices for international capacity vary widely by region due to differences in available supply, levels of competition and cost of the underlying infrastructure. On large volume submarine cable routes, wholesale capacity is usually priced in 10 Gbit/s wavelengths and prices can vary considerably depending on the route. For example, on some of the most competitive inter-regional or intercontinental routes such as Hong Kong, China to Tokyo, Japan, a 10 Gbit/s wavelength costs an average of about USD 15 000 a month in 2013, while 10 Gbit/s from New York, United States to London, United Kingdom cost USD 7 000 a month. Prices on the same route also vary significantly – for example a 10 Gbit/s circuit between Los Angeles and Tokyo varies in cost between USD 16 000 a month and USD 33 000 a month, depending on the particular submarine cable operator. As would be expected, the cost of international capacity are often up to ten times higher on less competitive, longer distance and lower volume routes, especially those linking smaller economies. Even on the higher volume regional routes, for example Sydney, Australia to Tokyo, Japan or Hong Kong, China to Singapore, 10 Gbit/s cost about USD 35 000 a month, while Sydney – London is about USD 80 000, London to Mumbai, India USD 175 000 and London to Cape Town, South Africa about USD 200 000. Although there have not been any new cables on the Latin America to the United States route recently, cable upgrades have driven prices down substantially, so that Miami, United States – Sao Paulo, Brazil now costs about USD 100 000 a month for 10 Gbit/s[8].

Of particular significance, especially for smaller operators, is that prices are also affected by the size of the circuit being purchased and the length of the contract. On many 'thinner' routes, where there are only one or two cable links operating, prices can be much higher, especially when smaller amounts of capacity are purchased. For example, the cost of a STM-1 (155 Mbit/s) circuit on a short term contract (e.g., on a month by month basis), can be as much as USD 35 000 per month on the west Africa route – equivalent to over USD 2 million per month for 10 Gbit/s.

[8] www.telegeography.com/research-services/global-bandwidth-research-service/index.html

While 10 Gbit/s wavelengths comprise the majority of worldwide international capacity sales, there are significant financial incentives for customers with high bandwidth requirements to purchase 100 Gbit/s wavelengths. For example, median 100 Gbit/s prices on key international routes are on average seven to eight times the price of comparable 10 Gbit/s service[9]. These discounts for higher capacity have led groups of smaller commercial operators as well as members of National Research and Education Networks (NRENs) to band together to aggregate their needs, thereby achieving lower operating costs for their user-base.

With prices for international capacity varying by a factor of 10 or more for equivalent distances, it is evident that the volume and level of competition are the key determinants of the cost of international capacity. Of note is that globally, increased competition is driving capacity prices sharply downwards, by about 15–40 per cent a year, depending on the route. Between Q2 2014 and Q2 2015, prices on key international routes fell an average of 16 per cent, while monthly charges for an STM-1 circuit (Johannesburg to London) fell by more than 40 per cent/year since 2009[10].

With these large price declines on international routes it would appear that network operators would be reducing their international capacity expenditures. However, international bandwidth consumption is growing by much more than the rate of price reduction. It is evident, therefore, that expenditures on international capacity will continue to increase for some time to come. Considering the cost of international capacity has a major impact on end-user broadband prices, the importance of adopting strategies to reduce international capacity prices is evident.

2.3 Global transit

When traffic reaches one of the global hubs, such as Miami, New York and Los Angeles in the United States, or Amsterdam, London, Frankfurt and Paris in Europe, it is currently possible to purchase global transit in these locations for less than USD 0.50 a month/Mbit/s (USD 5 000 for a 10 Gbit/s circuit). Most independent retail broadband providers around the world purchase capacity to one of these locations and by using the regional IXPs present there, obtain the best mix of transit and peering arrangements to minimise their global traffic costs.

The very low costs for transit capacity at the global hubs highlights the need for developing countries to establish their own regional traffic consolidation points. This will create sufficient traffic for the large international carriers to have the incentive to build out their own infrastructure to reach them, rather than the developing countries having to foot the cost for all of their international traffic. These dynamics have been the focus of the ITU-T Study Group 3, which found that the high costs of the international circuit for Internet connectivity in the least-developed countries is a serious barrier to Internet access in these countries.

This resulted in Recommendation D.50 of the of ITU Telecommunication Standardization Bureau (ITU-T), which outlines actions that the international community could undertake, in particular “to include efforts to facilitate the creation of traffic aggregation within localities, countries or within regions in developing countries in order to avoid sending this traffic over satellite or cable links used for intercontinental traffic”. This would aim to maximize the retention of local and national traffic within these regions, and thus reduce their dependence on international communication links. In 2013, ITU also published ITU-T D.50 Supplement 2, which provided guidelines for reducing the costs of international Internet connectivity.[11]

[9] Data from TeleGeography. See https://telecomnewsroom.com/tag/wholesale-bandwidth-pricing-database
[10] www.itu.int/en/ITU-D/Regulatory-Market/Documents/Events/2015/Sao_Tome/Session6_Seixas_BBcosting-pricing.pdf
[11] www.itu.int/rec/T-REC-D.50-201305-I!Sup2/en

3 International connectivity provision

3.1 Ways and means of enabling international connectivity

Today, fibre optic submarine cables, regional terrestrial fibre backbones, and satellites provide the vast majority of international links, although there are still a few terrestrial microwave connections that provide the links between countries.

3.1.1 Optic fibre cable

For nations with coastal borders, submarine fibre optic cables provide the most common option for international connectivity, while terrestrial fibre cables have largely replaced microwave and satellite links on the trunk routes for landlocked countries. Terrestrial international cables may also include routes serving domestic locations, where, for example, there may be wireless base stations every 30 km along the route to the border. Due to the large number of potential locations served along a terrestrial route, a cable laid today will often contain up to 288 optic fibres (cores). Submarine cables are more constrained with the number of fibres due to the long distances involved (often there are only four or six pairs).

In most respects, the market dynamics and policy considerations for international optic cables are little different to domestic links. International cables may run for longer distances and cross borders, but they are not designed or implemented any differently, except perhaps in their ownership models, where they are more likely to have multiple owners in different countries sharing the cost. The availability of cross border utility infrastructure such as roads, rail lines, electricity grids and fuel pipelines, combined with appropriate infrastructure sharing regulations can also have an influence on the strategy adopted for international cable deployment.

In the shared ownership model, each of the investing network operators owns a subset of the total capacity or number of fibres if it is a terrestrial route (submarine cables usually only have about four fibre pairs). Other large networks that require long-term capacity on the route would purchase capacity, fibres or wavelengths on the cable from the consortium, usually on an indefeasible right of use (IRU) basis (long-term lease of capacity), while smaller networks would usually purchase capacity on a per Mbit/s basis, monthly or annually, from one of the operators with a share in the cable. If a spare duct is available on a terrestrial cable (which is usually the case when a dig-once policy is in place in the country), a large operator might also be able to rent access to the duct, and would blow their own cable along the duct on that route.

Fortunately, once a fibre cable is laid, the capacity available is virtually limitless. The electronics at break-out points and repeater stations may need to be upgraded to provide for higher capacities, but the optic cable itself normally has a life of some decades, and is unlikely to need replacing or augmenting to cope with future needs, unless subject to multiple breakages which can create signal attenuation at the splice points. Optic fibre data transmission technology has kept pace with exploding demand, and the latest 100 Gbit/s per wavelength technologies are now commercially available, providing at least 8 Tbit/s per individual fibre core (i.e., a 288 core cable would be capable of transmitting 2 300 Tbit/s).

These technology advances provide ever-increasing amounts of capacity on existing cables, as evidenced in January 2015 when Alcatel-Lucent and the ACE submarine cable consortium completed a field trial using 300 Gbit/s and 400 Gbit/s technology. When the ACE cable entered service in December 2012, it had an initial design capacity of 5.12 Tbit/s using 40 Gbit/s technology, while the trial achieved a transmission of 12.6 Tbit/s of data per fibre pair, demonstrating a more than a fivefold increase in the system's initial design capability to 25.2 Tbit/s [12].

[12] www.alcatel-lucent.com/press/2015/alcatel-lucent-and-ace-achieve-breakthrough-upgrade-africa-coast-europe-system-using-300g400g

Even higher speeds are now being implemented on the next generation of submarine cables, such as the new FASTER submarine running between the United States and Japan, which is due to go into operation this year. With six fibre-pairs in the cable, each carrying 100 wavelengths at 100 gigabits per second, it will have a peak capacity of 60 Tbit/s [13]. Alcatel-Lucent Submarine Networks (ASN) recently demonstrated a record data capacity of 144 Tbit/s on the C-Lion1 submarine cable system (18 Tbit/s per fibre pair) [14], and also in 2015, researchers from Bell Labs successfully sent 31 Tbit/s along a single fibre over a distance of 7 200 km[15].

3.1.2 Satellite connectivity provision

Prior to the Internet revolution, satellite technologies were a common type of international trunk route for many countries. The huge increase in demand for international capacity from broadband users has seen the prevalence of satellite links decrease in use for these high capacity routes (a multi-terabyte optical fibre can carry the traffic of all the world's satellites). However, the increasing importance of access to reliable communications infrastructure has seen the demand for satellite services continue to grow. Satellite remains a vital telecommunication option in remote and rural areas, where these systems have long been used as an efficient means of providing telecom services. In addition, satellites remain an efficient solution to broadcasting, domestic deployment of broadband access and mobile backhaul in remote areas.

Satellite links are inherently faster and easier to set up than burying cable in the sea or on land. For the cost of laying a single kilometre of terrestrial fibre, a satellite link can be deployed to link an isolated community virtually anywhere in the world, no matter how far they are from terrestrial connectivity. There are higher operating expenses with satellite, but lower Capex compared to fibre, so the cost of initial finance has a much lower impact and can make satellite a more viable option in many situations. In addition, the market for satellite capacity is highly competitive, with many different operators serving most locations, which, in contrast to the limited number of submarine or terrestrial fibre backbones that may be present, makes it possible to choose from a wider variety of suppliers.

The 2016 State of the Satellite Industry Report[16] shows that satellite industry revenue was USD 208.3 billion in 2015, with a growth of 3 per cent worldwide in 2015. According to the report, the number of satellites has increased 39 per cent over the last five years, and there were 59 countries with operators of at least one satellite (some as part of regional consortia). The report also found consumer services were a key driver for the overall satellite industry.

3.2 Market developments and strategies

3.2.1 Evolution of international Internet connectivity in the Pacific

Competitive markets, where a diversity of cables operate, clearly have a marked impact on the cost of capacity, as shown in the development of sub-Saharan Africa submarine cable routes. Initially, the only multi-country submarine cable servicing the continent was initially just SAT-3/WASC, except for the Mediterranean countries. The cable began operations in 2001 and the consortium owning and operating it was started by South Africa legacy operator Telkom SA, with investment parts by other incumbent operators along the route as well as with a few international operators. The cable runs from Cape Town to Portugal, stopping in some west Africa countries. Being the only international cable available (except in Senegal, which also had some limited capacity on Atlantis-2 to Brazil), the incumbent operators in the countries of each landing station had exclusive access to the capacity and were able to charge whatever the market would bear. Costs of capacity on SAT-3/WASC were

13 www.pcworld.com/article/2947932/heres-what-to-takes-to-lay-googles-9000km-undersea-cable.html
14 www.alcatel-lucent.com/press/2016/alcatel-lucent-submarine-networks-and-cinia-demonstrate-record-capacity-144-tbits-c-lion1-submarine
15 www.alcatel-lucent.com/press/2013/002876
16 www.sia.org/wp-content/uploads/2016/06/SSIR16-Pdf-Copy-for-Website-Compressed.pdf

notoriously high, by some estimates, 50 times higher than capacity prices in the United States at the time[17], and often priced as high as satellite bandwidth.

The pace of liberalization was such that it was almost 10 years before the next cables came online and prices began to tumble. In 2009, the privately owned SEACOM cable was the first on the east coast, linking South Africa with Europe and India, and landing in a number of east Africa countries along the way. In contrast to the predominant consortium model for financing international cable links, SEACOM was the first private independently owned submarine cable in Africa (no telcos were investors). At launch, the company stated that it would reduce capacity costs by up to 95 per cent to wholesale customers and likewise it provided deep discounts on capacity for academic and research networks in the countries where it landed.

Of note is that SEACOM also began a trend of partnering with terrestrial and other submarine cable operators to provide redundancy and establish points of presence (POPs) in other coastal and inland locations, including destinations as far from the coast as Rwanda. This allowed the company to sell regional services to customers with multi-country footprints, augmented by wholesale Ethernet and global IP transit services on its network and not just traditional SDH links.

In the Pacific islands, with very small populations scattered over a huge area and isolated by the ocean, the international connectivity challenges are very different. Satellite has a much larger role to play and inter-island collaboration is key to ensuring the economies of scale can support submarine fibre to the larger islands. In addition, taking advantage of the opportunities to gain access to larger inter-continental cable builds has had a major impact for some the island nations.

By mid-2015, 14 of the 27 Pacific island clusters were connected to a submarine cable system, a major improvement over a decade ago when less than nine of them were connected. For the most part, the islands have to rely upon costly satellite connections for both international traffic and traffic within their clusters as the Islands are usually too far from each other to be connected by terrestrial microwave.

- Across the northern Pacific, there is a growing number of high-capacity trans-Pacific cables, with Guam and Hawaii being the only Islands directly connected, although Papua New Guinea is connected to Guam and Australia by the PPC-1 cable and a number of Islands in the Federated States of Micronesia and the Marshall Islands are connected to Guam.
- Across the southern Pacific, there is one trans-Pacific cable, the Southern Cross. Only Fiji and Hawaii are directly connected. An increasing number of smaller Islands are starting to gain indirect connection though and this incremental increase in submarine cable connectivity is a significant improvement, offering lower wholesale prices for Internet transit traffic, lower latency and with less danger of signal attenuation than by satellites, which are subject to rain-fade.

In addition, and subject to sufficient funding, at least two new Australasia to the west coast of the United States cables are being planned. The APX-East[18] and Hawaiki[19] cables will follow routes similar to the Southern Cross, over 12 000 km as the crow flies. APX-East is, like the Southern Cross, designed as a two-cable system at an estimated cost of around USD 450 million, but with a designed capacity of 40 Tbit/s and next-generation 100 Gbit/s wavelengths.[20] The 14 000 km Hawaiki submarine cable system is aims to be built by 2017 with a designed capacity of 8 Tbit/s,[21] offering 64 x 100 Gbit/s wavelengths.[22]

Like the Southern Cross, these cables are planned to land in Hawaii and could potentially offer spurs to the Islands of Samoa, American Samoa, Vanuatu and the Solomon Islands via Fiji, and then to Tonga,

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17 The Case for "Open Access" Communications Infrastructure in Africa: The SAT-3/WASC cable. Association for Progressive Communications. www.apc.org/en/system/files/APC_SAT3Ghana_20080516.pdf

18 www.subpartners.net/cables/apx-east-progress.html

19 www.hawaikicable.co.nz/

20 www.subpartners.net/cables/apx-east.html

21 www.computerworld.co.nz/article/435701/new_international_cable_new_zealand_proposed/

22 www.hawaikicable.co.nz/index.php/network

Niue, New Caledonia, Wallis and Fortuna, French Polynesia, Norfolk Island, Kiribati. The likelihood of all these spurs being constructed is slim due to cost and because indirect routes now become available. Even though, the American Samoa-Hawaii (ASH) cable could now be decommissioned. It is a re-utilized optical fibre cable built in the 1990s known formally as the PacRimEast (PRE) cable connecting Hawaii with Auckland.

Offering a potential connection to the Southern Cross and the proposed trans-Pacific cables are the growing number of shorter cables connecting neighbouring Islands as outlined in Table 1. For example, the Fiji to Tonga cable is over 800 km, the ICN-1 cable from Fiji to Vanuatu just over 1 200 km, and the proposed ICN-2 extension to the Solomon Islands a further 3 500 km, and to Papua New Guinea another 1 500 km.

Table 1: Cable systems and connected Pacific islands, 2015

Islands	**Cables**[1]
Guam (United States Territory) is a cable hub in the north west Pacific connected by six major trans-Pacific cable systems and connected to **Papua New Guinea**, the **Northern Mariana Islands**, **Marshall Islands** and the **Federated States of Micronesia**.	
Guam – **Federated States of Micronesia** – **Marshall Islands**	HANTRU-1 low-capacity cable system to the **Marshall Islands** and **Federated States of Micronesia**[2] – cables to **Palau** – **Yap** – **Kosrae** approved by WB and ADB
Guam – **Northern Mariana Islands**	MTC – **Rota**, **Sapian**, **Tinian**
Australia – **Guam** – Japan	Australia-Japan Cable via **Guam**
Australia – **Papua New Guinea (PNG)** – **Guam**	APNG-2; PPC-1 (PIPE Pacific Cable 1) + **PNG** Spur
Hawaii (50th State of the United States) is a cable hub in south east Pacific connected by four trans-Pacific cables and three cables connecting to Australia, **American Samoa-Samoa**, and **Tahiti**	
Australia – **Fiji** – **Hawaii** – United States west coast	Southern Cross
Australia – **New Caledonia**	Gondwana-1
Australia – **Solomon Islands**	
PNG – **Solomon Islands** – **Vanuatu** – **Fiji** – **Tonga** – **(planned) New Caledonia**[3]	Interchange Network cable (ICN-2) connecting **PNG to Solomon Islands** to **Vanuatu** awaiting construction; ICN-1 **Vanuatu** – **Fiji** built; **Fiji** – **Tonga** approved; a spur planned to **Noumea (New Caledonia)**
Fiji – **Samoa** – **American Samoa** – **Hawaii** – United States west coast	**Fiji** (approved) – **Samoa** – ASH cable (**American Samoa** – **Hawaii**)
Hawaii – **French Polynesia**	Honotua cable **Hawaii** – **Huahine**, **Moorea**, **Tahiti**, **Bora Bora**
Planned cables	
Australasia – North America	APX-East[4] and Hawaiki[5] cables – potential to link up **Samoa, American Samoa, Vanuatu, Solomon Islands, Fiji, Tonga, Nuie, New Caledonia, Wallis and Fortuna, French Polynesia, Norfolk Island, Kiribati**

[1] ITU www.itu.int/itu-d/tnd-map-public/; Greg's Map www.cablemap.info/; Futures Perfect http://futures-perfect.com/Cable%20Systems%20-%20by%20Country.pdf; http://submarinecablemap.com/#/

[2] http://en.wikipedia.org/wiki/HANTRU-1

[3] *Islands Business* (16th Jan 2014) www.islandsbusiness.com/news/fiji/4284/fiji-vanuatu-cable-to-go-online/

[4] www.subpartners.net/cables/apx-east-progress.html

[5] www.hawaiikicable.co.nz/

Note: Names of Islands set in **bold**.

Source: TRPC research

3.2.2 Developments in the skies

In terms of satellite broadband, today there are five major operators: Eutelsat Tooway, HughesNet, ViaSat Exede, Inmarsat Global Xpress, and O3b. Other providers are affiliated with the established satellite operators. With high data rates and more reliable service, consumer satisfaction and confidence has improved, as illustrated by recent FCC broadband reports for best peak period download speeds using satellite. As a result, the satellite broadband market has seen 50 per cent revenue growth over five years, with subscriber numbers growing 11 per cent per year on average.[23]

Satellite for rural connectivity

New developments in satellite technologies and business models mean that satellite communications still has a major role to play in supporting national and international connectivity, in particular for rural and remote areas. Broadband demand is increasingly being met by the new high throughput satellites (HTS) and ground station equipment that have been developed to respond to the need for greater capacity. Through frequency reuse, spot beams and on-board processing, substantial reductions in costs have been achieved.

Eutelsat and Facebook for example are preparing to provide satellite connectivity solutions using in sub-Saharan Africa, based on Hughes' new Jupiter System, which can achieve 100 Mbit/s of throughput per terminal. The companies plan to use high-gain Ka-band spot beam capacity on the Spacecom Amos 6 satellite, which is due to enter service in early 2017.[24]

In 2014, Kacific has announced a five year contract with Tokelau.[25] Although a potential service drawback of Ka-band HTS in some regions is signal attenuation during heavy rainstorms, adaptive coded modulation (ACM) may be adapted to reduce the problem. It lowers signal power during a rainstorm to avoid fade and accelerates once the rain clouds have passed by. However, this is the reason why some satellite operators in the Asia and Pacific region are holding off a decision to invest in them.[26]

Medium earth orbit (MEO) satellite connectivity is gaining particular attention, offering even lower bandwidth costs compared to many GEO satellites while latency is reduced. The O3B (the 'Other 3 Billion' of unconnected people) satellite system consists of eight MEO satellites with hand-off between them.[27] The final four satellites were launched in 2014 and they already provide connectivity in the south Pacific to the Cook Islands, Federated States of Micronesia, Micronesia, Palau, Papua New Guinea, Timor Leste, and Samoa, and many other remote locations.

Next generation technology and innovation

A series of new technologies and innovative solutions based on miniaturization of electronic components are promising to provide new solutions to enhance connectivity. One example is the increasing role of various high altitude platforms (HAPs) such as drones as a miniaturized aerospace vehicle. Facebook, for example, has announced plans to launch drones with a wingspan greater than a Boeing 737 but weighing no more than a car that will soar at 60 000 feet (over 18 000 metres) using solar energy and laser beams to bring Internet connections to remote areas. Google 'Project Loon' HAP opts for Internet balloons 20 km above the Earth surface in the stratosphere guided by algorithmic software to calculate wind-speed and direction. By contrast, the Brazil Government *Conectar* project is experimenting with tethered balloons, fixed at an altitude of about 250 m, which could provide 'very high site' wireless connectivity at a distance of up to 50 km from the balloon[28].

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23 www.sia.org/wp-content/uploads/2016/06/SSIR16-Pdf-Copy-for-Website-Compressed.pdf

24 www.satellitetoday.com/telecom/2016/05/10/facebook-eutelsat-tap-hughes-for-jupiter-system-to-provide-internet-in-africa/

25 http://kacific.com/tokelau-selects-kacific-to-deliver-high-speed-broadband/

26 High Throughput Satellites: A Growing Opportunity in Asia. www.satellitetoday.com/publications/2014/05/14/high-throughput-satellites-a-growing-opportunity-in-asia/

27 www.o3bnetworks.com/

28 www.inpe.br/noticias/noticia.php?Cod_Noticia=3440 / www.theguardian.com/global-development/2014/jan/09/balloons-internet-brazilian-rainforest-amazon

Exploiting the economies of scale in the mass production of small satellites is also gaining increased attention, such as with the OneWeb project, which is partnering with Richard Branson's Virgin Galactic to launch a massive 648 spacecraft into 20 orbital planes at 1 200 km altitude to provide Internet globally at affordable prices. Through miniaturization, OneWeb ambitiously aims to bring the cost of each satellite down from upwards of USD 300 million to around USD 500 000.[29] Already developed is a new generation of miniaturised 'CubeSats' that can be fitted together on a modular basis and launched into low-earth orbit for less than USD 80 000.[30]

Helping bring down satellite launch costs is innovation in the space launch industry, with companies such as SpaceX developing reusable vertical take-off and landing rockets. SpaceX is also proposing to launch up to 4 000 satellites by 2030, which would provide universally accessible low-cost broadband and direct peer-to-peer connections.

It is too early to tell which emerging technologies will ultimately be the most suitable, but what does seem likely is that as some of these technologies move from fiction to fact and so will the idea of connecting everyone. By reducing both capital and operating costs, the demand for broadband access and services continues to grow and so the potential for financial sustainability of these projects should increase.

3.2.3 Leveraging the integration of terrestrial, submarine and satellite technologies

New network architectures, converged/unified licensing regimes and innovative business models for covering remote and rural areas can be used today to more effectively integrate the use of satellite, terrestrial and submarine telecommunication infrastructure, and as a result, new opportunities are emerging which can build on these developments.

The most evident trend in many countries has been the increasing involvement of mobile operators in building their own national fibre backbones, or forming partnerships with other operators to build shared fibre infrastructure. These operators often have presence in neighbouring countries and have found they can join their backbones to create cross-border links. As outlined below in the case of Kenya (see Figure 2), some countries with multiple borders have been able to take advantage of nearby submarine cable landings to become regional hubs which serve as a source of international capacity for their inland or landlocked neighbours. Many of these national backbones and cross-border links can be observed in the ITU interactive transmission maps[31].

A particularly good example of this trend is land locked Rwanda. The country has extended the government owned fibre backbone to all of its borders and it is now able to access submarine capacity from both Kenya (via Uganda) and Tanzania. The Tanzania route is the preferred one because it does not have to pay for the costs of going through a second country (Uganda) to obtain international capacity. In addition, the cross-border linkages, along with low cost of transit capacity in Tanzania, have been facilitated by the presence of the government owned national backbone in Tanzania and the good relations between the two countries. Once infrastructure is in place on the side of the Democratic Republic of Congo (DRC) of the Rwanda border, Rwanda is also expected to become the source of upstream capacity for the eastern DRC, which is currently cut off from the cable infrastructure present in the west of the country.

Across the sub-continent, this upstream/downstream role has also taken place in Cameroon (serving Chad), Ghana (serving Burkina Faso), Kenya (serving Ethiopia, Uganda and shortly South Sudan), Mali (serving Burkina Faso), Nigeria (serving Niger), Tanzania (serving Burundi, Malawi, Rwanda and Zambia), Senegal (serving Guinea Bissau, and Mali) and South Africa (serving Botswana, Lesotho, Swaziland, Zambia and Zimbabwe). In all of these situations, international traffic has essentially 'piggy-backed' on a national network deployment.

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29 www.bbc.com/news/science-environment-33268180
30 www.ft.com/intl/cms/s/0/2ad23aca-e55a-11e4-bb4b-00144feab7de.html#slide0
31 www.itu.int/itu-d/tnd-map-public/

Other recent examples of combined efforts to enhance connectivity include:

- Intelsat partnership with local satellite services operator Skynet de Colombia to bring high-speed broadband and Internet connectivity to 600 remote sites, across 250 municipalities in Colombia, making digital inclusion available to people who previously had no access and enabling the same types of advantages and services afforded to those who live in the more developed areas of Colombia.[32]
- Facebook strategy to deliver broadband to rural areas is shaping up to be multi-platform to include high-altitude aircraft and open-source telecom equipment, in addition to satellites. Within this context, Facebook had leased capacity on three in-orbit SES satellites to provide Wi-Fi connectivity in sub-Saharan Africa. SES said it would provide an undisclosed amount of transponder capacity to Facebook from three satellites – Astra 2G, Astra 2B, and Astra 4A. Astra 2G and 4A both have mixed Ku- and Ka-band capacity; Astra 2B is all-Ku-band. As mentioned above, Facebook has also partnered with Eutelsat to jointly lease the Ka-band payload on the Israel-based Spacecom Amos-6 satellite.[33]
- Intelsat satellite capacity supply agreement with Africa mobile communications company Vodacom to extend service to over 700 rural sites in the Democratic Republic of Congo, and has done so profitably with a cost-effective, quickly deployable solution that has given them a first-to-market advantage.[34]
- High throughput satellite Kacific is due for service by 2017 and aims to join an ITU initiative "to donate a total of 50 Mbit/s of dedicated bandwidth for a full year to the 11 Pacific island countries, complemented by 40 terminals. The total value of the donation is estimated to be about USD 380 000."[35]
- Intelsat has reached agreement with Detecon Al Saudia (DETASAD) to deliver Internet connectivity for corporate networks operating in and outside of Saudi Arabia, supporting financial transaction networks in the region (including thousands of ATMs), as well as maritime operators, oil and gas companies, government agencies and ISPs to help power the country's economy and deliver services to urban and remote areas.[36]
- Under the *Rural Satellite Connectivity Project for Pacific Island Countries*[37] – ITU is partnering with the International Telecommunications Satellite Organization (ITSO) and next generation satellite operators to fund services to Fiji, Kiribati, Marshall Islands, Micronesia, Nauru, PNG, Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu. The estimated cost is between USD 500 000 – USD 1 million.[38] The initiative envisages up to 100 'e-centres' on the islands where costs can be shared among users, including government services, community centres, and the like. Two of the partners are the operators of the new 17-31 GHz Ka-band high throughput satellites (HTS) service providers using medium earth orbiting (MEO) satellites in elliptical orbits.

3.2.4 Emergence of regional hubs: where countries and cables interconnect

Regional hubs have emerged around the world wherever a large number of cables provide a competitive environment for international capacity. In east Africa for example, Kenya became a regional hub after

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32 www.intelsat.com/intelsat-news/intelsat-and-skynet-de-colombia-bring-high-speed-broadband-connectivity-to-remote-areas-of-colombia/

33 http://spacenews.com/ses-announces-facebook-order-for-african-satellite-capacity-unclear-link-with-facebook-eutelsat-deal/#sthash.x8ZvfeRn.dpuf

34 www.intelsat.com/wp-content/uploads/2016/03/Delivering-rural-cellular-services-in-DRC-Vodacom-7251-CS.pdf

35 http://kacific.com/pacific-wave-conference-connectivity-key-to-economic-growth-and-resilience/

36 www.intelsat.com/intelsat-news/intelsat-and-detasad-enhance-broadband-connectivity-for-corporate-networks-in-saudi-arabia/

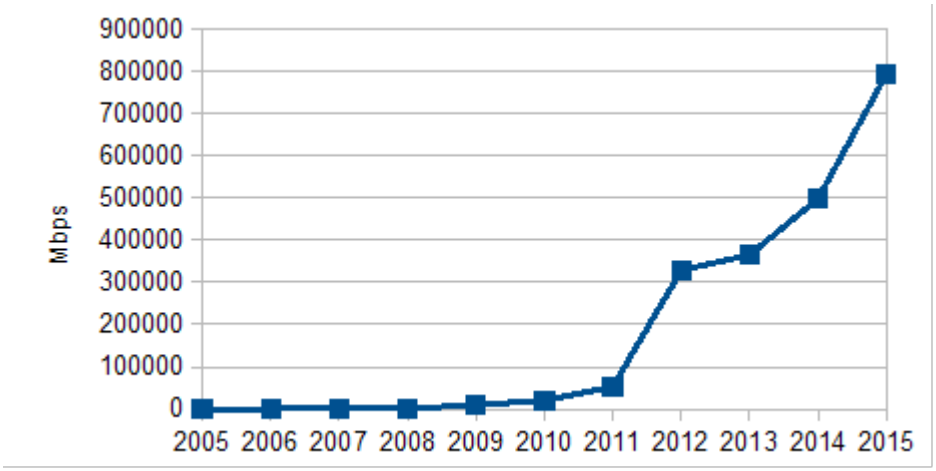
37 PITA/ITU (2013) 'Rural Satellite Connectivity Project for the pacific Island Countries'. www.itu.int/ITU-D/asp/CMS/Events/2013/PacificForum/ITU-APT-S1_Gisa_Purcell-Maui_Sandford.pdf

38 www.itu.int/net4/ITU-D/CDS/projects/display.asp?ProjectNo=7RAS14050

four different cables landed in Mombasa within the space of only five years[39]. This is seen as the result of Kenya's strategic location, combined with government investments in infrastructure and policy development, along with the general opening of the telecommunication markets in east Africa. With a competitive market for capacity, the cable landings in Kenya also serve as primary routes for landlocked countries inland – Uganda and Rwanda, as well as additional/backup routes for Burundi, Ethiopia, Somalia and Tanzania. South Sudan is also expected to obtain access via Kenya for some of its international capacity needs in the future.

With low costs of international capacity and a relatively competitive domestic market, Kenya network operators responded to the low cost of international capacity by investing heavily in local and backbone infrastructure. This, along with other local government initiatives caused Kenya's use of international capacity to take off exponentially, from 2010 onward, as shown in Figure 2.

Figure 2: International capacity in use in Kenya (Mbit/s)



Source: Communications Authority of Kenya www.ca.go.ke/index.php/statistics

3.2.5 Filling in the gaps and increasing capacity

As international capacity markets mature, new routes are often added to fill in gaps that were initially not covered. For example, despite the large number of cables now in service along both coasts of Africa, two major new submarine cable projects are planned that will provide alternate intercontinental routes, additional landing stations for countries with only one or two, and overall increases available capacity. Angola Cables and Telebras are currently planning to build the South Atlantic Cable System (SACS) between Angola and Brazil. Angola Cables is a consortium, comprised of incumbent Angola Telecom, ISPs MSTelcom and Movicel, and mobile operators Unitel and Startel. SACS was initially scheduled to enter service in the fourth quarter of 2014, but is now not expected to begin operations until 2017. The Cameroon government also announced plans last year for a cable linking to Brazil, but details are lacking.

More recently, Liquid Telecom, a southern Africa terrestrial cable operator, announced that it would build a submarine cable to link southern and east Africa with the Middle-East. The cable is expected to directly connect all coastal countries along the east coast of Africa and to provide new routes to the Middle-East and Europe. The project will include landing stations in several ports that are currently not served by existing sub-sea cables.

[39] SEACOM, TEAMS, EASSy, and France Telecom LION2. Also, soon LiquidSea. www.liquidtelecom.com/news-events/news/343-liquid-telecom-to-build-new-undersea-cable

3.2.6 Synchronising domestic network demand with international capacity deployment

The deployment of international capacity needs to take place in co-ordination with the development of domestic infrastructure, otherwise the economic viability of the investment in international infrastructure can be jeopardised. For example, in 2010 a privately financed[40] cable, MainOne, began service on the west coast of Africa, connecting Nigeria and Ghana to Portugal. MainOne rates for capacity were about 20 per cent of SAT-3 rates on the same route, but despite this, the company initially faced difficulties selling its available capacity due to the lack of local broadband infrastructure to service local demand in the countries where the cable landed.

This necessitated MainOne to build a Tier-3 data centre in Nigeria and to prioritise investment in extensions to its cable system in order to gain access to more customers. First, MainOne extended its infrastructure to Togo with an interconnection through Ghana, while servicing Benin from Nigeria. Then in 2015, MainOne built out its network from Lagos to Kribi, Cameroon. MainOne built the new system in partnership with Cameroon Telecommunications (Camtel) and Huawei Marine Networks, with additional investment provided by the Cameroon Government. Fortunately, the stubs had been planned into the original design of the cable and this allowed the company to substantially extend the reach of the MainOne system, both domestically and internationally, thereby much improving its overall revenue potential.

Similarly in October 2010, the Nigeria second national operator Globacom, launched its Glo-1 submarine cable, which linked Nigeria and Ghana to the United Kingdom. The cable was designed with a number of as-yet unused spurs along the way. In March 2016, Globacom announced that the cable would make use of some of its unused spurs and will shortly land in Cote d'Ivoire, Senegal and Gambia[41].

3.2.7 Using cable design strategies for optimal route sharing

Innovative cable designs can also be used to the optimal distribution of capacity to landing stations along the route. For example, in 2012, a consortium of network operators in countries on the west coast of Africa deployed the West African Cable System (WACS) linking South Africa to the United Kingdom, with 11 landing points along the way, providing a number of countries with their first direct connections to the global cable backbones (Namibia, DRC, the Republic of Congo, and Togo[42]). One of the four fibre pairs on WACS is a direct route from South Africa to Europe, a so-called express lane, which carries a large proportion of the overall traffic on the cable. The second and third fibre pairs are designed as semi-express lanes, one with two hops, from South Africa to west Africa, and west Africa to Europe and the other with three stops. The fourth pair is an omnibus fibre that stops off at all landing stations en route.

Also of note is that the landing stations support 'wavelength pass-through' which means that a wavelength coming into a landing station continues onwards through the rest of the cable system, allowing upgrades to be carried out without the necessity to perform an upgrade at each landing point.

One of the lessons learned in the ACE open access landing stations was to plan for the needs of the smaller network operators that wish to purchase capacity of less than an STM-1 (155 Mbit/s). This was not anticipated in some cases, and, as a result, the necessary multiplexing equipment to be able to divide capacity into smaller amounts was not budgeted for. The submarine landing stations took some additional time to obtain this equipment, leading to delays in being to sell capacity to small networks. This reduced the cash flow needed for repayment of the investment capital and delayed the provision of services by small operators.

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40 The major investors were the Africa Finance Corporation, the Pan-African Infrastructure Development Fund (PAIDF) and two Nigerian banks.

41 http://allafrica.com/stories/201603101216.html

42 www.oafrica.com/broadband/west-africa-cable-system-wacs-technically-goes-live

3.2.8 Maximising reliability by limiting the impact of cable breaks

The importance of taking measures to minimise the potential for accidental breakages and vandalism, and the need for ensuring sufficient resiliency through access to multiple physically different paths is highlighted by the experience of Kenya in 2012. In February that year, the TEAMS cable was accidentally cut by a Mombasa Ports Authority dredging ship. The repairs took about four weeks, because the repair ships were already occupied with multiple cable cuts between North Sudan and Egypt that had taken place at about the same time[43]. More than half of the networks in Kenya and Uganda were affected by the interruption and the impact of the break was exacerbated because TEAMS was also carrying re-routed EASSy traffic after three cables had experienced breaks in the Red Sea – Europe India Gateway (EIG), SEA-ME-WE 3, and EASSy[44].

The SAT-3 cable link to Nigeria was cut in June 2013 during a land reclamation project. As a result the local operator NITEL is said to have lost around USD 6 million in revenues during the period in which the infrastructure was inactive[45]. Similarly, the Benin SAT-3 landing station suffered a catastrophic fire that put it out of action for months.

Since the ACE cable began operations in 2012, there have been four service interruptions of about one week each (cable cuts or shunt faults[46]), two of which directly affected some of the west Africa countries due to the lack of an alternative international route. As a consequence, local operators were left scrambling to maintain limited services, which involved contracting for costly short-term capacity (USD 35 000/week for an STM-1) to other undersea cables via Dakar or Abidjan (fortunately the ACE cable had continued to function along these sections).

To accommodate the potential for service interruptions, most of the major international cables in Africa have made provisions for use of alternative routes in the event of a cut, and as a result, their customers can usually purchase 'protected' capacity at a significant premium. Alternatively, customers create their own resilience strategy by spreading their capacity purchases across different links if available.

Minimising the risk of cable breakages also needs to be part of the reliability strategy adopted by cable operators. This is especially important considering that multiple cables may be accidentally cut at the same time and repairs can take weeks. Using armoured cable, ensuring the route survey is accurate, deeper trenching and choosing the least risky but potentially longer route may increase the initial capital costs of the project, but in the longer term this is likely to pay off in lower maintenance costs and more revenues. Similarly, marking of the in-shore route and awareness raising with the shipping and fishing communities has helped to reduce the number of accidental cuts (about 70 per cent of all cable faults are caused by fishing and anchoring in depths of less than 200 m[47]).

Minimising the risk of cable cuts on point-to-point cables dedicated to serving small populations (such as connecting an island) is particularly important. This is because the main difference in establishing a dedicated small island link compared with participation in a larger cable project or consortium is that the risk of cost escalation cannot be spread across more participants. This suggests that projects require careful analysis to ensure the risk of unforeseen cost increases are reduced as much as possible, and in particular that the risk of cable breakages is minimised. Aside from the loss in revenues caused by service interruption, the costs to repair a cable fault can have a major impact on balance sheet, especially on thin route cables with more limited revenue streams. A single cable break can

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43 www.cio.co.ke/view-all-main-stories/4948-cable-cuts-whos-up-whos-down-.html

44 http://online.wsj.com/article/SB10001424052970203833004577249434081658686.html

45 www.telegeography.com/products/commsupdate/articles/2015/02/27/cable-compendium-a-guide-to-the-weeks-submarine-and-terrestrial-developments/

46 A submarine cable shunt fault occurs when the cable insulation is compromised, allowing water to contact the copper conductor.

47 www.kis-orca.eu/subsea-cables/maintenance-repair-operations#.V2nL3mIrJZ0

costs hundreds of thousands of dollars to fix (a cable ship is needed to travel[48] to the area, find the break and pull the cable to the surface for repair).

3.3 Ownership and financing models for international infrastructure

3.3.1 Submarine cables

The shared ownership model is the basis of one of the most common strategies for deploying fibre – a consortium of operators club together to share the costs of the project for their mutual benefit. Each operator obtains a proportion of the overall capacity of the cable in proportion to its share of the total investment required. This is a sunk cost (aside from the annual maintenance fees of about 3-5 per cent of the capital cost), for which the operator can choose to recoup over a longer or shorter period, depending on their business/pricing model, for example by providing discounts for higher capacity purchases or longer contract lengths.

In the first two major submarine cables in Africa, the two different ownership models that initially emerged were the consortium model (SAT3/WASC), where a club of operators financed the cable in proportion to their use of the capacity provided, and the independent private investment group financing a cable 'startup' (SEACOM), where the primary aim was to take advantage of a market opportunity. Since then a variety of other business/financing models have also emerged, some with public-private partner (PPP) ownership and in some cases, state monopolies in landing station ownership.

EASSy – A hybrid consortium model

In contrast to the pure consortium or investor driven models that were used in the first two international cable projects in Africa (SAT-3/WASC and SEACOM), the next cable, EASSy,[49] was noteworthy for being a 'hybrid consortium', with an open access element to the cable ownership. This was achieved through the establishment of the West Indian Ocean Cable Company (WIOCC) as one of the shareholders in the EASSy cable (along with 15 other large on-continent and off-shore telecom operators). As a peer with the other consortium members, WIOCC is able to supply capacity at the same price to its own shareholders – 14 of the smaller network operators in Africa, with financial support from five international development finance institutions: International Finance Corporation (IFC), African Development Bank (AfDB), French Development Bank (AFD), German Development Bank (KfW) and European Investment Bank (EIB).

Similarly to the SEACOM and MainOne business strategies mentioned above, WIOCC also broadened its offering beyond purely the provision of capacity on the submarine cable, and has made investments in other submarine cables, providing its customers with route diversity and a virtual 'ring' around the continent. In addition, it has also established a number of inland POPs to provide capacity for networks located in land locked countries.

ACE – Open access landing stations on a consortium cable

Open access elements to international cables were also included in the subsequent and most recently deployed submarine cable, the Africa Coast to Europe (ACE) consortium financed system, which went into service along the west coast of Africa in December 2012. The USD 700 million project was initiated by Orange/France Telecom, primarily to support its subsidiaries along the west coast of Africa. However, some additional operators and a number of governments along the route also participated – Benin, Gambia, Guinea, Liberia, São Tomé and Príncipe, and Sierra Leone. These were supported by the World Bank West African Regional Communications Infrastructure Program

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[48] Alcatel now maintains a cable distribution and repair depot in Cap Verde, and a SAT-3 cable maintenance ship is stationed in Cape Town.

[49] On the east coast, the Eastern African Submarine Cable System (EASSy), came online in July 2010, linking South Africa with Sudan and nine other east coast countries along the way with then the highest capacity system serving sub-Saharan Africa – more than 10 Tbit/s.

(WARCIP), which loaned each country the USD 20 to 25 million investment required for participation in the ACE consortium.

In each country, special purpose vehicles were established to manage the capacity and operate the landing station, in which the government and local operators took shares. The proportion of shareholding corresponded to the percentage of the landing station total bandwidth capacity allocated to the shareholder. A significant portion of the shareholding/capacity was held by government for future operators, as well as retaining some for their own potential use in public sector connectivity projects, such as connecting health and educational institutions.

It is also of interest to note that WARCIP financing not only covered the funds necessary to become a consortium member in the ACE cable but also included funds to support the development of an enabling policy environment for broadband infrastructure in the country.

As a result, of the ACE open access cable landings, capacity costs in the countries that did not previously have access to international fibre have dropped substantially. For example, in Liberia before the arrival of the cable, network operators were paying about USD 2 000/Mbit/s a month for international satellite connectivity. After the ACE landing, the mobile operator Cellcom 10 per cent share gave access to an initial 600 Mbit/s of capacity at a one-time cost of USD 2 million (not taking into account the Cellcom cost of finance). To provide a rough idea of what this means in effective costs, if Cellcom fully amortized the USD 2 million investment over only five years, its cost for international capacity would be just USD 60/Mbit/s per month – a reduction of over 30 times.

Table 2: List of investors in international submarine fibre infrastructure in Africa

Access Kenya Group	MaIN OnE
African Development Bank	Mauritius Telecom
Angola Telecom	MTN (SA)
Angola Cables	Neotel (SA)
BCS Group	OCPT (Office Congolais des Postes et
Benin ACE GIE	Telecommunications)
Bharti Airtel Limited (India)	ONATEL Burundi
Botswana Telecommunications Corporation	Orange Cameroon
British Telecommunications	Orange Guinée
France Telecom	Orange Kenya Ltd.
Broadband Infraco	Orange Mali
Cable & Wireless	Orange Niger
Cable Consortium of Liberia	Portugal Telecoms
Canalink	PT Comunicações
Comores Telecom	**Republic of Cameroon**
Congo Telecoms (formerly Sotelco)	**Republic of Equatorial Guinea**
Convergence Partners	**Republic of Gabon**
Côte d'Ivoire Telecom	Safaricom Ltd.
Dalkom Somalia	Saudi Telecom Company

DFI Consortium (World Bank/IFC, EIB, AfDB, AFD,

and KfW)

Djibouti Telecom

Dolphin Telecom

Etisalaat (United Arab Emirates)

Expresso Telecom Group

France Telecom

Gambia Submarine Cable Company

Gilat Satcom Nigeria

Government of Kenya

Guineenne de la Large Bande

Herakles Telecom LLC (Blackstone)

Industrial Promotion Services (Aga Khan Fund for

Economic Development)

International Mauritania Telecom

Jamii Telecom Ltd

Lesotho Telecommunications Authority

Libyan Post, Telecom and Information Technology

Company (LPTIC)

Liquid Telecom Kenya Ltd

Shanduka Group

Sierra Leone Cable Company

Sonatel

Sotelgui

SPIN Gabon

Sudan Telecom Company

STP Cable (Sao Tome)

Tanzania Telecommunications Company (TTCL)

Tata Communications (Neotel)

Telecom Malagasy

Telecom Namibia

Telecommunicacões de Mocambique (TDM)

Telkom Kenya

Telkom/Vodacom (SA)

TelOne Zimbabwe

The Government of Seychelles

Togo Telecom

U-COM Burundi

Uganda Telecom Ltd.

VenFin Limited

Vodacom

Wananchi Group

Zambia Telecommunications Company

Zantel Tanzania

Zanzibar Telecom

Note: Names in **bold** reflect non-telecom investors.

Source: ITU

Lessons can be learnt from the experience of ACE. One issue with participation in many submarine fibre cable projects is that the administrative costs of the cable and landing station were higher than expected. For example, contributions to the ACE cable maintenance programme costs each landing station party about USD 720 000 per year, and staffing and power supply also needs to be covered. A revenue stream to cover these costs needs to be built into the initial business model or the budgeting and cash flow calculations. In the case of the Liberia ACE landing station, the shareholders dealt with this by each ceding 25 per cent of their capacity to the landing station itself, which could then sell this to smaller networks in order to cover the administration costs.

Another dynamic highlighted by the ACE cable experience relates to the fact that each consortium participant normally incurs remote activation fees to bring up the circuit on the ACE cable. In addition, as is the case everywhere, the purchaser of capacity on the cable must also pay transit fees at the destination to carry traffic on to the global backbones. Orange/France Telecom recently began using its market position to make the France cable landing more competitive with the Portugal landing by reducing the activation fee for circuits to France from USD 10 000 per STM-1 to a virtually negligible amount (USD 250/STM-1). This is expected to attract more business by helping to compensate for the higher transit fees that are present in France compared to Portugal (due to the higher level of competition from multiple cables landing there).

3.3.2 Satellite

The most significant aspect of HTS satellites is the business model they can offer based upon their greater efficiency at various stages along the communications chain.[50] Traditionally, in high-density regions, the 'Mbit/s model' is used where a single operator provides the whole range of satellite services, including Earth stations and terminals, and sells Mbit/s to an intermediary, such as an Internet service provider (ISP) and a content distribution network (CDN) or directly to end-users. In smaller markets, the 'MHz model' is more likely where the satellite operator leases out transponder capacity to different service providers that sell capacity to wholesale service providers on the ground that operate the Earth stations and terminals such as VSATs (very small aperture dishes) and satellite phones, and that separately package terrestrial Mbit/s retail services.

The lowest Mbit/s prices in the 'Mbit/s model' maybe around USD 1 800 per Mbit/s per month if 50 Mbit/s capacity is purchased and USD 800 if 100 Mbit/s is purchased. The corresponding figures for the 'MHz model' are likely to be USD 1 000 and USD 600. But for small projects providing rural connectivity where the economies of scale are lacking, the cost of a small C-band satellite capacity may well be around USD 3 000 per month. Although by lengthening the period of the contract to a minimum of ten years and negotiating a sharing of multi-transponders amongst islands it is possible to bring down costs per MHz by up to 80 per cent.[51] For individual islands even HTS prices can seem high, but if HTS transponder capacity can be shared with other islands using spot-beam technology that can target the footprint to multiple markets and costs can be reduced.

3.3.3 Regional backbones

Another approach to the provision of international capacity has been taken by some larger scale initiatives to create regional networks, which interconnect multiple countries terrestrially. These projects have consisted of knitting together national backbones, or completely new greenfield cable digs, or making creative use of existing passive cross-border infrastructure.

In the first category are the long-standing efforts of the regional economic communities to improve regional integration by linking together the backbones of the national operators, primarily the legacy fixed line incumbent operators. In southern Africa, this project is known as SRII (SADC), in west Africa; Intelcom II (ECOWAS) and EABS in east Africa (EAC). These projects have had limited success due to their reliance on often cash-strapped state owned or partially state owned operators with little incentive to invest in regional infrastructure. They have also been overtaken by multi-country mobile network operators that have linked their national backbones where they share common borders.

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50 This includes their use of spot beams to optimize coverage, by combining C, Ku and Ka-band transponders to maximize business opportunities, and by operating next generation gateways that can handle the higher throughput with greater levels of efficiencies while using less rack space, thereby reducing unit costs. See 'High Throughput Satellites and the Asia-Pacific Region' Dave Rehbehn, Senior Director, Marketing, International Division, Hughes Network Systems High.

51 Figures from www.itu.int/ITU-D/asp/CMS/Events/2013/PacificForum/ITU-APT-S1_Gisa_Purcell-Maui_Sandford.pdf

In total, four private network operators present on the continent have built significant multi-country optic fibre networks to provide regional connectivity services. These are:

- Etisalat/Maroc Telecom with the cross border networks it has built from its acquisitions or investment in operators in 13 countries in Africa[52].
- Orange/France Telecom, which has similarly built a regional platform through its operations in sixteen countries in Africa[53].
- Phase3, a Nigeria based private wholesale telecom infrastructure provider that uses high-tension power line infrastructure to provide an aerial fibre optic network in Nigeria linked to other west Africa countries. This has commenced with Benin, Togo and Niger, with on-going plans to extend the network to Ghana, Côte d'Ivoire, and as far as Senegal[54].
- Liquid Telecom, owned by Zimbabwe-based fixed and mobile operator Econet, has constructed a large regional fibre network spanning southern and east Africa through a combination of new buried cable and acquisition of other network operators. In March 2016, Liquid Telecom also announced plans for a submarine cable that will take another route to Europe via the Red Sea, and interconnect east Africa countries en-route[55].

Liquid Telecom's move into the submarine cable arena has parallels with the expansion of submarine cable operators into the terrestrial market, as described above for MainOne, SEACOM, and EASSy. Aside from Liquid Telecom's regional fibre backbone across east and southern Africa, it also has satellite and wireless operations in its group. In this respect regional operators are becoming increasingly air/land/sea agnostic in their international network offerings.

4 Countries with special challenges in meeting international connectivity needs

Connectivity issues vary tremendously from one country to another and it can be difficult to generalize about their causes and solutions. Nevertheless, it is also possible to identify countries that are likely to face the most difficulties in achieving affordable universal access.

Among the developing countries, these can be divided or selected, according to the following features or groupings:

- Small Island Developing Nations (SIDS) – as discussed earlier, these are nations isolated by oceans and combined with their small size, have low economies of scale relative the cost of providing international capacity
- Landlocked[56] low-income countries, dependent on their neighbours for obtaining international capacity, often at a much higher cost than their coastal counterparts
- Least developed, small coastal nations without submarine connections – dependent on terrestrial connection(s) with neighbour(s)
- Countries with, or emerging from, civil strife which has damaged infrastructure and have high real or perceived risk for investors.

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52 www.etisalat.com
53 www.orange.com/en/About/Global-footprint/Orange
54 www.phase3telecom.com
55 www.liquidtelecom.com
56 Being landlocked refers to the geographical location of a country without direct access to the sea (Glassner, 1970). According to this definition, there are 44 landlocked countries in the world. Of these, the United Nations lists 32 as landlocked developing countries that are low and middle-income countries based on the World Bank country classification (LLDCs) with a population of nearly 440 million.

This section draws on case studies and examples from developing regions to identify and discuss the various policy and regulatory issues that have an impact on the development of international telecommunication infrastructure.

4.1 The case of the Pacific islands

Ensuring good international connectivity is a particularly difficult challenge for small island nations and other low-income countries with small populations or geographic isolation. This section draws on case studies in the Pacific islands to consider the special constraints they face, however the lessons may still apply to many other countries where connectivity issues may not be quite so severe.

Among the island nations of the Pacific, there are a variety of reasons for lack of access to international infrastructure:

- **Distance and remoteness**: the distance between island states is often thousands of kilometres, and between islands and islets within a Pacific island state frequently hundreds of kilometres, too far for the use of domestic microwave.
- **Size**: There are 21 Pacific island states. The largest is Papua New Guinea (PNG) with a population of over 7.5 million, followed by Fiji with a population of 890 000. Thereafter only nine states have populations above 100 000. The smallest is Niue with 1 000, Norfolk Island with 2 000 and Tuvalu with 10 000. The economies of scale for network investment are lacking, especially when these populations are scattered across many islands.
- **Scale and scope**: Due to small population size and often low incomes, the demand for value-added services has been limited. This is slowly changing due to the advent of the digital age and some markets will sustain new entrants and the demand for international connectivity.
- **High cost of submarine cables and satellites**: Investment for a single (no-redundancy) cross-Pacific submarine cable is not less than USD 200 million and the revenues to cover the investment come mainly from the demand for broadband capacity and services in North America and Australasia.
- **Lack of inter-island sharing**: Sharing satellite capacity is possible where satellites are capable of dynamic spectrum assignment (DSA), meaning they can split their transponder paths with beams to cover islands in different geographical locations. However, the Pacific islands have had difficulties in collaborating to bring about such cost-sharing arrangements.
- **Facilities and services competition**: In many islands, there has been a lack of competition due to the dominance of an incumbent and a failure of regulation to open markets, partly in the belief that markets are too small to support multiple operators or service providers. In recent years, this picture has changed dramatically, notably with the assignment of radio spectrum to competing mobile operators. However, regulations that open international capacity to competition through equal access to the cable landing station are lacking.
- **Information and knowledge**: A major hurdle facing the islands has been a lack of local expertise in rapidly changing telecom technologies, spectrum management best practices, in market data collection and analysis, and in incentive regulation. This has not been helped by loss of technology skilled human resources. Again, the picture is slowly changing, faster in some island states than others.

Fourteen of the 20 Pacific island states either have connectivity to one of the trans-Pacific Ocean submarine fibre cables or firm plans for a connection. This is a transformation from a decade ago when only nine were connected to cables. The submarine connections to the islands mainly owe their existence to the high-volume cable routes from Asia to Europe and Africa going westwards, and to East Asia and North America going eastwards. Very little of the traffic on the six cables actually originates or terminates in the Pacific islands. This is also true of the islands to the south.

Despite the fact that the Pacific island states are not in a strong position to take direct advantage of these economies of scale because the volumes of traffic they originate and terminate are too low, they can nevertheless benefit from the economies of scale elsewhere. As broadband and ICTs come to drive the surrounding economies of North America, East Asia, South-East Asia, Australia, and New Zealand, so these technologies and services are having an impact on the Pacific islands. For example, Internet and cloud computing are encouraging the spread of outsourcing and Fiji in particular has been developing as a centre of outsourcing for Australian companies for over a decade.[57] Another example is Tonga, where the use of Internet went up five-fold within six months of the opening of the cable to Fiji in 2013.[58]

However, Internet transit prices remain high, and this arises from low economies of scale. The wholesale price (USD 475/Mbit/s in November 2014) for access to the Tonga to Fiji undersea cable seems to be an issue of current capacity use, struggling to cover fixed costs of the cable. The wholesale price would be lower if more capacity is used. In effect, operators and the consumers are paying for the unused portion of the cable because the most significant cost of undersea cables is their fixed cost. The Vanuatu-Fiji cable, for example, costs about USD 350 per Mbit/s at 1.1 Gbit/s utilization, yet it has similar fixed costs to Tonga Cable Limited (TCL), such as a cable maintenance ship and landing station access in Fiji[59].

Hopefully, the growth of broadband-enabled sectors of the economy (from tourism and business process outsourcing to e-commerce, social media and online services, such as e-health and e-education) will ultimately be reflected in international bandwidth utilization. The current challenge is to put in place the local infrastructure that can help drive these developments.

4.2 The case of Rwanda: a landlocked country

Rwanda is a low-income, landlocked and predominantly agricultural country of around 12 million people, where even pre-paid wireless broadband is relatively expensive for most inhabitants. In terms of continental distances to submarine cable connectivity, it is akin to being a Pacific island.

Nevertheless, Rwanda has been proactive in securing access to closer submarine landing stations and is connected to two submarine cables on the east coast. The first, EASSY, is accessed through Uganda to the landing station in Kenya, a 10 Tbit/s, two fibre-pair configuration that was upgraded in 2010 to 40 Gbit/s wavelengths and in 2014 to 100 Gbit/s wave-lengths. [60] The second is the 5 000 Km East African Marine System (TEAMS).[61] TEAMS came online in 2009 and is planning to add a fifth underwater fibre to its capacity, which "will have larger capacity than the current four other cables altogether."[62] Partners in the cable include the Wananchi Group, owner of the Zuku pay TV and fibre brand with presence in Kenya, Tanzania, Malawi, Zambia, and Uganda[63], and Liquid Telecom, operator of the largest international terrestrial fibre open access cable network in southern and eastern Africa, including Rwanda.[64] MTN membership of the EASSY consortium allowed the operator to increase its broadband capacity to 355 Mbit/s from 200 Mbit/s, of which 155 Mbit/s was over optical fibre and 45 Mbit/s from backup by satellite.[65]

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57 Charles Davis, et al (2004) 'Realising the Development Potential of North-South Business Processing Outsourcing: The Case of Fiji'. www.ryerson.ca/~c5davis/publications/Davis-McMaster-Nowak-potential%20of%20BPO%20in%20Fiji.pdf

58 Noelle Francesca de Guzman (2015) 'What you need to know about the Internet in the Pacific' Internet Society. www.internetsociety.org/blog/asia-pacific-bureau/2015/06/what-you-need-know-about-internet-pacific

59 PRIF, 2015, 'Economic and Social Impact of ICT in the Pacific' p.54.

60 www.eassy.org/news.html

61 www.teams.co.ke/about-us/

62 www.teams.co.ke/kenya-lands-a-fifth-underwater-fibre-optic-cable/

63 http://wananchi.com/

64 http://liquidtelecom.com/about-us/network-map

65 Telegeography (2010) 'MTN Rwanda taking it EASSy in the New Year' 29 December. www.telegeography.com/products/commsupdate/articles/2010/12/29/mtn-rwanda-taking-it-eassy-in-the-new-year/

For any landlocked country to connect to cable landing stations via overland cables, the costs involved include rights-of-way, securing all the licences, permits and permissions that are required from different ministries and local authorities in each of the neighbouring countries, and then the costs of trenching and ducting or the construction of towers. If highways or railway tracks or power lines are available, this can cut the costs and the time it takes to build the cable connections to the coast, although where these conduits by-pass towns that need to be connected then additional costs will be incurred building spurs. Given these obstacles, by comparison laying a cable across the Pacific Ocean is relatively straightforward, but the important difference is that overland cables can more easily pick up traffic along the way, making the business case for the investment stronger.

Rwanda, along with Burundi, Kenya, Tanzania and Uganda, is a member of the East African Community (EAC) that, with backing from the African Development Bank (AfDB), has been supporting a number of initiatives that promote an integrated regional approach to a broadband infrastructure. Under its *Connect Africa* framework, the African Development Bank (AfDB) helped finance EASSY and is supporting the East Africa Broadband ICT Infrastructure Network (EAC-BIN). The latter is an effort to integrate the broadband networks of EAC Member States to promote cross-border broadband traffic and trade, link the landlocked countries to coastal landing stations and encourage the harmonization of broadband regulations across the region. A significant progress in this area was achieved through the joint EU-ITU *Harmonization of ICT Policies in Sub-Saharan Africa* (HIPSSA) programme for African, Caribbean, and Pacific Group of States (ACP).[66]

Building and operating cables across country borders is challenging. First, authorizations and licences are required for each jurisdiction. Second, cabling by ducting is generally more secure, but expensive. Cabling by towers and poles is less expensive, especially where facilities sharing may be involved, but more vulnerable to extreme weather and other causes of damage. In either case, selecting routes and permissions is time consuming and will incur expenses. Third, local carriers may raise obstacles if the cable operators are seen as commercial rivals. Fourth, regulations governing cross-border transit charges, interconnection charges, or accounting rates need to be established in an efficient manner. Similarly, local open access provisions are necessary to ensure that the additional capacity is available at competitive prices. And fifth, relations between neighbouring countries needs to be on a good working basis, unimpeded by conflicts.

The 'One Area Net' project is another important regional initiative taken by Rwanda as part of the EAC that will improve wireless broadband demand and usage by reducing roaming charges across the region, and it is already having an effect. Kenya mobile operator Safaricom has "already implemented the initiative with all operators in Rwanda, resulting in a reduction of retail roaming and international calling rates by 60 percent."[67] Rwanda cross-border traffic rose by more than 150 per cent (incoming) and 350 per cent (outgoing) after just one month following implementation in October 2014.[68]

Regional fibre networks

Two services that provide a direct link between international, regional and domestic markets are mobile roaming, as just discussed, and the other is broadband Internet connectivity and traffic. An important player in both Rwanda and the regional markets is Liquid Telecom, a subsidiary of Econet. In 2011, Liquid Telecom acquired ownership of the optical fibre network of Rwandatel, the Rwanda incumbent fixed-line operator, and in 2013 of Altech East Africa (AEA), a subsidiary of Altech of South Africa, and with it a combined ownership of a 15 000km optical fibre network straddling South Africa, Botswana and Lesotho in the south to Kenya, Uganda, Rwanda, the Democratic Republic of the Congo

66 EU-ITU (2013) 'Access to Submarine Cables: ECOWAS. www.itu.int/en/ITU-D/Projects/ITU-EC-ACP/HIPSSA/Pages/default.aspx

67 PC World (2015) 'One Network initiative creates cheaper calls in East Africa' 16 January. www.pcworld.com/article/2871992/one-network-initiative-creates-cheaper-calls-in-east-africa.html

68 ITU (2015) 'Regional roaming with East Africa – One Network Area. www.itu.int/en/ITU-D/Regulatory-Market/Documents/Events/2015/Sao_Tome/Session5-1%20_Lukas0regional%20roaming.pdf

(DRC), Zambia, and Zimbabwe in east and central Africa.[69] Liquid Telecom offers IP transit, VSAT, and high-speed data services through Altech Stream in Rwanda.

National networks

Within Rwanda, the national backbone optical fibre network was undertaken by a public-private partnership joint venture with Korea Telecom to support Internet and backhaul for mobile operators on an equal access wholesale basis. In 2014, the nationwide optical fibre network, which adds 3 000 km to network of Rwandatel,[70] started operations in support of a 4G LTE wireless broadband network.[71] The total cost of the network was estimated at USD 260 million of which Korea Telecom invested USD 140 million. A Public-private partnership joint venture company Olleh Rwanda Networks (ORN) operates the wholesale network, licensed for 25 years, and the three mobile operators (Airtel, MTN and Tigo) lease accounts from Olleh at wholesale rates and resell them to end-users.[72]

Another wholesale model is the sharing of towers. In 2013, MTN sold on a leaseback basis all its towers to IHS, a communications infrastructure company in Africa.[73] Towards the end of 2014, Bharti Airtel concluded a similar arrangement.[74] The Rwanda Utilities Regulatory Authority (RURA) has been particularly supportive of facilities sharing to reduce costs and encourage investment in network coverage and capacity, introducing comprehensive guidelines in 2011.[75] RURA is a standout case of incentive regulation, enforcement and transparency that is a key component of the success of Rwanda in driving access and the demand for connectivity. RURA and the Rwanda Development Board (RDB),[76] the agency responsible for the ICT Masterplan, have joint roles in the creation of, and access to, broadband networks in Rwanda. It may be compared to the role of the Singapore regulator, the Infocomm Development Agency (IDA).[77] Both sets of regulatory agencies play a proactive role in fostering the ICT sector linked to the development of technologies, such as fast Internet and HDTV that require broadband.

City metropolitan area network (MAN)

Part of the agreement with Korea Telecom was to construct the Kigali Metropolitan Network broadband network to interconnect all government agencies in the capital city, Kigali, and some homes and businesses using a high-capacity optical fibre backbone, including a RWF 4.5 billion (USD 6.2 million) WiBro project.[78] It complements the national broadband backbone (NBB) project to which the World Bank Regional Communications Infrastructure Program (RCIP) contributed USD 24 million.[79]

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69 "AEA operates a network of fibre-optic, satellite, WiMAX, Wi-Fi and microwave radio infrastructure across key markets in East and Central Africa, including Kenya, Rwanda and the DRC. The firm's subsidiaries also have interests in some submarine cable systems in the region such as TEAMs and SEACOM." BMI Research (2013) 'Liquid Telecoms Gains Scale With Altech East Africa Acquisition' 30 January. www.bmiresearch.com/news-and-views/liquid-telecoms-gains-scale-with-altech-east-africa-acquisition

70 Reuters 'Rwanda signs 4G internet deal with South Korea's KT Corp' 10 June 2013. www.reuters.com/article/2013/06/10/net-us-rwanda-internet-idUSBRE9590SH20130610

71 Republic of Rwanda 'Rwanda 4G LTE project scoops Global Telecom Business Innovation Award '15th May 2015. www.gov.rw/news_detail/?tx_ttnews[tt_news]=1193&cHash=20a177278a02e615b7520cdf478759dc

72 MYICT (2014) *Rwanda ICT Sector Profile 2013.* www.myict.gov.rw/fileadmin/Documents/ICT_Sector_Profile_2013/ICT_Sector_Profile_for_Web_copy.pdf

73 IHS 'MTN announces sale of mobile network towers to IHS in Rwanda and Zambia' 20 December 2013. www.ihstowers.com/media/press-releases/2013/12/20/mtn-announces-sale-of-mobile-network-towers-to-ihs-in-rwanda-and-zambia/

74 The New Times 'IHS, Airtel finalise tower takeover deal' 20 February 2015. www.newtimes.co.rw/section/article/2015-02-20/186161/

75 RURA (2011) Guidelines for siting and sharing of Telecommunication Base Station Infrastructure. www.rura.rw/fileadmin/docs/Board_Decisions/GUIDELINES_SITING_SHARINGB_BTS.pdf

76 www.rdb.rw/departments/information-communication-technology.html

77 President Kagame himself has referred to Rwanda as the "Singapore of Africa". CAI (2010) 'Going Online: Bringing the Internet to Rwanda'. www.consultancyafrica.com/index.php?option=com_content&view=article&id=384&Itemid=224

78 The New Times (2011) 'Kigali WiBro trail process impressive' 2 March. www.newtimes.co.rw/section/article/2010-03-02/17235/

79 World Bank (2015) 'Regional Communications Infrastructure Program (Phase 2) – Rwanda Project'. www.worldbank.org/projects/P106369/regional-communications-infrastructure-program-phase-2-rwanda-project?lang=en

According to the Rwanda implementing agency, the Rwanda Development Board (RDB),[80] the project has increased "the availability of broadband to over 700 Rwandan institutions including schools, health centers and local government administrative centers",[81] and assisted in interconnecting to the two east-coast submarine cable systems, EASSY and TEAMS.

A study in 2011 by the World Bank found a strong correlation in landlocked countries between policy liberalization and economic growth, and that opening the telecoms sector "would on average result in an increase of cellular subscriptions by 7 percentage points and an increase in mainlines by 4 percentage points."[82] Such developments provide the incentive for investment and for demand for international connectivity. Rwanda has adopted forward-looking ICT policies, well thought-out regulations to encourage investment in broadband networks and services, an openness to foreign investors and the adoption of a wholesale model of equal access built on a PPP-basis.

4.3 The case of a country emerging from civil strife

Countries emerging from civil strife or manmade disasters might be faced with a range of peculiar challenges, too. If not handled timely and effectively at the political level, those can result in bottlenecks to the development of and access to ICT services and applications. This is the case where, for instance, a foreign state detains control over the nation's international gateway or when all international traffic has to be routed through that foreign state. In some cases, national operators are not allowed to operate while foreign operators are, withholding radio spectrum for wireless broadband network investment. Restrictions on the assignment of radio frequencies for security reasons are sometimes extended to spectrum for the provision of mobile broadband services. In other cases, countries might not be adequately connected to otherwise available international connectivity links, fibre or satellite, because of the lack of political will or clearance. To illustrate a related issue, in Box 1 there is a non-exhaustive list of systematic obstacles to importing ICTs.

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80 The original implementing agency was to be the Rwanda Information Technology Agency (RITA) that was also proposed by the government to invest in EASSY, but that initiative was finally given to MTN in the private sector. RITA was folded into the RDA. See MYICT ICT Sector Strategic Plan, 2013-2018, p.19. www.academia.edu/6160755/ICT_Sector_Strategic_Plan

81 Rwanda Development Board (RDB) Infrastructure. www.rdb.rw/departments/information-communication-technology/infrastructure.html

82 Ingo Borchert, et al. (2011) Landlocked or policy Locked? How Services Trade Protection Deepens Economic Isolation The World Bank. www.imf.org/external/np/seminars/eng/2011/trade/pdf/session3-Borchert-paper.pdf

Box 1: Systematic obstacles to importing ICTs

- Official list of restricted items listed under the dual-use (e.g., mobile phones) that need to be approved by authorities prior to import.
- Complex procedures regarding the import of such ICT devices and spare parts, and delay in equipment inspection and in security checks, thus disrupting the supply chain and ultimately penalizing customers of ICT services.
- High cost and delays related to clearance of the devices and appliances covered by manufacturer warranty that are requested by maintenance centres.
- Additional conformity and interoperability requirements imposed without legal ground.
- Strike action at ports and airports that increases shipment costs.
- Absence of a permanent and trusted import regulation information channels and lack of information on newly-introduced rules, procedures and regulations.
- Lack of business opportunities for local operators that are de facto excluded from the national ICT market.

Source: Author's research.

In all such cases, the impact upon the economy can be devastating. Income losses to the private sector as well as to the national government can reach hundreds of millions. Lack of broadband wireless connectivity implies lack of development of an ecosystem around it, lack of the applications that could increase the local productivity of users, lack of products and services to market at home and abroad, lack of devices for the spread of e-commerce and e-services, and lack of demand for streamed digital content. The consequences of denying international connectivity and 3G spectrum and therefore access to mobile broadband is not limited to consumer interests and convenience; rather, it has material consequences for the entire economy and society.

In this setup, the problems are political, not technical, financial or economic. Indeed, greater and cheaper international bandwidth would boost the economies, encourage inward investment and generate more international traffic. This suggests that interested stakeholders have an interest to find solutions that achieve a more open market and at the same time do not compromise on security issues. In other words, unlike cases in Africa and the Pacific islands, the focus of stakeholders is not likely to be primarily on the financial issues but on ways to surmount security concerns and barriers to entry.

5 Economics of international Internet connectivity

5.1 Factors having an impact on international Internet connectivity

In considering the demand-side factors that directly influence a country's international capacity requirements, aside from the obvious aspects of population size, economic development, language isolation and level of domestic network coverage, there are also a variety of other important factors:

- **The uptake of broadband and telephony among the local population**: in countries where access to broadband is unaffordable for many, or there are other basic constraints, such as limited electricity, the needs for international capacity will be correspondingly lower.
- **The role of the country in providing international capacity to neighbouring states**: some countries carry international traffic for their neighbours, most often because the downstream

countries are landlocked, or in need of backup routes for traffic, or because operators there wish to take advantage of the lower international capacity prices that may be present in the upstream country (often a 'hub' country with access to many different international cables – see below).

- **The availability of local applications and content**: if these are at low levels of development, then the local population is likely to access a higher proportion of international content, for example if there is a lack of local e-payments platforms. By the same token, if the country is the source of applications and content that are in demand elsewhere in the world, then international bandwidth needs will also be correspondingly higher.
- **The level of interconnection between local networks**: when there is a low level of development of hosting and interconnection infrastructure (data centres, leased lines, Internet exchange points (IXPs), then domestic networks must exchange traffic between each other abroad, resulting in even higher needs for international capacity, than would otherwise be the case. Similarly, little content will be hosted locally. Along with physical network interconnection, operators have also adopted widespread use of content caching facilities[83]. These and other shared local resources, such as DNS servers, reduce international bandwidth needs while improving network performance for users. However, this only takes place when the domestic distribution infrastructure is in place, which is not yet the case in all countries. As a result, some countries have unnecessarily high needs for international capacity.
- **The degree of language isolation of the country**: in smaller countries that have less common national languages, the population is more unlikely to visit international sites; the most well-known example of this is the Republic of Korea. Other cultural, demographic and climatic factors may also affect relative levels of broadband utilisation between countries, however little research has taken place to identify their significance.
- **The level of international content blocking**: some countries have put in place measures to limit access to foreign web sites, which results in relatively lower needs for international capacity, and by the same token, less local capacity is also required.

5.2 Barriers to connectivity

International connectivity projects can be subject to delays

The inherently multi-country nature of international connectivity projects can lead to unexpectedly long lead times before the project is finalised. The development of the EASSy cable project was a protracted process that took four years, subject to extended negotiations between the country governments and state owned operators along the east coast. The delays, combined with doubts over the initial business model that was proposed, lead the Government of Kenya to fast track an independent submarine cable project in partnership with United Arab Emirates incumbent operator, Etisalat, called The East African Marine System (TEAMS). The cable directly linked Kenya with the Etisalat hub in Fujairah, and 20 per cent of the cost was financed by the Kenya Government, with the remainder from Etisalat and Kenya network operators.

High cost of cross connects

An issue encountered by many cable operators where landing points are in markets with little competition or regulatory oversite, such as in the cases of both EASSy and TEAMS, was the high cost of the cross-connect fees charged to allow the passage of traffic through to the other cables present at the landing point. TEAMS and EASSy are relatively short cables and do not land at one of the globally competitive hubs in Europe or Asia. Therefore to provide access to the global backbones, as well as to maximise resiliency, short fibre cables (the cross-connectors) need to be present between the landing stations of the different cables present – in this case, in Djibouti (EASSy) and Fujairah,

[83] As a result, many of the most popular international web sites and streaming video services such as Youtube, Facebook, and Netflix actually use much lower amounts of international traffic than would be expected.

United Arab Emirates (TEAMS). In many cases the cable lands at a station that hosts multiple cables, so installation of cross-connects is often relatively trivial.

For EASSy, the cross connects are levied by the incumbent monopoly operator, Djibouti Telecom, which charges more for 1 metre of cross connect cable to the SEA-ME-WE-3 (for example), than it costs for capacity from Djibouti to London. Similarly, for TEAMs, to get to Europe, high cross connect charges are present in Fujairah where the landing station is owned by Etisalat.

Challenges to open access/equal access models

Open access business models for infrastructure help ensure that smaller operators are not disadvantaged when competing against larger operators, which helps to drive down capacity prices, however these models are not as easy to implement as the traditional consortium or private investment models. The West African Cable System (WACS) cable project for example, was originally planned as an open access project, initiated by the South Africa Government in early 2008 to ensure reliability and sufficient low cost international capacity to cater for the FIFA 2010 football world cup. Negotiations between potential participants in the cable project took longer than expected. One of the sticking points in the negotiations was that the larger operators (such as MTN, Telkom and Vodacom), who were going to invest the bulk of the funds for the cable, did not wish to assume the majority of the financial risk without being able to obtain a capacity price advantage over the smaller investors.

In the end, the interests of the larger players won out and the cable became a traditional consortium of the larger players, and the other smaller telecom operators in the region were excluded from making minor investments in the cable. Because of this, and due to there being only one consortium investor in the cable per country, prices for WACS capacity are controlled by a single landing party/ investor (except in SA). As a result, operators in the other countries where the cable lands are able to charge prices that make it less competitive for other carriers to use capacity on the system, even those investing in the cable from other countries.

Landing station fees and local ownership requirements

Fees to the government for establishing a submarine landing station and local ownership can also drive up the cost of international capacity. To make investment in the provision of submarine cable infrastructure more attractive, some countries have adopted limits to submarine landing fees.

A related issue is that incumbent fixed line operators are in some countries still seen as having rights to all international infrastructure. For example, in the case of WACS, the landing station in Cameroon was initially owned by mobile operator MTN, but the government decided that the incumbent fixed line operator, Camtel, still had the only rights to service international traffic, and after long negotiations, the landing station was eventually transferred to the Cameroon Government in 2012.

6 Possible operational strategies for improving connectivity

6.1 Ensuring reliability

In international backbone infrastructure and cross-border links, at least two physically independent connections are usually required for reliability. Ideally, more than three will also help to ensure competitive pricing based on market forces, thereby reducing the burden of regulated pricing. Similarly, access to a minimum of two independent submarine cable landings and/ or satellite redundancy is required for reliability, while competitive pricing is usually achieved with more than two landing stations.

6.2 Joint planning and shared deployment costs

In terrestrial networks, the civil works necessary to bury the cable is by far the largest cost item for new optic fibre deployment (up to 90 per cent). The bulk of this investment is preserved if dig-once policies are in place and coordinated duct planning is carried out[84]. Thus, the financing required in order to upgrade links to meet additional demand will be much smaller than the initial Capex. Once the ducting and fibre is in place, marginal investments are required to upgrade capacity when it is needed, and costs can easily be covered by the revenue generated by the link.

Inclusion of ducts on all new roads/rail lines, pipelines and power grids infrastructure cuts costs for cable deployment by an order of magnitude, helping to ensure affordable pricing and encouraging investment in low traffic cross-border links and rural areas that would otherwise be uneconomic to serve. The additional marginal cost for the inclusion of ducts or fibre in these utility infrastructure projects usually adds less than 5 per cent to the overall budget, and the benefits more than justify the added expense.

In particular, optic fibre and electric power distribution are often deployed together to achieve considerable cost savings. Optic fibre is normally included in high-tension power lines to provide high speed communications to control the substations, and excess fibre cores can be used for telecommunication purposes. Additional fibre cores solely for telecom purposes can also be included when planning the energy distribution network.

In many cases, high-tension power lines are used to distribute power across borders, resulting in many opportunities to use these grids to establish low cost international fibre links. As a result, many communication network operators around the world have formed partnerships with electricity supply networks to provide capacity. In addition, a number of power distribution agencies have formed subsidiaries to sell telecommunication capacity on their networks.

Perhaps less well-known is that this approach can also be used when supplying electricity through sub-sea cables. For distances up to 500 km, submarine power distribution is now a well-established industry[85]. Optic fibres are already included in cables manufactured by companies such as Nexans[86] that, for example, supplied a system to provide power between two Indian Ocean islands (Pemba and Zanzibar) and this link is now being to provide telecom capacity.

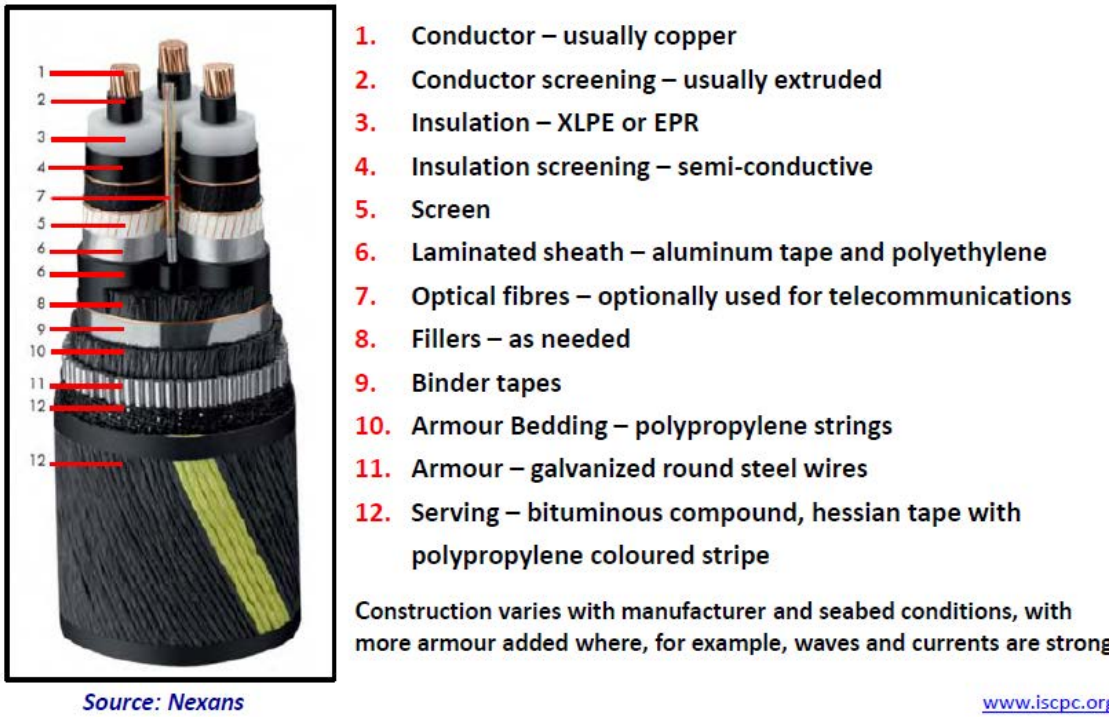
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84 Conduit/ducts of sufficient size and buried sufficiently deeply (or protected overhead) to minimize the chances for accidental breakage or vandalism.

85 http://en.wikipedia.org/wiki/Submarine_power_cable for a list of submarine cable projects.

86 Nexans marine power and fibre optic cable supplier: www.nexans.co.uk

Figure 3: 3-Core AC submarine power cable



Source: Nexans

6.4 Planning for future links – submarine cable branching units and stubs

Submarine cables are generally not amenable to adding branches or spurs after the cable has been deployed. Each landing station location needs to be already known when the cable is being planned. In some cases, the cable operator may have a high degree of confidence that a new landing station will be required at a date after the cable has been deployed. In these cases, the cable can be deployed with a stub at the appropriate location, which makes it possible to extend the cable to the new landing at some point in the future. For example, both the MainOne and Glo-1 submarine cables running along the west coast of Africa have left stubs for future landing stations. The ACE cable, also running along the same route, recently made use of a stub it had left for Benin, which had not been able to finalise its participation the project by the time the cable was initially laid.

6.3 Linking coastal countries: Festoon systems

Coastal festoon systems use low cost repeaterless fibre cables, which require no submarine power or electronics. The systems have been used as a means of connecting points up to about 500 km apart, and are often strung together to link a series of coastal cities.

Depending on the location, festoon systems also present an option for meeting some international backbone requirements, however backup links are also required to ensure reliability when disruptions occur.

6.5 Making use of the next generation of high-capacity satellite systems

The main features of the newly emerging satellite systems is that they are relatively fast to develop and cheap to build and launch, compared to their earlier counterparts. In addition, they make use of low and medium earth orbits (LEO/MEO). Being located much nearer to the Earth surface compared to geo-stationary satellites, this greatly reduces the latency or lag; the time that takes for signals to travel from the Earth to the satellite and back again (about 130 ms for packet round trip time compared

to about 650 ms for a geostationary satellite). The effect is to greatly improve performance when compared to geostationary satellites, allowing the satellite operators to provide a quality of service that is much closer to fibre.

LEO/MEO orbits have been used before, for relatively low capacity data and some voice, however the new satellites offer considerably more capacity, and thus cost savings over traditional satellites. For example the O3b system of 12 satellites, which have already been deployed, is able to provide capacity at about USD 400/Mbit/s. By using two earth station terminals, capacity available on a single link is up to 800 Mbit/s downlink and 650 Mbit/s uplink.

As a result, a growing number (31 in mid-2016) of mainly island countries have adopted the O3b service, including the Cook Islands, East Timor, Papua New Guinea, South Sudan, Madagascar, and the DRC. The Solomon Islands, Palau are among other island nations that are in the process of implementing them. In American Samoa, O3b is a backup for the existing fibre-optic network.

The O3b current total constellation capacity is 192 Gbit/s. Given that this is less than two wavelengths of a single fibre, it is apparent that current satellites will not be used for the major routes between countries, or even for backing them up, but will instead find their chief use in domestic thin-routes and perhaps to link some very small island nations.

However, new projects in planning propose to use constellations of hundreds if not thousands of satellites to provide cheaper and higher capacity links than currently available. One such project is OneWeb, which is aiming to launch 648 small satellites into 20 orbital planes at 1 200 km altitude to provide Internet globally at affordable prices. OneWeb aims to bring the cost of each satellite down from about USD 300 million to USD 500 000.[87] Started by Virgin Galactic and Qualcomm, OneWeb has announced that it has secured USD 500 million in initial investment from additional partners Airbus, Bharti Enterprises, Hughes Network Systems, Intelsat, Coca-Cola and Totalplay.

Similarly, Oneida, LeoSat, and a variety of other initiatives are in the process of investing billions in high capacity satellites.[88] A new generation of miniaturised 'CubeSats' have already been developed that can be fitted together on a modular basis and launched into low-earth orbit for less than USD 80 000.[89] In addition, satellite operators Iridium and Globalstar have begun plans to launch a series of LEO satellites to provide broadband and voice services. Helping bring down the launch costs is the idea of Elon Musk, a founder of PayPal and the Tesla electric vehicle, whose SpaceX project is developing reusable launch vehicles.[90]

If these projects come to fruition, it is possible to envisage that a different topology for the direction of some international traffic may exist at some time in the future – where data packets never touch the ground at all, moving directly between the satellites linking two individuals in different nations.

Last but not least, a variety of innovative new high altitude platforms are being tested as options for better local connectivity. These include drones, high altitude and tethered balloons, as described in section 3.2.1.

87 www.bbc.com/news/science-environment-33268180
88 http://wftp3.itu.int/pub/epub_shared/BDT/2016/2016-Trends/flipviewerxpress.html
89 www.ft.com/intl/cms/s/0/2ad23aca-e55a-11e4-bb4b-00144feab7de.html#slide0
90 www.spacex.com/news/2013/03/31/reusability-key-making-human-life-multi-planetary

7 Policy and regulatory consideration with regard to international Internet connectivity

7.1 Easing access to rights of way

As indicated in the discussion above efficient permitting and affordable access to rights of way (ROW), for green field digs, as well as on utility infrastructure such as roads, energy grids, rail lines, fuel pipelines and sanitation systems, are important to help minimise the financing needs for cable infrastructure and to reduce delays in deployment.

Where roads, power grids, pipelines and rail link cross international borders, smooth access to rights of way can substantially simplify the process for laying cable along these routes.

7.2 Addressing land crossing requirements

Local land crossing laws may need to be taken into consideration in deploying multi-country cables. One of the unexpected issues encountered by SEACOM when laying its cable up the east Africa coast to France, was that it was unable to traverse the Suez Canal, and was instead required by Egypt to make a 'land crossing' to Alexandria and continue from there. The land crossing needed to take place through leasing capacity from Telecom Egypt, which added to the overall cost of services to SEACOM customers. The other submarine cables following the route from the Indian Ocean to the Mediterranean have also been required to make land crossings, although the FLAG cable actually travels along the Suez Canal route (not actually under water, but along the canal wall).

7.3 Regional mechanisms to ensure equal access by all network operators

At a regional policy level, the Economic Community of West African States (ECOWAS) has developed regional guidelines[91] in 2011 for policy makers in Member States to promote better access to submarine cables, especially for the land locked countries and operators that are not members of cable consortia. The guidelines were developed with assistance from the ITU HIPSSA project to help harmonise ICT policies in ACP countries, and building on existing regulatory frameworks on interconnection. It is still necessary to transpose the guidelines into regulations within national frameworks, at which point they will aim to ensure that:

1. service providers have access to the international bandwidth capacity under the same terms as cable consortium members;
2. access is not be unduly prevented or delayed by the consortium member having control over cable landing station;
3. landing stations have transparent and non-discriminatory access charges.

7.4 Political projects

Some regional projects have had a broader political dimension to support continent-wide socio-economic integration. In support of this vision, in 2012 African Heads of State endorsed the Programme for Infrastructure Development for Africa (PIDA), which is an integrated programme of projects across the continent for energy, transport, ICTs, and water infrastructure[92].

One of the ICT components of PIDA was designed to respond to earlier requests by Heads of State to close infrastructure gaps and ensure that every country on the continent has access to at least

[91] www.itu.int/en/ITU-D/Projects/ITU-EC-ACP/HIPSSA/Documents/FINAL%20DOCUMENTS/FINAL%20DOCS%20ENGLISH/submarine_cables_ecowas_regulation.pdf

[92] www.au-pida.org

two international fibre optic cables. Partially in response to this, a joint declaration was signed by the governments of Algeria, Niger, and Nigeria for the roll-out of a 4 500-kilometre terrestrial cable running from Algeria to Niger and to Nigeria, taking advantage of the planned Trans-Sahara Highway and fuel pipeline on that route. The project was initially scheduled for completion in 2013 and although Algeria and Nigeria had built backbone infrastructure to their borders, Niger and Chad lacked the funds for the construction of the 200-kilometre link from Assamaka (Algeria) to Arlit (Niger). Then in early 2016, the African Development Bank announced that it would fund the missing link[93].

7.5 The island-hopping approach

The 'island-hopping' approach involves linking islands together with submarine cable using international aid and supporting loans to these island economies, for example, the World Bank and the Asian Development Bank (ADB). Similar to the financing of the ACE open access landing stations described earlier, the strategy involves individual Pacific island states in contractual relationships with the DFIs, including their adoption of good regulatory practices, such as equal access, transparency and the promotion of competitive markets, and at the same time involves collaboration between the Island states as traffic transits between them.

In the past, it often proved difficult to achieve collaboration despite the efforts of regional organizations to promote the common good, due in part to the uncertain economic and financial returns involved. But as modern economies come to depend ever more on ICTs, this in turn drives up the volumes of international traffic, so the economic returns become more transparent and attainable, especially in areas such as tourism, health and education, monitoring and managing the marine environment to reduce over-fishing, and coping with early warnings and disaster relief. These activities are in turn expected to ease some of the financial burden of investment in submarine cable capacity.

7.6 Regional connectivity initiatives

The regional connectivity initiatives of the World Bank in west and east Africa have been discussed earlier, and similar such initiatives exist in most other developing regions of the world. For decades, the goal of providing international telecommunication connectivity across such vast distances by satellite or by submarine cable has been an agenda item of multilateral and aid agencies, and of regional organizations such as:

- the Pacific Forum, the Pacific Islands Telecommunications Association (PITA);
- the Pacific Islands Computer Emergency Response Team;
- the Pacific Islands Internet Chapter of the Internet Society (PICISOC);
- the World Bank-funded Council of the Regional Organizations in the Pacific (CROP);[94] and since 2010-11
- the Pacific ICT Regulatory Resource Centre (PIRRC).[95]

To meet challenges of bringing international connectivity to the Pacific islands a necessary step has been the collection and analysis of data to identify the gaps, the needs and the potential benefits. But that too has proved a challenge and to meet it, in 2008 the World Bank and other donors supported the establishment of the Pacific Region Infrastructure Facility (PRIF).

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93 http://allafrica.com/stories/201603280956.html. Also see PICI 2015 annual report: www.nepad.org/resource/presidential-infrastructure-champion-initiative-pici-report

94 CROP comes under the auspices of the Secretariat of the Pacific Islands (SPC), which includes all 22 Pacific islands, see http://gsd.spc.int/crop and also www.spc.int/en/about-spc/history.html

95 Founding members: Cook Islands, FSM, Fiji, Kiribati, Nauru, Niue, Palau, PNG, RMI, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu. www.pirrc.org/home/index.php?option=com_edocman&task=document.viewdoc&id=50&lang=en

In addition, a growing cause for optimism is the increasing involvement of regional organizations and their collaboration with multilateral agencies and other stakeholders, such as investors in networks, including the donor agencies and investment banks, other regional bodies and regulatory associations, and island governments. For example, ITU has partnered with other entities such as, for example, the International Telecommunications Satellite Organization (ITSO) in its initiative and part-funding of the *Rural Satellite Connectivity Project for Pacific Island Countries* project.

Another initiative, started in 2009 with the European Commission, is the project on *Capacity Building and ICT Policy, Regulatory and Legislative Frameworks for the Pacific Island Countries* (ICB4PAC)[96], which focuses on ways to achieve broadband universal access and service and looks in detail at 15 Pacific small island state economies. The project is also part of the ITU-EU *Harmonization of Policies for the ICT market in the ACP*[97] programme, working in close collaboration with the Pacific Islands Forum Secretariat (PIFS), Secretariat of the Pacific Community (SPC), Pacific Islands Telecommunication Authority (PITA), and the Pacific ICT Regional Regulatory Centre (PIRRC) and supported by the University of the South Pacific (USP).

7.7 Domestic infrastructure and demand building

The synergistic relationship between international and domestic infrastructure has been referred to a number of times in this report – good local broadband infrastructure builds demand for international capacity, and vice versa.

Thus, one of the key issues for countries with special challenges in international connectivity is to stimulate sufficient demand so that connectivity solutions can be more sustainably deployed. A wide variety of factors affects the uptake of bandwidth. These in turn also affect supply, by making it more or less attractive for new providers to enter the market, or for existing suppliers to take advantage of improved economies of scale. The key demand-side factors include:

- Cost and coverage of access, which is directly influenced by the level of competition in the sector and by the business strategies of the wholesale and retail providers, such as low-cost data plans and usage independent tariffs, and distance independent cross-border tariffs implemented by the regional mobile operators.
- Availability of payment services, multimedia services, local language content.
- Indirect constraints such as literacy and income levels, availability of electric power, import duties and service taxes.
- Extent of smartphone, tablet, IP TV and personal computer usage.
- Government as a consumer – government is potentially a very large consumer of broadband and can therefore have a big impact on the level of demand.
- Other anchor consumer, such as universities, medical centres, financial institutions and others.

7.8 Capacity building and innovation

Another related challenge facing these countries is human capacity in policy-making, such as experience in drawing up well-formulated legislation, effective enforcement and a transparent, accountable and corruption-free environment. Ongoing capacity building programmes are needed here. An additional strategy here is to quickly respond to new technology developments, which could have an impact on access provision by setting up innovation units within governments to test the feasibility of emerging technologies. Such units could identify regulatory roadblocks and also

[96] ITU (2013) Universal Access and Service: Knowledge-based Report ICB4PAC www.itu.int/en/ITU-D/Projects/ITU-EC-ACP/ICB4PAC/Documents/FINAL%20DOCUMENTS/uas.pdf

[97] African, Caribbean, and Pacific Group of States (ACP).

work closely with other stakeholders to gauge the prospects and implications of these emerging technologies.

Making use of the latest technologies and innovative business models will also be a special priority for these countries in order to build sufficient demand. This could range from using the new HTS satellites and dynamic spectrum access technologies such as TV White Space (such as the example of the Philippines), to providing free WiFi in public spaces.

In this respect innovative uses of radio spectrum and new means of managing spectrum are emerging as important tools to meet connectivity needs at low cost. As a result, expertise in the area of radio spectrum and adoption of strategies to maximise the potential of innovative use of spectrum may be needed.

Unlicensed WiFi technologies hold particular promise for stimulating demand because the technology is very mature; anyone with a smart phone can use it and it is highly cost effective. An interesting example of an initiative using WiFi is Liquid Telecom in Kenya, which will this year invest USD 1 million in hundreds of free WiFi hotspots[98]. The company has launched an app mapping the more than 350 free Wi-Fi hotspots it has installed so far across the country, all of which have some form of free, public access, running from a minimum of 15 minutes of free use to unlimited free use. The project uses a local partnership model, so for example, the hotspots in the town of Nakuru are between the State House Digital Team, Nakuru County government and Liquid Telecom.

A platform for ideas in innovation, covering technologies, finance and regulations is a constructive way to engage stakeholders. This can be supplemented with data collection and analysis of global, regional and local trends to identify emerging opportunities, and to help develop business planning models and identify special needs. An advantage of this approach is that these units can work together with enterprises that develop these technologies to be involved in shaping or 'co-creating' the technology so that it more fully suits the local needs of the country. Such 'innovation centres', are already operational within governments in countries such as Denmark, Singapore, South Africa, and United States.

7.9 Special arrangements for landlocked countries

As indicated above, a particular problem for the landlocked countries is the inherent extra costs of traversing the networks of neighbouring countries in order to reach the submarine landing stations. This makes it much more difficult for these countries to achieve the same level of wholesale pricing for bandwidth that can be achieved by the coastal countries.

Considering the importance of this issue, and that there is often government participation in many of the national fibre backbones, one option is to reach agreement at the regional policy level to determine a specified price for cross-border wholesale capacity. For example, this approach has already been used to set common electricity tariffs across west Africa for use of the West African Power Pool (WAPP).

7.10 Ensuring strong regulation to address market dominance

Ultimately, considering there are likely to be only a few dominant operators in these markets, a vital component in any strategy for connectivity challenged countries will be the role of regulation in ensuring services are affordable. In particular, regulation will need to focus on the conditions of access to cable landing stations, and/or the wholesale pricing models the incumbent is permitted to use.

Aside from the standard tariff cap, other innovative ways of regulation in this area need to be considered. For example, in the Pacific, the PRIF has suggested that the high wholesale prices charged in Tonga could be paralleled by larger allocations of unutilized bandwidths at those prices. This would

[98] www.telecompaper.com/news/liquid-telecom-launches-app-mapping-350-free-wi-fi-hotspots--1135596

maintain the revenue to the incumbent and at the same time give service providers an opportunity to reduce retail prices and to stimulate the domestic market.[99]

8 Principles and guidelines for ensuring better international access

To aid in the process of formulating the most appropriate local strategies to improve international and domestic connectivity, based on the lessons outlined above, a set of guidelines with high level principles to promote communication infrastructure development has been developed, as described in detail below.

The set of guidelines aims to provide a systematic way of ensuring that all the relevant factors affecting the connectivity environment are identified and addressed. The assumption is that if all the building blocks that are described below are present at their optimal levels, then the country in question will have a sufficiently enabling environment and an unobstructed potential to achieve maximal levels of domestic and international connectivity.

The building blocks as outlined below have been divided into three categories:

1 Availability of basic infrastructure and openness of markets.

2 Strength of policy making and regulatory institutions.

3 Enabling strategies and incentive schemes.

8.1 The connectivity strategy building blocks

#	Building Block	Description	Principle
1	**Availability of Basic Infrastructure and Openness/Competitiveness of Markets**		
1.1	**Security and Affordability of International Capacity**	Provisions for multiple international links and wholesale international capacity available at competitive prices: 1) Plans for more than 1 international link, with each submarine landing /earth station/ border crossing at separate physical locations 2) Cost based submarine station landing, earth station and border crossing fees, with streamlined permitting processes 3) Open access, competitive or capped wholesale capacity pricing 4) Tariff caps on cross-connect fees between different cable NOCs/Landing /Earth stations in the same country 5) Sustainable business model for administration of the international facility 6) Capacity building of marine community to minimise accidental cable cuts 7) Co-ordination of international infrastructure deployment with domestic needs for international capacity	Duplication of international circuits on different physical paths is vital to maintaining reliable connectivity to the rest of the world and also to aid in competitively priced wholesale services to local operators. Countries with only one or two international links may have unreliable international connectivity and can find prices charged for capacity are not competitively priced and may require price caps. International infrastructure needs to be able to meet domestic demand without congestion.

[99] PRIF (2015) 'Economic and Social Impact of ICT in the Pacific' p.54.

#	Building Block	Description	Principle
1.2	**National Backbone Capacity**	Pervasive national backbone networks complemented by terrestrial wireless and satellite links where necessary: 1) Open access, competitive or capped wholesale capacity pricing 2) Coverage of all significant population centres 3) Metropolitan area networks (MANs) in major urban areas 4) Extension to national borders where needed (including for international and cross border traffic)	As bandwidth requirements grow, optic fibre will ultimately be required to interconnect virtually all wireless base stations, necessitating national backbones extending to remote and border areas.
1.3	**Inter-connection**	Local traffic stays local with minimal congestion and efficient interconnection: 1) Mandatory, transparent cost-based interconnection agreements 2) Availability of DID numbers/VoIP gateways to the PSTN 3) Presence of Local Internet Exchange Points (IXPs) in major urban areas	Reduces potential for market dominance, improves opportunities for using low cost VoIP services and cost of entry for small operators, allows for increased customer choice and improved competition, and downward pressure on costs and improved service quality along with improved network performance and resiliency for the end-user.
1.4	**Hosting and Cloud Services**	Affordable and reliable local content distribution and hosting services that also help ensure local data stays local: 1) Multiple (competitive and reliable) local carrier neutral data centre(s) 2) public VPN services 3) Secure and competitive local web hosting and cloud services 4) Presence of international Content Distribution Networks (CDNs) 5) Simple, fast and low-cost multilingual Domain Name registration with authentication and encryption 6) Legislation protecting against intermediary liability	Keeps data local and therefore reduces costs to operators and improves network performance for end-users as well as improving local navigation, security, branding, control and management of local content and domain name services. Improves ability for international and local web services to gain traction and better data sovereignty. Helps to attract foreign Content Distribution Networks (CDNs), thereby reducing the amount of international capacity required.
1.5	**Radio Spectrum**	Cost based, transparent, efficient radio spectrum licensing: 1) Cost based spectrum assignment fees 2) Access to existing unlicensed spectrum bands 3) Provision for shared use of the TV wavebands for TV White Space (TVWS) broadband 4) Availability of the digital dividend spectrum for mobile broadband 5) Dynamic spectrum management regulatory frameworks.	Improves availability of a vital resource for delivery of broadband services. Allows for the use of the latest, most efficient technologies, limits ability of incumbents to maintain franchises through technology. Low- spectrum fees reduces the cost of service to the end user. Use of TVWS will have a major impact on the potential for wireless broadband systems to reach areas that were previously cut off by distance and obstacles such as hills, vegetation and buildings, while minimising the potential for interference.

#	Building Block	Description	Principle
1.6	**Licensing**	An open market for telecommunication services with provisions for encouraging universal access: 1) Service and technology neutral licence structure 2) Streamlined licensing process 3) No legal barriers to market entry except minority local ownership requirement in certain cases 4) Tiered licensing frameworks which limit licensing burdens on small local community level operators (e.g. small entrepreneurs, municipalities or cooperatives) 5) Wholesale capacity licences available to both private and government operators for providing bandwidth to retail/end-user providers, dark fibre, ducts and tower space 6) Requirement for operators, which provide both wholesale and retail services to separate their operations and accounts. 7) Streamlined provisions for facilities-based/passive infrastructure providers – dark fibre, duct and tower operators which minimise (or eliminate) telecom licensing requirements. 8) Licensing obligations which promote inclusion and universal access and service obligations, including: i Contributions to the Universal Service Fund ii connecting public institutions iii Connecting marginalised social groups, including those with disabilities iv Submitting usage data regularly v Network neutrality adherence	Allows competition that is not restricted by limiting market access to types of technology or services, and encourages local communities to self- provide services, and ensures the availability of competitive wholesale fibre services. Historic markets with large installed customer base of fixed copper and co-ax (cable TV) may require separate treatment. Similarly, more densely populated urban areas may require separate treatment to rural areas.
1.7	**Market Structure**	Measures in place to address negative influence on the market by dominant operators: 1) Tariff caps on wholesale capacity and passive infrastructure such as masts 2) Asymmetric interconnection rates 3) Open access for other operators to essential facilities 4) Local loop unbundling 5) Number portability 6) No prohibitions on VoIP. Note: Needs competition authorities and regulators with sufficient capacity to implement measures to address Significant Market Power (SMP), when involving large companies often with even larger international parent companies or interests aligned with government (see next section).	Operators with a large proportion of the market may need special regulation to ensure their market dominance does not disadvantage smaller market entrants. Measures to address dominance create increased customer choice and therefore improved competition and downward pressure on costs while improving service quality. This section is also related to the conditions set in the national licensing regime.

#	Building Block	Description	Principle
1.8	**Consumer Protection and Ownership Alignment**	Limitations imposed on cross-ownership and state ownership of dominant retail ICT service providers, and in content/access services bundling: Restrictions on relative size of shareholding specified in law.	Cross ownership and government ownership in dominant retail broadband service providers and/or broadcasting networks can cause a conflict of interest with other private operators, as well as within government, which on the one hand wishes to maximise profitability of its shareholding while on the other, the public requires the most affordable services. Operation of internal government networks by parastatal entities usually fall outside this provision.
2		**Strength of Policy Making and Regulatory Institutions**	
2.1	**Institutional Governance**	Maintenance of independence: 1) Executive structures from vested interests, governmental entities, broadcasters and telecom providers 2) Provided with authority, jurisdiction, accountability to enforce regulations, including effective regulation of anti-competitive behaviour. 3) Incentives within agencies to work across other government agencies to promote government, health and others to serve as early broadband adapters	Regulators aim to be strong advocacy for consumer/public interests – decision making needs to be objective and not influenced by politics or vested interests. Improves independence and effectiveness but may also need supportive competition / anti-trust authority.
2.2	**Operational Support**	Ensuring stability of income for the regulator: Sufficient and predictable funding streams to support the capacity needed to develop, implement and enforce regulations.	Helps ensure independence and that regulator has human and financial capacity to enforce regulations that affect large private or public vested interests
2.3	**Decision Making**	Confidence and transparency of decision-making: 1) Track record of regulatory certainty with clear, transparent regulations 2) Evidence-based policymaking and regulatory procedures that include public participation	Helps ensure the most appropriate policies and regulations are adopted and minimises investor sense of risk and improves ability of private sector to make long term investments.
2.4	**Data Gathering**	Up-to-date market information: Regular (quarterly) data collection and publication of key market indicators disaggregated according to vulnerable groups (including gender) and including pricing, speed, total bandwidth and adoption rates. Note: needs licence obligations to include requirement to submit market data.	Provides the basis for informed decision-making and evidence-based policy development.
2.5	**Information Sharing and Capacity Building**	Institutional development: Participation in international networks and associations for sharing best practice and learnings. Broadband and ICT training across government departments	Helps to ensure regulatory framework stays up to date and is harmonised within the region.
3		**Enabling Strategies and Incentive Schemes**	

#	Building Block	Description	Principle
	National Broadband Strategy	Up to date plan ensuring all citizens have access to sufficient broadband at affordable rates along with sufficient high quality international capacity: A coherent and integrated approach to implementing the other building blocks, with: 1) targets and timelines 2) top level executive support 3) guided by a multi-stakeholder cross-sectoral advisory committee. Targets would include: i Everyone with affordable multi-megabit broadband connections and their own e-mail address ii Every business with an online presence iii Direct fibre access to regional and international hubs.	Improves co-ordination, economies of scale, accountability and cross-sectoral synergies while reducing duplication. A well co-ordinated cross-sectoral broadband deployment strategy aimed at reaching all people in the nation requires clear goals, clear support from head of state, tight inter sectoral co-ordination, and effective feedback mechanisms from government, private sector and civil society.
3.1	**National Infrastructure Atlas**	Geographic decision support for infrastructure deployment and maintenance: Use of a national utility infrastructure database/GIS containing routes and features of telecom/transport/energy grids/water/waste pipelines) augmented by complementary data such as location of population centres and public service outlets (schools, clinics, municipal authorities).	Improves planning process, reduces cost of network deployment and increases reliability of networks by helping to minimise accidental fibre cuts. Has spin-off benefits for public planning in other sectors such as national health and education systems.
3.2	**Rapid Deployment Framework**	Fast, cost-effective and efficient permitting process for infrastructure deployment: 1) A one-stop shop for access to rights of way/wayleaves, ducts, poles, masts, government land/buildings 2) Rapid cross-border permitting 3) Tariff caps for lease fees and submarine landing station fees. 4) Transparent dispute resolution procedure 5) Streamlined environmental impact assessment procedures.	Helps to minimise network deployment time and overheads, and reduces the cost of infrastructure operations.
3.3	**Infrastructure sharing**	Minimise infrastructure deployment and operational costs, and time to deploy: 1) Mandatory dig once public works requirements – first to dig/lay must share conduit 2) Co-ordinated infrastructure deployment – all new roads/pipelines/rail lines must have ducts and fibre included, OPGW on electricity grids 3) All new public buildings and housing estates and other anchor institutions, e.g., universities, health facilities, banks, power include provision for ducts in order to obtain planning permission.	Minimises disruption and creates major savings in costs of telecom network deployment and improves the competitive environment. Research shows that network deployment costs can be dramatically reduced if operators collaborate with each other for example, in deploying shared fibre optic backbones or masts for wireless broadband. Even greater impacts have been noted when other utility infrastructure such as roads, rail lines and power cables are shared with telecom operators, especially when 'dig once' policies require the inclusion of ducts for optic fibre and provisions for masts in any new public works project.

#	Building Block	Description	Principle
3.4	**Infrastructure finance**	Source of capital for underserved areas: Supportive PPP environment – Provision of guarantees for long-term soft finance and other incentives for rural infrastructure investment, such as an efficient Universal Service Fund which subsidizes infrastructure in non-market attractive areas and is available to all players on a non-discriminatory basis.	Improves opportunities for private sector to invest in network deployment in areas with marginal profit potential. Improves potential for private sector to leverage government support
3.5	**Taxation Regime**	Minimising costs for deploying infrastructure, purchasing access equipment and using communication services: Low taxation levels and import tariffs on broadband goods and services.	Reduces network deployment and maintenance costs as well as minimising customer equipment acquisition and service costs
3.6	**Government Services**	Exploiting the potential of digital services in government while building demand: 1) Investment in e-government applications development 2) Connectivity for government service outlets – municipalities, libraries, schools, clinics, community centres 3) Support for academic and research networks. 4) Support for those with disabilities.	Improves potential for universal access and thus improves overall demand for broadband services and therefore attractiveness of further e-government and private applications and services investment
3.7	**Inclusion Strategies**	Encourage access among low-income households and minority social groups: 1) Subsidised access for low income groups 2) Digital and functional literacy training 3) Building a cadre of information intermediaries 4) Investment in public access facilities 5) Support for community network self-provisioning Requires building awareness among policy makers of the need to support public access facilities.	Helps to ensure equal access among all population groups and builds demand for local services. For those that cannot afford their own equipment and connectivity, public access facilities (such as in public libraries) should offer an alternative to personal access. However, public investment in libraries, tele-centres, and multi-purpose community centres and other venues that can support public access to the Internet has so far been relatively limited.
3.8	**Content-Use and Convergence Policies**	Policy incentives that ensure confidence and security of data: 1) Legal framework for cyber security and protection of privacy 2) Restrictions on content blocking, except due to human rights violations 3) Clear and transparent IPR legal framework 4) Open Data Strategy for government and private information 5) Planning process for ensuring smooth convergence of broadcast (radio and TV) and broadband channels for mass-media use.	Ensures abuses of the Internet and associated risks for the public are minimised. Underlies adherence to democratic freedom of speech values. Creates incentives for business investment and allows re-use and value addition from existing information.

#	Building Block	Description	Principle
3.9	**Innovation and Learning**	Facilitate local capacity building in connectivity provisioning, content and applications development: 1) Support use and teaching of ICT at all academic levels 2) Investment in campus fibre networks, and National Research and Education Networks (NRENs) 3) Encourage presence of iHubs, incubators, science parks and other shared research, learning and workspace environments 4) Mechanisms to ensure coordination in regulation of emerging technologies and integration of strategic technology foresight into policy making	Affects level of demand from the public and ability to grow broadband-based businesses from skilled population. Supports ability to exploit the latest technologies, and generally benefit from improved innovation, skills development, networking, knowledge sharing and business development.
3.10	**E-Payments**	Efficient and Widespread means of making electronic payments: Support for presence of open carrier neutral mobile and broadband payments and banking platforms.	Basis for broad-based adoption of e-commerce
3.11	**Energy Supply**	Reliable and affordable electric power: Efficient low cost, reliable electricity distribution	Affects cost of network operation and ability of end-users to make use of the network.
3.12	**Business Environment**	Enabling environment for commerce: 1) Business registration – minimal overheads and rapid transaction times 2) High transparency of procedures, absence of corruption 3) Availability of startup and investment finance 4) Low interest rates 5) Low tax rates and tax incentives 6) Favourable trade policies	Affects ability to start and operate businesses thereby affecting availability of services to potential customers.

In addition, some concrete recommendations have been formulated based on the experience of sub-Saharan Africa[100], and the Americas and the Caribbean[101] to enable dynamic competition in the ICT market as well as for the reduction of the cost of Internet connection at the international level. The two studies also contain proposals and measures to encourage use of the Internet, and to promote development of local content especially in developing countries.

8.2 Monitoring and evaluation of the impact of connectivity strategies

To gauge the success of strategies and identify emerging issues, changes in a set of expected outcomes can be measured over time. The measures need to be pragmatic, rather than exhaustively accurate, i.e. they need to be easily obtained, objective, comparable and up-to-date. Comparison between countries can be useful in identifying effective policies, but the key aim with the use of indicators is to be able to measure progress in a country over time. Therefore, the data points should ideally be updated on a quarterly basis and authorities may need regulations to ensure that network operators provide the necessary data in a timely fashion.

[100] See ITU, Study on international Internet connectivity in sub-Saharan Africa, 2013. www.itu.int/dms_pub/itu-d/opb/pref/D-PREF-EF.IIC.AFR-2013-PDF-E.pdf

[101] See ITU, International Internet connectivity in Latin America and the Caribbean, 2013. www.itu.int/dms_pub/itu-d/opb/pref/D-PREF-EF.IIC.CAR-2013-PDF-E.pdf

Additional 'nice-to-have' indicators are described below, but the following set of three measures would be sufficient to provide not only an indication of the level of connectivity in terms of numbers of people connected, but also the overall level of Internet utilization:

- Number of broadband subscriptions per capita (%). 'Broadband' being defined as a connection of at least 512 Kbit/s today but growing to the higher rates available in developed countries. Data should be disaggregated according to gender, age, geographic area and minority groups. Full data disaggregation may only be feasible on an annual basis.
- Domestic data traffic per capita – bits per second (bit/s per capita). Defined as the total of all domestic network fixed and mobile data circuits provisioned, divided by the total population.
- International Data traffic per capita – bits per second (bit/s per capita). Defined as the total of all international network fibre, satellite and terrestrial microwave circuits provisioned, divided by the total population.

A number of additional indicators can be useful in helping to determine the source of problems in achieving the expected levels of connectivity. These are:

- Network coverage: Proportion of geographic territory and population for which broadband connectivity is available.
- Affordability: Cost of 10 Gb per month of broadband data traffic relative to average income levels (% of GNI/capita). 10 Gb is a common tariff package and on a monthly basis would be a desired minimal level of utilisation, corresponding to a 10-20 hours per month of video.
- Broadband Speed: Average download and upload speed per subscriber (bps)
- Reliability and Maturity: Autonomous System Numbers (ASNs) per capita. AS numbers are used by IP networks that are reliable, they are needed if the network has more than one connection to the rest of the Internet. As a result, they provide a reliable indication of the extent of network development in the country. AS number visibility is also easily measurable and available in real-time, and up-to-date statistics are simple to produce.
- Regional connectivity: Number of ASNs visible in-country that are from neighbouring and regionally associated countries.
- Global connectivity: Number of ASNs visible in-country that are from out-of-region/all other countries.

8.3 Global and regional collaboration to improve international capacity for developing countries

The wide variety and large number of factors in the connectivity equation outlined above underscores the need for an integrated approach to maximising connectivity levels. A bottleneck in any component of the broadband ecosystem acts to limit overall use. For example, limited local interconnection infrastructure is also likely to have a negative impact on local content development and on the presence of foreign carriers and content distribution networks.

There is also a close relationship between the qualities of international versus domestic infrastructure – countries with more international connectivity have lower domestic broadband prices and countries with better domestic infrastructure have lower international bandwidth prices. It is for these reasons that building local demand should be an essential part of the international connectivity strategy, and it is necessary to take into account the interrelation of many independent components when developing strategies for improved connectivity, as envisaged in further ITU work on international Internet connectivity strategy building blocks.

Accelerating the deployment of needed international connectivity will benefit from discussions among key stakeholders to reach a global commitment to collaborate on identification of challenges, take advantage of opportunities and to develop and execute solutions to specific problems. The solutions could include international, regional or other groupings that address common challenges of a more specific nature, such as a submarine cable group, a satellite group, a cross-border cable group etc.

Annex 1: References and further resources

ITU Broadband Capacity Indicators

www.itu.int/en/ITU-D/Technology/Documents/InteractiveTransmissionMaps/Misc/BroadbandTransmissionCapacityIndicators.pdf

ECOWAS Regulation on Access to Submarine Cables – ITU 2013

www.itu.int/en/ITU-D/Projects/ITU-EC-ACP/HIPSSA/Documents/FINAL%20DOCUMENTS/FINAL%20DOCS%20ENGLISH/submarine_cables_ecowas_regulation.pdf

Green Cables Funding Study, ITU-WMO-UNESCO IOC Joint Task Force, 2016,

www.itu.int/en/ITU-T/climatechange/task-force-sc/Documents/JTF%20Report%20Green%20Cable%20Funding%20Study.pdf

Haut débit en eau profonde: www.lemonde.fr/pixels/visuel/2016/03/10/haut-debit-en-eau-profonde_4880125_4408996.html

International cables, gateways, backhaul and international exchange points, OECD 2014

http://oecdinsights.org/wp-content/uploads/2014/02/International-cables-gateways-IXPs.pdf

International Internet Connectivity in Sub Saharan Africa – March 2013

www.itu.int/en/ITU-D/Regulatory.../IIC_Africa_Final-en.pdf

International Internet Connectivity in Latin America and the Caribbean – March 2013

www.itu.int/dms_pub/itu-d/opb/pref/D-PREF-EF.IIC.CAR-2013-PDF-E.pdf

International Bandwidth and Data Markets – Asia Pacific and Middle East 2013

www.slideshare.net/jokosuryana90/international-bw-and-data-market

International Satellite Directory 2016

www.satnews.com/products.php?product=isd

ITU Interactive Transmission Map

www.itu.int/itu-d/tnd-map-public/

ITU-T Manual – Fibre, Cables and Systems, 2009

www.itu.int/dms_pub/itu-t/opb/hdb/T-HDB-OUT.10-2009-1-PDF-E.pdf

Mapping Support for Africa Infrastructure Investment (OECD 2012)

www.oecd.org/daf/inv/investment-policy/MappingReportWeb.pdf

Master Plan for wireless broadband in Asia and the Pacific 2012

www.itu.int/net4/ITU-D/CDS/projects/display.asp?ProjectNo=9RAS10036

Open Access To Submarine Cables. Presentations from the 2012 Kigali Knowledge Sharing Event.

www.itu.int/en/ITU-D/Projects/ITU-EC-ACP/HIPSSA/Pages/HIPSSA_Preparatory_work/Open-access-to-submarine-cables.aspx

The regulation of undersea cables and landing stations.

www.cablesm.fr/2007_esselaar-et-al-2007-undersea-cables.pdf

SADC Regional ICT Infrastructure Development Master Plan (2012)

www.sadc.int/documents-publications/show/Regional_Infrastructure_Development_Master_Plan_ICT_Sector_Plan.pdf

Submarine Cable News

www.subcablenews.com

Submarine Telecoms Forum

http://subtelforum.com

Where are the funding sources for submarine cables projects? Andrew Lipman 2013.

www.suboptic.org/wp-content/uploads/2014/10/WE2A-2_Oral_5.pdf

WSIS Targets Review: Connectivity

www.itu.int/en/ITU-D/Statistics/Documents/publications/wsisreview2014/WSIS2014_review_target3.pdf

Annex 2: Glossary and abbreviations

Backbone	The trunk routes of a network, also used as the path for transporting traffic between different networks. Backbones can be the physical telecommunication cable infrastructure, or the circuits established over them by a particular network operator.
Bandwidth	The size or capacity of a communications channel indicating its ability to transfer data, usually measured in the speed of data transfer, in bits per second (Bps) for packet networks such as the Internet, or SDH STMs, or also often stated in the frequency range assigned to the channel, measured in Hertz (Hz).
Bit	Binary Digit – a 0 or a 1 – the way information is encoded digitally
BPL	Broadband over electric Power Lines – use of power cables to transmit data
Business Process Outsourcing (BPO)	Use of a third party, often offshore, to carry out a set of business activities for a company, such as a help desk, or accounts processing
Bits per Second (BPS)	The number of bits passing a point every second. The transmission rate for digital information, i.e a measure of how fast data can be sent or received. Often expressed as Mbit/s, for Megabits per second, or Gbit/s, for Gigabits per second for high speed links.
Broadband	A high speed (multi-megabit) data connection sufficient to support streaming multimedia connections. Target speeds for broadband are continually evolving.
Byte	8 bits of data, sometimes called a "word" or and "octet" – used as a measure of storage capacity or traffic – e.g a 1 Gigabyte mobile data package.
Cable Landing Station (CLS)	The facility where a submarine cable 'lands' on shore with equipment for distribution of the capacity and in most cases also for powering the cable.
Cloud Service	A service provided via the Internet that gives access to applications and data storage facilities that are hosted on the service provider's network and servers, typical examples are Amazon WS, DropBox, Gmail, MSN.
Co-location	The renting of space for housing computer server equipment, usually in specially designed buildings (called data centres, telehouses or carrier hotels).
Connection Redundancy	Two or more communication links via physically separated network providers. Redundancy ensures reliability – continued operations in the event of one connection going down.
Construction and Maintenance Agreement (C&MA)	A type of detailed shareholder's agreement made between consortium members/owners of a fibre project.
Content	The data that travels over a network – traffic – any form of digitised information ranging from text to multi-media audio and video, and may include software/applications as well as financial and gaming transactions

Dark Fibre	Optic fibre which is not yet in use, and therefore unlit.
Demand Forecast	Projects future demand for capacity on system, typically for at least ten years, assuming market growth and competition factors.
Dense Wave Division Multiplexing (DWDM)	A technology that enables data from different sources to be transmitted simultaneously on a single optical fibre, each signal (data source) being carried on a discrete optical wavelength. Up to 80 (and theoretically more) wavelengths can be transmitted on a single optical fibre.
Detailed Feasibility Study (DFS)	A demonstration that a system can be economically viable based on projected cash flow given the demand forecast and cost estimate along with projected pricing for capacity in the system
Domain Name	A name, registered with, and held on a database by a 'domain name registry', consisting of a name, sometimes a second level domain and a top level domain. E.g. total.com.ng, mycompany.co.uk
Desktop Study (DTS)	A preliminary layout of the cable system based on assumptions about landing points and known route details – includes armouring and burial assumptions
Downstream	A network's paid traffic – in contrast to upstream traffic, for which a network must usually pay transit fees, and peered traffic, which is usually settlement free, downstream traffic is paid for by network users.
Digital Subscriber Line (DSL)	A technique for delivering broadband services over copper cables
Exabyte	A billion gigabytes
Fibre optic cable	A technology using glass fibre for the transmission of data. The signal is imposed on the fibre via pulses (modulation) of light from a laser or a light-emitting diode (LED). With advances in modulation technology, international fibre cables are now usually deployed with terrabit capacities.
Fibre to the Home (FTTH)	The provision optic fibre broadband communications links to domestic premises – a more generic term to include other buildings or to the kerb would be FTTx
Gigabits per second (Gbit/s)	A data transfer rate of Giga (a billion or a thousand million) bits per second. (Also Gb/s)
Hosting	A loose term for the service of managing data servers or web sites for third parties. Similar to co-location but may be on shared equipment
Instruction to Proceed (ITP)	A document authorising a system supplier to begin work on a system before a formal contract is negotiated, in the interest of timeliness. Requires system developers to commit a fraction of the system cost immediately.
International gateway	A facility to provide international connectivity and termination points. In practice it is a licensing term used by many government regulators which only allow licensed operators to carry international voice traffic or lease international data circuits (IPLCs see below).

International Private Leased Circuit (IPLC)	A physical circuit of dedicated capacity provided at two points – one inside the country and one outside the country. In many cases the circuit is charged in two sections, each from the location to the border, or in the case of submarine cable, one local origination and one foreign origination.
Internet	A global mesh of networks sharing a common communications protocol called TCP/IP. The Internet's international backbones are high-speed fibre trunk lines usually owned by telecommunication companies.
Internet Exchange Point (IXP)	A physical infrastructure allowing many ISPs to exchange Internet traffic. Traffic is exchanged by peering agreements made between the ISPs connected to the Internet Exchange. By peering at an Internet Exchange the connected ISPs reduce their reliance on a small number of networks (usually their upstream provider(s)), and this improves the delivery and receipt of traffic.
Internet Service Provider (ISP)	An organisation that connects end-users and businesses to the public, global Internet. ISPs often provide other services such as storing and forwarding email, and hosting web sites for their customers. They may or may not own the underlying physical infrastructure used to provide the service. ISPs which purchase bandwidth from other companies that have direct links to the Internet in turn sell that bandwidth to customers in smaller chunks.
Internet Protocol (IP)	See below.
IP Packet	A discreet datagram of Internet traffic constructed according to the Internet Protocol, between 40 and 1599 bytes long, having source, destination (i.e. routing information) and other management information as well as the actual user's data (the 'payload').
Indefeasible Rights of Use (IRU)	A means of purchasing long term rights (usually 10-15 years) to the capacity or physical resource (optic fibre or wavelength) on a communications circuit. IRUs are treated as assets for accounting purposes that adds to their tax advantage compared to leasing.
Leased Line	A telecommunications circuit leased between two or more locations from a telecom provider.
Link Aggregation	Various methods of combining (aggregating) multiple network connections in parallel to increase throughput beyond that which a single connection cn sustain, and to provide redundancy in case one of the links fails.
Local Area Network	(LAN) A network of computers spread over a relatively small physical area, often in one building and often belonging to one organization. See also MAN, WAN.
Long Term Evolution (LTE)	A standard for 4G wireless networks.
Memorandum of Understanding (MOU)	Defines relationships among developers.
Metropolitan Area Network (MAN)	Metropolitan Area Network – usually an optic fibre network covering a city.
Mbit/s	A data transfer rate of Mega (million) bits per second. (Also Mb/s).

National Regulatory Authority (NRA)	See Regulator.
Network	Two or more interconnected computers or data communications devices See also IP Network MAN, WAN.
Open Access	When referring to optic fibre infrastructure, Open Access service delivery models ensure that all operators, regardless of the size of investment or capacity purchase, have equal terms of use for access to fibre optic cables on a capacity (Mbit/s), wavelength, or dark fibre basis.
Optical Fibre Cable (OFC)	The cable that carries data by modulating light pulses, usually in glass fibres, although plastic fibres can be used over short distances.
Optical Ground Wire (OPGW)	A cable that runs along high tension electric power lines used to provide control information for the power network. OPGW often has additional cables for use by communication network operators.
Packet	A discreet "chunk" of data traffic. See IP Packet.
Peer	A network with which one has a peering relationship, where traffic is usually exchanged between peers at no cost to either party.
Petabit	One thousand terrabits.
Point of Presence (POP)	A location where a network has physical infrastructure to provide services to end users or to interconnect with other networks.
Public-Private Partnership (PPP)	A mutually beneficial relationship between government and private sector entities, such as shared investment in a submarine fibre cable and landing station. Not to be confused with Purchasing Power Parity, a mechanism to compare the relative values of currencies.
Public Switched Telephone Network (PSTN)	The traditional voice telephone system, including both fixed and mobile networks. Most networks today are in a process of migrating from a switched architecture to an IP packet based architecture.
PTO	Public Telecom Operator, usually refers to the incumbent often legacy state-owned operator, although technically, the distinction between fixed line, mobile operators and ISPs is increasingly blurred (see PSTN above).
QOS	Quality of Service – a measure of the quality of the service provided by a network. There are many different QOS measures, depending on the nature of the traffic – common examples include ping time, packet loss, round-trip time etc. Also see Service Level Agreement (SLA). QOS rules can also be applied to different types of traffic passing through a router – for example voice traffic might be given a higher priority to email.

Regulator	A government entity that has responsibility for executing national policy by establishing a set of regulations that govern the telecom sector. The regulator is normally semi-autonomous, with an income derived from licence fees, although the state usually appoints the executive body. The regulator helps ensure that there is a level playing field in the market and it has a major responsibility to curb the impact of market dominance of the incumbent operators, especially in developing countries. In some economic regions with a high level of integration, such as the EU and ECOWAS (west Africa) a substantial amount of policy and regulatory development takes place at the regional level, which the Member States are obliged to adopt.
Request for Proposal (RFP)	A formal request for suppliers to propose their detailed solutions for provision of a system, defining the system technical and commercial details as closely as possible.
Rough Order-of-Magnitude (ROM) Estimate	An approximation of system cost based on knowledge of route and product prices, using standard estimating practices.
Route	The path of a cable, radio transmission or through one or more networks that is taken by IP packets. Due to the dynamic nature of routing on the Internet, packets from the same data stream may travel to their destination by different routes and reassembled by the router at the final destination.
Significant Market Power (SMP)	A definition used by regulators to help ensure a level playing field in the presence of an operator which is dominant in the market and therefore able to charge uncompetitive prices (often the incumbent previously state-owned monopoly and mobile operators). An SMP determination will allow the regulator to set tariffs charged and place other conditions on the operator.
Submarine Line Terminal Equipment (SLTE)	The electronics necessary to carry traffic over the fibre optic cable.
Supply Contract	The formal detailed definition of the suppliers' obligations to manufacture, install, and test the system, and the developers' obligation to pay.
Special Purpose Vehicle (SPV)	A company set up for a particular purpose, often with not for profit goals where shareholders are a mix of public and private entities, such as an open access submarine cable landing station.
Synchronous Digital Heirarchy (SDH)	The traditional carrier network transmission protocol (see below), now being superseded by Ethernet and IP services.
Synchronous Transport Module (STM)	The SDH ITU-T fibre optic network transmission standard – an STM-1 has a capacity of about 155 Mbit/s, an STM-4 has a capacity of 622 Mbit/s.
Terabit (Tb)	One thousand gigabits. The latest fibre optic cables are able to carry tens of terabits per second over thousands of kilometres.

Transit	Transit is an arrangement in which a network sells access to other networks. Transit charges are set by negotiation, and are often not disclosed publicly. Transit arrangements typically provide access to an array of networks, not limited to one country. In many cases one Internet transit arrangement with a large network is used to provide a small network with access to the Rest of the World (ROW).
Upstream	The network traffic generated or consumed by the network's users that is passed out of or into the network from or to other networks. Typically a proportion of the upstream capacity required is peered away to some other networks at no cost, while the rest of the capacity required is purchased from a transit provider.
Wavelength	A carrier of data on a fibre optic cable. See DWDM.
Weighted Average Cost of Capital (WACC)	A measure of the financing cost of the capital used in making an investment, such as in a submarine cable
Wide Area Network	(WAN) A network of computers spread over a large physical area, from regional to global. WANs may be operated and used by single organizations, or used by many. Perhaps the ultimate WAN is the Internet. See also MAN.

Annex 3: Technical background to optic fibre communications

A3.1 Introduction

With the invention of the laser in 1966, it was discovered that modulated laser beams traveling through optical fibres might be the best choice for telecommunications as they are capable of transmitting light over long distances. By 1970, the dramatic reduction in high transmission losses in fibre from 1000 dB/Km to 20 dB/Km and technical feasibility of operation of Gallium Arsenide semiconductor lasers at room temperature, gave a big boost to further research in the area of optical communications through fibres.

Further innovations led to reduced path losses (to the tune of 0.04 dB/Km), availability of compact and efficient optical sources and detectors, verity of optical multiplexers/demultiplexers and other related devices and low cost systems. This has resulted in extensive deployment of optical fibre networks all over the world.

A fibre optic network is composed of optical fibre cable, a transmission system, active and passive components and some accessories. ITU has defined standards for different types of fibre optic cables, subsystems, and protocols, etc. The following subsections provide a brief overview of fibre optic system components and respective ITU recommendations.

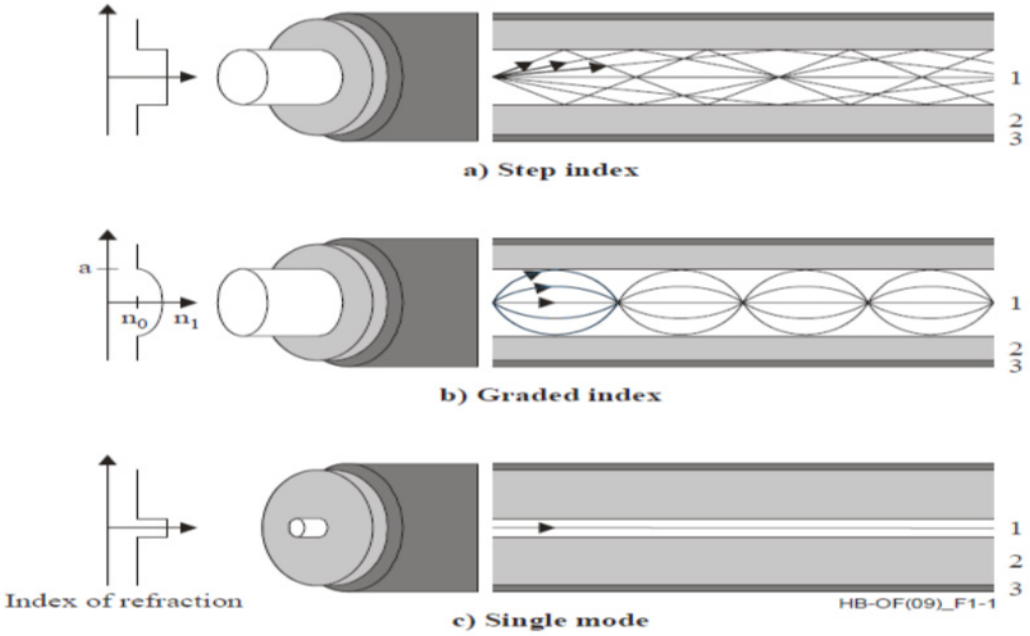
A3.2 Optical fibre

Optical fibres are dielectric waveguides. Two types of fibres are used for telecom applications. These are single-mode and multimode optical fibres.

Multimode fibre cores may be either step index or graded index. Step index multimode fibre derives its name from the sharp step like difference in the refractive index of the core and cladding. In the graded index multimode fibre the light rays are also guided down the fibre in multiple pathways. But unlike step index fibre, a graded index core contains many layers of glass radiating outwards from the axis, each with a lower index of refraction. The effect of this grading is that, to match those rays taking the shorter pathway directly down the axis, the light rays speed up in the outer layers. The result is that a graded index fibre equalizes the propagation times of the various modes, so that data can be sent over a much longer distance and at higher rates.

Figure A1 shows light in these modes (a, b and c) following these paths, where the core, cladding and coating, are numbered 1, 2 and 3 respectively. The cladding glass has a refractive index slightly lower than the refractive index of the core glass.

Figure A1: The three types of fibres



Source: ITU

The fibre in Figure A1 (a) is called step index because the refractive index changes abruptly from cladding to core. Graded index fibres are commercially available with core diameters of 50, 62.5 and 100 microns. The single mode fibre allows only a single light ray or mode to be transmitted down the core. This virtually eliminates any distortion due to the light pulses overlapping. The core of the single mode fibre is extremely small, approximately five to ten microns. The single mode has a higher capacity and capability than either of the two multimode types. For example, undersea telecommunication cables can convey 60 000 voice channels on a pair of single mode fibres. By reducing the core diameter and the refractive index difference between the core and the cladding only one mode (the fundamental one) will propagate and the fibre is then "single-mode" (Figure A1 (c)).

The optical fibres are specified in the following ITU-T Recommendations ITU-T G.650.1, ITU-T G.650.2, ITU-T G.650.3, ITU-T G.652, ITU-T G.653, ITU-T G.654, ITU-T G.655, ITU-T G.656, ITU-T G.657 and ITU-T G.651.1.

Optical fibre cable

The basic purpose of optical fibre cable is to keep the transmission and mechanical strength properties of the optical fibres stable in the course of the cable manufacturing, installation, and operation.

The dimensional and transmission characteristics of the optical fibre cables used for telecommunication must follow ITU-T Recommendations ITU-T G.651.1, ITU-T G.652, ITU-T G.653, ITU-T G.654, ITU-T G.655, ITU-T G.656 and ITU-T G.657.

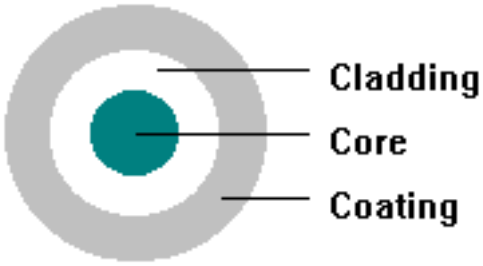
General structure of optical fibre cables

The three basic elements of a fibre optic cable are the core, the cladding and the coating.

- Core: This is the light transmission area of the fibre, either glass or plastic. More light will be transmitted into the fibre when the core is larger.
- Cladding: The function of the cladding is to provide a lower refractive index at the core interface in order to cause reflection within the core so that light waves are transmitted through the fibre.

- Coating: Coatings are usually multi-layers of plastics applied to preserve fibre strength, absorb shock and provide extra fibre protection. These buffer coatings are available from 250 microns to 900 microns.

Figure A2: The basic elements of a fibre optic cable



Source: ITU

Fibre size

The size of the optical fibre is commonly referred to by the outer diameter of its core, cladding and coating. Example: 50/125/250 indicates a fibre with a core of 50 microns, cladding of 125 microns, and a coating of 250 microns. (A sheet of paper is approximately 25 microns thick). The coating is always removed when joining or connecting fibres.

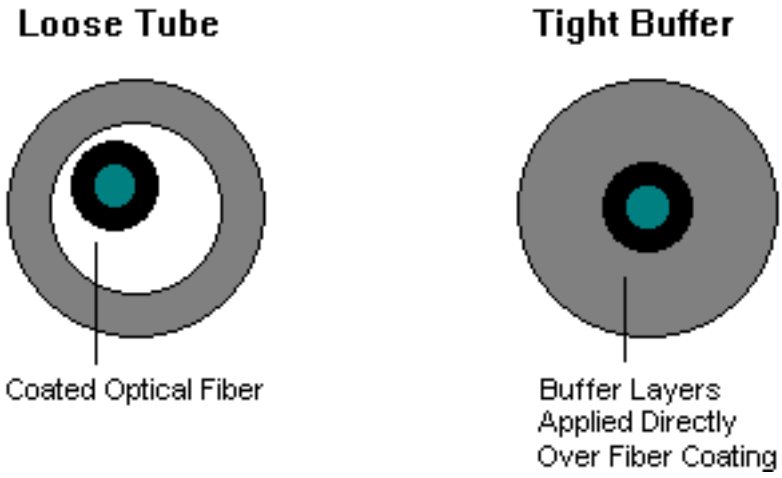
Design considerations

Considerations of tensile strength, ruggedness, durability, flexibility, size, resistance to the environment, flammability, temperature range and appearance are important in constructing optical fibre cable.

First level of fibre protection

The optical fibre is a very small waveguide. In an environment free from stress or external forces, this waveguide will transmit the light launched into it with minimal loss, or attenuation. To isolate the fibre from these external forces, two first level protections of fibre have been developed: loose tube and tight buffer.

Figure A3: The first level protections of fibre



Source: ITU

In the loose buffer construction, the fibre is contained in a plastic tube that has an inner diameter considerably larger than the fibre itself. The interior of the plastic tube is usually filled with a gel material. The loose tube isolates the fibre from the exterior mechanical forces acting on a cable. For

multi-fibre cables, a number of these tubes, each containing single or multiple fibres, are combined with reinforcing to keep the fibres free of stress, and to minimize elongation and contraction. By varying the amount of fibres inside the tube during the cabling process, the degree of shrinkage due to temperature variation can be controlled, and therefore the degree of attenuation over a temperature range is minimized.

Tight buffer is the other fibre protection technique. It uses a direct extrusion of plastic over the basic fibre coating. Tight buffer constructions are able to withstand much greater crush and impact forces without fibre breakage. The tight buffer design however, results in lower isolation for the fibre from the stresses of temperature variation. While relatively more flexible than loose buffer, if the tight buffer is deployed with sharp bends or twists, optical losses are likely to exceed nominal specifications due to micro-bending. A refined form of tight buffer construction is breakout cable. In breakout cable, a tightly buffered fibre is surrounded by aramid yarn and a jacket, typically PVC. These single-fibre subunit elements are then covered by a common sheath to form the breakout cable. "This cable within a cable" offers the advantage of direct, simplified connector attachment and installation.

Each construction has inherent advantages. The loose buffer tube offers lower cable attenuation from microbending in any given fibre, plus a high level of isolation from external forces. Under continuous mechanical stress, the loose tube permits more stable transmission characteristics. The tight buffer construction permits smaller, lighter weight designs for similar fibre configuration, and generally yields a more flexible, crush resistant cable. The type of installation of the fibre optic cable in the telecommunication network decides the basic characteristics of the structure and dimensions and the materials of an optical fibre cable.

Various ITU-T recommendations define different fibre optic cables for different applications. Some of the commonly used fibre cables with ITU-T recommendations are:

ITU Recommendations	Fibre optic cable for
ITU-T Rec. L.10	ducts, tunnels and bridges
ITU-T Rec. L.43	directly buried in the ground
ITU-T L.26	Arial applications
ITU-T G.978	Submarine cable installation
ITU-T G.972	Use in different type of protected environments

Recommendation ITU-T G.972 describes different types of protected cables with mechanical characteristics and the ability of the cable to be installed, recovered and repaired.

A3.3 Transmission systems

In an optical communication system, a source of monocratic light source is modulated as per electrical voice, data, and video signals. This modulated light is made to travel through optical fibre cable over long distances. Different data streams can be launched in the same fibre on other monochromatic light beams. Since the signal loses its power due to attenuation in the fibre, repeaters / signal boosters are provided to maintain the desired signal level. On the way, many signal tributaries are added and dropped in response to traffic requirements. At the receiving end, the modulated light signals are detected using a light detector and converted to electrical signals. An optical transmission system includes the following main components / subsystems:

- optical transmitters;
- sources and modulators;

- optical receivers;
- optical amplifiers and their different applications;
- adaptive chromatic dispersion compensators;
- PMD compensators;
- OADMs / ROADMs;
- photonic cross-connects;
- optical wavelength MUX/DMUX;
- regenerators and transponders;
- optical attenuators and optical branching devices.

Optical transmitters

The optical transmitters are used to convert an electrical input signal into an optical signal and then transmission of optical signal through optical fibre as a communication channel. The major components of optical transmitters are the optical sources and the modulators.

Optical sources

Optical transmitters use semiconductor optical sources such as light-emitting diodes (LEDs) and semiconductor lasers because of advantages such as monochromatic source of light, compact size, high efficiency, good reliability, small emissive area, possibility of direct modulation.

- Light emitting diode (LED): LED emits light when a voltage is applied between its two terminals. If this voltage varies according to the intelligence (signal), then the output light gets modulated. This modulated light is transmitted through fibre to the desired location.
- Semiconductor Laser: Semiconductor lasers are costly in comparison with LEDs but provide much better performance characteristics in comparison with LEDs. Though the laser can be directly modulated by a large signal, the sharp pulse does get distorted and hence external modulators are used.

Optical receivers

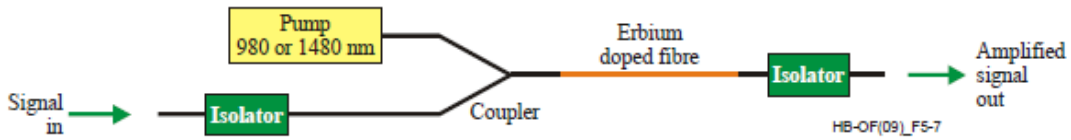
An optical receiver converts the optical signal back into electrical form and recovers the data transmitted through the optical system. It uses a *photo detector* to convert light into electricity through the photoelectric effect. Generally, PIN photodiodes and avalanche photodiodes of compact size with high efficiency and good reliability are used.

Optical amplifiers (OA)

The transmission distance in an optical system is generally limited by optic fibre losses. Such losses are compensated by using regenerators / optical amplifiers. In regenerators, the optical signal are first converted into an electric current and then regenerated using a transmitter. The regenerators become complex and inefficient for wavelength division multiplexed (WDM) systems. Alternatively, optical amplifiers are used to compensate such optical losses. In optical amplifiers, the optical signals are boosted directly in the optical domain without conversion to electronic format.

Recommendations ITU-T G.661, ITU-T G.662 and ITU-T G.663 describes optical amplifiers in detail. Optical amplifiers are based on laser principles and simultaneously amplify all wavelengths. For long distance communication, generally erbium-doped fibre amplifier (EDFA), semiconductor optical amplifiers (SOA), and Raman amplifiers are used.

Figure A4: Basic EVDO Amplifier

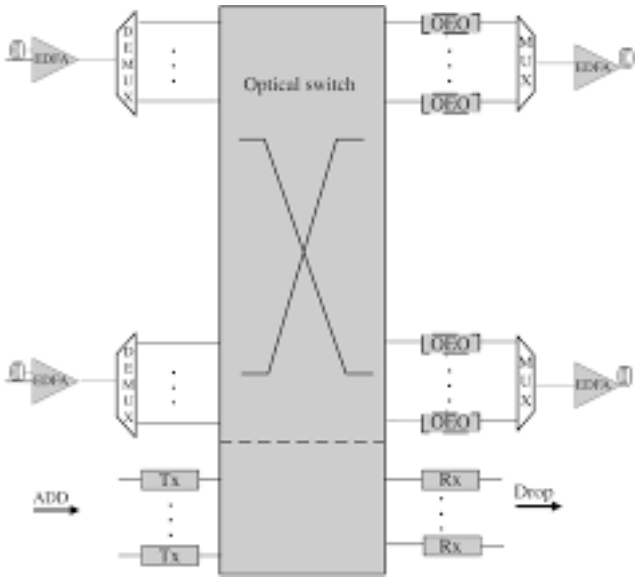


Source: ITU

Optical cross connects or photonic cross connects (OXC or PXC)

Optical cross connects, described in ITU recommendations ITU-T G 680, are used in wide area WDM (wavelength division multiplexing) networks for switching traffic in an optical domain. Optical cross connects facilitates optical switching of optical signals from any input port to any output port of the cross connect. This is analogous to electronic switching function in an electronic telephone exchange.

Figure A5: Optical cross connect

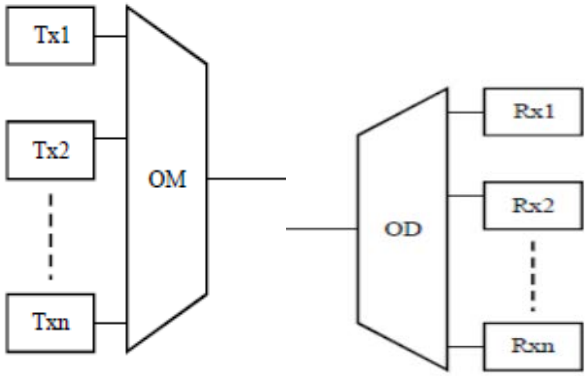


Source: ITU

Optical wavelength MUX/DMUX

The main function of an optical de-multiplexer is to receive from a fibre a beam of multiple optical frequencies and separate it into its frequency components, which at the output are coupled in as many individual fibres as there are frequencies. An optical multiplexer functions in the opposite manner. It receives many optical wavelengths from many fibres and converges them into one beam that is coupled into a single fibre.

Figure A6: Optical multiplexer and de-multiplexer

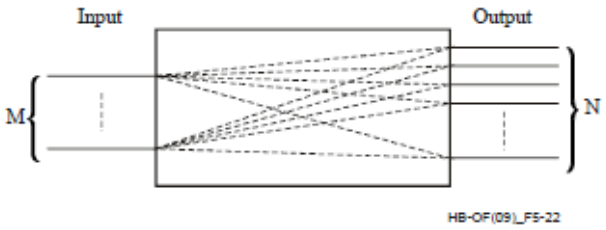


Source: ITU

Optical branching devices including passive optical network splitters

An optical branching component (optical dividers, optical combiners etc.) described in ITU Recommendations ITU-T L.37 and ITU-T G.671 is a passive component with three or more ports, that shares optical power among its ports in a predetermined fashion, without any amplification, switching, or other active modulation. Optical branching is a method of splitting optical signals between input and output ports. Optical branching components are used for splitting an incoming optical signal into two or more fibre lines or when several signals coming from different fibre lines have to be mixed in to a single fibre line.

Figure A7: Splitters: input - output



Source: ITU

Optical branching

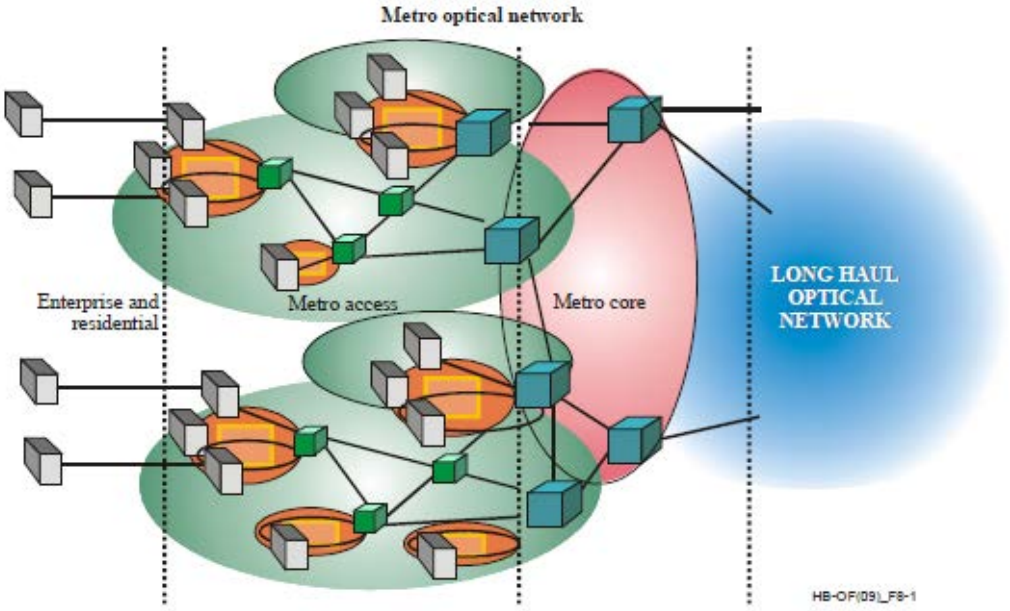
In passive optical networks (PON) with a point-to-multipoint distribution architecture, optical splitters are used to connect an OLT to several ONUs located at subscriber premises. ITU recommendation ITU-T G.671, defines the parameters of optical branching components such as insertion loss, reflectance, optical wavelength range, polarization-dependent loss, directivity and uniformity etc. for passive optical networks.

A3.4 Fibre optical communication systems and networks

The optical transport network (OTN) is a combination of:

- access networks;
- metropolitan access networks;
- metropolitan core networks (or regional networks); and
- long-haul networks (or backbone networks).

Figure A8: Metro optical network



Source: ITU

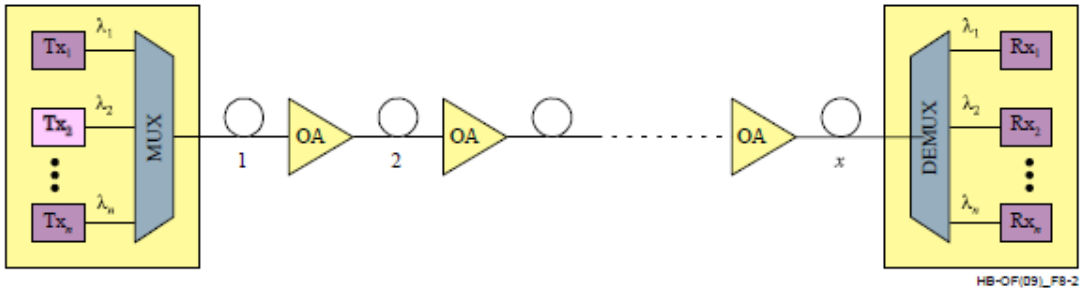
An optical transport network (OTN) is composed of a set of optical network elements (ONEs) connected by optical fibre links, which provide functionality of transport, multiplexing, routing, management, supervision and survivability of optical channels carrying client signals, according to the requirements given in Recommendation ITU-T G.872.

ITU Recommendations on key optical network topologies

Point-to-multipoint topology is generally used for access networks, while ring topology is generally used for metro networks. Backbone nodes are usually interconnected by point-to-point WDM lines in a mesh topology.

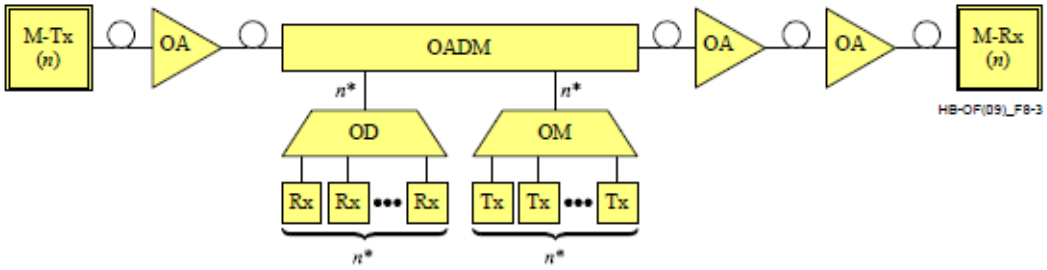
Recommendations ITU-T G.692, ITU-T G.693 and ITU-T G.959.1 relates to point-to-point transmission systems, generally used for access networks. Recommendations ITU-T G.695, ITU-T G.698.1 and ITU-T G.698.2 includes optical add/drop function (bus structure). Recommendation ITU-T G.983.x and the ITU-T G.984 x-series covers a point-to-multipoint topology for optical access networks. Recommendation ITU-T G.959.1 and ITU-T G698.1 specifies DWDM system for metro networks

Figure A9: WDM optical point to point link



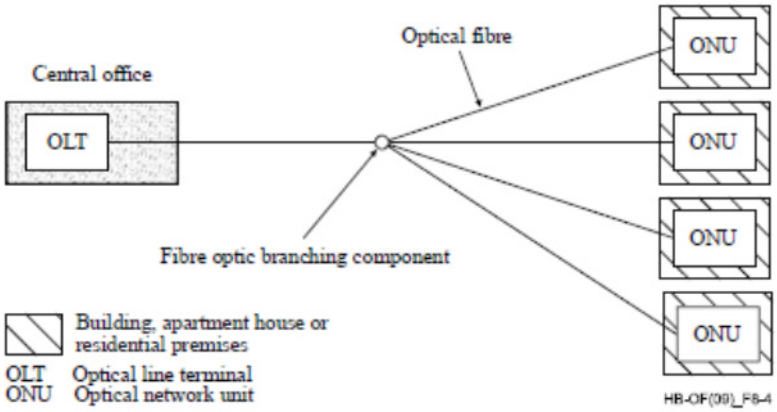
Source: ITU

Figure A10: Optical bus with optical amplifier and add/drop multiplexer



Source: ITU

Figure A11: Point to multipoint structure

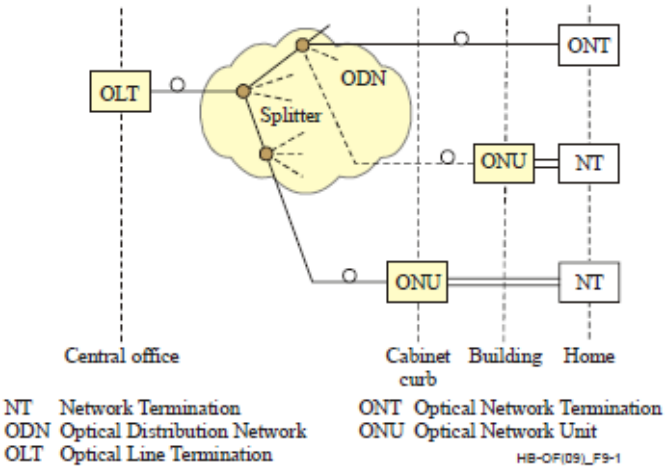


Source: ITU

Passive optical network (PON)

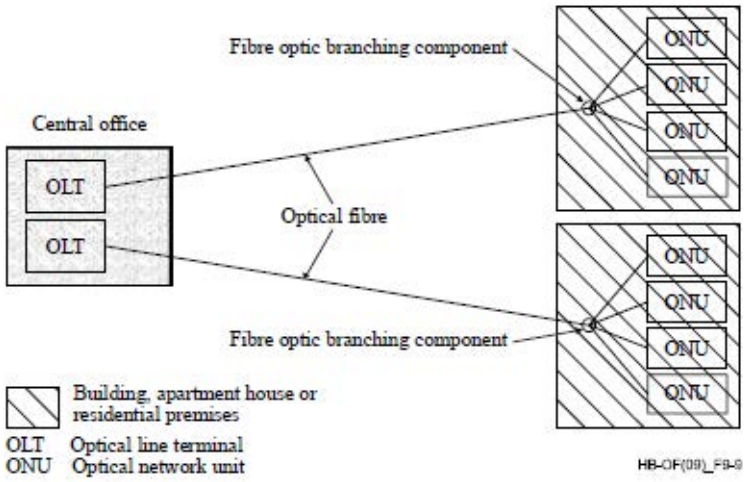
Passive optical networks are optical access networks used to extend optical signals from central office to subscriber premises. PONs are generally characterized by the absence of active components, with the exception of the sites where the OLT (optical line termination) and the ONU/ONT (optical network unit / optical network termination) are placed. However, a PON can also include a RE (reach extender), which contains active components, when a long distance between the OLT and the ONU is required. PONs are generally based on tree network topologies that use passive optical splitters.

Figure A12: Passive optical network



Source: ITU

Figure A13: PON configuration for buildings



Source: ITU

References: ITU recommendations as mentioned in the text: ITU-T Manual 2009 “Optical Fibre Cables and Systems”

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Strategic Guidelines

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DRAFT FOR DISCUSSION



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1 Introduction

This paper, as part of the ITU LET'S ROAM THE WORLD Initiative launched in 2015 by Mr. Brahima Sanou, Director of the International Telecommunication Union Development Bureau (ITU-D)[1], presents Building Blocks for Strategic Guidelines on International Mobile Roaming (IMR).

The issue of high IMR service prices at the national, regional and international level is recognized as an increasingly important issue, with national regulatory authorities (NRAs) and policy makers looking for appropriate regulatory and policy solutions. Discussions are not only focusing on just voice or data roaming, or on international trade-related principles (e.g. Most Favored Nation principles under the GATS Agreement), but also addressing changes in revenue streams, usage and traffic, new business models as well as new opportunities and innovative measures on roaming for Machine-to-Machine (M2M) communications and the Internet of Things (IoT). The issue is still evolving and policy makers and regulators will continue to seek solutions.

Although demand for IMR services and actual usage are increasing, this does not always translate into higher roaming revenues for Mobile Network Operators (MNOs). There is a need to balance business innovation, on one hand, and revenues, on the one hand, while seeking lower roaming tariffs for consumers. Business models and revenue streams are changing and technology brings new solutions for consumers. This presents challenges to policy makers and regulators.

The treatment of possible roaming alternatives such as OTT services (e.g. Skype, WhatsApp, Line, etc.), raises particular issues given that such services are becoming a tool for consumers to have access to more affordable means of communication while also raising regulatory challenges in terms of quality of service (QoS), consistency of costumers' experience known as quality of experience (QoE), availability of free Wi-Fi, network performance, etc. Furthermore, IoT and M2M roaming also differs from traditional consumer voice and data roaming services and raises particular regulatory issues and consumer protection concerns. Considering that changing roaming business models and regulatory innovations will bring direct benefits to consumers as well as business, internationally harmonized principles and guidelines can help foster innovative roaming solutions at the global, regional and national levels.

From an international perspective, information and knowledge exchange for ITU members around the world is key to building capacity and creating the necessary enabling environment for this challenging issue.

Given the international nature of roaming, stakeholders should work together at the regional and international level or through bilateral/multilateral country agreements to address structural measures in the IMR market, regulatory price measures, as well as to ensure transparency, and to permit NRAs to monitor price development in the IMR markets, including sharing of information.

The aim of these Building Blocks is to provide a basis for discussion for stakeholders with the aim of improving the delivery of IMR services for the benefit of consumers, reduce what are generally perceived as high mobile roaming retail prices and enhance efficiency and transparency of retail roaming prices and services. By addressing future issues such as IoT and M2M, a basis for discussion on future challenges has also been proposed.

[1] The ITU Global Dialogue on International Mobile Roaming, initiated in Geneva in September 2015, gathered a diverse selection of stakeholders to review recent developments in the area of international mobile roaming, exchange best practices and – together - define strategic guidelines on International Mobile Roaming (www.itu.int/en/ITU-D/Regulatory-Market/Pages/Events2015/Roaming/Dialogue.aspx).

2 Methodology

The main objective of the LET'S ROAM THE WORLD Initiative is to provide a neutral platform to exchange experiences and best practices among ITU Membership (see full list of stakeholders in Annex 3 and Figure 1). The initiative is designed to encourage constructive discussion on existing as well as future regulatory issues on International Mobile Roaming (see figure 2).

Recognizing the importance of collaboration among all stakeholders involved in IMR, the BDT Director convened a first workshop for all stakeholders on 18 September 2015.

Figure 1: IMR Building blocks



Bearing in mind that different regional and international associations as well as private sector associations had already developed regional guidelines, a First IMR Consultation Meeting was held in Geneva from 15 to 16 September 2016, targeting these organizations. The objective of this first consultation was to facilitate collaboration with this first group of stakeholders to gather information from the respective regions and draft a first version of the building blocks. The main output of this first document is a consolidated set of IMR Strategic Guidelines for regulators, on the one hand, and the private sector, on the other.

Figure 2: the LET'S ROAM THE WORLD Strategy



Following the guidance given by stakeholders during the First Consultation Meeting, the BDT secretariat consolidated inputs from RAs, international organizations, consumer associations and private sector associations to develop the first draft of the **Building Blocks of IMR Strategic Guidelines**. Various other resources were also leveraged in the process, including available guidelines applied by different regional associations and tools, recommendations, materials and research previously developed by ITU. The report and guidelines take into account IMR regional initiatives, identifying common denominators.

In addition, an extensive consultation process was carried out in order to build the basis for consensus. The first draft of IMR Strategic Guidelines was shared electronically with this first group of stakeholders for a first round of comments in December 2016. Comments from several associations were received and integrated. A second round of comments was sought in March 2017 and the inputs received were integrated to improve the draft set of guidelines.

This report contains the latest version of the draft IMR Strategic Guidelines, presented here as a discussion paper together with an overview, in annex 2, of the key regulatory issues to be considered and a summary of existing regional and international initiatives.

Next Steps

The BDT Director will organize a Second Consultation Meeting inviting all stakeholders in September 2017 to enrich discussions and aim to reach consensus on common measures for IMR at the national, regional and global level, to be presented at the High Level Round Table to be held in October 2017 at the World Telecommunication Development Conference.

3 International Mobile Roaming Strategic Guidelines

Recognizing the importance of collaboration among stakeholders in IMR, ITU, in its role as facilitator of expert information exchange, has drafted **Building Blocks for IMR Strategic Guidelines**. The aim of these Building Blocks is to provide a basis for discussion and to create a common understanding of the complexities of the issues and to foster solutions as defined in a common set of Strategic Guidelines.

The Guidelines have been structured in terms of what is most relevant for National Regulatory Authorities (NRAs), on the one hand, and for Mobile Network Operators (MNOs) and Service Providers, on the other, with special focus on consumer protection, as described in Figure 3.

Figure 3: Building Blocks for IMR Strategic Guidelines - Structure



Source: ITU

3.1 Guidelines for National Regulatory Authorities (NRAs)

In the context of bilateral, multilateral and regional initiatives:

General principles:

- Roaming regulation at regional level should aim to maximize social benefits and harmonize national policies without unduly jeopardizing MNO's revenues, while accommodating essential national requirements and differences[2];
- Bilateral, multilateral and regional initiatives shall provide for third party membership on condition that participating countries are legally able to ensure full compliance with all the requirements of the framework;

[2] ONA In East Africa – lessons to be learned.

- Bilateral, multilateral and regional initiatives shall encourage co-operation with other regions or sub-regions through treaties and agreements; and
- To ensure that mobile roaming grows the real economy, and in the particular instance where the IMR regulations being studies at the moment is still between neighbouring countries, regions should take into account policy initiatives, travelling levels, bilateral traders, geographic issues and cost of travel when defining a roaming area in bilateral, multilateral and regional initiatives; as well as to consider the GATS principle of the most favoured nation (MFN).

Legal Mandate:

- Bilateral, multilateral and regional initiatives shall clearly define the responsibility of NRAs, including the methodologies to be followed and the data requirements for monitoring developments in IMR markets and ensure that developments in the market, in particular price changes, are monitored on a regular basis;
- Bilateral, multilateral and regional initiatives, in defining roaming regulation, should ensure that it shall be sustainable, and provide for regular monitoring and evaluation and revision, as appropriate; and
- Bilateral, multilateral and regional initiatives shall provide NRAs with the mandate and legal authority at regional level to:
    - Obtain/collect data, such as those on retail and wholesale costs and prices, for IMR services;
    - Enforce measures to monitor development in the IMR markets retail and wholesale prices, and
    - Enter into agreements, including the sharing of information, with counterparts in other countries or at the regional level. Such information could be made anonymous where possible (at global levels) to avoid breach of any commercial issues between the operators.

Taxation:

- In the regional context, work in coordination with Ministries of Finance, to promote that all surcharges on international incoming calls and other revenue raising taxes by countries must be retracted, at least on calls originating within the countries integrating the bilateral or regional initiative. It is necessary to evolve towards schemes that allow to reduce the high tax burden on roaming services and to avoid double taxation.

Pricing Regulation:

- Bilateral, multilateral and regional initiatives shall ensure that prices for all roaming services are not less than underlying actual costs;
- Bilateral, multilateral and regional initiatives may consider structural measures in addition to any price regulation, such as, unbundling IMR services from domestic services and allowing market entry to foreign MVNOs to interconnect with local MNOs;
- Bilateral, multilateral and regional initiatives shall consider follow-up in terms of structural measures which would allow for the development of IMR services as separate unbundled services; and
- Bilateral, multilateral and regional initiatives shall distinguish between measures applicable to either wholesale price regulation or to both wholesale and retail prices and the time frame for price reductions. It is strongly recommended that price regulation be applied at both

retail and wholesale levels in order to avoid any abuse of power by MNOs when setting price caps on retail prices.

In the context of national markets:

General Principles:

- NRAs should apply and promote the application of the ITU International Telecommunication Regulations (ITR), the ITU Recommendations and the Regional Association recommendations of their jurisdiction;
- NRAs should promote/participate in bilateral and multilateral, as well as in regional initiatives/agreements;
- If IMR regulation is applied, NRAs are encouraged to provide credible evidence that roaming regulations will lead to more economic and social integration or greater use of the service[3];
- NRAs are encouraged to take steps to remove any unjustifiable obstacles which may limit the availability of substitutes to IMR for voice, messaging and data services and the ability of these services to compete in traditional mobile roaming markets;
- NRAs are encouraged to apply ITU-T recommendations D-98[4](Charging in international mobile roaming service) and D.97[5] (Methodological principles for determining international mobile roaming rates) and use the ITU International Mobile Roaming (IMR) Cost Analysis Tool[6] to set and benchmark wholesale and retail prices;
- NRAs shall increase the technical and human capacity of the staff dealing with IMR tariff and regulation issues; and
- NRAs are encouraged to investigate solutions regarding Internet of Thing (IoT) and Machine2Machine (M2M) services in order to promote measures to apply permanent roaming services, and the application of specific prices and conditions for IoT traffic.

Competition Principles:

- NRAs are encouraged to improve competition in the IMR market in particular by facilitating market entry of MVNOs and by ensuring that they can interconnect on reasonable terms with MNOs for the purpose of offering roaming services on fair, affordable and reasonable conditions; prices for roaming services must be transparent, fair and non –discriminatory;
- NRAs and policy makers, taking into account specific national or regional conditions, should encourage harmonization of IMR policies and regulations and may introduce regulatory

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[3] SAMENA council at the ITU IMR Consultation Meeting (www.itu.int/en/ITU-D/Regulatory-Market/Pages/Events2016/IMR_Consultation/home.aspx)

[4] http://www.itu.int/rec/T-REC-D.98-201209-I/en

[5] http://www.itu.int/rec/T-REC-D.97-201610-I

[6] The ITU International Mobile Roaming Cost Analysis Tool is a tool designed to forecast the cost of international mobile roaming compared to domestic mobile. It was developed in the framework of ITU-T Study Group 3. This tool is based on the 2015 ITU-T Guide for NRAs on IMR cost analysis, available at: www.itu.int/net4/roamingtool/.

interventions on IMR service tariffs for the benefit of consumers by encouraging competition. Possible interventions may include a range of regulatory measures such as: to enhance mobile consumer awareness, alerts, bill caps, tariff caps and pre-selection[7];

- NRAs are encouraged to liberalize international gateways, where appropriate;
- NRAs can play an important role in improving IMR competition by ensuring that MNOs maintain the principle of network neutrality and discourage blocking the use of VoIP and other messaging applications on smartphones.

Pricing Principles and Regulation:

- NRAs shall promote fair and transparent pricing of IMR services and ensure that consumers are paying for only the services used (e.g. wholesale and retail IMR services per second or Kb for data);
- NRAs shall promote that prices for IMR services should be cost based and not be too excessive in comparison with prices charged for the same services at national level;
- NRAs shall consider that roaming regulation not to lead to MNOs incurring losses on the provision of roaming services, recognizing different cost basis for roaming services[8];
- NRAs shall collect wholesale and retail cost and price data in order to benchmark progress in reducing prices. NRAs need to have the authority to collect information on wholesale IMR rates charged by their national operators to foreign operators, including Inter Operators Tariffs (IOTs);
- NRAs should encourage discussions with the private sector about the transparency of IOTs to inform future or current regulatory proceedings in relation to these services;
- If NRAs determine that market dynamics are insufficient to produce reasonably competitive wholesale prices, they are encouraged to regulate wholesale roaming prices, including by reaching bi- or multilateral agreements, as appropriate, and/or through the introduction of price caps based on commonly established principles. As a last resort, implement retail price regulation to protect customers from paying excessive prices for using roaming services[9].

Consumer Protection:

- NRAs are encouraged to promote transparency of information provided to customers by international roaming providers regarding tariffs and use of roaming services[10]; Information should be accessible to customers with special needs;

[7] ITU, Telecom Standardization Bureau, Recommendation ITU-T D.98, Charging in International Mobile Roaming Service, http:www.itu.int/rec/T-REC-D.98-201209-I and ITU-T D.97, Methodological principles for determining international mobile roaming rates, https://www.itu.int/rec/T-REC-D.97/en

[8] SAMENA council at the ITU IMR Consultation Meeting (www.itu.int/en/ITU-D/Regulatory-Market/Pages/Events2016/IMR_Consultation/home.aspx)

[9] Based from OECD, 16 February 20102, Recommendation of the Council on International Mobile Roaming Services, Paris 2012

[10] See ITU-T Recommendations D.98 and D.97 (https://www.itu.int/rec/T-REC-D/en).

- NRAs are encouraged to require MNOs to provide data roaming customers with information on the risk of automatic and uncontrolled data roaming connections and downloads; including, where available and required, specific solutions for cross border roaming and explanations about how to switch off these connections[11];
- NRAs are encouraged to require MNOs to provide customers living near borders with specific solutions to avoid cross border roaming;
- NRAs are encouraged to define measures that all customers are entitled to receive a free personalized automatic message providing basic roaming information and prices when the customer enters the visited country;
- NRAs are encouraged to advise customers about IMR in general or have a webpage on their websites, if possible, dedicated for provision of IMR-related information and advices to consumers,[12] including where available, hyperlinks to the web pages of individual operators dedicated for IMR-related information;
- NRAs should encourage international roaming providers to provide customers with special plans in order to agree financial limits, beyond which voice and data roaming transmission would be stopped, unless the customer follows an indicated procedure and personalised notifications when data roaming services have reached a certain proportion of an agreed financial limit;
- NRAs should require MNOs to provide customers with information on emergency services for visited country;
- NRAs should have clear process/procedures to resolve disputes between MNOs and customers.

3.2 Guidelines for Mobile Network Operators (MNO) / Service Providers

General Principles:

- MNO should ensure the application of the ITU International Telecommunication Regulations (ITR), the ITU recommendations and the Regional Association recommendations of their jurisdiction;
- MNO should maintain the quality of service (QoS) parameters and standards for roaming services at least equivalent to those prescribed by their NRA and provided at the national level;
- MNO are encouraged to improve the current information exchange systems to allow shorten the timing for exchange of information between operators to avoid fraud[13];

[11] Idem.

[12] Asia Pacific Telecommunity (APT), International Mobile Roaming Working Group Working Group Report, 15 May 2012, at www.apt.int/sites/default/files/2012/05/APT_IMR_Working_Group_Report_Final.pdf

[13] Adapted from ASIET presentation at the International Mobile Roaming Consultation Meeting, Geneva, 15-16 September 2016 - www.itu.int/en/ITU-D/Regulatory-Market/Pages/Events2016/IMR_Consultation/home.aspx.

- Subject to national legislations and regulations, MNO are encouraged to follow network neutrality principles by not blocking the use of VoIP and other messaging applications on smartphones.

Pricing:

- MNO are encouraged to use an IMR price structures do not affect consumers by paying for services which are not rendered/used, such as retail IMR services per second or Kb for data;
- MNO should share wholesale and retail data with the NRA in order to demonstrate progress in price reduction and allow the NRA to assess the national market;
- MNO should maintain, as possible, transparency vis-a-vis NRAs of Inter Operators Tariffs (IOTs) and commercial agreements;
- MNO are encouraged to implement solutions for the provision of Internet of Things (IoT) services, including specific wholesale roaming charges and conditions;
- MNO are recommended to develop packages integrating competitive national and IMR rates for voice and data services.

Consumer Protection:

– Any roaming network connection should be established with the consumer's consent;

– MNOs are recommended to provide clear, accurate and easy to understand information on IMR services to customers, including by informing subscribers of different charging structures for IMR tariffs compared to national services;

– Before their departure, consumers should be encouraged to obtain information from their MNO on the detailed information of IMR charges applicable to their visited countries;

– Customers should be reminded that they may manually select the designated network under the "manual" mode of the network selection when travelling in the visited country, as well as on how to deactivate all or some IMR services;

– Unless they have opted not to receive such information, all customers are entitled to receive an automatic message providing basic roaming information including the roaming charges applied in the currency of the home bill when the customer enters the visited country;

– Customers should be informed by SMS whether there would be any difference in charges in the currency of the home bill for voice and data services among different mobile networks in the visited country;

– MNO should provide a free phone number from which the customers can obtain more detailed personalised information on voice calls, SMS, or data roaming services (including MMS) and prices;

– Where a customer contacts their home operator requesting further detailed information, the operator should ensure that the information on the prices of roaming voice calls, SMS and data services for that customer is immediately available in the currency of the home bill, regard-less of the time of day. If using automated machines to comply with this, the home operator should ensure that the customer can access the required personalised information speedily and easily;[14]

[14] Adapted from BEREC Guidelines.

- In the visited country, customers must have the possibility of accessing the emergency services by dialling a free of charge number, this information should be provided by the local operator when the customer connect its network;
- To avoid cross boarder or inadvertent roaming, MNO should inform by SMS customers, free of charge, that they are roaming and the prices for voice and data services. MNO are encouraged to work to minimize the negative effects produced by cross border or inadvertent roaming, and to create special plans of prices for the customers living in these areas; In any case, mobile operators should inform their customers about the measures for preventing inadvertent roaming (e.g. the manual selection of the operator when using the device near the border);
- MNOs should facilitate a timely and easy to use settlement of consumer complaints free of charge. NRAs could have access to this data.

ANNEXES

Annex 1 – Key IMR Regulatory Issues

1.1 Looking to the Future: Internet of Things (IoT) and Machine-to-Machine (M2M) – a challenge to IMR or an opportunity for all?

The Internet of Things is changing the quality of life for customers and offering real opportunities for business. IoT has the potential to enhance affordable communications and is influencing the provision and use of ICTs across the sectors, including health, transport, agriculture, security, education, as well as logistics, invoicing, sales, manufacturing, etc. IoT also provides a new ecosystem for the development of the Apps economy. Although this ecosystem basically depends on mobile networks, it has different characteristics in the areas of ICT service provision and charging models required to deliver IoT services.

The Internet of Things (IoT) has been defined in ITU Recommendation ITU-T Y.2060 (06/2012) as a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies[15]. ITU-T Study Group 20 *on IoT and its applications including smart cities and communities (SC&C)* is working on the development of frameworks and roadmaps for the harmonized and coordinated development of IoT, including M2M communications, ubiquitous sensor networks and smart sustainable cities and communities. This work includes the development of frameworks and requirements for infrastructure and services, as well as guidelines, methodologies and best practices related to standards to help cities (including rural areas and villages) deliver services using the IoT.[16]

At present, no specific regulations exist with regards to IoT and IMR. A 2016 BEREC Report[17] provides that this issue should be assessed whether and, if so, to what extent the existing rules which were primarily construed for voice telephony can be applied to IoT and M2M communications or not. In view of the Digital Single Market (DSM) review, BEREC considers that special treatment of IoT services and/or M2M communication is necessary for the following areas:

- Roaming;
- Switching;
- Number portability.

For BEREC the key issues regarding the regulatory situation of IoT services when based on mobile connectivity involving international roaming are in particular:

- whether these types of services are under the scope of the Roaming Regulation and, furthermore,
- whether the Roaming Regulation applies when the connectivity is provided based on permanent roaming.

[15] http://www.itu.int/en/ITU-T/gsi/iot/Pages/default.aspx

[16] More information on ITU-T Study Group 20 mandate and roles is available at: http://www.itu.int/en/ITU-T/studygroups/2013-2016/20/Pages/mandate.aspx

[17] Reports on OTT services and the Internet of Things, as well as guidance on the new international roaming rules - February 2016 (http://berec.europa.eu/eng/document_register/subject_matter/berec/press_releases/5759-berec-publishes-reports-on-ott-services-and-the-internet-of-things-as-well-as-guidance-on-the-new-international-roaming-rules).

According to BEREC, According to BEREC, despite the fact that the above-mentioned reports do not explicitly refer to IoT services, it is clear that a connectivity service is always essential for the provision of IoT services. When that connectivity service consists of public mobile connectivity for a roaming device, this service should fall within the scope of the roaming regulatory framework, regardless of the parties affected by the connectivity contractual obligations. Therefore the main regulatory measures regarding roaming are generally considered applicable to the mobile connectivity service's underlying IoT services, implying that any IoT service provider/mobile operator benefits from the roaming access right as well as from the price caps. MNOs, on the other hand, benefit from the right to refuse access requests on the basis of objective criteria.

In addition, another important issue is whether it is "permanent" or "periodic" roaming. In the case of permanent roaming, the connected device is sold outside the country of production but uses a Subscriber identity module (SIM) with an International Mobile Subscriber Identity (IMSI) of the country of production (e.g. cars, e-readers). It is noted that the provisions do not differentiate between person-to-person communications and M2M communications and do not foresee any special treatment for IoT communications. In the light of the fast developing nature and diversity/solutions of IoT services/business models as well as different permanent roaming scenarios the scope and application of the European Roaming Regulation is indeed questionable. Against this background a case-by-case evaluation and legal interpretation should take any specific (technical) details and parameters of the respective IoT service in consideration in light of the purpose of the European Roaming Regulation. However, any case-by-case approach carries legal uncertainty. Therefore, further clarification in the European Roaming Regulation and/or in a Commission Communication with regard to permanent roaming in the IoT context might be helpful.[18]

In January 2017 the European Commission (EC) launched a public consultation on Building the European Data Economy[19]. This consultation closed on 26 April and results will be published one month later. The objective of this consultation was to collect information on different issues addressing data localisation restrictions, portability, interoperability and standards. It will also treat the emerging IoT issues, robotics and machine-generated data.

IoT could also be interesting for operators in the provision of roaming services. They can address this by implementing, for instance, intelligent roaming solutions, such as real-time roaming detection, targeted offers, customer segmentation, in order to gain a stronger position to retain subscribers and benefit from their share of the expanding roaming market and IoT market. Since roaming is an established industry with the business relationships and underpinning technologies already in place, tapping into these revenues could be an evolution of current practices. By leveraging real-time data intelligence tools/applications, operators could provide subscribers individualised pricing offers that could be guided by usage patterns. These customized pricing offers could encourage consumers to use their mobile devices anywhere they travel.[20]

1.2 Price Regulation

Price regulation is not very effective if carried out unilaterally by one country since the only regulated prices concern national operators' retail margin imposed on wholesale roaming charges for national clients when roaming internationally or wholesale charges imposed by national operators on foreign

[18] Idem.

[19] https://ec.europa.eu/digital-single-market/en/news/public-consultation-building-european-data-economy

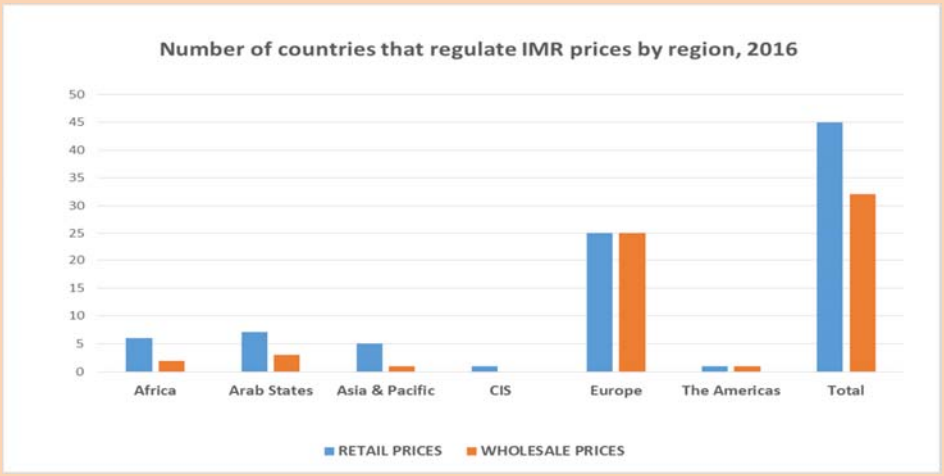
[20] www.iot-now.com/2015/04/24/32449-before-the-internet-of-things-there-was-roaming-the-importance-of-getting-the-basics-right/

operators entering into roaming agreements. Bilateral and regional agreements are more effective in lowering IMR prices where there is agreement by two or more member states and where NRAs have the legal authority and empowerment to implement.

In addition, there are several transnational challenges that characterize international roaming, such as different policies and regulation in countries in the same region. According to the experiences from EU regulation an essential premise for lower retail roaming prices is a mutual/common wholesale price regulation covering more than one country.

Figure 4, based on the ITU Tariff Policies Survey, shows the number of countries that are applying IMR regulation in the different regions targeting retail prices. It is important to note that countries by region corresponds to the BDT list of country distribution[21].

Figure 4: Number of countries that regulate IMR prices by Region



Source: ITU Tariff Policies database 2016, ICTEye (www.itu.int/net4/itu-d/icteye/)
Note: number of responses received for the survey by region in 2016: Africa 22; Arab States 9; Asia and Pacific 13; CIS 6; Europe 35; Americas 22.

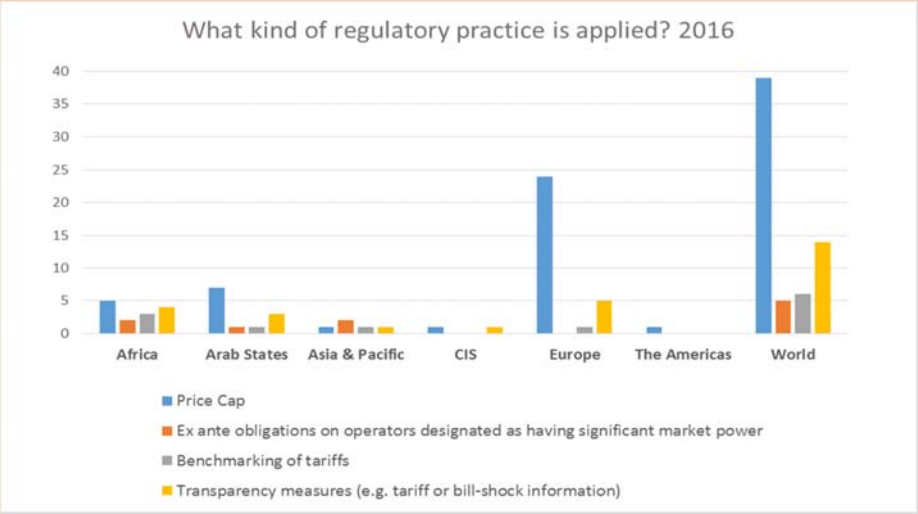
Although prices may decrease temporarily, price regulation should only be an interim measure. In the long term, sustainable competition in the IMR market is required if prices are to achieve efficient levels. Without the development of effective competition in the IMR market there is a risk that there will be a continued, long-term, need for price regulation which is not a desirable outcome.[22] NRAs should have access to information on existing IMR retail and wholesale prices as well as relating to desired prices. Unfortunately, no database exists with this type of information and most commercial agreements between operators concerning Inter-Operators Tariffs (IOT) are considered by them as confidential.

Figure 5 illustrates how price cap is a more common regulatory approach in Europe, whereas regions such as the Arab States, the CIS countries and the Americas are combining such regulatory measures with the Benchmarking of tariffs.

[21] ITU ICTEye - http://www.itu.int/net4/itu-d/icteye/CountryProfile.aspx

[22] ITU Paper International mobile roaming services: Facilitating competition and protecting users, edition 2013, available at www.itu.int/pub/D-PREF-EF/en

Figure 5: Regulatory practice application by region for IMR retail prices, number of countries



Source: ITU Tariff Policies database 2016, ICTEye (www.itu.int/icteye/)
Note: this graphic is based on the responses received from NRAs to the ITU Tariff Policies Survey.

1.3 Taxation

The issue of taxation is becoming more and more relevant with respect to IMR. Taxation, and especially double taxation, generally inflates consumers' prices. This situation not only affects consumers with higher prices, but also operators and government revenues.

During the last ITU IMR Consultation Meeting, Regional Regulatory Associations as well as Operators Associations highlighted the need for action to address the issue of taxation issues and define solutions to avoid double taxation. The price of international roaming services in Latin American countries, for example, is between approximately 35% and 60% more expensive than a price without taxes[23] due to double taxation between VAT and other sectorial taxes.

The issue is that the problem continues and substantially increases the price of roaming services, especially considering the different range of taxes across countries. In addition, many countries charge other local or specific taxes, such as state taxes, sector specific taxes, environmental taxes which further increase final prices.

The EU has adopted a directive which provides that from 1 January 2015, value-added tax on telecommunication services provided by a supplier located in EU will be charged in the jurisdiction

[23] From ASIET presentation, at the International Mobile Roaming Consultation Meeting, Geneva, 15-16 September 2016, available at: www.itu.int/en/ITU-D/Regulatory-Market/Pages/Events2016/IMR_Consultation/home.aspx, (Latin America IIRSA Project).

where the customer belongs[24]. In addition, Paragraph 8.3 of the International Telecommunication Regulations (ITRs) states:

"*8.3.1 Where, in accordance with the national law of a country, a fiscal tax is levied on collection charges for international telecommunication services, this tax shall normally be collected only in respect of international services billed to customers in that country, unless other arrangements are made to meet special circumstances.*"[25]

Government and operators, at national level, together with regional regulatory associations should address the issue in their respective countries/regions and work on the creation of mechanisms or structural measures to limit the effects of double taxation on IMR services and introduce uniform roaming service pricing with uniform taxing rules. Furthermore, in setting any relevant price caps, whether on retail or wholesale levels, appropriate and related taxes should be taken into consideration by the NRAs when setting such caps.

1.4 IMR Market Competition

The current structure of the IMR market does encourage long-term competition. For customers, it is often difficult to compare mobile roaming prices when they enter into a contract with a national mobile operator when their prime concern is generally the relative cost of the domestic package, and mobile roaming services are part of the bundle offered by the mobile operator. When arriving in a visited country, customers do not always have the choice to select the less expensive international mobile roaming operator, as they are not necessarily informed about the prices they are charging until they are connected and receive a message informing them of the level of charges.[26] At present it is often impossible for consumers to compare roaming prices when leaving their home country and arriving in a visited country.

Changes in the market have helped in lowering prices, for example, the expansion of MNOs with wide cross-border footprints has brought some improvements in certain regions, but such expansions are not global. A recent example is in Central America, where MNOs decided by themselves to provide domestic rates in all countries where they have a footprint, for voice and data services (see section 4.2 Regional and Multi-Countries Initiatives). Other measures that have helped to reduce prices is traffic routing. This has allowed MNOs to negotiate better wholesale IOT agreements.

Recognizing that excessive regulation in this market is not recommended, there are a number of structural solutions that could improve IMR market competition, including[27]:

- To allow market entry in national markets to MVNOs or resellers, including MVNOs that may limit their service provision to the provision of IMR services whether these services are targeted at nationals of that country, visitors to that country or both.

[24] Council Directive 2008/8/EC of 12 February 2008 amending Directive 2006/112/EC as regards the place of supply of services, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:044:0011:0022:EN:PDF

[25] http://www.itu.int/en/wcit-12/Pages/itrs.aspx

[26] ITU Study on International Mobile Roaming Services: Facilitating competition and protecting users, 2013. www.itu.int/en/ITU-D/Regulatory-Market/Pages/Roaming_info.aspx

[27] Idem.

- To allow the liberalization of international gateways to facilitate the transmission and reception of international calls, if not already liberalized.

These structural solutions may require some kind of price regulation and close monitoring of market developments by NRAs in order to decide when it would be appropriate to reduce or remove any regulatory obligations. Market players should be treated in a transparent, non-discriminatory and proportional way with no undue burdens imposed on them. Of course, the implementation of any type of solution or procedure would need close collaboration between all stakeholders through national, bilateral, multilateral and regional initiatives at the global level.

On the other hand, it is important to consider the GATS principle of the most favoured nation (MFN). MFN means treating one's trading partners equally on the principle of non-discrimination. Under GATS, if a country allows foreign competition in a sector, equal opportunities in that sector should be given to service providers from all other WTO members[28]. In the framework of bilateral/multilateral country agreements, to consider structural measures in the IMR market could be a delicate issue, if the countries not participating in the agreement be subject to different conditions. In this sense, Roaming agreements can be part of a substantial sectoral coverage trade agreement (Article V of GATS)[29].

1.5 Consumer Protection

Government policy and regulation in the telecommunication/ICT sector has been focused mainly on service provision, market competition and other aspects such as universal access, interconnection, licensing, price regulation, etc. In order to provide consumers with access and services in an efficient and affordable manner. However, the participation of consumers is becoming more and more active, not only because they "use" the services, but also because they can also have an active involvement. As "informed consumers" they could exert their ability to choose between service providers, and this is very important to encourage operators to innovate, improve quality and compete.

The main objective of the International Mobile Roaming Building Blocks for Strategic Guidelines (*this guideline*) is to empower consumers and allow them to gain access to the necessary information, via transparency of prices and greater awareness, which allows them to become "informed consumers". This would enable customers to better manage their consumption of roaming services, take the necessary measures to avoid inadvertent charges, and choose the best offer when roaming internationally. In addition, all stakeholders should work together to improve transparency of prices, to provide consumers with more awareness about the prices that they may face when travelling outside their home country.

It is also very important to facilitate a timely and user friendly consumer complaint process. NRAs could make use of the complaint system information as an indicator showing the IMR market evolution and performance of service providers.

As a reference, ITU approved in September 2012 the Recommendation ITU-T D.98, which was also further enhanced in 2016 with Recommendation ITU-T D.97[30]. Section 4 of the D.98 Recommendation

[28] https://www.wto.org/english/thewto_e/whatis_e/tif_e/agrm6_e.htm. (This applies even if the country has made no specific commitment to provide foreign companies access to its markets under the WTO.)

[29] See also article by Michael H. Ryan "The Application of the GATS to Bilateral Arrangements for the Reduction of International Mobile Roaming Charges": http://files.arnoldporter.com/application%20of%20the%20gats%20to%20bilateral%20arrangements%20for%20the%20reduction%20of%20international%20mobile%20roaming%20charges_(europe_12573280_1).pdf.

[30] ITU Recommendation ITU-T D.98 on Charging in International Mobile Roaming Service, and ITU-T D.97 on Methodological principles for determining international mobile roaming rates: www.itu.int/ITU-T/recommendations/index_sg.aspx?sg=3

contains principles for lowering IMR rates including empowering consumers. The main aspects relating to consumer protection are highlighted in Box 1.

Box 1: Excerpt from ITU Recommendation D.98 Charging in International Mobile Roaming Service

Recommendation ITU-T D.98 proposes measures to empower consumers to benefit from efficient competition and regulation so that they have the information and transparency to take appropriate actions; to identify measures for improving the way the market works; and proposals for regulatory actions, which may include measures to lower rates.

Empowering consumers:

1. Transparent information on IMR retail rates and structure before users roam internationally;
2. Usage alerts when users start to roam;
3. Warning alert when a certain cost has incurred;
4. Roaming cost caps;
5. Special user protection measures for inadvertent roaming in border regions;
6. User choice of visiting network.

Source: ITU Recommendation ITU-T D.98, Charging in International Mobile Roaming Service[31]

[31] Idem.

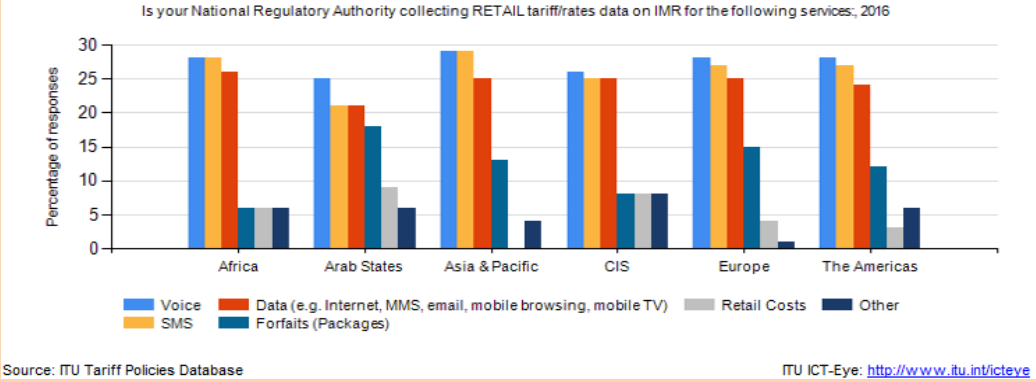
Annex 2 – Overview of Existing Regional and International IMR Initiatives

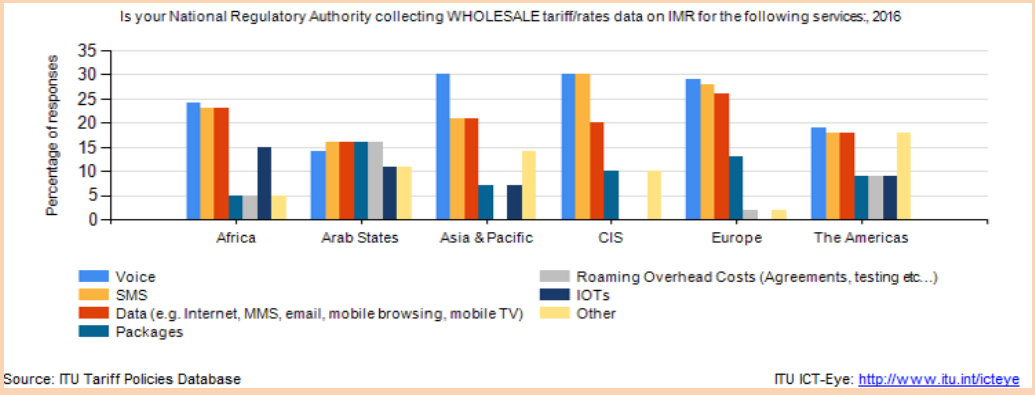
IMR tariffs remain high, with the cost structure of roaming services being seen as a primary driver of roaming tariffs. Changing market structures with for example the entrance of MVNOs, the introduction of price packages or offers has led to more competition and decreasing prices over time.

The roaming market and any regulation thereof is very complex with multiple impacts and implications and requires a thorough understanding of retail and wholesale cost structures, network elements, cost components involved and international commercial agreements between operators related to Inter-Operator Tariffs (IOT). For operators in particular, data collection requires a deep understanding of different underlying (billing) systems as well as cost components and structures involved, complex relationships, dynamics and commercial sensitivity of the information, alongside the need for regulators to have the right legal powers to obtain information.

A particular challenge many NRAs face is one of collecting data across countries to enable them to analyze wholesale markets in those countries. However, according to the ITU Tariff Policies Survey, NRAs are becoming more and more active in collecting information on retail and wholesale prices for the different roaming services offered by operators. Figure 6 below illustrates how voice, SMS and Data services are monitored for both retail and wholesale, with almost one-third of NRAs world-wide collecting such information.

Figure 6: Data collection by NRAs on retail and wholesale roaming rates by region, 2016





Note: these graphics are based on responses received from NRAs to the ITU Tariff Policies Survey.

Given that the evolution of roaming rates is a complex process and may involve multiple jurisdictions there is no "one-fits-all-off-the-shelf" solution. One regulatory initiative in a specific country could significantly affect national operators of this country in the commercial relations with operators of

other countries. Many NRAs, regional regulatory associations and international organizations have either taken regulatory actions or made recommendations on how to increase transparency for consumers when they are roaming internationally and to assist them limiting charges incurred. Many MNOs have also reacted to the increased consumers' concern with regard to high IMR prices by improving the information available on their websites, trying to be more transparent. Many activities and initiatives are being done around the world to try to find a solution on IMR high prices, most of these are available at the ITU IMR Resources Portal[32].

This chapter presents an overview of tools that Regional Regulatory Associations have adopted as well ITU recommendations.

2.1 ITU Activities on Roaming

The revised International Telecommunication Regulations (ITR) [33] provide that "*Member States shall foster measures to ensure that authorized operating agencies provide free-of-charge, transparent, up-to-date and accurate information to end users on international telecommunication services, including international roaming prices and the associated relevant conditions, in a timely manner.*[34]

Within this context, ITU has defined a number of tools, including:

- ITU has developed a series of studies and tools containing best practices and guidelines to support regulators in their strategy to reduce the prices of roaming and enabling competition in this market, which are available on the ITU International Mobile Roaming (IMR) Resources Portal[35].
- ITU has developed the ITU National Regulatory Authority (NRA) Technical Guide and the ITU Online Cost Analysis Tool[36] developed in the framework of the ITU-T Study Group 3 activities on economic and policy issues.ITU-T approved in September 2012 Recommendation ITU-T D.98 on "Charging in International Mobile Roaming Service"[37]. This recommendation contains principles for lowering IMR rates including empowering consumers, market-based solutions and regulatory intervention. The main references from this Recommendation relating to consumer protection are highlighted in Box 1. In addition, and as mentioned before there is the new ITU-T recommendation ITU-T D.97[38] on "*Methodological principles for determining international mobile roaming rates"* that proposes a possible approach to the

[32] www.itu.int/en/ITU-D/Regulatory-Market/Pages/Roaming_info.aspx

[33] www.itu.int/en/wcit-12/Pages/overview.aspx - the ITRs that were reviewed during the 2012 World Conference on International Telecommunications (WCIT), serve as the binding global treaty designed to facilitate international interconnection and interoperability of information and communication services, as well as ensuring their efficiency and widespread public usefulness and availability.

[34] Article 4, 4.4 International Telecommunication Regulations, www.itu.int/en/wcit-12/Pages/itrs.aspx

[35] www.itu.int/en/ITU-D/Regulatory-Market/Pages/Roaming_info.aspx - This is a one-stop portal platform for stakeholders to access publications and information on activities undertaken by ITU, other regional and international organizations and roaming initiatives at national, bilateral, and regional level;

[36] www.itu.int/net4/roamingtool/

[37] www.itu.int/en/ITU-T/studygroups/com03/Pages/results.aspx

[38] www.itu.int/ITU-T/workprog/wp_item.aspx?isn=10399

reduction of excessive roaming rates, highlights the need to encourage competition in the roaming market, educate consumers and consider appropriate regulatory actions such as the introduction of caps on roaming rates.

2.2 Regional and Multi-Countries Initiatives - summary

European Union (EU)

Box 2: EU Roaming charges ended on 15 June 2017[39]

Roaming charges ended on 15 June 2017. Europeans travelling within the EU countries can Roam Like at Home and pay domestic prices for roaming calls, SMS and data irrespective of where they are travelling.

Phone calls, SMS and going online with their mobile device from another EU country will be covered in the national bundle. The minutes of calls, SMS and megabytes of data that a person consumes abroad (within the EU) will be charged the same as at home. People will not have bill shocks anymore.

If a person has unlimited calls and SMS, they will get unlimited calls and SMS when roaming in the EU. However if a person has unlimited mobile data or very cheap mobile data at home, his operator may apply a safeguard (fair use) limit on data use while roaming. If so, the operator will have to inform the customer in advance about such a limit and alert them when they reach this limit. The EU rules ensure that such a roaming data limit should cover the normal usage patterns of most travelers. If a person reaches the limit, they can continue to use data roaming for a very small fee: up to 7.7€/GB + VAT, which is 6.5 times less than before 15 June 2017 and 25 times less than before that.

Background

Following the adoption of the 2015 Regulation, the European Commission (EC) in November 2015 launched a public consultation on roaming[40] to gather input for the wholesale roaming review, and looking for views on the fair use policy and on sustainability of roaming. The consultation aimed to gather input for the wholesale roaming review and the preparation of implementing acts that set out detailed rules on fair use policy and on the methodology for assessing the sustainability for individual operators of abolishing retail roaming surcharges. The overall objective laid down by the EU legislators in Regulation 2015/2120 (the "Telecoms Single Market" TSM Regulation) is to enable the sustainable abolition of retail roaming charges (roam-like-at-home or RLAH) by 15 June 2017.

Several initiatives pre-dated this consultation:

- The European Commission's first rules to address overcharging in roaming prices came in 2007, with the “Eurotariff” applying to all consumers, unless they opt for special packages offered by operators. The Eurotariff capped maximum prices for phone calls made and received while abroad. These rules have since been periodically reviewed and reformed, with further reductions in price caps and automatic protections against data roaming bill shocks.
- On 11 September 2013, the European Commission adopted a legislative package[41] for a "Connected Continent: Building a Telecoms Single Market" aimed at building a connected, competitive continent and enabling sustainable digital jobs and industries.

[39] https://ec.europa.eu/digital-single-market/en/policies/roaming

[40] https://ec.europa.eu/digital-single-market/en/news/summary-report-public-consultation-review-national-wholesale-roaming-markets-fair-use-policy

[41] http://ec.europa.eu/digital-single-market/en/node/67489/#roaming

- In October 2015 the European Parliament's plenary voted in favour of ending roaming charges by June 2017. The decision provided that consumers will pay the same price for calls, texts and mobile data wherever they are travelling in the EU. As a result, from April 2016, operators will only be able to charge a small additional amount to domestic prices up to €0.05 per minute of call made, €0.02 per SMS sent, and €0.05 per MB of data (excl. VAT).

The Commission services published a revised draft of the rules needed to avoid abuses of the end of roaming charges in time for June 2017. This follows on from discussions in the College of Commissioners held on 21 September 2016 during which Commissioners endorsed a new approach to the fair use principle and agreed that there should be no limits in terms of timing or volume imposed on consumers when using their mobile devices abroad in the EU. At the same time, the new approach provides a solid safeguard mechanism for operators against potential abuses[42].

Considering these EU roaming rules, the cost of making and receiving calls abroad within the EU was at that time substantially cheaper that in 2007, when the EU first started to tackle excessive roaming charges. The propose price caps for June 2017 are presented in figure 7.

Figure 7: The EU maximum tariffs (excluding VAT) for calls, texts and downloading data

Service	1 July 2014	30 April 2016**	15 June 2017***
Outgoing voice calls (per minute)	€0.19	domestic price + up to €0.05	no extra roaming fee, same as domestic price
Incoming voice calls (per minute)	€0.05	€0.0114	no extra roaming fee, same as domestic price
Outgoing texts (per SMS message)	€0.06	domestic price + up to €0.02	no extra roaming fee, same as domestic price
Online (data download, per MB*)	€0.20	domestic price + up to €0.05	no extra roaming fee, same as domestic price

*The tariff is per Megabyte to download data or browse the Internet whilst travelling abroad (charged per Kilobyte used).
**From 30 April 2016 onwards, the roaming fee equal to domestic price + €0.05 may not exceed €0.19 for voice and €0.20 for data. The roaming fee equal to domestic price + €0.02 may not exceed €0.06 for SMS.
***When travelling in the EU

Source: EC Digital Single Market, Roaming Tariffs (https://ec.europa.eu/digital-single-market/en/roaming-tariffs#Article)

These price caps are the maximum permissible prices. Operators and service provider are free to offer cheaper rates, so be on the lookout for better deals. EU Member States' national telecoms regulators must ensure that mobile phone operators comply with the new rules on data roaming and the lower prices of voice calls. Consumers can contact the national regulator in the Member State where their mobile operator is based if they have any problems or questions about the new limits.

[42] https://ec.europa.eu/digital-single-market/en/news/roaming-fair-use-rules-commission-services-submit-draft

Next Steps

The European Commission formally adopted a roaming fair use policy on the 15 December 2016. This draft regulation proposal is in relation with the implementing regulation laying down detailed rules on the application of fair use policy and on the methodology for assessing the sustainability of the abolition of retail roaming surcharges and on the application to be submitted by a roaming provider for the purposes of that assessment. BEREC is currently updating the general guidelines taking into account this new part of the Regulation[43].

The review of the wholesale roaming markets is undertaken by the EU Commission as set out in the Roaming Regulation. BEREC provided its valuable inputs to the EC public consultation to the wholesale roaming market review and published a wholesale market report in the first quarter of 2016.

As described in Box 2, Roaming charges ended on 15 June 2017 in the EU Countries. Europeans travelling within the EU countries can Roam Like at Home and pay domestic prices for roaming calls, SMS and data. A very small number of operators in the EU have been allowed by the national telecoms regulator to continue applying a small roaming surcharge after 15 June, in order to avoid negative effects on very low domestic prices. Such surcharges will be significantly lower than the ones applied before 15 June 2017.

Body of European Regulators for Electronic Communications (BEREC)[44]

Box 3: Intention of the BEREC Guidelines BEREC guidelines related to wholesale issues include an explanation on how to calculate the average wholesale charges for voice, SMS and data roaming which are subject to the maximum wholesale charges set out in the EU Regulation. This clarifies uncertainties that may arise for calculating the maximum charging intervals with regard to retail voice and data as well as wholesale voice, SMS and data roaming services[45].

Price regulation has resulted in a decrease in roaming prices of about 80 to 90% between 2007 and 2015. However, non-regulated alternative roaming packages remain above the EU regulated price cap.

BEREC has revised and presented an update of the BEREC Guidelines on the Third Roaming Regulation, following the adoption of the Telecom Single Market (TSM) Regulation,[46] which included amendments to the Roaming Regulation 531/2012. It is important to note that BEREC does not issue legal provisions, this is the responsibility of the EU Commission. BEREC advises the European Commission and gives guidance to stakeholders about how to apply the legal provisions, therefore contributing to a harmonized implementation of the regulation in the European Economic Area (EEA). These BEREC guidelines also help NRAs when monitoring the application of the legal provisions and in their procedures. It should be noted that the BEREC guidelines are not legally binding but NRAs have to take utmost account of it.

[43] http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=40823

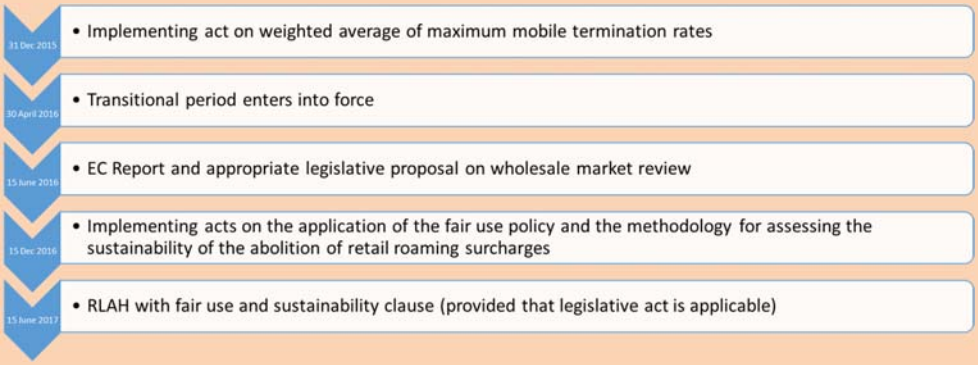
[44] BEREC assists the European Commission and the national regulatory authorities (NRAs) in implementing the EU regulatory framework for electronic communications.

[45] http://berec.europa.eu/eng/document_register/subject_matter/berec/regulatory_best_practices/guidelines/5750-berec-guidelines-on-regulation-eu-no-5312012-as-amended-by-regulation-eu-no-21202015-excluding-articles-34-and-5-on-wholesale-access-and-seperate-sale-of-services

[46] EU Regulation 2120/2015, adopted by the European Parliament on 27 October 2015 and published in the Official Journal of 26 November 2015

This revision is considered necessary as the Third Roaming Regulation, as amended by the TSM Regulation, incorporates substantial changes to the existing provisions and leads to significant changes to the current roaming regime. The changes in this update of the BEREC Guidelines relate to the implementation of the transitional regime, where operators from 30 April 2016 until 14 June 2017 are only allowed to charge the domestic price plus a surcharge that shall not exceed the maximum wholesale charges for roaming services.

Figure 8: Provisions and deadlines of the new Roaming Regulation



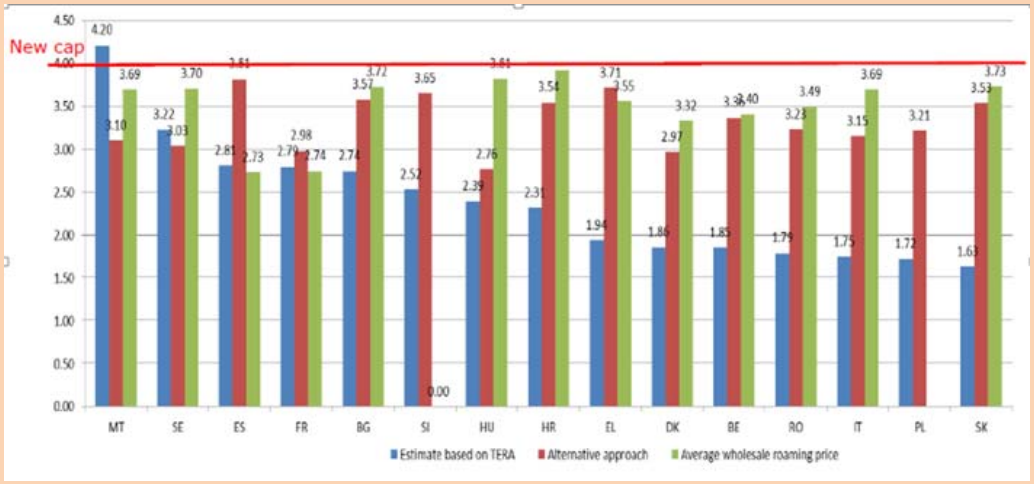
Source: BEREC

In the transitional period from 30 April 2016 to 14 June 2017 - Roam Like at Home (RLAH+) the roaming providers may apply a surcharge in addition to the domestic retail price for the provision of regulated retail roaming services. Any surcharge applied shall not exceed the maximum current wholesale charges for the provision of the service. In the case of received calls it shall not exceed the weighted average of maximum mobile termination rates (MTR) across the EU as indicated in the Implementing.

The EC carried out a wholesale market review that, in June 2016, confirmed that the RLAH rules will be applicable from 15 June 2017 if by that date, the legislative act is adopted and applicable. The study provided with a new wholesale caps proposal as follows:

- Voice: €c 4 (-20%)
- SMS: €c 1 (-50%)
- Data: €c 0,85 (-83%)

Figure 9: Results from the wholesale market review



Source: Commission services, based on TERA Consultants and BEREC, 2015

Significant structural differences exist between all the Member States, such as different MTRs and imbalanced roaming traffic. This could affect in the introduction of RLAH on a sustainable basis, as well as the potential impact of RLAH on operator's revenues, and their ability to recover their costs. [47]

In October 2016, BEREC also published the "*BEREC input to the European Commission Implementing Act on fair use policy and sustainability of the abolition of retail roaming surcharges*"[48]. This paper presents an overall assessment of the impacts of RLAH, a summary of the main elements of the proposals of the EC for the Fair Use Policy (FUP) and the sustainability mechanism shared with BEREC, as well as BEREC's assessment of the EC proposals, including:

- Risks related to wholesale charges – in relation with the risks arising from too low wholesale cap and too high wholesale charges.
- The application of the Fair Use Policy (FUP).
- Sustainability Mechanisms - to recover by operators the overall actual and projected costs from the overall actual and projected revenues from the provision of regulated retail roaming services.

Associação de Reguladores de Comunicações e Telecomunicações da Comunidade dos Países de Língua Portuguesa (ARCTEL-CPLP)

Box 4: ARCTEL Plan of Action

ARCTEL has developed a plan of action calling for the involvement of operators, on a voluntary basis as well as national regulatory authorities (NRAs). Member States adopted a Statement endorsed by the

[47] BEREC presentation at the International Mobile Roaming Consultation Meeting, Geneva, 15-16 September 2016, available at: www.itu.int/en/ITU-D/Regulatory-Market/Pages/Events2016/IMR_Consultation/home.aspx

[48] http://berec.europa.eu/eng/document_register/subject_matter/berec/opinions/6527-berec-input-to-the-european-commission-implementing-act-on-fair-use-policy-and-sustainability-of-the-abolition-of-retail-roaming-surcharges

Comunidade dos Países de Língua Portuguesa (CPLP) supporting this plan of action.

The ARCTEL Working Group on Roaming is:
- Monitoring intra-CPLP Member States Roaming fees (retail and wholesale);
- Monitoring user's complaints;
- Assessing International Laws, including under the WTO framework.

ARCTEL-CPLP is an association of regulators in Portuguese speaking countries that facilitates and enhances the sharing and exchange of information and knowledge among the various national regulatory authorities (NRAs), with the aim of contributing to the development of their communications markets and the sector as a whole. According to the memorandum of understanding of ARCTEL-CPLP, it seeks to:

- Promote the exchange of information between members on regulation of communications markets and the sector;
- Promote the adoption of best practices and harmonization of regulation in the communications sector;
- Develop studies and adopt positions on issues of common interest;
- Analyze, coordinate and defend the interests of the national regulatory authorities (NRAs) of the Portuguese language, create and defend common positions in international forums, within the framework of their respective competences;
- Promote the exchange of employees and technicians of the different NRAS, as well as the institutional visits among its members;
- Analyze the issues relevant to the development and universalization of communications services;
- Promote contacts and cooperation with other organizations.

Today, there are approximately 300 million telecommunication/ICT consumers within the ARCTEL countries as well as a high level of movement of people in terms of travel and immigration between these countries, with some Portuguese speaking countries having more people living abroad than in their country of origin. International Mobile Roaming (IMR) between these countries is essential for consumers and an opportunity for business.

ARCTEL is working on the implementation of an action plan on IMR, taking into consideration the following elements:

- Geographical distance between ARCTEL Member States;
- Different market power of operators in the various countries;
- Different purchasing power of consumers in the various countries;
- Differences in the international traffic flows between countries and operators; and
- Differences in regulatory approaches and level of national political support.

The 2016 ARCTEL Ministerial Meeting recognized the need to promote the concept of "Comunidade dos Países de Língua Portuguesa CPLP Market" as a distinctive brand for Portuguese speaking countries, and adopted a Digital Agenda for the Community of Portuguese-Speaking Countries, which includes International Mobile Roaming as a key issue.

Southern African Development Community (SADC)

Box 5: Recommendations Third Study: SADC Home And Away Roaming - Wholesale and Retail Roaming Regulation

The tariff data for mobile voice, messaging and mobile data services for roaming services in the SADC region show that roaming prices are significantly higher than domestic national mobile service tariffs. One SADC MNO has voice revenue

per minute for domestic calls at 1.0 cost units compared to roaming at 2.79 while SMS revenue per message if taken at a domestic rate of 1.0 implies a roaming rate 2.56, so the roaming markup for voice is 179 percent, and for SMS is 156 percent. Another MNO has roaming voice revenues which are 7 times the incurred roaming costs, and SMS roaming revenues which are 52 times the incurred cost. High markups are also evident when comparing IOTs with preferred partners, compared to the IOTs with non-preferred partners, which can differ by a factor of 30. Clearly, given such high margins between national prices and roaming prices, any lowering of roaming prices will provide important welfare benefits to residential and business subscribers in the SADC region.

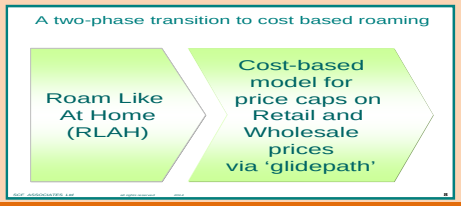
The report does not recommend implementing a 'Roam Like a Local' (RLAL) framework, in that it imposes high adjustment costs on mobile operators, a complex administrative burden for NRAs and lacks transparency for mobile subscribers and may not be always in their best interests. An alternative framework, is 'Roam like at home' (RLAH). Unlike RLAL, where roaming prices are linked to the prices of the visited country and roaming prices vary according to the country visited, in a RLAH framework, prices are linked to the subscriber's home prices and roaming prices are the same irrespective of the country visited. Thus the report recommends a Roam Like at Home framework, which over time would be replaced by a regulatory framework based on analysing the actual cost base of mobile roaming charges. Also, the report also puts forward an appropriate glide-path which can be used to set reductions in both retail roaming prices and wholesale roaming charges and which allows for immediate price reductions followed by step by step reductions in wholesale and retail prices as these are adjusted toward cost. Such a glidepath provides MNOs ample adjustment time while providing subscribers with immediate benefits.

Intervention by regulators to counter overcharging for IMR using this combined approach necessitates an understanding by NRAs of the real MNO cost-basis for roaming – both wholesale and retail. In practice a simple form of forensic accounting is needed to analyse the IMR process cost structure and its concomitant activities at an international level. To affect both the national MNO costs and those within the international wholesale IOTs also requires international regulatory co-operation – most probably among a regional group of NRAs – firstly across the SADC –then perhaps further overseas, involving trading partners.

The proposed guidelines presented need to be adopted by all CRASA members across the SADC Region in order to establish an effective regional framework which can reduce mobile roaming prices. This is because any counter-measures, by their international nature, must be multi-country across all of the Region. Hence appropriate regulation may be necessary in all SADC countries, in order to put in place a series of incremental price caps - just as the EU has followed in its series of limits on roaming tariffs, implemented in progressive fashion since 2007 for voice, data and SMS.

Implementing such a 'glidepath' towards zero additional roaming charges demands that a realistic estimate is found for the target increment of the additional cost of roaming above the domestic tariff. This might be considered as a maximum limit – which is the modus operandi of the mechanism used by the EU - with progressively reducing caps on roaming charges, approaching the cost of roaming added to the domestic retail tariff, with competition operating on tariffs beneath the maximum limit.

However, to introduce a common roaming market in the SADC region, through price caps, a transition phase may be useful. The concept of 'Roam Like at Home' (RLAH) with domestic retail level pricing used for retail roaming prices is proposed. RLAH provides a more consumer friendly framework which is simpler to regulate and to implement. This would be an interim introductory phase, before applying full cost-based price caps on maximum roaming prices are introduced, as shown below:



Source: Southern African Development Community (SADC)

Background and context

The Southern African Development Community (SADC) Roaming project's main aim is to provide an enabling environment for provision of affordable and competitive mobile roaming service in the

Region. The project emanated from the concerns raised by the SADC Ministers Responsible for Telecommunications, Postal and ICTs in July 2007 in regards to non-affordable roaming services in the Region. SADC established the Regional Alliance Task Team (RATT) on SADC Home and Away Roaming in 2008. RATT then comprised of representatives of the SADC Secretariat, CRASA, GSM Africa, Southern Africa Telecommunication Association (SATA) and SADC Parliamentary Forum as an observer. The RATT assisted SADC in project implementation until 21 November 2014 when ICT Ministers dissolved the team. In March 2015, the Communications Regulators' Association of Southern Africa (CRASA) Roaming Task Team (CRTT) was established to assist CRASA implement the ministerial directives.

Several studies have been carried out to understand the SADC roaming market as well as to provide the Region with best practices that would allow for co-regulation of the roaming services in the Region.

Understanding roaming in the region

In 2009, RATT instituted a study to gain more detailed understanding of among others:

a) the roaming tariffs (both wholesale and retail) in the SADC region and the effects of international roaming charges on regional and national termination rates and end consumer charges;

b) possible market and regulatory factors influencing international roaming wholesale and retail charges; and

c) factors that influence service delivery and performance of the market, specifically addressing pricing, network infrastructure and architecture, and quality of service.

The report was delivered in Angola in May 2010 to the Ministers responsible for Telecommunications, Postal Services and ICTs. The Ministers adopted a Policy Statement whose key objectives were:

a) to increase transparency and market liberalization;

b) Introduce Cost-based pricing for roaming services;

c) Introduce effective competition in the roaming ;

d) Improve regulatory certainty and predictability, and

e) Promote Regional integration and infrastructure development.

Wholesale and Retail Roaming Regulation

In 2013, the RATT with assistance from the International Telecommunications Union (ITU) initiated a Regulatory Impact Assessment study on SADC Home and Away Roaming and developed guidelines for roaming services in the region. The recommendations of the study are shown in Box 4.

In response to the 2014 SADC Roaming Report, the region agreed to implement the Roaming initiative in three (3) phases:

- Phase I: Liberalization, Transparency, Information and Data Collection; SADC developed the SADC Transparency Guidelines. The SADC ICT Ministers approved the Guidelines in 2013. The Guidelines became effective on 1 June 2013.

- Phase II: Wholesale and Retail (*Roam Like at Home*) Glide Paths (see Figure 9 **Table A and B**).

- Phase III: Cost–based Roaming Price Regulation[49].

Figure 10: Wholesale and Retail Roaming Tariff reduction – Glide Path

Table A: Retail Voice, Data and SMS Roaming Tariff Reduction Glide Path

2014	ROAM (Existing Roaming prices)
1 January 2015	RLAH + (ROAM – RLAH) * 67%
1 January 2016	RLAH + (ROAM – RLAH) * 33%
1 January 2017	RLAH + 5%
1 January 2018	COST + (RLAH – COST) * 67%
1 January 2019	COST + (RLAH – COST) * 33%
1 January 2020	COST + 5%

Table B: Wholesale Voice, Data and SMS Roaming Tariff Reduction Glide Path

21 October 2014	Existing IOT prices
1 January 2015	WTA + (IOT-WTA)* 67% +5%
1 January 2016	WTA + (IOT-WTA) * 33% + 5%
1 January 2017	WTA + 5%

***WTA: Weighted Tariff Average**

Source: SADC

Roam Like at Home Concept

The RLAH concept entails the following:

i) Adoption of progressive glide paths in setting of price caps for both the retail and wholesale prices on international roaming and this is being encouraged to be adopted simultaneously by all SADC Members;

ii) Addressing the wholesale rates for each MNO through establishment of price ceilings on the three (3) key routes with the highest Inter Operator Tariffs (IOTs);

iii) The need for SADC member states to consider removal of additional taxes on ICT services and establish policy frameworks for regional roaming;

iv) That NRAs put in place Roaming Regulations and monitoring procedures; and

v) The need for CRASA and MNOs to publish the Retail Roaming Prices on their websites.

In order to provide guidelines on implementation of the glide paths, the Region adopted the SADC Roaming Policy and Regulations[50].

SADC Roaming Policy Guidelines

The CRTT developed the SADC Roaming Policy Guidelines, which were endorsed by the SADC Ministers on 26 June 2015 in Walvis Bay, Namibia. The Policy Guidelines recommends the following guiding principles for roaming within the Region:

a) Prices for roaming services must be transparent, fair and non –discriminatory;

b) Consumers must be provided with adequate information with regards to the provision of roaming services in relation to retail prices and billing cycles;

c) Prices for all roaming services should not be less than underlying costs;

[49] Roaming Task Team (CRTT) website: http://www.crasa.org/crasa-content/id/74/crasa-roaming-task-team/

[50] Idem.

d) Prices for regional roaming services should be cost based and not be too excessive in comparison with prices charged for the same services at national level;
e) Prices charged and other obligations imposed on operators should not distort the competitive conditions between mobile operators within the Region;
f) Any roaming network connection should be established with the consumer's consent; and
g) The quality of service parameters for roaming services should at least be equivalent to those prescribed by the NRA of each Member State[51].

SADC Model Roaming Regulations

The CRTT also developed the SADC Model Roaming Regulations, which were endorsed by the SADC Ministers on 26 June 2015 in Walvis Bay, Namibia. The Regulation Guidelines recommends:

a) coordinated regional response to the formulation of roaming regulations;
b) development of regionally acceptable standards on roaming charges;
c) Establishment of direct routes to connect and roam with operators in other Members States
d) Adoption of fair usage policy to avoid instances of Network abuse through permanent roaming by roaming customers

The Draft SADC Model Roaming Regulations provides for the following:

a) Transparency and safeguarding of consumers and how to provide high quality of service to roaming consumers;
b) Costing for roaming and how to set ceilings for both wholesale and retail charges in the Region; and
c) Monitoring and reinforcement of the SADC Roaming Glide Paths[52].

Implementation of the glidepaths

As at 15 June 2016, seven (7) countries out of 15 SADC Member States were implementing the roaming glidepaths on reciprocal basis. Recognising that the glidepaths were an interim methodology to regulating roaming pricing, SADC is in the process of developing the Generic Roaming Cost Model that would assist regulators to determine the cost-based price ceilings for operators to apply to both their wholesale and retail charges. The Region is also pursuing an array of actions to reduce regulatory barriers to affordable roaming rates through market liberalisation, encouraging investor-friendly taxation policies and averting the wholesale market barriers through the 'three route principle'. In addition, SADC is pursuing increased transparency to roaming tariff; increase of the roaming footprints, especially in prepaid roaming services; promotion of multilateral cost-reduction measures; and establishment of roaming hubs in the Region.

[51] SADC Roaming Policy, 26 June 2015, Namibia, available at: http://www.crasa.org/common_up/crasa-setup/23-07-2015_SADC%20ROAMING%20POLICY%20.pdf

[52] Idem.

East African Community "One Network Area" (ONA-EAC) [53]

Box 6: Lessons to be learned from the ONA experience

There are lessons to be learned from this efficiently organised yet thorough process. Most importantly, to maximise mobile roaming's contribution to regional social integration and economic development, a regional framework for roaming regulation needs to be established, along with competent and accountable entities for implementing the framework. East Africa demonstrates that a workable set of policies can be formulated in a matter of months by a committee composed of the heads of national regulatory authorities supported by their respective Heads of State. The regulators' role was to gather and analyse market information to make proposals and recommendations to the Meeting of Ministers, taking into account input from the MNOs. The Meeting of Ministers then advised the Heads of States on what policy directives would be appropriate. This arrangement was sufficient to start the process. But for regional roaming regulation to be sustainable, persistent oversight and periodic course corrections are required. For that, more permanent processes are needed.

In East Africa, the Northern Corridor Heads of State catalysed and directed the ONA initiative. In other regions, a similar group of national leaders could guide the process. Alternatively, since changes in ICT development policies and telecom laws may be necessary, and tax revenues affected, an executive council of communications and finance ministers from the participating countries would strengthen links between national and regional policy making.

High wholesale prices for IMR can only be curbed by a transnational authority because international roaming is – and will always be – a cross-border transaction. In May 2014 a Heads of State Summit for Northern Corridor Integration Projects concluded that the high cost of in-region roaming was detrimental to the East African Community's (EAC) integration agenda. They agreed to fast-track the implementation of a "One Network Area" in East Africa by 31 December 2014. The original concept was for roamers to pay only the local domestic tariffs of the visited network. Eliminating all charges and surcharges for calls received while roaming was another part of the concept. Kenya, Rwanda and Uganda were the first to commit to ONA; South Sudan joined in January 2015; Burundi and Tanzania expressed interest in joining, too.

Legal Jurisdiction

Heads of State Summits in East Africa can set policy directions which reshape national laws and regulations because of Article 8 of the Treaty for the Establishment of the East African Community. Paragraph 4 of Article 8 states: "Community organs, institutions and laws shall take precedence over similar national ones on matters pertaining to the implementation of this Treaty." (The definition of "Community organs" includes Heads of State Summits.) In addition, Article 16 of the Treaty makes the regulations, directives, decisions and recommendations of the Council of Ministers binding on the Partner States. Regional cooperation in the telecom sector is mandated by Article 99, which notes in sub-paragraph (c) that the "Partner States shall… agree on preferential tariff treatment applicable within the Community…"

Implementing ONA in EAC Partner States

The Northern Corridor Heads of State Summit tasked the EAC's Sectoral Council on Transport, Communications and Meteorology (TCM) with responsibility for transforming the basic ONA decision into specific proposals for implementation. In June 2014, the Council directed the EAC Secretariat to convene a meeting of the Committee of the Heads of Communications Regulatory Authorities ("the Committee") to develop a work plan and guidelines for establishing ONA.[54]

[53] Extracted from the Final Report of the Case Study of One Network Area (ONA) - East Africa's ONA Roaming Initiative. Smart Africa Initiative in collaboration with the International Telecommunication Union. January 2016.

[54] Note that ONA developed as a Northern Corridor Integration Project. It will become an EAC project if and when the other EAC members join it.

Principles for determining roaming charges

Based on their analysis of the operators' tariffs, these principles were proposed for determining harmonised EAC roaming charges:

- Roaming charges should be "cost oriented" - that is, reflective of real costs but not mechanically derived from them.
- The harmonised EAC roaming framework only applies to traffic originating and terminating within EAC Partner Countries.
- Traffic originating and terminating within the EAC should be exempt from international traffic surcharges.
- Mobile telecommunication taxes (excise, VAT, etc.) should be regionally harmonised.
- Partner states should establish systems to prevent traffic re-filing, tariff fraud and illegal call termination.

Recommendations adopted by the EAC's Multi-sectoral Coordination Committee for the implementation of ONA

- Wholesale (inter-operator) tariffs should be capped at 7 US cents/minute for traffic originating and terminating within EAC;
- The retail tariff cap should be 10 US cents/minute, including taxes, for traffic originating and terminating within EAC;
- There should be no charge for receiving calls while roaming within the EAC;
- Existing inter-operator agreements should be amended by 31 January 2015;
- Systems should be established to prevent traffic re-filing, fraud and illegal termination of traffic;
- Partner states should harmonise taxes on telecommunication traffic and remove international surcharges for traffic originating and terminating within the EAC;
- The Committee of Heads of Communications Regulatory Authorities should meet every 3 months to review the ONA framework's implementation;
- The Committee should "consider in detail" inclusion of a "fair use" policy in the ONA framework.

Impact of ONA

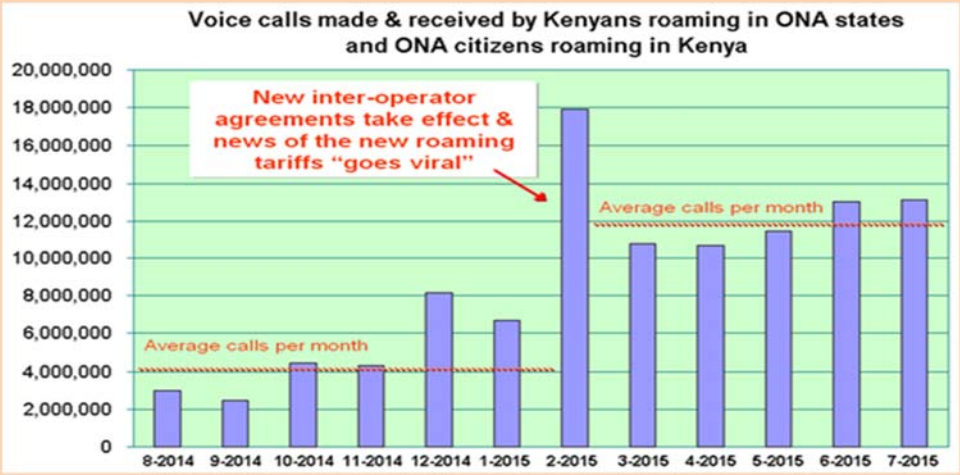
Although it is still preliminary to assess the full benefits of ONA, some notable achievements can be noted including:

1. **Lower tariffs on individual roamers is significant-** Cross border voice traffic has grown rapidly since ONA's implementation – tripling in both Kenya and Uganda, with a nearly 5-fold increase in Rwanda and a 30-fold increase in South Sudan. More analysis is required to assess if the growth is due to roaming and previously stifled demand or if there indeed other factors attributed to this.

2. **A *wholesale* price cap of 7 US cents/minute without surcharges let's all MNOs in the EAC offer roaming services profitably,** according to data collected by the EAC Sectoral Council before introducing ONA**.** Similarly the Council found that the regional average minimum retail price for roaming voice calls made in visited countries was 8.7 US cents/minute. The Council's analysis also found that the regional average for the lowest freely negotiated wholesale price for roaming was

7.63 US cents/minute including surcharges. So a retail price cap of 10 cents/minute left room for further voluntary price reductions due to competition.

Figure 11: Voice Calls made and received by Kenyans roaming in ONA States and ONA citizens roaming in Kenya



Source: ONA

The Economic Community of West African States (ECOWAS)[55]

Box 7: Intention of ECOWAS

The main intention of ECOWAS in ICT is the establishment of a single ICT Market in West Africa. Three conditions for high-quality roaming at affordable prices have been identified by the Technical Group on Roaming (ETGR):

- harmonised Community regulation;
- total cross-border connectivity between all the ECOWAS countries;
- a preferential Community tariff to encourage and boost the use of roaming.

The core objective of ECOWAS in ICT is the establishment of a single ICT Market in West Africa. In order to achieve that, ECOWAS works with 2 main pillars: the harmonization of ICT policies and the development of broadband infrastructure. The ECOWAS Authority of Heads of State and Government (HOSG) appealed to mobile operators to sign roaming agreements in order to facilitate communication in the region and set up the ECOWAS Technical Group on Roaming (ETGR) in 2005.

ETGR noted that Roaming should not only be seen as a business opportunity for mobile operators, but also must be considered as a social issue and a factor of exchange and regional integration and recommended:

- Promote liberalization of international gateways and direct connectivity between Mobile operators of neighboring states in order to reduce the costs of roaming traffic;
- Reduction and/or suppression of taxes included in the setting of Roaming tariffs in the ECOWAS region;
- ECOWAS to fix a ceiling for retail prices for the benefit of the consumers;

[55] Based from ECOWAS presentation at the International Mobile Roaming Consultation Meeting, Geneva, 15-16 September 2016, available at: www.itu.int/en/ITU-D/Regulatory-Market/Pages/Events2016/IMR_Consultation/home.aspx.

- Undertake a detailed study on the Roaming pricing including the possibility of integrated Roaming for the region;

Ongoing activities on Roaming

The main objective is to reduce the cost of roaming and potentially termination rates.

The engagement is split into two main activities:

1. Study on harmonization of cross-border communications costs supported by World Bank
2. Elaboration and adoption of a Regulation on Roaming in the ECOWAS space, in collaboration with the West Africa Telecommunications Regulators Assembly (WATRA).

The aim of this engagement are to:

- harmonise the costing and pricing of roaming services within the ECOWAS Region;
- address the high cost of roaming services within the ECOWAS Region in order to reduce/eliminate roaming charges;
- provide the minimum safeguards for consumers of roaming services to empower them to make informed decisions.

Reducing/eliminating Roaming charges will facilitate regional m-services and will improve regional traffic and business opportunities for Operators.

The Arab Regulators Network (AREGNET)[56]

Box 8: AREGNET has determined the following challenges on IMR:

- Different level of competition and different regulatory frameworks;
- Costing structures and bargaining power;
- Transparency and commercially sensitive information;
- Low ARPU operators challenging any initiatives to lowering roaming prices;
- Some practices like steering and home data register (HDR) blocking;
- Existence of loyalty fees (revenue sharing) from telecom sector;
- Practicing market power on roaming and set high wholesale and retail prices.

Roaming remains a main concern for all Arab Countries. It was noted that roaming rates are priced on the destination rather than cost-based, so that operators are generating a lot of profits, especially for data roaming. Efforts made through the Arab League and GCC are encouraging lower roaming and international prices. These efforts are positive but benefits are limited for other countries outside the region. AREGNET was tasked to coordinate efforts to alleviate the excessive roaming prices for the best interest of subscribers roaming across the Arab region. An important issue in the region is the number of countries and the differing market characteristics in each, one example is taxation, there are high differences among countries (e.g. in Qatar the taxation of telecom services is 0% and in Jordan 43.8%). This is also the case in regards to income per capita and average revenue per user (ARPU).

Internationally coordinated regulation is viewed as the appropriate way forward for the region. It is best to act multilaterally:

- Coordination to set affordable prices by intervening at wholesale and retail level;
- Widening the multi-lateral agreements (e.g. Jordan-GCC);
- Coordination to prohibit steering and HDR blocking;

[56] Based from AREGNET presentation at the International Mobile Roaming Consultation Meeting, Geneva, 15-16 September 2016, available at: www.itu.int/en/ITU-D/Regulatory-Market/Pages/Events2016/IMR_Consultation/home.aspx.

- The possibility to adopt more interventionist tool like decoupling.

The Gulf Cooperation Council (GCC) International Roaming Regulatory Initiative[57]

Box 9: GCC International Roaming Regulatory Initiative Recommendations

- to reduce the current level of price caps on outgoing calls and to introduce new price caps on incoming calls, SMS sent and data usage while roaming.

- to reduce the price caps gradually to reach the desired price caps in 2018 for outgoing calls, received calls and SMS sent, and in 2020 for data.

- to set the price control glide paths in such a way as to ensure that MNOs' IMR revenues remain in excess of the 2015 levels.

Following the consultation of September 2014, the Gulf Cooperation Council (GCC) Roaming Working Group (RWG) finalized its report on roaming regulation across GCC countries, and the GCC Ministerial Committee for Post, Telecommunications and Information Technology approved the recommended regulations in its 24th meeting of June 9, 2015 held in Doha, Qatar that changed the underlying cost estimates of different roaming services, in particular changing the proposed price caps. Like other regional initiatives, these proposals are a response to a mandate from the GCC telecommunications ministers committee to address the issue of high prices for IMR in order to achieve regional integration and social cohesion, and to protect consumers in the GCC.

The RWG considered different options:

- taking no action;
- encouraging MNOs to lower retail prices;
- implementing price controls; and
- taking steps to increase competition.

Although GCC member states have yet to adopt the necessary regulatory instruments that would oblige MNOs to implement the price controls and other regulatory measures, the Communications Regulatory Authority (CRA) Qatar and the Telecommunications Regulatory Authority (TRA) Oman have announced the new retail price caps that would apply starting from April 2016.

In particular, changes were made to:

- reflect the wide variation of taxes among GCC countries; and
- to take account of the fact that international gateways in Kuwait are still not liberalized, as a result of which MNOs incur additional costs (paid to the Kuwaiti ministry of communications) in order to terminate voice calls to MNOs in other GCC countries.[58]

In 2015 CRA in tandem with its counterparts in other members of the Gulf Cooperation Council (GCC) published the final report of consultation to assess the effectiveness of the existing regulations and a

[57] See: www.wto.org/english/tratop_e/serv_e/sym_march12_e/presentation_%20maitha_jaffar.pdf

[58] www.cullen-international.com/asset/?location=/content/assets/regulatory-intelligence/regulatory-news/cullen-international-mena-telecoms-report-september2015-rrteen20150001.pdf/cullen-international-mena-telecoms-report-september2015-rrteen20150001.pdf

review of IMR services. The final document also assesses the rationale for regulatory intervention at GCC level, and the approved new price caps for roaming charges. The reductions of roaming charges on both inter-operator wholesale level and customer retail level will take place gradually, over a three years period, for voice calls and SMS services, and over a five years period for mobile data services.

Caribbean Telecommunication Union (CTU)[59]

Box 10: The key tenets of CTU in respect of roaming policy are:

- Roam free area to facilitate movement of labour;
- Reduced charges as predictable cost of doing business;
- Roaming charges scaled down to zero;
- Application to voice and data;
- Area codes and geographical borders should not increase costs.

CTU was established in 1989 to coordinate/harmonize telecommunications policy development and ICTs. The main objective is the implementation of road map for single ICT space for the Caribbean, including the Eastern Caribbean countries Commission (OECS) and Eastern Caribbean Telecommunications Authority (ECTEL). Their mandate is oriented to the establishment of common frameworks for Governments, ICT service providers and consumers, in the areas of Quality of Service (QoS) standards, roaming, top level domain name management; local content; open data, licensing and authorizations.

Research and advocacy on roaming forms an integral part of the mandate of the Caribbean ICT Collaboration Committee (CICC)). This a regional grouping of private sector, public sector, civil society and regulatory agencies of the wider Caribbean and coordinated by the CTU Secretariat[60]. The CICC will promote discussions on roaming in all jurisdictions in the Caribbean.

Recognizing that citizen benefits from advances in telecommunications technology and liberalization, and that the Caribbean trails other integrated areas (e.g. EU), main challenges in respect to IMR are defined as being:

- The absence of political integration/arrangements (EU, GCC, SADC);
- Roaming cannot be controlled by single state (or single provider);
- Negotiating an appropriate institutional framework;
- Current ICT policy fragmentation;
- The paucity of political will;
- Prioritizing roaming as an ICT policy matter;
- Perception of loss of tax revenue from a zero rate regime;
- Uncoordinated responses/approaches to service providers.

In addition, the Caribbean Community (CARICOM) Heads of Government requested the CTU to prepare a Roadmap for the development of a CARICOM Single ICT Space. An important action in the Roadmap is the elimination or significant reduction in Roaming Charges in the twenty member states countries of CARICOM. This is justified since these countries are served by two dominant operators: Cable and Wireless and DIGICEL. From country to country roaming is on their own network. Accordingly, CTU has established a

[59] Based from CTU presentation at the International Mobile Roaming Consultation Meeting, Geneva, 15-16 September 2016, available at: www.itu.int/en/ITU-D/Regulatory-Market/Pages/Events2016/IMR_Consultation/home.aspx.

[60] http://www.ctu.int/events/2nd-caribbean-ict-collaboration-forum-2/

Collaborative Working Group to examine this matter and make recommendations. These deliberations are in progress.

Eastern Caribbean Telecommunications Authority (ECTEL)[61]

Box 11: ECTEL Recommendations

- A cost analysis should be conducted following the ITU Guide for NRAs on IMR Cost Analysis.

- Regulations may be made pursuant to the Telecommunications Act to regulate the roaming rates. However, since roaming is a technical and substantial area of the telecommunications industry indeed the best approach is to draft a Roaming Bill. It should be noted that ECTEL will recommend a new Electronic Communications Bill to the Member States in early 2017. This Bill will replace the current Telecommunications Act. ECTEL will ensure that the Roaming Bill and new Electronic Communications Bill are not in conflict.

- The retail or provider to consumer business needs to be regulated. Consumers will see a direct effect through rates from their provider. This is especially so for providers who operate in all ECTEL Member States. However, consumers may access services for other providers when roaming and so the provider-to-provider business should also be regulated, this is known as wholesaling. Wholesale rates are the rates that a provider charges another provider for handling mobile services of one provider's customer on another provider's network. This will affect roamers travelling into the ECTEL Member States[62].

- The proposed Bill shall be accompanied by regulations. The proposed rates or caps on the roaming rates as ECTEL decides shall be prescribed in the regulations. The prescription in the regulations will provide for easier or frequent amendments.

Pursuant to a decision of the Council of Ministers of the Eastern Caribbean Telecommunications Authority (ECTEL), the Regulatory Authority was mandated to develop the appropriate legislation to effect a reduction in roaming rates in its Member States. The first component of the process which involved the review of the legislation and pricing options has been completed. The Council accepted the report and recommendations and agreed to proceed with the development of the appropriate legal and regulatory instruments.

The specific objective of this project to be done during 2016 is to prepare a model Roaming Bill for enactment and appropriate supporting Regulations to be made in Saint Lucia and their subsequent adoption in the other Eastern Caribbean Telecommunications Authority (ECTEL) member states, as and when required. The Roaming Bill ECTEL states will be the most effective way to deal with the concern of costly roaming rates and strengthen the currently weak state of legislation in ECTEL member states in regards to mobile telecommunications roaming. As such the Bill will seek to regulate roaming rates for voice, short messaging service (SMS) text and data services.

Expected Results

It is expected that following a comprehensive review of the existing relevant legislation locally, regionally and internationally, the report and recommendations on pricing options and of the ITU Guide for NRAs on IMR Cost analysis - Technical Paper 2015[63], Saint Lucia and other ECTEL Member States would have for enactment a draft model Roaming Bill and the accompanying Regulations. The legislation would seek to place restrictions on the capacity of providers to charge for roaming within ECTEL Member States and achieve the overall policy objectives of reducing prices, protecting

[61] Based from ECTEL presentation at the International Mobile Roaming Consultation Meeting, Geneva, 15-16 September 2016, available at: www.itu.int/en/ITU-D/Regulatory-Market/Pages/Events2016/IMR_Consultation/home.aspx.

[62] ECTEL Member States: Dominica, Grenada, St Kitts and Nevis, Saint Lucia and St Vincent and the Grenadines.

[63] www.itu.int/dms_pub/itu-t/opb/tut/T-TUT-ROAMING-2015-03-PDF-E.pdf

consumers from unfair and unreasonable roaming policies, promoting sub-regional competitiveness and enabling the ECTEL Member States to move closer to a harmonized telecommunications space. In addition, a cost analysis should be conducted using the ITU Online Cost Analysis Tool as a guide. Once the analysis has been completed the results should be submitted to the Consultant to provide a direction on the regulation of the roaming rates. ECTEL developed a draft Roaming Bill and Regulations for regulating roaming in the Member States in collaboration with ITU. This draft Roaming Bill was submitted to public consultation from November 2016 to January 2017. The Bill is currently being finalized to be submitted to the Member States..

The major provisions of the Draft Roaming Bill for ECTEL States are:

- Wholesale rates to be regulated via price cap;
- Retail rates to be regulated using 'Rome like you are Home" option;
- Customers to be made aware of inadvertent roaming on networks of providers outside the ECTEL Member States;
- Home country provider to notify customer of emergency numbers in visitor country.

It is still under consideration to treat within the draft Bill issues of permanent roaming vs fair use policy, the use of national roaming in emergencies and for new entrants, number portability and finally roaming and Internet of Things (IoTs).

Comisión Técnica Regional de Telecomunicaciones (COMTELCA)[64]

Box 12: COMTELCA Standardization Committee Recommendations included

- The rate per minute, including taxes, of roaming services should not exceed one hundred thirty percent (130%) of the current rate of the Mobile international long distance call (from origin country to visited country);

- Gradual reduction of roaming rates over a period of 24 months;

- Establish a geographical strip of 5 km on both sides of the border line in the countries of the region in which roaming service fee will not be charged, and apply local rates for mobile service;

- Create a procedure to allow operators that do not have infrastructure in all countries, to provide roaming service with non-discriminatory rates[65].

Background

COMTELCA is the Regional Telecommunication Technical Commission that unites, disseminates and assists the telecommunication Regulatory Authorities in 6 countries of Central America (Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica and Panama). In 2012 the Board of COMTELCA instructed the Standardization Committee to develop a proposal to reduce roaming and regional long distance rates, taking into account that the Central American Parliament (PARLACEN) has expressed interest in eliminating roaming charges in this sub region.

In 2013 under a COMTELCA-BID Project (Inter-American Development Bank IDB) the first Regional workshop on Long distance and Roaming issues was held with the aim of promoting the reduction of these services rates in Meso-America countries. A channel of dialogue between operators and regulators was opened and an opportunity for all stakeholders to continue working together, with the challenge of agreeing the rate reduction, was generated. In 2016 the members of the Pacific Alliance

[64] Based from COMTELCA presentation at the International Mobile Roaming Consultation Meeting, Geneva, 15-16 September 2016, available at: www.itu.int/en/ITU-D/Regulatory-Market/Pages/Events2016/IMR_Consultation/home.aspx.

[65] Idem.

(Colombia, Chile, Mexico and Peru) decided to work together to eliminate roaming rates in the countries of the pact, trying to reach agreements with operators.

Current Situation

Traditionally, roaming traffic in the region was related to business activities. However, this trend has changed. The World Tourism Organization (WTO) figures indicate that 52 percent of worldwide travels are made for leisure, recreation and holidays; 27 percent for health, religion and other matters and only 14% for business and professional reasons. Latin America attracted 16 percent of international travels in 2015, equivalent to 192 million people, an increase of 5 percent compared to 2014.

Operators have invested in mobile platforms and have already deployed infrastructure in several countries. The presence and competition of operators is regional and they also face the challenge of Mobile Virtual Network Operators (MVNO) and Over the Top enterprises (OTT). To respond to these challenges, operators in the Central American region are offering packages that include calls, messages and data for consumers who travel to other countries at local rates.

The average price per minute of voice in Latin America has fallen from 11 dollar cents in the fourth quarter of 2008 to 6 dollar cents in the same period of 2013[66].

In Latin America, the first offers of roaming elimination were focused on consumers traveling to the United States (US) or Canada; however, the increasing of intraregional travels for business and tourism in recent years has encouraged mobile operators to reduce and/or eliminate the roaming charges in all countries in Central America.

The Response from Operators in Central America

Box 13: Concrete outcomes of the Central America "Without Border" initiative
Seven main operators across Central America have introduced roaming tariffs in the second semester of 2015, with the "without borders" plans, therefore the consumers can use their phone in the region and pay the domestic rates set in their home country. These plans could include data and voice services. This is an ongoing trend as operators increasingly work towards serving the needs of roaming consumers, which can be particularly seen in specialized tariffs for heavy commercial and tourism traffic in Central America. This will also help to eliminate inadvertent roaming in narrow border zones.

In the never-ending mobile phone wars among telecom giants, in the second semester of 2015, some mobile operators introduced the "without borders" plans, so the consumers can use their phone in the Americas region and pay the rates set in their home country, as national or domestic per minute tariff instead of roaming charges.

These plans could include data and voice services. Some examples of these private initiates are:

Movistar (Telefonica)

Movistar started its "*Sin fronteras*" (without borders) option for regional roaming in Central America in May 2015. Without further activation, customers can use data, voice and texts on the Movistar networks of Mexico, Guatemala, El Salvador, Costa Rica and Panama for the equivalent of a domestic tariff. Additionally, for a USD5 surcharge per day, customers can also use data at domestic tariff in the US, Canada, Argentina, Chile, Colombia, Ecuador, Peru, Uruguay, Venezuela and Brazil. This is available

[66] GSMA data.

for prepaid and postpaid plans. Data consumption exceeding the contracted plan also will be charged at local rate, regardless of the country where it is consumed.

Claro Central America

From April 2015 Claro eliminated roaming charges in Central America "*Talk and browse throughout Central America with your same local rate*". Postpaid customers that contract the unlimited calling plan at no cost, can also use it to communicate in other countries in the region on Claro network, with an additional charge (USD 3 monthly) consumers could also add US and Canada. The customer is saving about 40% per minute. Countries included in the Claro network are Mexico, Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica and Panama.

Telcel

Telcel following their competitors eliminated the Mexico-US border and allow mobile consumers to call from Mexico to the US and vice versa for just a minor charge. At present, this is available only for postpaid services. Telcel's mobile customers can call and text (SMS) to the US without paying long distance charges, and when they travel to US they will be able to use their minutes, messages and data just as they use it in Mexico, with no roaming charges.

Telcel charges a monthly service fee of 50 Mexican pesos (around USD3) for the "*Telcel Sin Frontera*" plan which subscribers can activate in Mexico or US.

AT&T

AT&T introduced the "*AT&T Mexico Roaming Bonus*" plan that customers can add for free. Customers who do so will receive unlimited texting (SMS) to anywhere in the world and unlimited voice calling within Mexico and from Mexico to United States. Additionally, customers will get 1 GB of data to use in Mexico for free (with overage charges of USD20 per GB).

Sprint

Sprint Open WorldSM add-on offers customers free calls and texts to Canada and Mexico with calls starting at just a nickel to Latin America, the Dominican Republic and more than 180 other countries when added to a domestic service plan. For those who like to travel, it boasts free unlimited calls and texts when traveling in Canada, Mexico and more than a dozen Latin American countries without the annoyance of roaming tariffs.

Sprint Open World includes 1GB of free data while traveling in these *Sprint Open World* countries: Mexico, Canada, Dominican Republic, Argentina, Brazil, Chile, Colombia, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama and Paraguay. The countries coming soon to Sprint Open World are Bolivia, Ecuador, Peru, Uruguay and Venezuela. Sprint customers needing more than 1GB of data pay just USD30 per GB, based on actual usage.

T-mobile

T-Mobile introduced **"***Mobile Without Borders***"**, an expansion of Simple Choice that lets customers use their phone in Canada and Mexico just like you would in the US. That means that calling and texting to, from, and between the US, Canada and Mexico won't cost extra, regardless of whether a mobile or landline phone is involved. And when they are in Canada or Mexico, they can use their mobile data plan just like they would in the United States.

Verizon

Verizon Wireless also updated its international roaming options as follows: for $5 per month its customers can now call Mexico and Canada for no additional per-minute fees, with calling minutes deducted from their current plans, this is also available to its prepaid customers.

Verizon's customers traveling to Canada and Mexico can now receive 500 calling minutes, 500 sent text messages and unlimited received text messages, and 1 gigabyte of data for USD25 per line, and customers can purchase additional data for USD20 per 1 GB.

Future Challenges

The main challenge in the region is to create an "America Free of Roaming", by developing new mobile platforms that take advantage of free communication services across the continent. Operators and services providers must adapt their current mobile offers to include roaming services for both pre-paid and post-paid, enhance existing services, and create new solutions and offers. These solutions should also consider to allow operators that do not have infrastructure in other countries to provide roaming services with non-discriminatory rates.

2.3 Operators and Services Provider Initiatives - summary

GSMA[67]

GSMA's mission is to provide consumers with clear and transparent pricing for mobile services when they travel internationally, along with the predictability and choice that mobile consumers expect. The mobile market continues to grow, and consumers increasingly use their mobile devices while travelling.

Mobile operators around the world are committed to offering competitive, optimized roaming offers that provide valuable services to their travelling customers — while ensuring prices for roaming services are clear.

Roaming alliances in different regions and increasing competition from mobile and other providers continue to deliver price reductions — up to 90% in some cases — improving customer value and resulting in higher customer use of roaming services. New roaming bundles and standard tariffs are giving customers more choice, with daily, weekly, monthly or service-specific offers.

Region-wide low roaming rates

Mobile operators that have a large regional presence increasingly offer low region-wide roaming rates similar to domestic tariff levels. In Europe, the Middle East and Africa, for instance, mobile operators are encouraging their customers to roam rather than acquire local SIMs when they go abroad. Sub-regional and bilateral packages, as well as regional offers for tourists through reduced rates and monthly, weekly or daily roaming bundles, are also facilitating cross-border travel and trade.

Calling using a local SIM

Local SIMs have always been an important substitute for roaming services, particularly among regular visitors and migrant workers. Some Middle Eastern operators are building on the concept of a local SIM by offering a temporary local phone number that works in parallel with a consumer's home number, without the need for an additional SIM.

Consumers in Asia Pacific are also making use of roaming substitutes. They have adopted SIM-based alternatives to international roaming across multiple regions. Call-by-call substitutes to roaming for corporate and business consumers are already having a significant impact on the roaming market in Asia. As the use of substitutes continues to rise, roaming prices will be reduced further.

[67] Extracted from GSMA website (http://www.gsma.com/publicpolicy/regulatory-environment/roaming).

Transparency
In June 2012, the GSMA launched the Mobile Data Roaming Transparency Scheme, a voluntary commitment by mobile operators to give consumers greater visibility of roaming charges and usage of mobile data services when abroad. Operators continue to improve transparency to ensure consumers receive better value from their roaming services. Easy access to personalized tariff and usage information allows consumers to quickly understand the range of options available in the market. Operators use several methods to ensure consumers are aware of the latest rates and offers, such as consumer-friendly websites and SMS messages welcoming roaming customers when they enter a country.

Within the EU, Gulf and other regions, comprehensive notification systems and informative websites have been developed to ensure consumers understand their usage. Data roaming services in these regions are managed according to regulation, competition and customer preferences, for example when a data usage limit is reached.

Removal of structural barriers and price regulation
From the GSMA point of view, governments and regulators should eliminate structural barriers that increase costs and cause price differences between countries. These include double taxation, international gateway monopolies and fraud, all of which should be removed before any form of IMR price regulation is considered.

Price regulation should be considered as a last resort, after transparency measures and innovative IMR pricing have failed to address consumer complaints, and after structural barriers have been removed. The costs and benefits of regulation must be carefully assessed, taking into account unique economic factors such as national variances in income, GDP, inflation, exchange rates, mobile penetration rates and the percentage of the population that travels internationally, as well as incidence of international travel to neighboring countries, all of which have an impact on IMR prices.

SAMENA COUNCIL

SAMENA Telecommunications Council is a trade association that represents telecommunications operators and service providers in South Asia, the Middle East and North Africa. The Council was founded in 2006 and its operational office is based in Dubai, United Arab Emirates.

Background
International mobile roaming ("IMR") is a service that enables a mobile subscriber to automatically and seamlessly make / send / access and receive voice calls, SMS/MMS and the Internet / data when travelling abroad without losing the connection. IMR has been a topic of intense discussion and concern with regulators and policy makers for many years now, mainly in relation to the level of IMR retail prices charged to consumers, the lack of pricing and usage transparency and resulting bill shock, and the level of wholesale payments made between mobile operators.

The reasons for high IMR prices are of a structural nature and relate to market mechanics and some behavioral aspects on the part of the consumer. These are (1) a quasi-oligopolistic market structure, (2) cross-border nature of the IMR service, (3) insufficient attention on the part of the consumer, and (4) low demand elasticity for IMR voice services. It is argued that in the absence of regulatory intervention, these characteristics prevent the emergence of competition and enable prices to remain high.

In terms of market effects, operators have been confronted with suppressed demand with customers switching off the roaming function on their phones to avoid bill shock. This has resulted in the emergence of a number of imperfect substitutes such as individuals having multiple SIM numbers across the different countries they frequently visit, call back options, the use of a local numbers offered

to visited country roamers, or the use of Wi-Fi together with the use of OTT services such as Skype, WhatsApp and Viber (where such services are not blocked).

With the roll-out of 4G networks and LTE roaming coupled with available OTT applications and services, demand for mobile data while roaming is likely to continue to increase significantly. This in turn will also drive competitive roaming offers. Given that the price elasticity of demand is much higher for data roaming in comparison to voice roaming, lowering prices sufficiently may have a significant volume effect, which can increase operators' revenues going forward. Operators consequently have responded with competitive roaming packages that include inclusive calls, SMS and data volumes that can be purchased separately and which are valid for a set number of days.

SAMENA Position

IMR is a competitive service that provides significant value-add to customers. It is technically and administratively complex, incurs costs and entails a number of different interrelated and non-transparent components that need to be well understood. These include legal / commercial aspects (roaming agreements / negotiation between MNOs), procedural aspects (what happens in terms of sequential process when a subscriber switches on his mobile device in a visited country and places or receives a call, sends an SMS or MMS, or accesses data), technical aspects (how do the home and visited networks "talk" to each other), and, lastly, what type of costs are incurred during the roaming process. Further complexities are added with rapidly changing technologies, services and applications and the advent of cross-border M2M communication and the IoT, all impacting the procedural and competitive roaming landscape.

Regulators and policy makers need to be mindful of these complexities when considering regulatory intervention. Any proposed regulatory intervention will need to be assessed as to its impact and potentially adverse or distorting effect (including the costs of implementation), which should be minimized.

While SAMENA Council agrees that price regulation in the form of price caps is an efficient means to achieve consumer benefit in the form of lower prices, the introduction of price regulation should be an intervention of "last resort". Moreover, price regulation should only be introduced following a rigorous analysis and only after other measures such as transparency obligations and the removal of structural barriers, including double taxation or international gateway monopolies and associated charges have been implemented. To avoid abrupt "shocks" and needless disruption to MNO revenues and profits, and to ensure continued investment and enable a smooth transition, any introduction of price caps should be accompanied by a multi-year glide path. Regulators should also consider introducing wholesale caps only, to ensure that there is sufficient pricing flexibility at the retail level, given the more competitive landscape at the retail level.

In the specific case of the GCC, given the high variability in underlying costs across the GCC (including termination, taxes, international gateway fees), price caps must be set sufficiently high to ensure that all operators affected can cover their costs and that sufficient pricing flexibility is given to offer alternative, commercially viable packages.

Asociación Interamericana de Empresas de Telecomunicaciones (ASIET)[68]

Box 14: ASIET proposals include:
- moving forward under schemes of self-regulation for the establishment of common quality standards among all operators involved in the provision of roaming services;
- working to minimize the negative effects produced by cross border roaming. To study the creation of mechanisms that warn these consumers when its device changes of operator involuntarily or study the possibility to create special offers for these customers;
- improving current information systems to allow to shorter the time for exchange of information between operators related to the roaming agreements to avoid fraud;
- evolving towards schemes that allow to reduce the high tax burden on roaming services.

ASIET is the association of telecommunications companies in Latin America, with more than 30 years dedicated to favor public policies that promote the sector development and the Information Society.

Although the traffic in roaming in the Latin American region was related to business activities in the past, according to the World Tourism Organization (WTO) this dependence is changing, given that at present globally 52% percent of trips are made by leisure, recreation and holidays; 27% for health, religion and other matters and only 14% for business and professional purposes. In the region mobile roamers will spend from 21.7 million in 2013 to 32.5 million in 2018.

Roaming is affected by a number of external and internal factors that make it difficult to improve the service, such as:

- the double taxation of VAT and other sectorial taxes applied in most of the countries of the region the price of the international roaming service is approximately between 35% and 60% more expensive than a price without taxes[69];
- many actors are involved at the end-to-end service. The mobile operator has no control of the entire chain, since they are involved among others, the long-distance operators;
- the cases of fraud are between 3% and 5% of operator's income;
- the higher risk of fraud is due to the delay in the exchange of information between operators;
- complex schemes of rates, by type of call, by country and by operator discourages use;
- the different technologies initially deployed by mobile operators in the region as well as the different attribution of frequency bands, delayed the development of the service and conditioned the use of more expensive terminals.

In the Latin American region some operators companies are reacting to face these challenges and respond to the needs of customers. Several operators companies with footprint in several countries started to introduce packages and offers to remove roaming charges (see COMTELCA).

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[68] Based from ASIET presentation at the International Mobile Roaming Consultation Meeting, Geneva, 15-16 September 2016, available at: www.itu.int/en/ITU-D/Regulatory-Market/Pages/Events2016/IMR_Consultation/home.aspx.

[69] Source: IIRSA project

Annex 3 – List of Regional Regulatory Associations (RA), International Organizations, Consumer Associations and Private Sector Associations – invited to participate at the LET'S ROAM THE WORLD INITIATIVE

1. Assemblée des Régulateurs des Télécommunications de l'Afrique Centrale (ARTAC)
2. Comité de Régulation des Télécommunications de l'UEMOA (CRTEL)
3. West Africa Telecommunications Regulators' Association (WATRA)
4. Economic Community for West African States (ECOWAS)
5. Association of Regulators for Information and Communication Services of Eastern and Southern Africa (ARICEA)
6. East African Communications Organization (EACO)
7. African Telecommunications Union (ATU)
8. Communications Regulators' Association of Southern Africa (CRASA)
9. Association of Communications and Telecommunications Regulators of the Community of Portuguese Speaking Countries (ARCTEL-CPLP)
10. Independent Regulators Group (IRG)
11. Body of European Regulators for Electronic Communications (BEREC)
12. European Commission (EC)
13. European Conference of Postal and Telecommunications Administrations (CEPT)
14. The European Telecommunications Standards Institute (ETSI)
15. Euro-Mediterranean Telecom Regulators (EMERG)
16. Arab Regulators Network of telecommunications and information technologies (AREGNET)
17. Gulf Cooperation Council (GCC)
18. League of Arab States (LAS)
19. Inter-American Telecommunication Commission (CITEL)
20. Caribbean Telecommunications Union (CTU)
21. Organisation of Caribbean Utility Regulators (OOCUR)
22. Eastern Caribbean Telecommunications Authority (ECTEL)
23. Telecommunications Regional Technical Commission (COMTELCA)
24. Latin American Forum of Telecom Regulators (REGULATEL)
25. South Asian Telecommunication Regulators' Council (SATRC) and
26. Asia-Pacific Telecommunity (APT)
27. Pacific Island Telecommunication Association (PITA)
28. Regional Commonwealth in the Field of Communications (RCC)
29. Réseau Francophone de la Régulation des Télécommunications (FRATEL)

30. Réseau des Consommateurs Africains des TIC (RECATIC)
31. International Telecommunications Users Group (INTUG)
32. Association for Progressive Communications (APC)
33. Caribbean Association of National Telecommunications Organizations (CANTO)
34. European Telecommunications Network Operators' Association (ETNO)
35. GSMA
36. Asociación Interamericana de Empresas de Telecomunicaciones (ASIET)
37. SAMENA Council
38. Commonwealth Telecommunications Organisation (CTO)
39. SMART AFRICA
40. International Organisation of la francophonie (OIF)
41. European Consumers' Organisation (BUEC)

Annex 4 – Glossary of terms

APEC	Asia-Pacific Cooperation Telecommunications and Information Working Group
APT	Asia Pacific Telecommunity
AREGNET	Arab Regulators Network of telecommunications and information technologies
ARPU	Average revenue per user
ASIET	Asociación Interamericana de Empresas de Telecomunicaciones
BEREC	Body of European Regulators for Electronic Communications
CARICOM	Caribbean Community
CITEL	Inter-American Telecommunications Commission
COCOM	Communications Committee (EU)
COMTELCA	Comisión Técnica Regional de Telecomunicaciones de América Central
CRA	Communications Regulatory Authority Qatar
CRASA	Communications Regulatory Association of Southern Africa
CRTT	CRASA Roaming Task Team
CTU	Caribbean Telecommunication Union
DSM	Digital Single Market
EAC	East African Community
EBITDA	Earnings before interest, tax, depreciation and amortization
EC	European Commission
ECOWAS	Economic Community for the West African States
EEA	European Economic Area
ECTEL	Eastern Caribbean Telecommunications Authority
EC	European Commission
ETGR	ECOWAS Technical Group on Roaming
EU	European Union
FUP	Fair Use Policy (EC)
GATS	General Agreement on Trade in Services
GB	Gigabyte
GCC	Gulf Cooperation Council
GDP	Gross domestic product
GSMA	GSM Association
GSR	Global Symposium of Regulators
HDR	Home data register
ICT	Information Communication Technologies
IDB	Inter-American Development Bank
IMR	International Mobile Roaming
IMSI	International Mobile Subscriber Identity
IOT	Inter-Operator Tariff
IoT	Internet of Things
ITRs	International Telecommunication Regulations

ITU	International Telecommunication Union
MB	Megabyte
M2M	Machine-2-machine
MFN	Most favoured nation (GATS principle)
MNO	Mobile network operator
MTR	Mobile Termination rates
MVNO	Mobile virtual network operator
NRA	National Regulatory Authority
OECD	Organisation for Economic Co-operation and Development
OECS	Eastern Caribbean countries Commission
ONA	One Network Area
OTT	Over-The-Top
QoS	Quality of Service
QoE	Quality of Experience
PARLACEN	Central American Parliament
PPDU	Project Preparation and Development Unit (ECOWAS)
RA	Regulatory Associations
RATT	Regional Alliance Task Team (SADC)
REGULATEL	Latin American Forum of Telecom Regulators
RLAH	Roam-like-at-home
RLAL	Roam Like a Local
RWG	Roaming working Group (GCC)
SATA	Southern Africa Telecommunication Association
SADC	Southern African Development Community
SIM	Subscriber identity module
SMS	Short message service
TSM	Telecom Single Market
TRA	Telecommunications Regulatory Authority Oman
US	United States
VAT	Value-added tax
VoIP	Voice over Internet Protocol
WATRA	West Africa Telecommunications Regulators Assembly
WCIT	World Conference on International Telecommunications
Wi-Fi	Wireless fidelity (IEEE 802.11 standard)
WTA	Weighted Tariff Average
WTDC	World Telecommunication Development Conference
WTO	World Trade Organization
WTO	World Tourism Organization
WTSA	World Telecommunication Standardization Assembly

REGIONAL INITIATIVES – AFRICA

The APP Economy in Africa: ECONOMIC BENEFITS AND REGULATORY DIRECTIONS

Report



Telecommunication Development Sector

The APP economy in Africa: economic benefits and regulatory directions

This report was prepared by the International Telecommunications Union (ITU) expert Mr Simon F. Molloy of Australian Economic Consultancy, Systems Knowledge Concepts Pty Ltd (www.skc.net.au) under the direction of the ITU Telecommunication Development Bureau (BDT). Inputs from Mr Scott Minehane and Ms Anthea McGurty of Windsor Place Consulting (www.windsor-place.com), and Derrick Kotze, CEO, MLAB, are also gratefully acknowledged. This study was first presented at the ITU Regional Economic and Financial Forum of Telecommunications/ICTs for Africa (Zimbabwe 30-31 January 2017)[1].

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[1] www.itu.int/en/ITU-D/Regulatory-Market/Pages/Events2017/Zimbabwe/home.aspx



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Foreword

It is my pleasure to present this ITU report on the app economy in Africa: Economic benefits and regulatory directions prepared by the Telecommunication Development Bureau (BDT).

Technological change is one of the most powerful drivers of national economic development. It represents the crystallisation of new knowledge as it is employed to improve the utilisation of all resources and to improve human welfare. Governments and Telecommunication/ICT National Regulatory Authorities (NRAs) are playing an important role in this new phase of twenty-first century development of information and communications technology. This report identifies the analytical basis for the various types of regulatory responses to different types of app economy disruption, focusing on the opportunities and challenges of the app economy in Africa.

I trust that the findings of this report will serve as strategic guidance to assist all stakeholders in their discussions and decision making for the identification of the best approaches to regulating the app economy.



Brahima Sanou,

Director, Telecommunication Development Bureau

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1 Introduction to the app economy

What is the app economy? What is the current state of the app economy in Africa? What are the actual and potential economic benefits, and what policy and regulatory settings are likely to maximize the benefits the app economy creates for consumers and citizens?

This report provides an overview of the development of the app economy in Africa, in particular, for Ghana and South Africa, with some additional comments on Kenya. Reference will be made to other Africa region countries where these provide additional context and perspective. This report also provides a working definition of the app economy and assesses the current state of regulation with emphasis on instances of successful collaborative regulation.

Recommendations to policy makers and regulators are provided concerning tools for collaborative regulation that enhance consumer choice, promote affordable pricing and maintain a level playing field for all players.

An overview of market players along the app economy value chain is also provided with analysis of market performance and business models for the various ICT digital service players. The role of the app economy and ICT more generally in promoting economic and social development in Africa is also a key focus. These technologies will play an important role in the Africa region countries achieving the sustainable development goals.

1.1 The app economy ecosystem

The app economy has been described as *the sum of all activity, products and services required to deliver app functionality to end consumers*[1]. The component parts of the app economy are shown in Figure 1.

Figure 1: Component parts of the app economy



Source: Systems Knowledge Concepts (www.skc.net.au)

[1] Global Symposium of Regulators 2016 discussion paper: *The race for scale: market power, regulation and the app economy*: www.itu.int/en/ITU-D/Conferences/GSR/Documents/ITU_AppEconomy_GSR16.pdf

This definition is clear enough conceptually but the objective of measuring the size of the app economy remains challenging. This is because the app economy has emerged within and across multiple industries – the telecommunication industry, the software industry and the computing hardware industry – in a rapid evolutionary process that has quickly blurred the borderlines between them. In fact, from this perspective, the emergence of the app economy could be viewed as another aspect of the ongoing process of convergence between communications, software and media that has been occurring for several decades.

Not only does the app economy operate across traditional converged industries – media, communications and information technology – as its disruptive influences reaches additional industries such as finance, transportation and accommodation, it increasingly incorporates economic activity that occurred within these traditional industry classifications. This means that the national statistical collections compiled by governments around the world, which are based on traditional industry classifications, are being challenged because of the influence of the app economy. Because the app economy crosses so many of these traditional industry boundaries, it is difficult to collect information that would enable an accurate quantification of its economic size.

Even within types of activity that are clearly linked to the app economy, there are some complicated definitional or 'edge' issues in trying to measure its size: for example, if the total value of cloud computing activity, what proportion of that should be attributed to the app economy and what proportion to non-app cloud services?

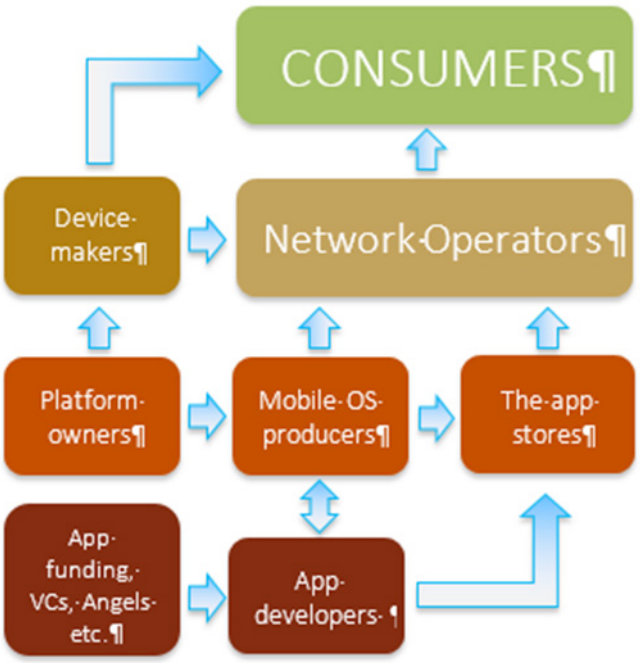
Despite these challenges in objectively determining the size and the progress of the app economy in a particular country, by understanding the app economy value chain, a range of data sources are identified that can provide useful indications of the progress and impact of the app economy in particular jurisdictions.

The final output of the app economy is a functioning app on a mobile device in the hands of businesses or individual consumers. Figure 2 shows the various sectors of the app economy and their relationship to final consumers. Note that final consumers' access to app services is mediated by telecommunication operators including access to app stores over either mobile or fixed broadband networks.

Figure 2 illustrates consumers, both business and individuals, as having a direct relationship with telecommunication operators and the sellers of mobile devices. Consumers use telecommunication operator services to update their mobile operating systems, search for apps, install and use them. Many apps require ongoing interaction between the end user mobile devices and the cloud, and telecommunication operators provide the services that enable these interactions.

Thus, telecommunication operators play a pivotal role in the app economy and its evolution has enormous consequences for this sector. One of the most important consequences for mobile operators, for example, is the app-driven shift to a world where 'everything is data'. Numerous apps such as Viber, WhatsApp, Apple FaceTime and Facebook Messenger offer communications services that directly compete with traditional operator voice and messaging offerings that have traditionally been relatively high margin components of the operator service offerings.

Figure 2: App economy ecosystem and value chain



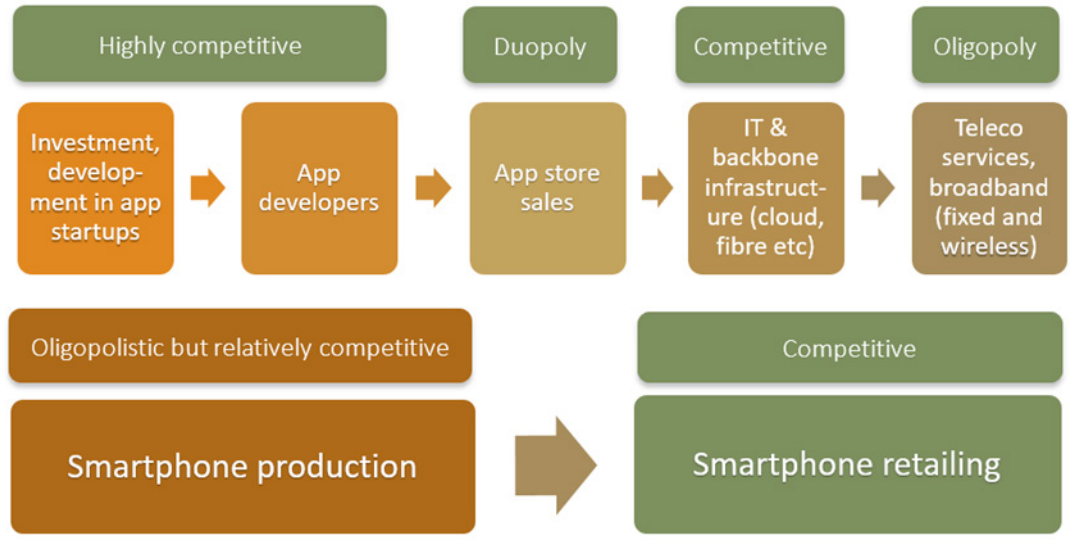
Source: Systems Knowledge Concepts (www.skc.net.au)

In the 'everything is data' world, the demand for mobile capacity is growing rapidly requiring substantial new investment in mobile infrastructure, while at the same time, operators are being driven by market forces to become commodity market mobile bandwidth suppliers. This arguably represents a significant decline in the market power previously enjoyed by such operators.

The combination of open-ended economies of scale in production, branding and marketing, coupled with powerful network effects, means that the most successful players in the app economy are increasingly in a position to develop significant market power (SMP)[2]. Figure 3 shows the app economy value chain and indicates, at a high level, the level of competitiveness in each segment.

[2] *The race for scale*: www.itu.int/en/ITU-D/Conferences/GSR/Documents/ITU_AppEconomy_GSR16.pdf

Figure 3: App economy value chain and competitiveness



Source: Systems Knowledge Concepts (www.skc.net.au)

The combination of the app economy capacity for business disruption with the existence of structurally uncompetitive markets raises issues relating to whether and how it should be regulated. To analyse the extent to which the app economy should be regulated and how it should be regulated, it is necessary first to understand the economic drivers of the rapid rise of the app economy and how new app-based businesses are able to so quickly and comprehensively challenge pre-existing business models.

1.2 The economics of disruption: How do apps disrupt existing business models?

1.2.1 Information costs, transactions costs and organization costs

The way that technological innovations impact commercial and business processes is overwhelmingly through the downward pressure they exert on costs. The underlying costs of providing goods and services shape what businesses are able to offer their consumers on an ongoing commercially viable basis, and innovations make existing products cheaper and/or better and enable new products to be brought to market.

Some technological innovations impact on the cost of physical inputs: for example, innovation in the design of internal combustion engines mean that consumers spend less on fuel per kilometre travelled. In the case of the app economy, innovations are primarily to do with the cost of acquiring, processing and communicating information. For example, consider the case of booking a taxi using the traditional telephone-based manual method and compare this with how app-based ridesharing companies such as Uber achieve a booking. The traditional method involves the customer placing a phone call, perhaps waiting on hold, providing details to the operator of their location and destination; the operator then radio-calls for drivers who are available and in the right location, and (perhaps) the operator communicates the result to the customer. In the app-based version, the user specifies a destination on the smartphone, the geo-aware phone knows the current location of the user, the software system broadcasts a call to drivers, and the location of the driver who wins the job is automatically communicated to the customer. Essentially, much of the process that was formerly manual is automated and this significantly lowers the cost of this component of the business process.

In fact, costs associated with processing information make up a far larger component of economic activity than most people recognise. The famous twentieth century economist, Ronald Coase, described the ubiquity and significance of *transactions costs* in all economic systems, and how changes

in these costs could lead to significant, and often counterintuitive, changes in industrial, commercial and economic structures. Transactions costs are, essentially, the costs associated with using the market to organise economic activity. If I'm a buyer, I must find the preferred seller, I need to research price, I need to research quality characteristics of the good or service that I want to buy, and, if I am purchasing a long-term service, I need to design, evaluate and manage a service contract.

Transactions costs are often highly significant; in some cases they may be greater than the value the buyer gets from the transaction itself, in which case the transaction will not proceed and, more generally, markets will not form (markets that could deliver significant benefits to buyers and sellers). But Coase pointed out that there are alternatives to using the market to organise economic activity. One solution is to organise activity within a firm. But organising activity within a business is also far from costless – the entire cost of the internal management, for example, could be characterised as such a cost. We could describe the costs of organising economic activity within a business as *organisation costs*.

The app economy can be considered in this context. Improvements in technology, particularly improvements in information technology, will lead to a decrease in both transactions costs and organisation costs. Thus, the changing relative costs of organising activity through the market, all within the firm, will drive changes to the viability of existing business models. If, for example, transaction costs fall more than organisation costs, then firms would be expected to shrink in size and conduct more activity in the marketplace: for example, to outsourcing and subcontracting. This represents therefore a significant driver of economic or industrial disruption.

Complicating this picture slightly, changes in information technology also lead to large increases in economies of scale, meaning that businesses can operate in a particular field at a much greater scale while lowering per unit costs of operation. In the case of the app economy, globe spanning companies enjoy enormous economies of scale in the collection, analysis and use of data.

Once these relationships between transaction costs in the marketplace, organisation costs within the firm and economies of scale are understood, the role of technological change in the process of business and industrial disruption can be more easily understood in a systematic manner.

1.2.2 Modes of digital disruption

Within the conceptual framework of information costs, transactions costs, organisation costs and economies of scale, digital disruption may take a number of forms:

Falling transactions costs creating new markets

Consider the problem of trying to develop a market for sellers of spare accommodation to temporary renters. Prior to the development of the Web and the app economy, it would have been technically possible to create a business that kept centralised records of spare accommodation in domestic residences around the world, which collected and maintained ratings for these properties and matched these with requests for such accommodation. Similarly, it would have been possible for any individual to call at random domestic residences at a particular holiday destination and attempt to negotiate an agreement for temporary accommodation. In the former case the organisation costs, and in the latter case the transactions costs, were prohibitively high and such a market simply did not develop. The AirBnB business innovation was to develop a scalable information technology system that enabled dispersed users to register available space, an interface for potential renters to find accommodation, a rating system for providers and users, and pro forma processes for reducing the costs of negotiation and payment. In effect, AirBnB used information technology to create a marketplace with massively lower transactions and organisation costs, and the significant investment for this system development is now amortised on a global basis, leading to relatively low unit organisation costs.

Retailing information rich products and the race for scale

Using scalable information technology systems, Apple was able to grow rapidly to become the world's biggest music distributor and Amazon did the same thing for books. Music and books are both complex 'information rich' products, it is difficult to evaluate the benefit they deliver until they are consumed. Consumers wish to discover new works that interest them and, because these goods are complex, they face relatively high transactions costs in finding what they want. Apple and Amazon have developed large and complex retail information systems that are globally scalable and that significantly reduce these transactions and operational costs. These systems enable such companies to specialise, on a global basis, on a particular type of retailing, displacing traditional bricks and mortar stores (Tower Records, which opened in 1968, and was the biggest music retailer in the United States, closed in 2006[3] and the Borders Group, which operated 511 superstores in the United States in 2010, closed its last stores in September 2011[4]). Once these systems are set up, and as they are improved over time, there is no limit to their scale – they become global shopping spaces. Because economies of scale are so significant, smaller firms will tend to fail and larger firms grow, leading to the potential for globe-spanning monopolies to develop. Within this context there will be smaller niche players.

Excising the information component of traditional businesses

The rise of Uber illustrates graphically how app economy entrepreneurs seek out the information components of traditional businesses and launch disruptive applications. The traditional taxi business can be thought of as consisting of two components: the physical business of moving passengers in cars from one geographic location to another, and the information business centre of receiving incoming calls from users, coordinating these requests with available taxis, dispatching taxis and managing a roster of drivers. To use the terminology often used by Nicholas Negroponte of the Massachusetts Institute of Technology, the taxi business has 'bits and atoms' components. Uber and other ridesharing applications provide an alternative means for operating the information component of the traditional taxi business. Figure 4 illustrates how Uber offers a disruptive new process by which customers and drivers, who both carry GPS capable devices, interact with Uber distributed broking software to generate automated efficient solutions that replace human dispatchers in the traditional taxi business.

Because the basic problem of geo-coordination and taxi despatching is similar all over the globe, Uber can use its application and back-end server infrastructure anywhere in the world where GPS signals are available on handheld consumer devices. Uber's innovations have enabled processes that previously operated inside firms to be taken outside into a newly created marketplace. Uber has also introduced demand-responsive pricing for ride services which arguably results in more efficient operation than traditional business models can provide. This is illustrated in Figure 4.

Traditionally, taxi businesses operate both the information and physical components within a single firm. The Uber software, its app and its cloud-based back-end, enable it to effectively 'excise' the information component and execute the business functions within this component more efficiently. The physical component is left to Uber drivers. One of the most noteworthy aspects of this app disruption is that Uber can essentially operate the information component of the taxi business at a global level. It therefore can enjoy enormous economies of scale in the production and use of its software systems.

As well as business disruption, such innovations also create regulatory disruption, and regulatory responses by authorities play a large role in determining the success or otherwise of these new app-based corporations. The taxi industry is heavily regulated for good reasons, primarily user safety. Regulatory systems, as economists have observed, are subject to regulatory capture over time resulting in the regulation serving, to some extent, the interests of the industry being regulated. Business disruption offers new opportunities to reset regulation so that it better serves consumer interests.

[3] www.theguardian.com/business/2006/oct/09/retail.usnews (accessed 27/12/2015)
[4] https://en.wikipedia.org/wiki/Borders_Group (accessed 27/12/2015)

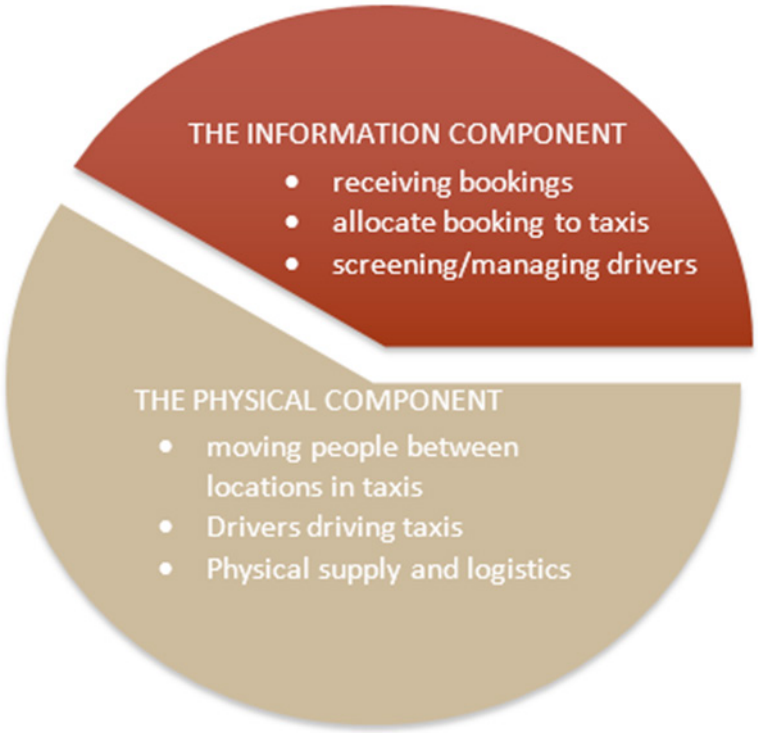
1.2.3 The race for scale and the future of market power

One of the early hopes of many, associated with the rise of the Internet, was for a democratisation of marketplaces in which many small-scale sellers could reach many buyers with unique niche preferences. Whilst this has happened, with companies like eBay providing small-scale marketplaces, and Google enabling advertisers to operate at any scale, as the Internet matures, there is a rise of globe-spanning technology companies operating international business models that show no signs of reaching a maximum efficient scale. Many of these companies have the means to exert significant market power (SMP) and have many characteristics of natural monopolies.

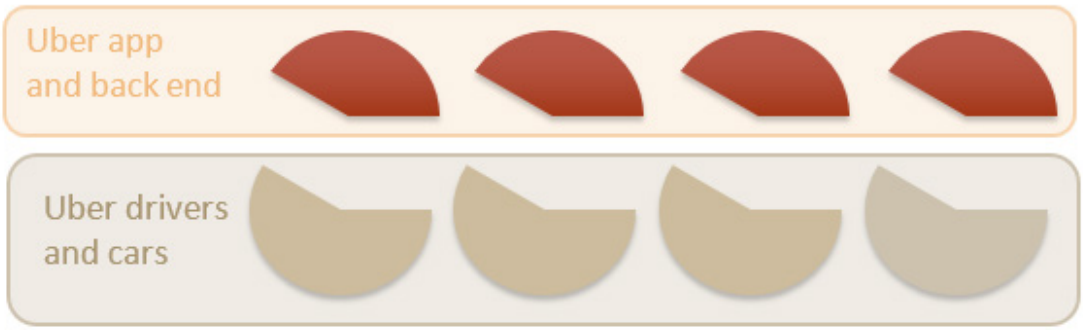
The rise of the app economy and ubiquity of smart mobile devices seems to create even greater opportunities for companies to offer global scale solutions and systems than the Internet alone.

Figure 4: Disrupting the taxi business

The pre-UBER taxi business: Physical and information components within a single firm



The post-UBER taxi business: UBER takes the information component, drivers take physical components



Source: Systems Knowledge Concepts (www.skc.net.au)

The outcomes of the interactions between falling transactions costs, falling organisation costs and increasing economies of scale are difficult to predict but some are of the view that these changes will ultimately make global corporations more powerful.

The history of competition regulation in the information technology industry suggests that recurring waves of technological change weaken the market power of dominant firms in the long run. Just as Microsoft unseated IBM in the 1980s, so Microsoft itself was unseated by the Internet itself and by Google as the Twenty-First Century began. Currently, Google is in ongoing negotiations with EU competition authorities regarding alleged use of its market power in the presentation of search results that favour its own products. The app economy itself provides a challenge to dominant firms of Internet search by enabling consumers with alternative pathways to the products and services that they seek[5]. Perhaps again the march of technological change will erode the market power of entrenched dominant firms. On the other hand, the Internet, in combination with the app-economy, offers companies new ways to dominate particular narrow niches:

As diseconomies of scale are destroyed, it becomes more and more practical to run a globally integrated firm -- indeed, a global monopoly -- provided, again, that the firm maintains a strong focus, picking one activity and doing all of it for the whole world. The picture that results is a large collection of focused monopolies, each of them taking a precision "slice" through the world economy by means of global computer networks and by the grace of the standardized world that it both depends upon and helps to create.[6]

Thus, while the emergence of the app economy has attracted significant interest from telecommunication regulators, it is also likely that it will attract the attention of general competition regulators as well.

2 Regulation and the app economy: general considerations

2.1 Introduction

Over the past year, new regulatory responses to app economy businesses have emerged. Several considerations come into play when contemplating the appropriate regulatory response to app economy disruption. These include:

- as a principal, regulation should only be imposed where it is clearly necessary and will generate benefits for consumers and citizens with appropriate consideration being given to unintended consequences of any regulatory intervention;
- it is desirable to facilitate technological innovation that delivers benefits to consumers and greater efficiencies in production;
- a level playing field is desirable to enable traditional players to compete effectively with disruptive new entrants.

There are several factors that drive the uptake of app businesses. One factor is the regulatory environment. Regulators, if they are to maximise economic benefits, need to find the best possible trade-offs between consumer protection, investment stimuli and innovation for the whole of society. Regulators around the world have endorsed a set of best practice guidelines to protect consumer interests while ensuring a level-playing field for traditional and new market players by fostering a light-touch

[5] www.nytimes.com/2015/08/28/technology/google-eu-competition.html?_r=0 (accessed 27/12/15)
[6] Phil Agre, The market logic of information, *Knowledge, Technology, and Policy* 13(3), 2000, pages 67-77.

regulatory approach (Figure 5). OECD also recognized the importance of the app economy implying the need for a relatively liberal approach to regulation in a 2013 report:[7]

Apps are one of the main new sources of innovation in the economy and remain an area of spectacular growth during this economic downturn. Mobile apps enable significant efficiency gains by improving the way people communicate, access information and obtain services. Apps extend the rich communication potential of the Internet beyond the traditional desktop computer and enable users to benefit from a myriad of information services practically anywhere or anytime they want. Economies rely on information to function effectively and the app economy represents a leap forward towards the goal of an informed and efficient knowledge-based society.

The app economy is extremely dynamic and evolving, and policy makers are keen to maximise its innovative potential and benefit for all sectors of the economy and society. Policy makers need to understand the mechanisms of the app economy in order to support innovation and ensure the maximum benefits possible for users.

During the 2015 ITU Global Symposium for Regulators (GSR), regulators from around the world discussed and adopted best practice guidelines on facilitating the uptake and widespread use of mobile applications and services through targeted regulation, Box 1 presents an extract of these guidelines.

Box 1: ITU Global Symposium for Regulators Best Practice Guidelines

For over 15 years, the ITU Global Symposium of Regulators (GSR) has brought together heads of national telecommunication/ICT regulatory authorities from around the world and has earned a reputation as the global annual venue for regulators to share their views and experiences. Every year, GSR adopts best practice guidelines on topical regulatory and policy issues.

In 2015, GSR adopted best practice guidelines to facilitate the widespread adoption and use of mobile applications and services through targeted regulation. They also urged regulators to simulate demand and protect consumers and suppliers, regulators recognized the importance of facilitating availability, access and use of m-services and digital apps by stating:

"*New generation networks are the foundation of innovation in the ICT sector and the engine for the development of m-services and applications. Therefore, we believe that unified rules for facilitating infrastructure deployment and open access to networks at national and regional level can strongly contribute towards stimulating the development of m-services and apps. Cooperation among all public authorities involved at the international, regional, national, and local levels is key to rapid, smooth and efficient implementation. Policy makers and regulators must be mindful of the importance of designing flexible, incentive based and market-oriented policy and regulatory frameworks with regard to spectrum allocation and assignment for mobile broadband services, so as to create trust and provide the necessary conditions for m-services and apps markets to thrive. The development of new markets and the industry for mobile devices need to be sustained through adequate regulatory measures, in particular in developing countries.*

Revisiting and reviewing, where necessary, current Government policies to make sure that they are still valid and appropriate for the new environment and ensuring privacy and security of government, business and consumer data may be necessary while open and collaborative regulatory frameworks are needed to promote the development of cross-cutting services such as m-commerce, m-banking and mobile money, as well as m-health. We recognize that creating a converged reference framework for competition, interconnection and interoperability can effectively facilitate the relationships among the various providers of infrastructure and services, as well as among them and apps and content providers.

[7] Working Party on the Information Economy, The App Economy, www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=DSTI/ICCP/IE(2012)1/FINAL&docLanguage=En

Recognizing that it may be commercially attractive to share network elements between service providers to avoid duplication costs, and provide opportunities for more m-services to be made available, regulators may consider promoting network sharing practices in all network and value chain layers while maintaining healthy competition between network providers. We believe that innovative, out-of-the-box measures should be put in place to stimulate the take-up of m-services and the creation of locally-relevant apps in remote and rural areas.

Among other measures, universal service strategies can be defined and the appropriate mechanisms used to create ICT incubators or for funding local developers and locally-relevant apps. We call for regulatory measures, private initiatives and partnerships to reduce the cost of m-services and apps in order to ensure equal and universal access. We further recognize that acquiring digital skills is essential for the wide take-up and efficient use of m-services and apps, and inclusive training programmes for different target groups need to be established. We reiterate the relevance and value of the GSR13 Best practice guidelines on the evolving roles of both regulation and the regulators in a digital environment; and of the GSR14 Best practice guidelines on consumer protection in a digital world."

Source: GSR 2015 Best practice guidelines

In addition, as part of the GSR17 consultation process, regulators were invited to identify innovative and collaborative policy, regulatory and business measures[8] needed to lift the barriers and achieve affordable access to the digital world in the following areas:

- **Infrastructure and connectivity**: Innovative measures at the international, national and local levels.
- **Consumer access**: To ICT services (subscription, plans, platforms and apps) and devices (smartphones, tablets, computed-based, etc.).
- **Market and business opportunities**: Market access, sustainable models, cross-sectoral approaches and economic incentives.
- **Funding and financing**: Private funding, partnerships, public financing and regulatory incentives to support affordability and sustainability in uneconomic markets.

The 2017 GSR best practice guidelines recognized that regulation has a pivotal role to play in encouraging today's fast-evolving markets to thrive while shaping future markets for digital services that are innovative, balanced and inclusive. The guidelines emphasised that more inclusive, incentive-based and collaboration-driven regulation will not only benefit consumers and businesses, but will help fast-track a digital future for the billions who remain unconnected[9].

ITU-D Study Group 1, in its 2014-2017 study period addressed over the top services (OTTs) in Question 1/1 Policy, regulatory and technical aspects of the migration from existing networks to broadband networks in developing countries, including next-generation networks, m-services, OTT services and the implementation of IPv6. Chapter 3 of the final report[10] presents the development and deployment of IP-based services and applications (OTT) services, and identifies four main objectives:

- policy tools to facilitate the availability to consumers at the local and national levels of competitive IP-based services and applications;
- alternative successful business arrangements that have been used to meet growing demand and other changes in the market;

8 www.itu.int/en/ITU-D/Conferences/GSR/Pages/GSR2017/GSR-17-Consultation.aspx
9 www.itu.int/en/ITU-D/Conferences/GSR/Documents/GSR2017/GSR17_Best%20Practice%20guidelines_E.pdf
10 ITU-D Study Group Question 1/1: www.itu.int/net4/ITU-D/CDS/sg/index.asp?lg=1&sp=2014

- best practices and policies that create incentives for investment in IP-based services and applications; and
- evaluate the challenges and provide an overview of best practices and guidelines regarding legal frameworks.

In addition, ITU-T Study Group 3[11] on Tariff and accounting principles and international telecommunication/ICT economic and policy issues, is dealing with the economic and regulatory impact of the Internet, convergence (services or infrastructure) and new services, such as over the top (OTT), on international telecommunication services and networks, discussion are under way[12].

In 2015, the European Commission launched its consultation on Online Platforms, Cloud and Data, Liability of Intermediaries, and the Collaborative Economy[13]. The Consultation is part of the Commission's assessment of the role of online platforms, promised in its Communications on a Digital Single Market Strategy for Europe on 6 May 2015. The enquiry asks whether platforms should be left to market dynamics, self-regulated or subject to regulatory measures

The European Commission has summarised the scope of the Consultation as:

the social and economic role of online platforms, transparency (e.g. in search results), terms of use, ratings and reviews, the use of information by platforms, the relation between platforms and their suppliers, the conditions of switching between comparable services offered by platforms, and the role of online intermediaries, including ways to tackle illegal content on the Internet.[14]

The latter has already generated a substantial level of commentary and debate within Europe and no doubt this is but the start of a broader dialogue in that market and globally. Industry stakeholders are concerned that the review will lead to developing unnecessary regulations for the Internet economy. This debate will undoubtedly play out in 2016 and beyond.

Irrespective of the approach (top-down, industry by industry, by the courts, etc.), for the app economy to thrive, legal provisions are needed, and at the same time the applicable body of law must not hamper the spread of innovation and progress within the app economy. This is indeed a balancing act especially since most regulation is national (or regional, in the case of Europe) when the app economy is in many ways global. In formulating the optimal approach for the regulation of the app economy, there is a need to address governments, regulators including both ICT and non-ICT regulators, and key stakeholders.

2.2 A regulatory taxonomy of the app economy

The rapid emergence of the app economy, coupled with its highly disruptive nature, has left policymakers around the world uncertain about what regulatory responses are appropriate. A key reason that it is so difficult to get an analytical handle on the app economy in order to form regulatory responses, is that, in reality, the app economy is not one thing. From a technological perspective, it is true that all apps run on the technology troika of the smart mobile device, mobile network, and cloud computing. Apps themselves, however, represent a dizzying diversity of functions and characteristics that span multiple types of users and industries.

From a regulatory perspective and, in particular, from the perspective of telecommunication regulations, the following categorisation is useful in developing an analytically grounded response to the

11 ITU Telecommunication Standardization Sector: www.itu.int/en/ITU-T/studygroups/2017-2020/03/Pages/default.aspx
12 www.itu.int/en/ITU-T/studygroups/2017-2020/03/Pages/questions.aspx
13 https://ec.europa.eu/digital-single-market/en/news/public-consultation-regulatory-environment-platforms-online-intermediaries-data-and-cloud
14 www.lexology.com/library/detail.aspx?g=9e8cbf28-c3ab-456d-b32d-0050a1e422d1

phenomenon on of the app economy. This categorisation starts with a distinction between 'pure OTT' app and 'bits and atoms' apps.

- **Pure OTT apps** exist entirely or primarily in the network. They may be messaging or communications apps transmitting voice, messages, image, video or they may offer a package of service, which in the case of Facebook includes publishing, content and contact management, messaging, scheduling etc.
- **Bits and atoms apps** use the network specifically to achieve some outcome in the world outside the network, for example: Uber provides an app designed to connect users seeking rides with car operators to move them to their desired location for a fee; AirBnB seeks to connect providers and users of accommodation; digital money apps seek to enable low value financial transactions at much lower charges than traditional banking systems.

These different types of app imply different types of regulatory response. In addition, there is a different and broader type of regulatory response required to the app economy *en masse* and this has to do with the competition and taxation implications of the rise of app economy companies with their sophisticated corporate structures. This is not specifically an app economy issue but is one that is exacerbated by hugely increasing value of economic activity in the app economy.

App economy companies are also characterised by the large role that intellectual property plays in their value creation. The ephemeral nature of intellectual property provides these companies with a great deal of flexibility regarding the geographic location of the value creation centres and therefore significant discretion regarding payment of taxation and duties. This is a concern to all governments as the app economy incorporates ever greater shares of economic activity.

Communications OTT apps

A communications OTT app is one that can be developed and deployed purely in software that runs on the user handset and in the cloud that primarily delivers communications services. A communications OTT app is one that provides communications services that compete directly with the offerings of the operators. There are many players in this category including: Viber, Line, WhatsApp, Wechat, Kakao Talk and Kik. Another is Skype, which, started on the desktop but has now migrated into the mobile handset as well.

Figure 5: Communications OTT players



Source: Wavestone, Challenges and impacts created by "over-the-top" (OTT) players In the African telecommunication sector, www.wavestone.com/app/uploads/2016/09/OTT_UK.pdf

Other OTT apps

There are a number of OTT apps that are not primarily providing communication services and are therefore not competing as directly with the operators as a communications app. There are dozens of social media apps[15] with most being relatively specialised, whereas a few of the bigger players such as Facebook and LinkedIn that not only offer messaging services, but continuously expand the functionality they offer their users, including communications features.

[15] See, for example, https://en.wikipedia.org/wiki/List_of_social_networking_websites

Given these trends, it is likely that there will be some future convergence between communications 'pure OTT' players and other 'pure OTT' players, particularly amongst the large-scale examples.

Industry specific *bits and atoms* apps

In contrast to the pure OTT apps, the bits and atoms players use apps and cloud-based systems to connect buyers and sellers for physical products. The leading examples in this category are AirBnB and Uber. These companies are using app-based software systems to achieve business processes in the physical world, such as providing taxi rides or accommodation services, in ways that are more efficient than the traditional business processes.

The reason that this category is distinctive from a regulatory perspective is that the disruptive effects are concentrated in the industry that is being targeted by these app companies- in this case the taxi and accommodation industries- and it is in these industries that the regulatory responses, if any, will be required.

Cross-industry disrupters

In contrast to the industry specific bits and atoms apps, cross industry disrupters are effectively in the process of creating new industrial sectors by using communications and computing hardware and services to create new kinds of product categories.

A leading example in this category are the video streaming players such as Netflix, Hulu, Amazon Instant Video, Sling Orange. These companies are having a massive disruptive effect on traditional broadcast and cable television companies and, on the production side, the Hollywood studio system. Again, these systems started life in the lounge room but they are now very much 'any device' offerings. Increasingly, television is becoming a 'big tablet' and a mobile phone a small television. These players have created a new kind of video service product that does away with the two-part, advertiser funded traditional model of free to air television, that also does away with time-based 'appointment viewing' and, through global scale in content production and management, delivers unprecedented consumer choice on a global scale. However, geographical restrictions still exist to protect certain business models and revenue streams, and policy and regulatory questions arise as to the regulation of such services and their content.

This is a category of app-based activity that clearly requires regulatory responses to be developed – preferably collaboratively- by broadcast, media and telecommunication regulators to be comprehensive and effective.

Another example of app-based cross industry disruption is the fintech sector (financial technology) including mobile money, which has emerged rapidly in Africa. Using communications networks to develop new businesses and systems for delivering a broad range of financial products is a significant growth sector in the app economy. Figure 6 groups fintech companies by the type of financial service being offered.

Again, the experience of M-PESA is of interest in relation to the need for 'collaborative regulation'. According to one member of the team that was responsible for setting up M-PESA[16], the Kenyan financial regulators were initially not very supportive of the concept even though their participation was encouraged. It's reasonable to assert that M-PESA was established in spite of collaborative regulation, not because of it, and the system would likely have been better implemented and more quickly adopted if financial and telecommunications regulators had collaborated earlier[17] (see Paul Makin's article in particular for a fascinating insider's account[18]).

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16 Regulatory Issues Around Mobile Banking, New initiatives to bank the poor are straining the world's financial regulatory systems, Paul Makin, OECD, http://www.oecd.org/ict/4d/43631885.pdf

17 ibid

18 ibid

Figure 6: Fintech companies and type of financial service



Source: BBVA presentation at the BoAML Digital Conference May, 2015, www.growadvisors.com/blog/fintech-innovation-forum-2015-innovating-business-in-asia

Mobile money apps are probably of such great significance that they justify their own category. This discussion also emphasises the importance of 'regulatory precursors', the pre-existing regulatory environment into which M-PESA was launched. For example, the fact that Kenya had a pre-existing identity card system greatly facilitated the 'know your customer' (KYC) regulatory requirement for providing financial services. The conclusion that can be drawn from such experience is that initial conditions are critical success factors (and they may not be apparent or obvious at the outset) and collaborative regulation will also contribute to success.

Types of app disruption and regulatory issues

There are some key regulatory elements and issues at the core of policy and regulatory debates along with critical questions including: [19]

1. **Net neutrality**: The open Internet net neutrality principle, which asks operators to treat all data equally, and not intentionally block or slow down traffic that competes with their own services. Net neutrality is also relevant to traffic management policies. Zero rating (when end customers are not charged for data used for specific Internet applications or services in capped data plans) is also currently a topic that is being discussed among regulators.
2. **Zero rating**: The practice of some mobile network operators not charging end customers for data used by specific applications or Internet services in capped data plans. Should mobile network operators (MNOs) be allowed this practice? Should regulators continue to apply a hands-off approach to business practices and commercial agreements between MNOs and other partners? Are there certain circumstances under which zero rating should be encouraged for example, programmes in which the ISP neither receives payment from the content provider nor charges the consumer for accessing content, programmes that are open to any content that meets the same technical criteria, or those designed to address a specific social need (such as connecting the public with government services)?

[19] GSR-17 discussion paper on communications regulation in the brave new world of the app economy also discussed these issues: www.itu.int/en/ITU-D/Conferences/GSR/Pages/GSR2017/default.aspx

3. **Market reviews**: When competition is considered not effective, regulatory measures aiming to address market failure can be imposed on dominant firms by national regulatory authorities (NRAs) after conducting a thorough market review.
4. **Consumer rights**: Certainly challenging for consumers to understand the impact of traffic management on their Internet use as it becomes more complex and widely used.
5. **Feasibility**: Telecommunication operator business model sustainability takes into account decreasing revenues and constant investment for increased bandwidth. For example, the European Union political (digital) agenda has demanding objectives.
6. **Competition**: Ensuring a level playing field between telecommunication operators and online service providers, and preventing anti-competitive behaviour, taking into account the market power.
7. **Innovation**: Online service providers provide innovative services for consumers. Heightened regulation risks destroying these benefits.
8. **Lowering the regulatory burden on traditional telecommunication operators:** Regulators should consider lowering the regulatory burden on telecommunication operators where other general consumer protection or other laws already cover the behaviour at issue.

2.2.1 Competition and macro level regulatory issues

The app economy has significant implications for each national economy, perhaps even more so in developing countries, the app economy has a critical role to play in economic growth and development. This is because the app economy can facilitate the development of markets and institutions more rapidly and at lower costs that is possible compared with the historical development processes that have occurred in some countries.

Along with these positive potentials for growth and development come significant regulatory challenges. These include the rising market power of companies in the app economy ecosystem, the discretion that transnational companies have in setting up structures that minimise taxation (where value creation is based on intellectual property), and the question of how best to facilitate the growth of the app economy within national borders while avoiding the risks and downsides.

2.2.2 Platform wars

The preceding discussion concerns regulatory responses to individual businesses or groups of businesses undertaking similar activities. At a larger scale, a number of issues related to but not exclusive to the app economy will very likely be of increasing focus in the years ahead.

One prominent example is the high-stakes ‘platform wars’ between companies such as Apple and Google (now Alphabet) or between Samsung and Apple. This is a contest that takes place on many fronts including: handset features, operating system features, the app ecosystem for each platform and so on. Box 2 provides an example of this ongoing contest between platforms.

Box 2: Platform wars

Google Voice is an app that adds certain calling features to phones. Google provides users with a distinct phone number and then redirects calls to other numbers of the user's choosing when calls arrive.

On 31 July 2009, the Federal Communications Commission (FCC) sent Apple, Google and AT&T letters of inquiry. The FCC inquiry focused on potential anticompetitive behaviour relating to an application that Google submitted for approval to the Apple App Store. Apple allegedly rejected the Google application and removed related third party software that used the Google Voice service.

- The FCC wanted to understand the reasoning behind the removal of the third-party software and the alleged rejection of the Google Voice application.
- The FCC required Apple to disclose specific details as to why it rejected the Google Voice application while allowing other applications with virtually identical features.

The matter was eventually resolved and the Google Voice app is now available

2.2.3 Market power and competition

Market power is shifting on a continuous basis and perhaps more rapidly than ever before. Apple, Google, Microsoft, and Amazon are, in some cases, an order of magnitude larger by market capitalisation than telecommunication operators around the globe, and changes to net neutrality rules will affect a wide range of negotiations between app economy, OTT and telecommunication companies.

Google faced anti-competitive objections from the EU 2015 for biases in search results. In July 2016, the EU alleged that Google was favouring its own comparison shopping services in search results and that results from its 'AdSense for Search' are also biased. The EU is also investigating whether Google gives preferential treatment to its own products, including Google Search and Chrome, in its Android operating system. The EU observes that "Device manufacturers are obliged to place Google Search and Chrome on the primary home screen of Android devices, as well as other Google apps, if they want to provide access to the Google Play Store- the single largest source of third-party Android apps"[20].

Even the largest jurisdictions in the world face significant challenges in bringing actions against companies the size of Apple and Google. It is difficult to imagine that much smaller jurisdictions in Africa will be able to exert a decisive influence on the behaviour of these companies.

2.2.4 Transnational corporate structures and taxation

Although the app economy has the potential to stimulate economic growth and create jobs and wealth, it comes with significant consequences in terms of taxation revenue national jurisdictions. One way in which taxation is lost can be seen by considering the way Uber, for example, affects the taxi business. When a driver acts as a driver for Uber, a commission on every fare is paid to the company. This payment is, in effect, for Uber services in coordinating drivers and passengers using its app and back-end systems. From a national accounting perspective, the Uber service represents an import of services and, to the extent that this replaces domestic economic activity, this represents a loss of a value added taxable activity in that country.

[20] European commission files third antitrust charge against Google, www.theguardian.com/technology/2016/jul/14/european-commission-files-third-antitrust-charge-against-google

This mechanism would not be of such concern except that transnational technology companies have enormous discretion in setting up their affairs so that they minimise tax payments, i.e. once economic activity is lost to the transnational, it is lost from the domestic economy tax base. It is only since 2009, following initial concerted action by G20 nations, that a broad-based effort to address taxation issues for transnational companies has really begun to gather momentum. The OECD Global Forum on Transparency and Exchange of Information for Tax Purposes now has 138 members and has positioned itself as the premier international body for ensuring the implementation of the internationally agreed standards of transparency and exchange of information in the area of taxation. The effort to address taxation of transnational technology companies is obviously one that cannot be undertaken except through extensive international cooperation.

There are clear signs that leading jurisdictions are becoming more aggressive on the taxation front, for example, the EU is currently in a protracted and complex action involving Ireland and Apple. The EU is claiming that it is owed around EUR 13 billion in tax concessions granted by Ireland to Apple.

The United Nations Second Committee (Economic and Financial) and the Economic and Social Council meeting in 2015 emphasised that developing countries are more vulnerable to economic and social losses due to tax avoidance than countries that have much larger and deeper tax bases. At the meeting Eric Mensah, Assistant Commissioner of Ghana Revenue Authority and Member of the United Nations Committee of Experts on International Cooperation in Tax Matters said that:

"… capacity-building was necessary in the areas of tax audit, transfer pricing and treaty negotiations, as developing countries needed the technical capacity to engage in international tax matters with the players on the international tax scene. From personal experience, he and his team of treaty negotiators had 'stumbled from one negotiation to the other, literally giving away taxing rights on a silver platter', but had benefited from capacity-building programmes by the international tax community, and were thus more able to effectively engage the system."[21]

The developing nations of Africa can contribute to the problem of international tax avoidance by participating in international forums that target transnational tax avoidance and by building the expertise of our public servants.

There is enormous pressure to find taxation revenue in the developing world and this pressure occurs in a context of underdeveloped taxation collection mechanisms and relatively poorly developed accounting systems in the public and private sectors. Under these circumstances there is a strong temptation to tax those products or services that are simply easy to tax. But a tax that is easy to levy from the perspective of government is not necessarily an efficient tax from a wider perspective.

Some countries in Africa, such as Congo, Ghana, Gabon, and Senegal, have taxed or are taxing inbound international calls in the form of a surtax on international inbound termination rates. This is an easy tax to impose because all such calls are recorded by operators and therefore the calculation of tax liability is simple.

A study by Deloitte[22] points to the consequences of this type of tax: reduced call volumes from overseas, lost export opportunities, reduced competitiveness, higher local business operating costs and so on. Such taxes are ultimately self-defeating because they discourage the growth economic activity and investment therefore leading, over time, to the economy and therefore the tax base being smaller than it otherwise would be. It is critical that all governments seek sources of revenue that are as efficient as possible and not on the basis of whether they are easy for government to collect or not.

In many cases, the app companies that disrupt traditional industries are transnational companies, and increasingly, particularly in the information technology sector, these companies have complex

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21 Combating Tax Evasion Especially Critical for Developing States, Second Committee, Economic and Social Council Meeting on Domestic Resource Mobilization, www.un.org/press/en/2015/gaef3438.doc.htm

22 Mobile taxation: Surtaxes on international incoming traffic, www.gsma.com/mobilefordevelopment/wp-content/uploads/2011/09/Mobile-taxation-Surtaxes-on-international-incoming-traffic-Executive-Summary-English.pdf

corporate structures designed to minimise taxation liabilities by providing great flexibility in determining where profits are realised. When such a company disrupts an existing industry, at least part of this industry is inadvertently 'internationalised' in the process. Take the example of Uber once again. Prior to Uber, taxi businesses tended to be local with 100 per cent of the value-added economic activity being local and these entities paying tax according to national laws. When Uber enters a country, that country in effect begins importing 'software mediated taxi logistical services' from Uber and some proportion of the country's tax base is lost to that national jurisdiction.

As information technology continues to account for an increasing proportion of national economic activity, national governments are losing their ability to tax such activity. Increasingly, these companies derive their value from intangibles such as patents and software, and this increases the flexibility in constructing centres of value in whatever jurisdictions they find most advantageous. This is not a problem peculiar to the app economy, but certainly the capacity that the app economy has demonstrated to draw ever greater domains of economic activity into the realm of software will certainly accelerate this phenomenon.

An earlier ITU GSR 2015 discussion paper on the impact of taxation on the digital economy identified the distortive effect of taxes in the digital eco-system on three levels: (i) Potential disparity in tax burdens imposed on telecommunication operators when compared to other operators of the digital eco-system (for example, digital advertisers, social networks); (ii) Taxes on asymmetry among global players in the digital sector and (iii) In country taxation asymmetry between the telecommunication sector and other providers of other goods and services[23]. This paper also recommends that, considering the impact of digital technologies on the economy, by increasing efficiency of production processes, facilitating the circulation of goods, creating new businesses, etc. the taxation of digital goods and services should be approached with care, preventing any erosion of their spill-over contribution to GDP growth. It has been shown that excessive taxing digital goods and services could limit adoption, restricting the positive contribution to GDP. Thus, the tax collected is outweighed by tax foregone on 'lost' GDP. In this sense, in developing fiscal policies, governments need to consider the trade-offs between revenue generation and the potential negative impact of the development of the digital sector.

2.3 Regulatory responses to the app economy

The app economy is incredibly diverse and an app economy taxonomy provides a more analytical basis for considering regulatory responses. Table 1 highlights the nature of regulatory issues for each type of app and the characteristics of appropriate regulatory responses.

Table 1: An app taxonomy and regulatory approaches

App type	Regulatory issues	Regulatory approaches
OTT Communications (e.g.: Whatsapp, Viber, Skype)	– falling margins and weakened market power for telecom operators – rising market power of OTT players – congestion of existing infrastructure – reduced telco margins and capacity for investment – OTT players don't pay taxes	– collaboration between telco regulators and other relevant government agencies such as those responsible for innovation – agencies for social inclusion and empowerment
Other OTT (e.g.: Facebook, LinkedIn, Google+)	– consumer protection, privacy, use of consumer data, the right to be forgotten, harassment and/or bullying on social media	– collaboration between consumer protection and telco regulators

[23] www.itu.int/en/ITU-D/Conferences/GSR/Pages/GSR2015/GSR15-discussion-paper.aspx

App type	Regulatory issues	Regulatory approaches
Bits and atoms (e.g.: Uber, AirBnB,	– maintenance of consumer protection standards in affected industries e.g. accommodation, taxi services – complex issues of finding a level playing field for providers with significantly different business models	– primarily responsibilities of regulators of affected industries but consultation with telco regulators likely to enhance regulatory outcomes
Cross-industry disrupters (e.g.: Netflix, M-PESA)	– financial stability, integrity of monetary policy – management of consumer funds, – protection of identity, know your customer requirements, prevention of illegal use, money laundering – encouraging production of local content and services over streaming channels	– collaboration between financial and telco regulators essential and also competition regulators – collaboration between telco regulators and media/broadcasting regulators
Competition and macro level	– Industrial disruption causing increases in market power within particular industries – competition issues arising from global reach of disrupters – taxation issues arising within particular industries due to disruption – nation and global level taxation issues arising from opportunistic corporate structures by global firms	– collaboration between competition authorities and taxation departments is critical – responses will include policy and legislative changes at the highest political level – international collaboration and agreement between policy makers and at the political level will be critical

Source: Systems Knowledge Concepts (www.skc.net.au)

The objective of this taxonomy is to provide some analytical framework for the various regulatory approaches that are most likely to be appropriate for each type of app economy disruption. For example, if a particular app appears to fit into the 'bits and atoms' category (see section 2.2), it is likely that the most effective regulatory responses to app-driven disruption will be from traditional industry regulators, for example, local city councils in the case of the accommodation industry. In contrast, in the case of cross industry disruptors, there is clearly a need for telecommunication regulators to collaborate with regulators of affected industries.

Perhaps the most obvious example where there is a need for comprehensive and widespread regulatory collaboration is the case of mobile money and, more generally, mobile financial services. As such, mobile money illustrates the challenges to achieving the regulatory innovation required to deliver the benefits of the app-economy.

The following section uses the example of mobile money to provide a specific example of the regulatory collaboration required to deliver an effective solution. There is widespread acceptance that regulation needs to be as light-touch as possible, flexible and adaptive and that collaborative regulation will be a necessary part of the mix of regulatory responses to the app economy. These are valid generalisations that there is a need for a more analytical approach in order to craft the range of variable regulatory responses that will be required to respond effectively to the diversity of the app economy.

The app economy is also highly dynamic. Regulatory frameworks must evolve as markets evolve – it is not possible to regulate the future into the past. In addition to technology neutrality, regulatory frameworks must also be as future-proofed as possible. Flexibility is arguably the key but there is little doubt that new arrangements, approaches and tools are likely to be necessary. As highlighted

above, some of those frameworks may need to be temporary and transitional, even experimental and tentative.

Supporting innovation is not, however, the only goal. There are some elements of regulation that ought to be immutable. These pillars include the need for effective competition policy – both between competing substitutable services and in the supply of connectivity, consumer protection, data protection and privacy, and that the services supplied especially to consumers of are merchantable quality.[24] Many systems of regulation have been in place and developed over long periods to protect consumers whether they be taxi passengers or the users of accommodation services or tenants entitled to the quiet enjoyment of their shared apartment buildings. These protections should not be allowed to be eroded because of the appearance of new intermediaries and new markets facilitated by apps however innovative those apps and markets may be. Taxation and the application of domestic laws on the international supply of services and content further highlight the complexity of this new environment and the upcoming challenges. The optimal approach to the app economy does not mean more regulation but better and flexible regulation.

2.3.1 Regulatory responses to OTT communications apps

OTT communications apps are radically disrupting the traditional economics and business of telecommunications, including in Africa. Telecommunications operators are alarmed at the impact on their relatively high margin services of voice and SMS revenues due to consumer uptake of OTT services. It is the communications OTT apps that present the most direct challenge to the traditional operators.

In considering regulatory responses to OTT services a useful starting point is the objective that underlies all telecommunication regulation: the long-term interest of end users (LTIE). In telecommunication regulation, the LTIE concept was defined in terms of traditional 'carriage services', a concept which is already obsolete. Nonetheless, regulatory decisions in relation to OTT services need to be formed in the context of maximising benefits for consumers and citizens. In all the debate concerning regulation of OTT services, none has made the claim that consumers do not benefit from the increasing sophistication and availability. Thus, the default regulatory position should be not to needlessly suppress the development and growth of OTT services. While the and immediate consumer benefits are clear, it is reasonable to be concerned that in the longer run, loss of revenues and margins for premium telco services may lead to decreased willingness or capacity to invest in new infrastructure. The counter to this argument is that operators are experiencing an explosion in demand for mobile bandwidth that is generated largely by OTT services.

From a more general perspective, the question arises to what extent any regulator or government should seek to accommodate or compensate incumbents in the face of technological or more generally, economic change. It is likely that any such accommodation will slow the process of change, which in turn is likely to limit productivity benefits and benefits to consumers, and which will eventually lead to a loss of national competitiveness and lower economic growth. Notwithstanding this perspective, telecommunication operators have called for a 'level playing field' and have argued that OTT players should not be exempt from regulatory impositions. Figure 7 shows that telecommunication regulation is complex and multifaceted and illustrates the significant differences in treatment between operators and OTT players.

Telecommunications is still relatively heavily regulated in most countries in the Africa region, and it is understandable that calls for some relief of regulatory burden in response to the emergence of OTT services. It is worth noting that in the taxi sector, which is also relatively highly legislated, changes in

[24] In other words, "*when the buyer, expressly or by implication, makes known to the seller the particular purpose for which the goods are required, so as to show that the buyer relies on the seller's skill or judgment, and the goods are of a description which it is in the course of the seller's business to supply (whether the seller is the manufacturer or not), there is an implied condition that the goods shall be reasonably fit for such purpose.*" See Sale of Goods Act, Queensland, 1896, section 17: www.austlii.edu.au/au/legis/qld/consol_act/soga1896128/s17.htm l

policy to accommodate ridesharing disrupters such as Uber have included compensation payments to the holders of existing taxi licences that have been substantially devalued.

The alternative perspective to the demands for a level playing field is one that suggests the telecommunication sector needs to accommodate current disruption and that existing telecommunication companies need to devise appropriate commercial responses. As noted above, telecommunication operators are seeing very rapid growth in demand for mobile data. In addition, new technologies such as LTE and voice-over LTE (VoLTE) reduce operating costs and allow high definition audio voice calls and therefore the ability to compete with OTT services on a quality basis. Box 3 suggests that significant growth is ahead for the South Africa telecommunication market.

Figure 7: Regulatory disparities between network operators and OTT

Area of Regulation	Network Operators	OTT
Licensing (ECS/ECNS) including annual fees, licence obligations and spectrum licence obligations	Yes	No
Interconnection and interoperability	Yes	No: OTT providers are per definition "over the top" of the network, and don't require interconnection.
Quality of Services (QoS)	Yes: End-User and Subscriber Service Charter	No: OTT QoS problems generally blamed on network provider, not the OTT
Universal Service Obligations (USO)	Yes, usually a license obligation.	No
Provision of legal intercept	Yes	No: OTT content often encrypted and cannot be intercepted. E.g. WhatsApp does not comply with South African RICA laws.
Financial reporting and taxation	Yes: All related laws and obligations apply	No: Offshore operators not obliged to adhere to national accounting standards, financial reporting systems. Most revenue realised outside of the country.
National ownership rules	Yes: National ownership and company structures designed to reverse historical injustices apply.	No: Offshore OTT operators not obliged to adhere to South Africa's company ownership rules and their transformative objectives
Consumer Protection Act, other National Socioeconomic obligations	Yes: Local operators and services providers must adhere to all personal and public protection laws and other social obligations.	No: Offshore OTT operators are not obliged to adhere to any of these laws and related social obligations such as labour laws, skills development levies, etc.

Source: Industry Briefing on Over the Top (OTT) Services in South Africa, Portfolio Committee on telecommunications and postal services, 26 January 2016

Box 3: PwC forecasts for the South Africa telecommunication market 2014-2018

According to PwC Annual Report on Entertainment and Media Outlook 2014 – 2018:

- Internet access in South Africa will generate more consumer spend than any other media product or service in the next five years.
- South Africa Internet access market is dominated by the mobile platform.
- 72 per cent of South Africa mobile phone users by the end of 2018 will be mobile Internet users (35.2 million people).
- A growing number of South Africans are able to be connected through mobile Internet connections including WiFi.
- It is expected that by the end of 2018 there will be an estimated 53.7 million HSPA subscriptions in South Africa. 3G and 3.5G will drive Internet growth as legacy GSM is phased out.
- Globally, mobile will generate 60 per cent of every dollar spent on Internet access by 2018.
- Increasing affordability of mobile broadband devices will contribute to the growth of the Internet market.

Source: Industry Briefing on Over the Top (OTT) Services in South Africa, Portfolio Committee on telecommunications and postal services, 26 January 2016

The South African Portfolio Committee articulated the following points which are reasonably widely shared among national regulators:

- OTT technologies, products and services are disruptive innovations that make the same product more affordable and accessible so that a far larger population can afford it, want it, and be able to use it.
- Disruptive Innovations are a natural and highly desirable consequence of technological evolution.
- They present new entrants and incumbents with new opportunities to create new products and services, and enable improvements and cost reductions of existing products and services thereby driving user demand and satisfaction upwards.
- They encourage traditional operators and service providers to leave their comfort zones of past successes, to become highly competitive innovators of new products and services.

In May 2016, Ghana Deputy Minister of Communication, Mr Ato Sarpong, announced that the Government, "*has no intention whatsoever of regulating the operations of over-the-top (OTT) in the country*"[25]. According to him the government wants new technologies to flourish in Ghana and so cannot implement policies to regulate its operations. Although the telecommunication sector had argued "the National Communication Authority and the Government should move in to regulate the operations of over- the- top (OTT) services in Ghana to enable players within the telecom industry stay in business."[26]

South Africa and Ghana have established a relatively liberal approach to regulating communications OTT services, at least for the time being. It may be, however, that as the situation evolves some of the outstanding and unresolved regulatory issues to do with security and privacy, among others, will need more proactive intervention in the operations of OTT players. It is also likely that in addition to some regulation of OTT players that some reduction in regulatory intervention for traditional operators

[25] www.biztechafrica.com/article/government-rules-out-ott-regulation-ghana/11345/
[26] ibid

may be deemed appropriate by regulators. This could include, for example, changes to or even the abolition of universal service obligations and/or quality of service requirements. As the Australian Media and Communications Authority comments in 2014:

"*Concepts such as a service provider of last resort underpin the traditional regulatory obligations of telecommunications universal service. For example, the universal service obligation requires the universal service provider to make a standard telephone service and/or payphone reasonably accessible to all Australians. This obligation is designed to achieve the social and economic good of all Australians being able to connect to each other and to emergency services, public services and general information services. There is potential in this emerging OTT service environment— where alternative network and service pathways can be established by an individual consumer—for this obligation to be achieved in ways other than a regulated service.*"[27]

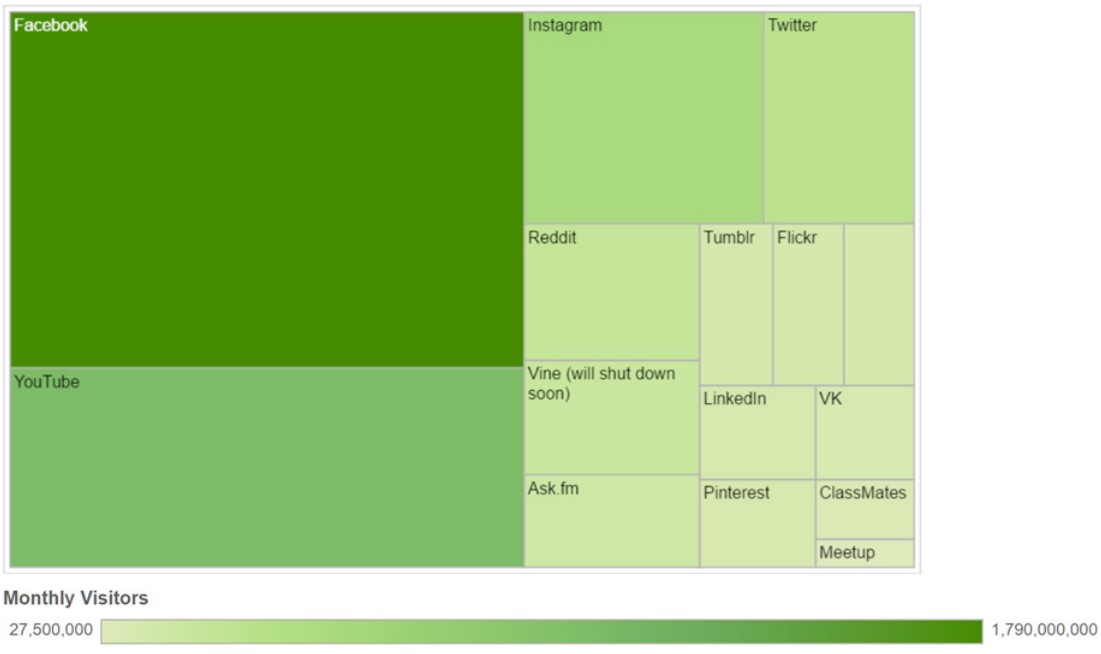
Perhaps the area in which the 'regulatory disparity' is most significant is in the areas of financial reporting and taxation. This issue is dealt with below under the heading of macro issues.

2.3.2 Regulatory responses to other OTT players

The main type of app in the 'other OTT player' category is undoubtedly social media companies. With Facebook recently becoming one of the top 10 largest publicly traded companies in the world, the regulation of social media cannot be regarded as a 'fringe issue' any longer.

The social media landscape is completely dominated by Facebook but other players such as LinkedIn, Pinterest, Instagram, Tumblr, Google+ attract users in the millions. As Figure 8 shows, Facebook monthly visits are in the billions.

Figure 8: Social media companies and their relative size in terms of user visits



Source: DreamGrow, Content Marketing & Social Media Information, www.dreamgrow.com/top-15-most-popular-social-networking-sites/

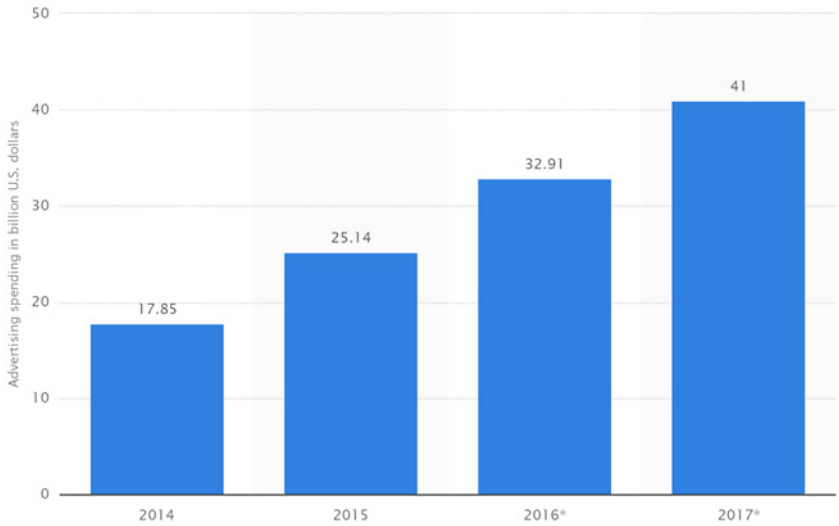
[27] ACMA, Six emerging trends in media and communications, Occasional paper November 2014, www.acma.gov.au/~/media/Research%20and%20Analysis/Research/pdf/Six%20emerging%20trends%20in%20media%20and%20communications_Final%20pdf.pdf

Forrester Consulting identifies five main areas of regulatory concerns with respect to social media:

1. Data protection and privacy: Laws and regulations that ensure customer rights to privacy are covered (and appropriately stated in public privacy statements) when organizations collect, store, and use social media data. Example regulation: The proposed EU General Data Protection Regulation, including the "right to be forgotten" provision.
2. Employee rights: Guidelines that dictate how companies can construct social media policies as well as to what extent they can monitor the activity of current employees and prospective hires. Example regulation: The National Labor Relations Act, which the National Labor Relations Board has cited to push companies such as Target and Costco to rewrite their social media rules.
3. Disclosure and third-party endorsement: Proper protocols for product marketing, endorsements, and disclosure of corporate financial information, ensuring these activities take place in a "clear and conspicuous" manner on social media, and that social features, such as Facebook "likes" and Twitter "re-tweets," are appropriate. Example regulation: The Federal Trade Commission updated .COM Disclosures Guidance.
4. Governance and oversight: Rules that require companies to establish proper processes, controls, and monitoring for worker business use of social media. Example regulation: Federal Financial Institutions Examination Council proposed Social Media Consumer Compliance Risk Management Guidance.
5. Information archiving and retention: Parameters that specify how and in what circumstances organizations should capture and retain social media conversations for the purposes of legal holds and investigations, treating social media as another form of electronic communications. Example regulation: Financial Industry Regulatory Authority Regulatory Notices 10-06 and 11-39.[28]

This regulatory agenda clearly requires participation from a wide range of regulatory agencies and a collaborative regulation approach is likely to minimise the complexity and maximise the effectiveness of regulatory responses. In addition to these regulatory concerns, it is likely that the larger social media players will eventually attract the attention of competition authorities. Social media advertising revenue continues to grow rapidly reaching an estimated USD 41 billion in 2017 (see Figure 9), and the industry is relatively concentrated with Facebook being clearly dominant.

Figure 9: Social network advertising revenue from 2014 to 2017 (USD billions)



Source: Statista, www.statista.com/statistics/271406/advertising-revenue-of-social-networks-worldwide/

[28] Five Common Legal & Regulatory Challenges With Social Media Posted by Nick Hayes, http://blogs.forrester.com/nick_hayes/13-07-31-five_common_legal_regulatory_challenges_with_social_media

2.3.3 Regulatory responses to bits and atoms apps

As described in the taxonomy above, bits and atoms apps use the infrastructure of the app economy to create new forms of intermediation between buyers and sellers creating new markets, and new sources of supply that tend to undercut and disrupt traditional businesses that occupy these markets. There are hundreds of examples that exploit numerous niches creating ever more specialised submarkets including sharing of garden tools, sharing car with neighbours, finding people to do odd jobs, bicycle sharing and so on.

Many, if not most, of these enterprises fall beneath the radar of regulators and it is difficult to generalise about when regulatory intervention may or may not be appropriate given their number and diversity. One generalisation that is likely to be valid, however, is that if such enterprises do need some form of regulatory intervention that primary responsibility will be with the regulators who are already concerned with the industry.

To use the example of Uber and AirBnB once again, regulators of the taxi industry are primarily concerned with the Uber and the other ride-sharing companies. The impacts of AirBnB on local communities have drawn responses from local city councils.

Last month Airbnb abandoned legal action against the City and State of New York and lost a major court case in San Francisco. Berlin has banned holiday letting in residential apartments, Barcelona has fined them twice for breaching tourism laws, Amsterdam has imposed a whole-home limit of 60 nights per year and Vienna has demanded that Airbnb hosts pay tourist tax. Even Queenstown in New Zealand is getting in on the act, raising council rates by 25 per cent for 800 holiday letting hosts. On a much larger scale, in London, Airbnb agreed to restrict listings to 90 nights per year if the properties do not have planning permission, at an estimated potential cost of USD 500 million a year in lost revenue. [29]

Because the bits and atoms app players do not compete directly with the telecommunication operators, regulatory issues in telecommunications are generally not raised by their existence and growth.

2.3.4 Regulatory responses to cross industry disrupters

Cross industry disrupters are using the telecommunication system to create new business models using new telecommunication based communications and delivery systems. They are different to the bits and atoms apps in that they do not just take an existing service and decrease transactions costs thereby expanding the market (although this is part of what they do), rather, they create new types of activity bringing services to new consumers usually at dramatically lower costs compared with substitute products. Since they make such intense use of telecommunication services and disrupt traditional industries, regulatory responses need to be distinctly collaborative in order to formulate effective responses. In the Africa context, there is little doubt that the emergence of mobile money services represents the most important development in this category. See Box 4 for main points from a recent ITU paper on mobile money on the need for mobile money systems and associated barriers.

[29] Murray Cox: The Australian pricking Airbnb's global bubble, www.domain.com.au/news/murray-cox-the-australian-pricking-airbnbs-global-bubble-20170120-gtulnp/

Box 4: Key points on need for mobile money solutions and barriers

Digital financial services: Regulating for financial inclusion- an ICT perspective

Access to financial services is a crucial enabler of economic and social development. Until recently, policy efforts to develop financial services focused on the formal banking sector and its intermediating function in converting savings into investment. This meant that the wealthy, urban population enjoyed access to financial services while financial institutions neglected low income population segments (who generated low or negative returns) and rural areas (which required costly bricks and mortar branches).

Barriers to financial inclusion on the demand side include:

- affordability, such as high interest rates on loans, high premiums on insurance products, minimum balances on accounts and high deposit account fees;
- awareness and understanding, both as to availability of products and how they are structured, priced and used;
- accessibility, with financial products typically offered in urban centres and near high income users, and subject to heavy bureaucratic processes; and
- desirability, with many products not designed for the needs of low income users.

Many would save through hiding cash, and borrow from friends and family or unlicensed money lenders – with all of their implications of limited capacity, security risks and high costs. A minority of the population in developing countries have held bank accounts. Banks have traditionally not pursued low income and rural populations, as returns would not justify the capital and operating costs of a brick and mortar branch and ATM networks. Traditional lending involves substantial costs including due diligence and credit risk assessment, as well as arranging collateral, which also faces delays and legal uncertainties in many countries.

Source: www.itu.int/dms_pub/itu-d/opb/pref/D-PREF-BB.REG_OUT02-2016-PDF-E.pdf

2.4 Mobile money

It sounds like a simple enough idea: enable mobile phone users to transfer money between each other using their phones. And while it is true that the concept is relatively straightforward, the reality is that the regulatory demands are relatively high for this new type of financial service.

It is a simple observation to say that the disruptive power of the app economy arises from the technology providing consumers with new ways to do old things. But these new approaches often create new regulatory challenges. Mobile money potentially has profound economic consequences for Africa and this means considerable effort should be focused on creating the regulatory environment that facilitates its growth and development. This does not mean the risks and needs for regulatory intervention should be ignored but that regulatory responses should be measured and directed towards facilitation rather than blocking mobile money initiatives.

Activities such as managing bank accounts, transferring money and accessing credit have been evolving for hundreds of years and while these services are available to everyone in advanced economies, many of the world's poor do not have access to banking services. Mobile money services provide access to these traditional banking functions but at much reduced transaction costs per user and per transaction. Given the existence of mobile coverage and relatively high mobile device penetration, mobile money systems can be deployed relatively easily, at least compared with the real-world alternative of physical bank branches and the larger traditional banking system. Nonetheless, the

developers of mobile money systems are, to some degree, taking on the functions of a bank, which means engaging with the significant regulatory landscape that surrounds banking. This last point emphasises the fact that the term 'bank' it is not an absolute. Rather, there are a range of functions undertaken by a range of entities. In fact, the various types of activities undertaken by financial entities and the regulatory constraints that apply to them is the basis for significant differentiation in financial services and financial activities that occur in advanced economies.

The emergence of mobile money in developing economies can be viewed as a technologically enabled response to the demand for banking services that cannot be provided to lower income populations on a commercially viable basis using old technologies and methods. Thus, the first point to make about regulatory issues in mobile money is that regulatory responses need to be commensurate with the type and level of services that are being offered through mobile money systems. Put in another way, it is inappropriate to impose on a mobile money system that provides simple account management and transfers, the full weight of regulatory requirements that would be imposed on a full service bank. Such heavy-handed regulatory impositions will only undercut the viability of mobile money initiatives therefore depriving lower income consumers of these important banking services.

2.4.1 Regulatory collaboration and the M-PESA experience

Returning to the example of M-PESA provides insights about what types of regulatory approaches will either facilitate or inhibit the development of mobile money systems and how these regulatory approaches can be put in place. Paul Makin, writing for the OECD[30]

"Many of the mobile initiatives are partially – in some cases wholly – led by non-bank organisations that are traditionally outside the scope of financial regulation, and with whom the financial regulator has traditionally had little or no contact. This has naturally led to concern amongst [financial] regulators, and, for good or bad, threatens to disrupt the regulation of the financial sector in many of these countries."

Makin points out that financial regulators are responsible for the security of the national financial system, a role that is tremendously important for economic stability and the welfare of citizens. While the financial regulators of developing economies also understand that extending the reach of financial services is critical for development, they typically regard this goal as substantially subservient to the broader economic goals. Traditional financial regulators tend to be careful towards innovation largely because of unfamiliarity.

"A lack of familiarity with non-bank institutions has also been raised. Generally, regulators feel comfortable with their existing relationships with the banks and other financial institutions they regulate – they know what figures and reports to look at, and they are familiar with the levers available to them to influence those institutions' operations. Of course, there is no reason why any other institution should not be able to provide similar satisfactory mechanisms, but this is a question of familiarity."[31]

Makin who was involved with the conception and development of M-PESA, describes the initial resistance of the financial community in Kenya:

"Notable by its absence from the list of partners in M-PESA is any member of the Kenyan financial community, with the exception of the Commercial Bank of Africa (CBA), who provide commercial banking services to M-PESA. This absence has caused something approaching outrage in some of the regulators we have spoken to. This was not for want of trying. The M-PESA team spent many hours, over a period of weeks, talking to as many high-profile members of the Kenyan financial community as possible, in the hope of recruiting a partner. Perhaps they were suspicious of becoming involved with a mobile operator, or perhaps they felt that the proposal was too radical, and doomed to fail.

30 Regulatory Issues Around Mobile Banking: New initiatives to bank the poor are straining the world's financial regulatory systems, Paul Makin; www.oecd.org/ict/4d/43631885.pdf

31 ibid

Whatever the reason, no suitable financial sector partner could be found, and so eventually Vodafone and Safaricom decided to go ahead without one."[32]

While this lack of financial partners is not optimal, it is nonetheless unsurprising. The boards of traditional banks face difficult decisions in responding to app driven disruption of their markets. Even though banks have few customers among the very poor, they may nonetheless perceive that they may lose future, or even existing, customers to new financial service offerings. This resistance may be one of the significant barriers to such deployments and innovation.

In the case of M-PESA, the financial regulators at least were supportive:

"In this regard, the [M-PESA development] team were very fortunate to have a regulator who was not only careful to ensure that his responsibilities to the Kenyan economy in general, and to the financial sector in particular, were fully satisfied, but who also viewed the aim of "extending the reach and depth of financial services" as a high priority, and to that end was willing to explore new ideas, and listen to potential new market entrants."[33]

Some of the factors in the development of M-PESA that were critical in winning the support of financial regulator included:

- comprehensive reporting and management tools on the system side enabling detailed reporting of every transaction;
- full compliance with the Kenya anti-money laundering legislation, which was, at the time, still in draft form;
- although not offering a full range of financial services, M-PESA sought to behave like a fully-regulated financial institution;
- the pre-existing Kenya identity card scheme.

This last factor was particularly important:

"*The M-PESA team were lucky in Kenya – there is an established national ID card scheme in place, and so M-PESA is able to rely on that (as an aside, many have suggested that the Kenyan ID card scheme is less than perfect. It doesn't matter; it's a national ID scheme, and the Kenyan Government stands behind it, and that's sufficient). The advantage this confers on a scheme becomes obvious when the difficulties experienced by schemes launched in other countries without ID cards are examined, such as M-PESA's own launch in Tanzania."*[34]

In summary, the experience of the development of M-PESA provides useful lessons regarding current and future mobile money systems and for the development and regulation of app driven services in other industries. Figure 10 illustrates the regulatory issues and relevant regulatory agencies in responding to mobile money innovation.

[32] ibid
[33] ibid
[34] ibid

Figure 10: Mobile money regulatory issues and areas for regulatory collaboration

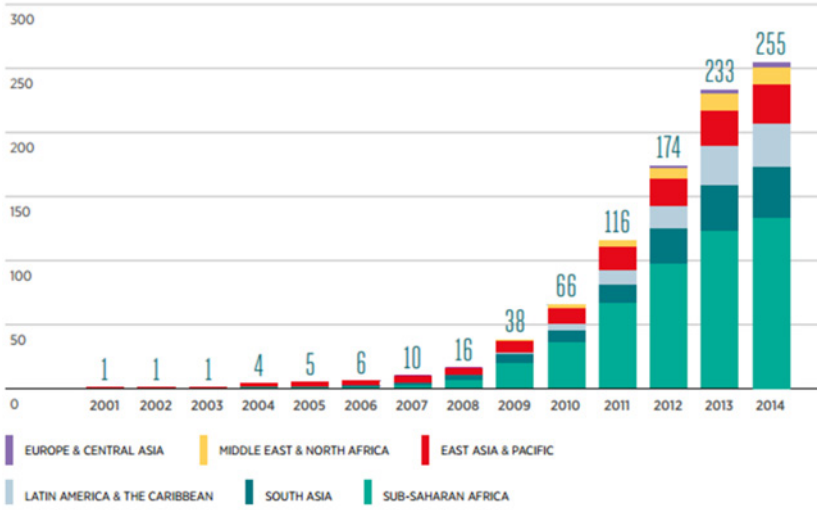


Source: Systems Knowledge Concepts (www.skc.net.au)

2.4.2 Further progress in mobile money

The success of M-PESA has encouraged the deployment of many mobile money systems around the world. Figure 11 illustrates the growth in mobile money services by region from 2001 to 2014. By 2014, there were over 250 live mobile money services in almost 90 countries with the number of mobile accounts reaching almost 300 million supported by about 2.3 million mobile money outlets[35].

Figure 11: Mobile money services by region (2001-2014)



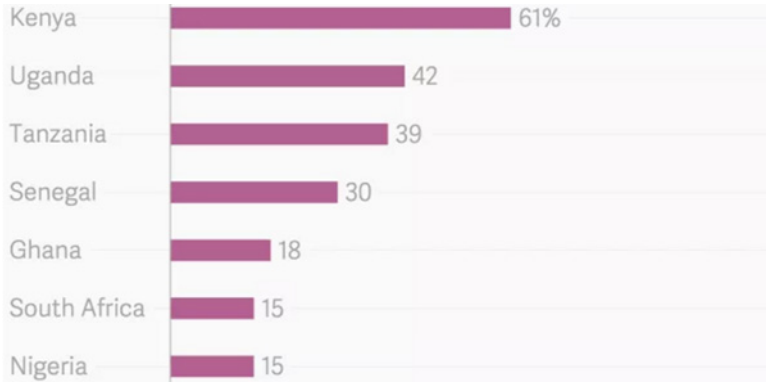
Source: GSMA, Mobile Money: Landscape, Regulation, & Sustainability, presentation at Axiata Group Regulatory Meeting 8 October, 2015

[35] *"In the case of mobile money, an agent outlet is a location where one or several mobile money agents are contracted to facilitate transactions for users. The most important of these are cash-in and cash-out (i.e. loading value into the mobile money system, and then converting it back out again); in many instances, agents register new customers too. Agents usually earn commissions for performing these services."* www.gsma.com/mobilefordevelopment/wp-content/uploads/2016/04/SOTIR_2015.pdf

Figure 12 shows the proportion of African cell phone users of mobile payments. It indicates significant progress with the majority of Kenyans having mobile accounts, and six other Africa region countries making significant progress.

The existence of accounts per se, however, is not sufficient for mobile money to have a significant effect on financial empowerment and positive impacts on economic activity. Accounts need to be supported by a sufficient number of mobile money outlets and their needs to be a sufficient number of individuals, businesses and government agencies willing to conduct transactions mobile payments

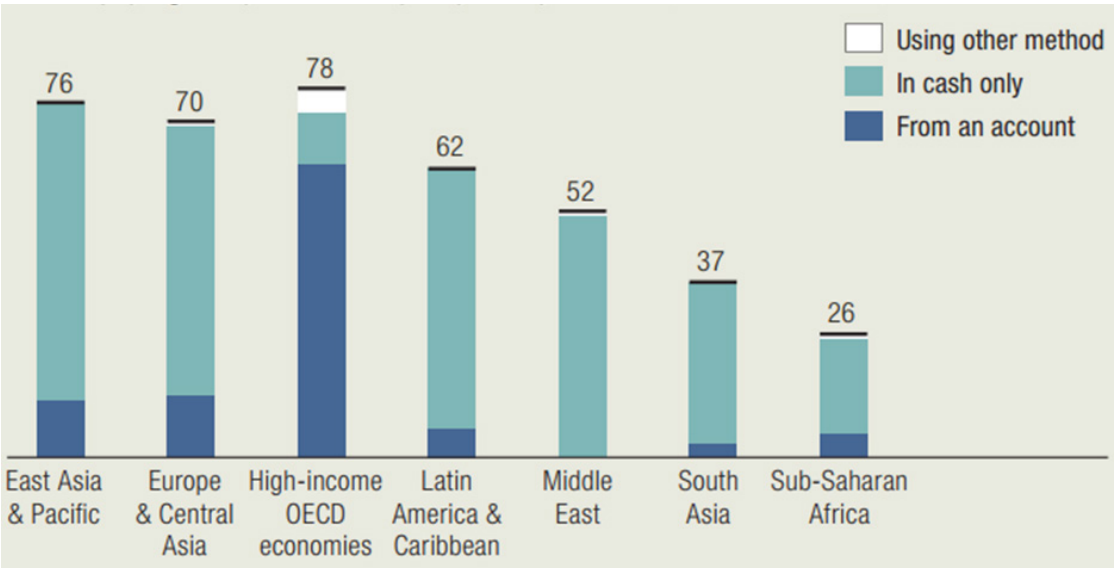
Figure 12: Where cell phone owners use mobile phones for payments (Africa 2014)



Source: www.africanbusinesscentral.com/2015/04/16/the-top-7-african-countries-for-mobile-money-infographics/

Figure 13 shows that, in sub-Sahara Africa, cash is still by far the dominant form of payment for utilities. The contrast between high income OECD countries and sub-Sahara Africa is stark. Only South Asia and the Middle East make a lower proportion of utility payments from an account[36].

Figure 13: How utilities are paid: Adults paying utility bills in the past year, by method (as per cent of all adults), 2014



Source: The World Bank, Development Research Group, Finance and Private Sector Development Team, April 2015, Policy Research Working Paper 7255, The Global Findex Database 2014, Measuring Financial Inclusion around the World

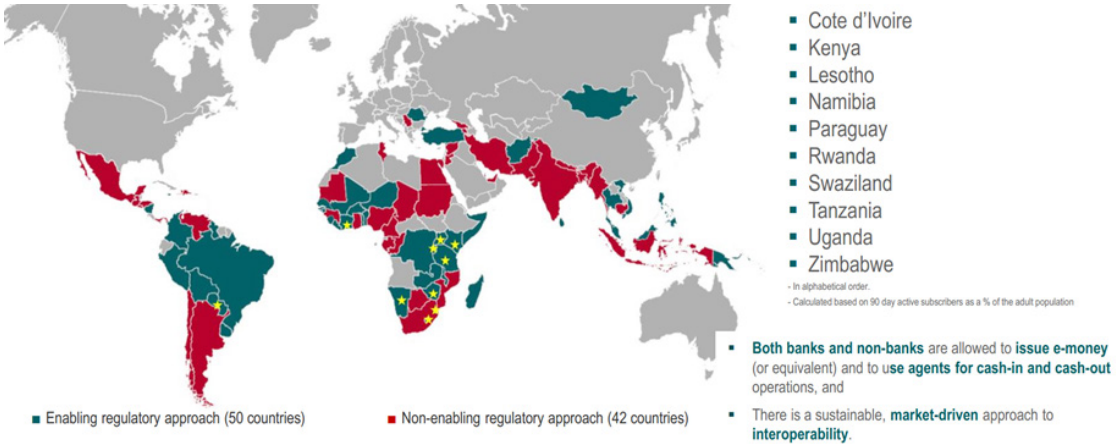
[36] An account at a bank or another type of financial institution or with a mobile money provider.

Notwithstanding the success of M-PESA, mobile money systems are still developing in many countries, and it success varies widely between different countries, with many countries yet to adopt mobile money, and even among those that have, growth has faltered and sputtered in many. The number of substantial revenue generating mobile money operators is limited, even if it is growing. Only 15 mobile money providers had monthly revenues greater than USD 1 million in 2015, three of these were not MNOs, and only twelve had over one million 'active accounts.' For all the waiting time saved paying utilities by mobile money instead of cash, even these are still largely paid in cash. Cash remains predominant even in Kenya, where M-Pesa has been deeply integrated into daily economic life (though where payment is made electronically, the main means is mobile money)[37].

In South Africa, in May 2016, Vodacom decided to close down its South Africa implementation of M-PESA.[38] The reasons discussed for the failure in South Africa included the different demographic of South Africa compared with Kenya, a pre-existing higher-level of financial inclusion in South Africa, the fact that the South Africa telecommunication market is more competitive, and that banking regulations in South Africa are stricter than in Kenya. No doubt the factors are complex but it is highly likely that South Africa banking regulation played a part in M-PESA not succeeding.

In contrast to the South Africa experience, in Ghana, in 2015, the bank of Ghana published new guidelines aimed at providing mobile money operators increase freedom to set up their systems. This change enabled mobile operators to set up their own mobile money systems without requiring them to have traditional banks as partners. The changes also included simpler registration processes for customers. The difficulty or otherwise of registration and identification processes is another important regulatory variable. As noted above, the pre-existing Kenya identity card system was regarded as an important factor in the success of M-PESA in Kenya. Figure 14 shows that the countries where mobile money is most successful are those where both banks and nonbanks are allowed to issue e-money and use agents for cash-in and cash-out operations and where there is a market driven approach to interoperability between mobile money systems.

Figure 14: The top 10 markets with the highest mobile money penetration have a very similar regulatory approach



Source: Mobile Money: Landscape, Regulation, & Sustainability Axiata Group Regulatory Meeting 8 October, 2015

[37] GDDFI discussion paper, Digital financial services: regulating for financial inclusion an ICT perspective, Macmillan Keck Attorneys & Solicitors.

[38] Why M-Pesa 'will never work in South Africa', Sunday Times, www.timeslive.co.za/sundaytimes/businesstimes/2016/06/05/Why-M-Pesa-will-never-work-in-South-Africa

Mobile money has been in operation now for long enough for longitudinal statistical analysis to be viable. A recent article titled *The long-run poverty and gender impacts of mobile money*, concludes that:

"… access to the Kenyan mobile money system M-PESA increased per capita consumption levels and lifted 194,000 households, or 2% of Kenyan households, out of poverty. The impacts, which are more pronounced for female-headed households, appear to be driven by changes in financial behavior—in particular, increased financial resilience and saving—and labor market outcomes, such as occupational choice, especially for women, who moved out of agriculture and into business. Mobile money has therefore increased the efficiency of the allocation of consumption over time while allowing a more efficient allocation of labor, resulting in a meaningful reduction of poverty in Kenya."[39]

This analysis points to the value of mobile money systems and underscores the importance of adopting appropriate regulatory settings to promote its long-term and multidimensional success. The important conclusions are that:

- pre-existing regulatory and institutional arrangements will have a significant bearing on the success of mobile money systems (e.g. a pre-existing citizen identification system, a relatively liberal banking legislation);
- new mobile money operators that provide simple financial services such as account balances and funds transfer should not be treated as if they are banks because they do not undertake the more sophisticated banking functions such as lending, undertaking complex investments, and offering a variety of sophisticated financial products to depositors;
- regulatory responses need to be measured, for example, if there are concerns regarding money laundering these can be dealt with by imposing relatively low maximum daily transaction limits;
- many concerns about accountability can be addressed by ensuring that sophisticated software systems underpin mobile money systems that enable detailed scrutiny of individual transactions and provide tools for aggregate analysis.

The early success of M-PESA in Kenya and early successes elsewhere is encouraging for the growth of financial inclusion. It could still turn out, however, that mobile money systems end up being successful in fewer countries than would be the case if regulatory settings were more favourable. It should also be pointed out that 'success' is a multidimensional concept. Success means that account holders constitute a high proportion of the population, that they use mobile money services often for a significant proportion of their transactions, and, in general, use mobile money services in such a way that delivers them long-term economic benefits. All these dimensions of success need to be facilitated by the appropriate regulatory settings.

2.4.3 Video streaming services

One area of app economy activity that raises issues for broadcast and telecommunication regulators is video streaming. While video streaming is more about *bits* than it is about *atoms*, the video streaming industry is disrupting traditional broadcasting in ways quite similar to the disruptions by players such as Uber and AirBnB.

At a high level, the streaming phenomenon represents the shift of video content from the broadcasting distribution mechanism to digital transmission over telecommunication systems. Netflix, one of the largest players in this space has experienced very rapid growth. When the company added a record 7.05 million subscribers, it was almost two million more new viewers than even Netflix expected, with a fair number of them overseas, streaming services in 190 countries, and 47 per cent of its subscribers living somewhere other than the United States.[40]

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[39] Science 354 (6317), 1288-1292. [doi: 10.1126/science.aah5309] Tavneet Suri and William Jack (December 8, 2016) The long-run poverty and gender impacts of mobile money

[40] Wired, Netflix Is Killing It—Big Time—After Pouring Cash Into Original Shows, www.wired.com/2017/01/netflix-investing-original-shows-finally-pays-off/?mbid=nl_12017_p3&CNDID=44683374

In 2016, Netflix spent around USD 6 billion on original programming and this figure is expected to rise to USD 7 billion in 2017. Netflix is a prime example of the phenomenon of 'the race for scale' – as builds its subscriber base it can afford more original programming which makes it more attractive to subscribers while, at the same time, it can reduce its infrastructure costs per subscriber making it more efficient than its rivals. It is not, however, all plain sailing for Netflix. It has struggled to achieve uptake in some markets in Asia-Pacific region. It will take time for Netflix to establish content that is suitable for non-English speaking markets and markets that are culturally quite different to the United States market.

Broadcasting regulators have been concerned for decades with promoting local content in their broadcasting markets. While this has been relatively straightforward when broadcasting was wholly internal to particular jurisdictions, dealing with the global phenomenon of video streaming presents a different set of challenges. As traditional broadcasters see their advertising revenue decline, they are less able to fund local production leading to concerns about loss of domestic cultural identity.

Video is very demanding of telecommunication bandwidth and, in Africa where landline penetration is very low, it is likely that video streaming services are not as great a near term competitive threat to traditional broadcasters as it is in countries where landline penetration is high and xDSL or fibre is available to the home. As the rollout of 4G and LTE services continues and as more spectrum becomes available, streaming services over wireless broadband will inevitably compete more with traditional broadcasting.

2.5 Guidelines and recommendations on regulatory approaches to the app economy

Given the above, the suggested advice to businesses as well as to ICT policy makers and regulators in relation to future regulation for the app economy in particular relating to its intersection with the telecommunications/ICT sector is set out in Box 5 and Box 6.

Box 5: Suggested advice to businesses in addressing sector regulators and stakeholders

Be collaborative (rather than defensive) with regulators: The app economy is a new concept and as new business models are involved these may be unfamiliar to existing market players including regulators. Increasing understanding takes time. There is often an assumption that sharing economy firms are trying to make a profit by skirting the regulations 'traditional' industries face. Without explaining the nature of your firm clearly to regulators you will likely be regulated as a traditional market player not as say, an intermediary (providing a platform for consumers rather than providing services directly) resulting in higher taxes and requirements.

Be responsive to regulators' legitimate concerns: Many app economy business models do raise legitimate concerns about user safety, privacy and access. These need to be addressed such that entities proposing new models should make compelling arguments they would believe if they were regulators.

Use state of the art approaches to reaching out to government: The best practices in approaching government include, forming coalitions and industry associations to represent a shared point of view rather than each company approaching regulators independently and only in times of crisis. There is a need to be an active participant, taking part in open consultations, seeking place on the decision-making table, being open and transparent about one's expectations and the challenges ahead. Further, app economy firms should seek outside validation from external third party stakeholders.

Share your data: Data need not be made public in order to share it with Government, and can help your case by reducing regulator concerns.

Make a well-researched case for the value provided by your firm: Rather than relying on maxims about the usefulness of the app economy, it helps to have concrete data.

Find the best regulations out there and share them with the Government: Governments are often under-resourced and many existing rules are simply out-dated and are not relevant given the business model of app economy firms. There's no reason firms themselves cannot find the best rules out there and propose such optimal rules. Having said that, industry has specific (and often technical) knowledge and experience of business that they could contribute to the discussion – in order to avoid decisions and regulation not solidly grounded.

Source: ITU modified version of Sarah Cannon and Lawrence H Summers, *How Uber and the Sharing Economy can win over regulators*, Harvard Business Review, 13 October 2014.[1]

[1] https://hbr.org/2014/10/how-uber-and-the-sharing-economy-can-win-over-regulators/

Box 6: Suggested advice to government and telecommunications/ICT regulators

Undertake a review of the regulations applicable to network operators and OTT players: Assess whether such regulations are appropriate, whether forbearance should be applied to network operators, whether additional rules should apply to OTT providers and map how regulation of market participants – especially for substitute/competing services- should converge over time. Likewise review content regulation to ensure in a global market with greater levels of realism (e.g. virtual reality and similar) are appropriate and consistent with domestic conditions and cultural policy objectives. A key element of such a review is to consider market definitions and whether such definitions currently permit a differentiated regulatory treatment for OTT.

Update the licence conditions and as required provide deeming provisions for non-resident OTT providers etc.: Update analogue/legacy licence conditions so as to reflect the move to digital/IP services and as required enact legislative amendments to provide for deeming provisions (e.g. to be say, a special class licence) for non-resident OTT providers etc.

Assess and continually monitor the state of competition in the market. It is critical to assess and critically monitor the state of competition in ICT markets. Ensure there are no gaps in regulation between telecommunication regulators and general competition regulators including where services are offered from outside the jurisdiction. Promote competition whilst recognising that ICT services markets are no longer national and that there is a range of competing services which are domiciled domestically. Ensure that operators with significant market power do not foreclose or significantly dampen the innovative service offerings and OTT services. Further, acknowledge as outlined earlier in this paper that while initially they may have provided strong disruptive competition, as new digital businesses grow and scale almost exponentially, they may be tempted to exercise their market power. Regulators will need to be watchful that the digital economies of scale and scope are not exploited contrary to law.

Collaborate with tax authorities: Ensure that there is, to the extent possible a level playing field for competing services. Such analysis should include the applicable income and value added taxes applicable to competing services.

Promote and facilitate ubiquitous broadband: Recognising the political, economic and societal need for ubiquitous broadband formulate policies to facilitate nationwide broadband using a mix of cable/fibre, wireless, satellite and other technologies. In particular, given the growing importance of wireless broadband to the meeting of global broadband density targets that there is sufficient International Mobile Telecommunications (IMT) spectrum of at least 760 MHz but preferably 840 MHz IMT spectrum available and allocated to such services by 2020. In addition, to promote investment in backhaul transmission and higher speed broadband services in urban/economically viable regions.

Ensure adequate and up to date data protection, privacy and cyber security legislation based on global exemplars: Ensure that domestic legislation for data protection, privacy and cyber security is based on global exemplars and that agencies charged with ensuring compliance and promoting education are properly resourced and staffed by experts. The scope of such legislation should be wide and include legacy and new systems including the Internet of Things (IoT). It is also critical to enact digital identification (digital ID) legislation.

Establish co-ordination procedures between regulators: Establish co-ordination procedures between communications sector regulators and regulators of broadcasting/content (if separate), competition, financial services and privacy/data protection to ensure consistent regulation and comprehensive inter-working arrangements.

Engage in greater public awareness and advocacy campaigns in relation to digital/ICT services: It is important that the public including all sections and age groups in society are well-informed as to their digital rights and responsibilities.

Regulators must engage more broadly with education and training sector: As many skills needed in the future and indeed the jobs of the future are very different from today, there is a role for sector stakeholders lead by the regulator to engage with Education and training Ministries, universities, tertiary institutions, schools and other places of learning to ensure that curriculum and syllabus reflect the app economy and the move to a digital society.

Source: GSR-16 Discussion paper, The race for scale: market power, regulation and the app economy

3 Opportunities and challenges for the app economy in Africa

3.1 Opportunities and challenges

To say that Africa is both an opportunity and a challenge for app economy companies is both true and something of a cliché. It is an opportunity because there are many areas of large population with potentially high rates of economic growth that are starting from a relatively low level of income per capita and a low level of smartphone penetration. Since the demand for mobile services is income elastic, the demand for these services can be expected to grow very rapidly over the next decade or two as more economies develop in the Africa region.

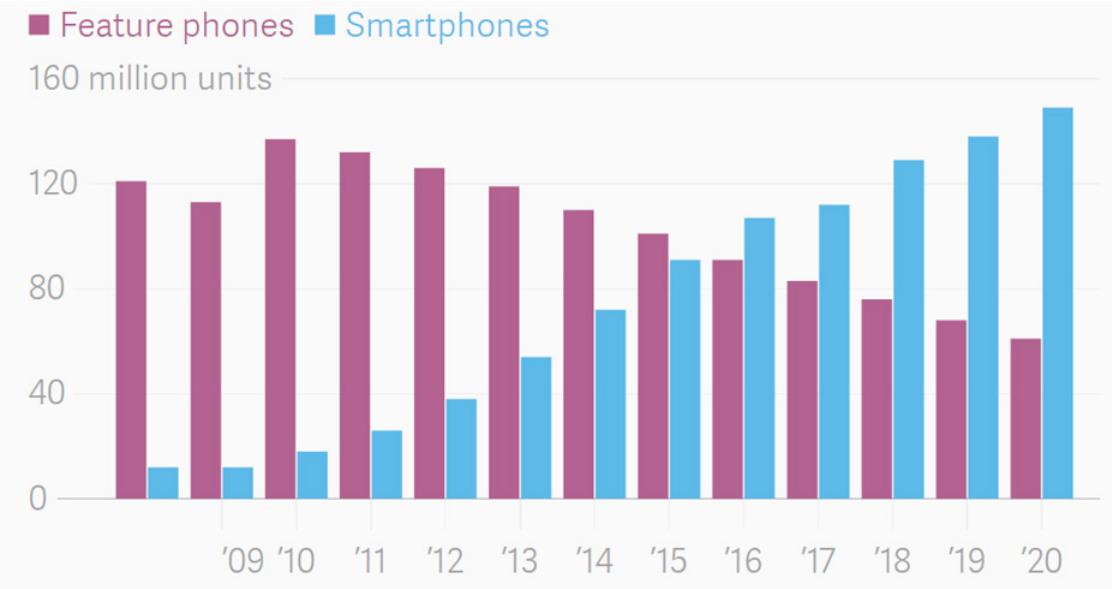
Figure 15: Mobile network rollout in Africa



Source: Wavestone, Challenges and impacts created by "over-the-top" (OTT) players In the African telecommunication sector: www.wavestone.com/app/uploads/2016/09/OTT_UK.pdf

As Figure 15 shows, 4G rollouts are proceeding rapidly. Extensive mobile coverage and high smartphone ownership are the preconditions for app economy take-off, and the Africa region is moving quickly towards being an app-ready region. As Figure 16 shows, smartphone shipments have already overtaken those of feature phones. The projections by Statista show smart phones dominating by 2020 but even this scenario may be relatively conservative if the price of entry level smartphones continues to fall at current rates.

Figure 16: Annual mobile phone shipments in Africa



Source: Jefferies & Co via Statista | Projections from 2011 onwards http://qz.com/451844/africas-smartphone-market-is-on-the-rise-as-affordable-handsets-spur-growth/

On the other hand, Africa is coming late to the app economy party. The large players are already well-established, primarily in the United States, but also in Europe, China, and Japan, and these players are among the largest companies in the world by market capitalisation. To some extent, this closes off certain possibilities for app companies in Africa. Nonetheless, the experience of M-PESA points the way to the kind of development that is hugely valuable in the Africa region context and has created opportunities for many across the continent and beyond to participate in the digital economy. China has a unique online and app ecosystem show that significant opportunities arise within national borders for the app economy. While it is true that developments within China have much to do with restrictions on Internet traffic, it is also true that, with the app economy still less than 10 years old, there is a long way to go yet and it is likely that many more unique opportunities will arise in Africa.

3.2 The nature of the app economy opportunity

The mobile phone is driving social and economic transformation everywhere, not least in the Africa region and this positive perspective on the prospects for the app economy in Africa is based on several factors including:

- apps are relatively cheap to produce (compared with traditional desktop software) and the major platforms of Android and iOS provide commodity distribution services at very low cost to app developers;
- the cost of basic simple smartphones is falling rapidly and they will soon be within reach of the majority of people in the Africa region;
- mobile phone coverage in Africa is rapidly improving and in many areas rollouts may leapfrog quickly to LTE delivering high speeds and advanced functionality;
- there are many unique economic contexts within the Africa region that create opportunities for unique African solutions, and while these are not yet at the scale of companies such as Facebook or AirBnB, they nonetheless represent opportunities from which further development can take place in the future.

In essence, these factors mean that app-driven responses to a range of unique challenges faced by people in the Africa region because of poor infrastructure, underdeveloped markets and, in some cases, weak institutions, will create a large appetite for app solutions that address these problems.

The ethos pervading this new ecosystem — centred in Nairobi, Lagos and Johannesburg but with offshoots across Africa — was encapsulated recently by Mark Essien, creator of one of the first hotel booking websites in Nigeria. Far from being a handicap, the deficit in physical infrastructure such as landlines and indeed railways, provides the Africa region with a unique chance to step ahead, he argued at a recent Lagos conference, "*… the future of technology for Africa is not in playing catch-up. But in looking at the things we lack and using each of those gaps as an opportunity for us to invent something we can use to leapfrog the rest of the world*".

The first big leap came with the adoption of mobile phones. The next wave of technological advances are occurring as high speed Internet and smartphone handsets become more accessible. Already there is an app developed in Africa for almost everything: herding cattle in Kenya (i-Cow), private security in Ghana (hei julor!), remotely monitoring patients in Zimbabwe (Econet) and in Uganda, an Uber-like service (Yoza) connecting dirty laundry to mobile washerwomen. Married to this explosion of creative endeavour are the continent demographics — over 70 per cent of the fast urbanising population are under 30.

Another way of thinking about the potential of the app economy in Africa is from the perspective of a branch of economics called 'new institutional economics'. This is an area of economics that emphasises the importance of 'institutions' in the economic development of nations. Institutions can take the form of formal legal rules and regulation, and of informal social norms, as well as the central governance organisations such as the courts, universities, regulatory authorities, central banks and government itself. The concept of institutions in this body of economics includes, critically, well-functioning markets.

Institutions are a kind of 'invisible infrastructure' that, like physical infrastructure, enables societies and economies to function more efficiently. A country may have access to cutting-edge technology, but if it lacks efficient education systems and programmes, effective policy making, rule of law, or well-functioning markets, or if its political systems are unstable, it is unlikely it will prosper economically in the long-term. Good institutions provide effective laws and regulation, provide the certainty that supports investment and enable markets to function efficiently.

Over the past two decades there has been much discussion of the process of 'telecommunication leapfrogging' that has taken place around the developing world as new and improving mobile communications technologies have delivered mature services without the need to deploy expensive landlines.

Enhanced connectivity achieved through telecommunication technology, especially as it matures into the converged app economy, offers Africa not only the usual benefits of improved productivity and efficiency that are associated with advances in many technologies, but also new ways to develop and improve its institutions and potentially, leapfrog many of the institutional development processes that have occurred elsewhere over hundreds of years.

Consider a specific example. The development of the banking system entailed many processes including legislation and regulation, the growth of physical banking infrastructure – branches, offices etc. – and the development of regulatory organisations and administrative processes. In the app economy, the combination of cheap and ubiquitous smartphones, mobile coverage, and mobile money software applications have enabled the development of functioning banking systems more quickly at much lower cost and everywhere.

While there is no substitute for good governance and well-functioning political systems, mobile communications technologies combined with emerging software innovations such as blockchain (the technology that underlies bitcoin) have the potential to deliver institutional infrastructure and the associated economic development benefits far more quickly than has been possible in the past.

These changes can probably happen more quickly than most people believe. The Ericsson mobility report for 2016 estimates that mobile subscriptions in Africa are approaching one billion (see Figure 17). While there are obviously flaws in comparing the single nation subcontinent of India with the 54 heterogeneous nations of Africa, the two are in a remarkably similar phase of telecommunication development. Both have around 1 billion mobile subscribers and in the first quarter of 2016, India added 21 million new subscribers and Africa added 16 million. Mobile penetration rate for the two countries is almost identical with Africa at 81 per cent and India at 80 per cent.

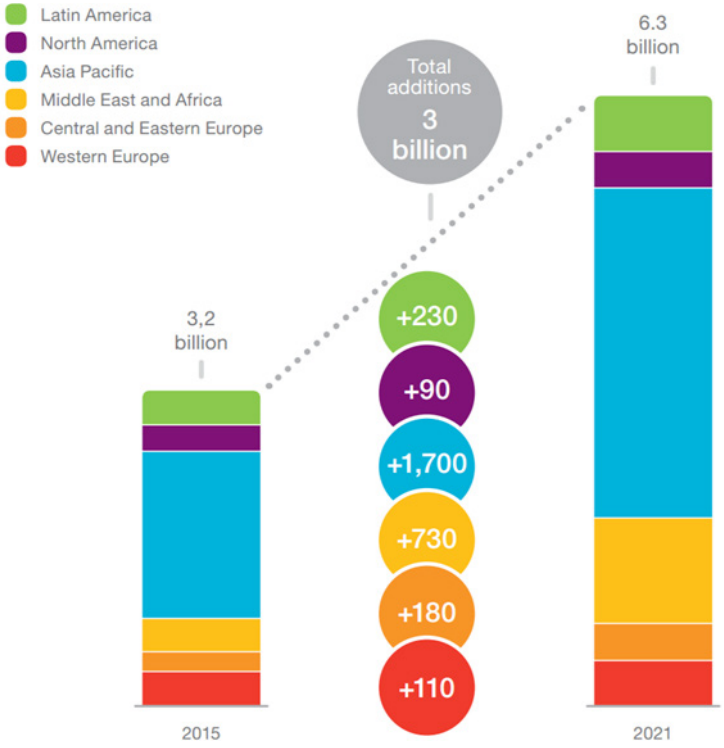
Figure 17: Mobile subscriptions (millions)



Source: https://www.ericsson.com/res/docs/2016/ericsson-mobility-report-2016.pdf

Of course, the app economy runs better on smart phones than on the simple feature phones that are still common in Africa. A critical question for the development of the app economy is how quickly Africa can convert its stock of feature phones into smartphones. Again, the answer is, probably more quickly than most people expect. Ericsson expects there will be an increase of around 730 million smartphone subscriptions in the Africa and Middle East region by 2021 (see Figure 18).

Figure 18: Mobile subscriptions (millions)



Source: www.ericsson.com/res/docs/2016/ericsson-mobility-report-2016.pdf

With entry-level smartphones below USD 50 now appearing in the marketplace[41], a smartphone in Africa today, in real terms, probably costs less than a feature phone did in Africa 10 years ago when the race to 1 billion subscriptions was just getting started. Thus, Africa has the culture, the need, mobile coverage and the affordable handsets that will enable it to become ubiquitously app-capable very soon. No doubt the app economy will deliver many economic benefits to Africa, but will it become a region of app consumers or will it take place in the global community of app developers?

3.3 Challenges for Africa in building the app economy

App development is taking place across the globe, but as Figure 19 shows, it is highly concentrated in the United States, Europe, China and Southeast Asia. Add to this the fact that the major platform owners, Apple and Alphabet, are United States based and it is easy to understand concerns that smaller, less economically developed countries may miss out on the benefits of being creators and producers in the app economy.

[41] https://www.techchange.org/2014/07/30/cheap-smartphones-under-50-dollars/

Figure 19: Global locations of app developers



Source: Wavestone, Challenges and impacts created by "over-the-top" (OTT) players In the African telecommunication sector, https://www.wavestone.com/app/uploads/2016/09/OTT_UK.pdf

Recent research to take a comparative development view on how well the global app economy serves developers and international trade flows, based on a survey of data from the Apple and Android app stores, sought to answer questions such as: Who is successfully making apps? Who is making money, and in what markets? How do the structure and design of the app stores affect value capture and trade? In broad terms, their analysis concludes:

"… despite its egalitarian appeal, developer participation in the app economy is heavily skewed toward the largest and richest economies, with the United States, Japan, and China dominant. Because the app markets function as winner-take-all markets, the top-ranked apps in the most-lucrative markets earn multiple orders of magnitude more revenue than low-ranked apps in markets of the Global South. The result is that 95% of the estimated industry value is being captured by just the top 10 producing countries. For lower-income countries, the outlook is relatively bleak: Most have very few developers, and even those who had significant numbers of developers—for example, India—earned very little revenue; as a group, the 19 lower-income countries in our sample earned an estimated 1% of global app economy revenues. Even the much-hyped "Silicon Savannah" of East Africa was mostly absent from the data."[42]

These conclusions are no doubt somewhat gloomy in terms of the potential for the app economy to contribute to economic development in less developed nations. The Caribou report examines the numbers of developers in various countries, the numbers of apps that they produce and, critically, the revenues associated with these apps.

Figure 20 shows the relatively small number of developers in Africa (that register in the top app store rankings) compared with Europe and, of course, the number of developers in the United States is greater again. The Caribou report also notes that the United States is still the dominant region of app development but that East Asia is rising in significance and that this represents a significant change from the preceding era of software development for the personal computer:

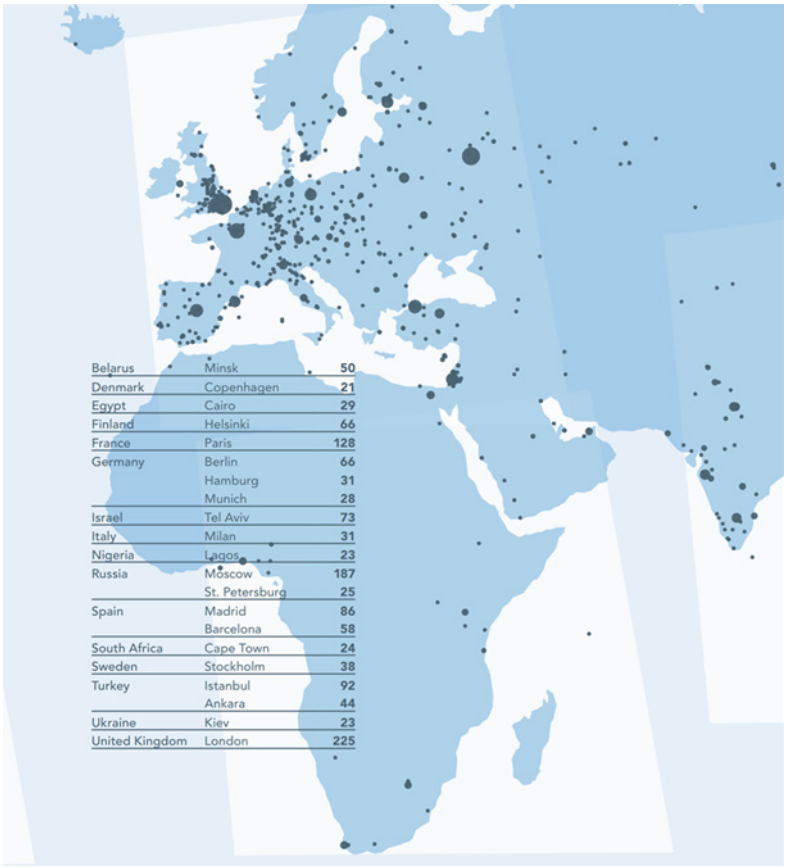
"Compared to the PC era of software development, the mobile app landscape shows a clear shift in gravity away from the West and toward East Asia. The United States is still the leader, which is

[42] *Winners & Losers in the Global App Economy*, Bryan Pon, Caribou Digital. http://cariboudigital.net/wp-content/uploads/2016/02/Caribou-Digital-Winners-and-Losers-in-the-Global-App-Economy-2016.pdf

unsurprising given its dominant historical role in computing and software development, but Western Europe in particular seems to be playing a lesser role compared to the large Asian economies. This landscape is strikingly different from the PC software sector, where as recently as 2011, 70 of the top 100 packaged software companies globally were American. Of the remaining 30 firms, 19 were from Europe, 4 were from Japan, 1 was from China. In the app economy, China (#2), South Korea (#4), and Japan (#6) have all become top-ranked countries in terms of commercially successful app developers."

This geographic shift is a significant phenomenon and worth considering in the context of possible future development paths for the app economy in Africa. One of the primary impacts of the two main app platforms and app stores is a hugely reduced cost of app development and app marketing distribution compared with the PC software market. This changing economics of software production and distribution means that apps can be developed to address far smaller niches, be they geographic, functional, age-related, or language-based or whatever other relatively narrow characteristic of the target market might be in the sights of niche app developers.

Figure 20: Where are the developers?



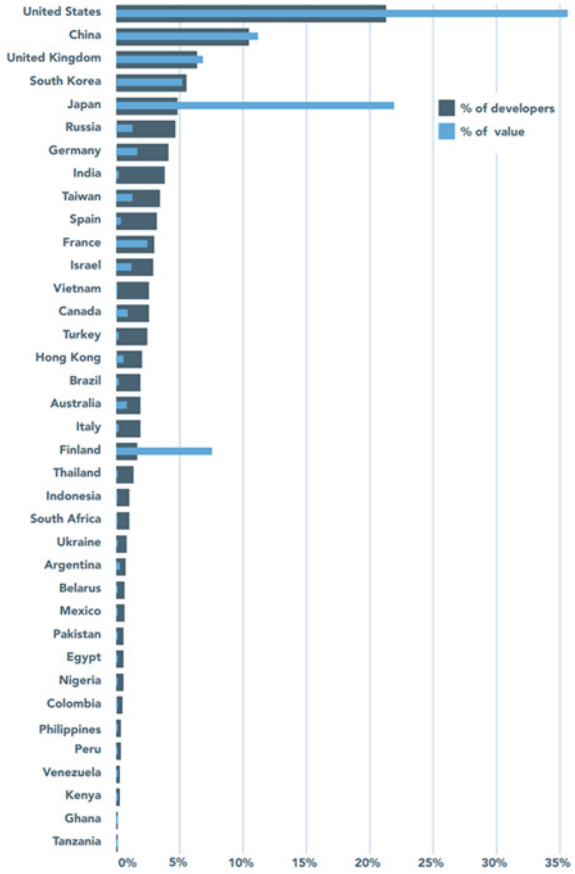
Source: Winners & Losers in the Global App Economy, Caribou Digital, 2016

This theme of local context and niche development will be treated later in this report. The other significant factor in app development is, of course, the much larger market for apps compared with PC software. As the Caribou report puts it:

"The more likely explanation for the large number of developers in these countries is the rapid increase in demand for apps, as large middle-class populations and relatively fast wireless networks have spurred rapid smartphone adoption. Because of their singular languages and other cultural preferences, this demand is most easily met by local producers, which further helps spur domestic production. In fact, we see that in general, the highest revenue-generating markets produce the highest number of successful developers."

The Caribou report also focuses on revenue flows and Figure 21 illustrates the fact that, there are large differences between each country's share of the number of app developers and its share of app revenues. The United States, for example, has around 22 per cent of the world's developers but earns about 36 per cent of global app revenue. Japan and Finland are other standout performers.

Figure 21: Relative share of developers and value capture across 37 markets.



Source: Winners & Losers in the Global App Economy, Caribou Digital, 2016

One of the important conclusions from this analysis from the Africa region perspective is that countries with smaller economies and lower income per capita tend to underperform in terms of value capture from the app economy. The underlying challenges of scale and market size are, in the case of many Africa region nations, exacerbated by policies particularly in the Google app store.

Google only allows developers in certain countries to monetize their products through the Google Play app store: Developers who want to earn revenue from Android apps on the Google Play app store are required to set up a merchant account, which is what links their bank account to Google so that they can receive funds from the app store. However, Google merchant accounts are not available in 74 countries, with half of sub-Sahara Africa and much of Latin America excluded. Again, according to the *Winners & Losers in the Global App Economy* 2016 report, Google employee described the process as "*very complex and [involving] business negotiations between Google and the government of the countries in question. It can involve additionally complex subjects such as tax laws, currency exchange, and export laws*." While not every developer is trying to directly commercialize apps, it is reasonable to assume that the inability to monetize an app directly through the app store is a deterrent for participation. This exclusion of particular countries from Google app store revenue is a significant problem and the governments of affected countries should be encouraged to actively seek arrangements with Google that will enable app developers to charge for their products on the app store.

4 The app economy in South Africa and Ghana

This section provides an overview of the app economy in the case study countries of Ghana and South Africa.

4.1 South Africa

4.1.1 App developers

The countries in sub-Sahara Africa all showed very similar patterns: apps developed in the United States dominate market share, with almost no local app production. US market share in this region was highest of all the non-English dominant regions. South Africa was highest on the list of countries in the Africa region to register developers, but the narrow width of its value flow indicates local South Africa apps were low-ranking.[43]

4.1.2 Phone/app use

South Africa is experiencing growth in smartphone penetration and mobile app usage with a Mobile Marketing Association South Africa report showing that 17.7 million of the 37.2 million adult population make use of mobile apps or access the Internet via their smartphones. The uptake of mobile per capita in South Africa is among the highest anywhere in the world and, despite security and educational challenges around the adoption of mobile apps, uptake is increasing.[44] The country also leads in mobile application downloads in sub-Sahara Africa.

Helped by the establishment of enabling regulatory and competitive environments that encourage investment, 4G is gaining traction in South Africa. In South Africa, the Vodacom 4G network now covers 40 per cent of the population, providing a solid platform for growth.[45]

While a specific monetary figure has not been determined for the size of the app economy, the presence of 29 million smart devices in the hands of South Africa consumers is cited as a significant indicator of the potential growth of apps and their use in the country. Most new phones bought by consumers are smartphones, as the price point of entry-level smartphones – ZAR 500 – has dropped sufficiently to put them within reach of any citizen who can afford a phone. The growth rate of the market is estimated at 20 per cent a year.[46]

Spending on mobile applications in South Africa could surge from 31 million this year to 220 million in 2017. This is according to a Pyramid research study that says growth in the adoption of smartphones, increasing availability of apps and various new payment methods could result in greater demand for mobile applications. Other factors potentially driving up mobile app demand include undersea broadband connections such as the West Africa Cable System (WACS) enabling higher bandwidth and lower data prices.[47]

4.1.3 App distribution

Google prohibits developers in South Africa from monetizing directly through its app store. This means that developers are either restricted to free apps on Google Play or have to work through partners registered as merchants on another continent.[48]

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43 "*84 developers, or on a per capita basis, 1.5/million*": Winners and Losers in the Global App Economy, 2016, Caribou Digital

44 www.smesouthafrica.co.za/16149/Why-you-should-take-advantage-of-SAs-mobile-app-usage-growth/

45 https://www.gsmaintelligence.com/research/?file=721eb3d4b80a36451202d0473b3c4a63&download

46 http://zappzone.co.za/status-south-africas-app-economy/

47 www.itwebafrica.com/mobile/320-south-africa/230360-sa-mobile-apps-spending-to-hit-220mn-in-2017

48 https://support.google.com/googleplay/android-developer/table/3539140?hl=en

4.1.4 Challenges for app developers

In South Africa, there is a tendency for enterprises to do much of their development abroad. While this is often unavoidable, sometimes due to the shortage of skills, this may mean that enterprises miss opportunities from better localisation of their apps through inability to work closely with developers.[49] There is a skills shortage for mobile app developers in South Africa, and this means that many companies charge very high rates to develop apps. It also means that many of the app development projects are outsourced to countries like India where labour is cheaper.[50]

One challenge is the unlikely problem of a significant amount of enterprise development funding being available to support South Africa developers – in this case, too much money weakens the app ecosystem. While funding is crucial to take an app from idea to implementation, funding in South Africa is currently available through a variety of dispersed funding mechanisms, with little control to ensure that only truly worthwhile ideas are supported through to completion. Enterprise development managers are not usually equipped to evaluate the viability of mobile applications, leading to lots of investment with few good outcomes.

Another challenge in South Africa is that the skills shortage in this arena will become more pronounced as the app economy grows. More developer skills will be needed, and we can expect to see new coding schools springing up across the country over the next few years. However, these are not the only skills needed in this new app ecosystem. Designing user experience and interfaces is an art, and demand will grow for people skilled at building intuitive, user-friendly interfaces. In addition, successfully taking new applications to market will require business acumen and entrepreneurship, so there will be growing demand for business and management skills in the developer ecosystem.[51]

4.1.5 Regulatory developments for the app economy in South Africa

In January 2016, the Portfolio Committee on Telecommunications and Postal Services, of the South Africa Parliament, published an Industry Briefing on Over the Top (OTT) Services in South Africa.[52] This briefing emphasized the wide range of differences in regulatory treatment between traditional operators and OTT players including: licensing and licensing fees, spectrum licence obligations, interconnection and interoperability, quality of service, universal service obligations, provision of legal intercept, financial reporting and taxation, national ownership rules and compliance with consumer protection and other national socio-economic obligations.

The briefing also nicely articulated the high level policy dilemma posed by disruptive innovation. Large successful corporations such as the major operators were described as vital for the nation's wealth, well-being and social stability and important because of their jobs creation and contribution to social development. On the other hand, particularly in the technology industries, continuous innovation is required in order to remain competitive. To some degree, the processes of innovation and disruption are inseparable and new innovative companies will capture at least some of the customers of the incumbents.

In September 2016, the South Africa Government published a major document, the National Integrated ICT Policy White Paper. This is a broad ranging document but it does address specifically the South Africa policy on OTT services as follows:

49 www.smesouthafrica.co.za/16149/Why-you-should-take-advantage-of-SAs-mobile-app-usage-growth/
50 https://dreamweavedigital.co.za/the-cost-of-app-development/
51 http://ventureburn.com/2015/06/ibm-hopes-catalyse-south-africas-app-economy/
52 http://pmg-assets.s3-website-eu-west-1.amazonaws.com/160126SACF.pdf

"The ITU's guidance on the regulatory approach to over the top (OTT) is instructive in considering the approach to these and other services and will inform the policy-maker and regulator's approach. It has stated that:

- *Proliferation of content and applications services is to be welcomed as they introduce choice and innovation to users.*
- *Change is inevitable. As network operators migrate to next generation networks, voice services will become software applications riding over the network. Policy-makers need to find ways to balance innovation, investment and competition during this transition period.*
- *Regulators cannot hold back innovation and change to maintain the status quo.*
- *These changes are disruptive and inconvenient for those with a stake in existing arrangements, but the benefits of change to users outweigh the costs.*

Government is of the view in line with this that there is no need to immediately regulate Over-The-Top (OTT) services but that this position should be regularly reviewed by the regulator, based on the considerations detailed above."[53]

This relatively open position on OTT services contrasts with the South Africa approach to Uber. South Africa is one of the jurisdictions where there have been incidents of violence between traditional taxi drivers and Uber drivers. In March 2016, the South Africa Cabinet approved a new transport bill that treats Uber operators in the same way as traditional taxi drivers. This means more onerous requirements on Uber drivers and Uber itself going forward.

In the case of AirBnB, Cape Town is its top market in Africa. As is the case in Barcelona, this type of popularity creates pressures, with apartments potentially rented in contravention of their tenancy agreements and the potential for local residents to have difficulty in finding long-term rental accommodation. Although there is some pressure from the local tourism industry for AirBnB to be regulated more heavily[54], at this stage there does not appear to be any particular regulatory initiatives in respect of AirBnB.

In the case of OTT Communications apps such as Viber, WhatsApp and Skype, there is little regulatory intervention at all. Further, it is difficult to envisage what governments can do, especially the governments of smaller countries, to influence the global providers of these apps. Short of banning the apps outright within national jurisdictions, it would be difficult to negotiate with these companies.

4.1.6 App companies in South Africa

South Africa would appear to be the leading app economy nation in Africa. The South Africa Government and private sector players sponsor a number of organisations designed to encourage technology driven start-ups. These include:

mLab: an organisation that is supported by The Ministry of Foreign Affairs of Finland, The South African Department of Science & Technology, The Innovation Hub, The V&A Waterfront and the World Bank infoDEV.

Grindstone Accelerator: sponsored by Knife Capital, provides support for: Entrepreneurial Development, Investment Readiness and Growth Strategy.

New Ventures Studio: is a young entrepreneur accelerator. It is a platform for young individuals who want to be successful entrepreneurs, but realize the importance of up skilling themselves before

[53] South African Department of Telecommunications and Postal Services, National Integrated ICT Policy White Paper, 28 September 2016 NO. 1212

[54] www.tourismupdate.co.za/article/111751/Should-government-regulate-AirBnB

venturing out into the unfamiliar territory of entrepreneurship. The Studio is sponsored by Salesian Life Choices, a non-profit organization and Caban Investments, a venture capital business.

Examples of app companies in South Africa include:

SnapScan: which provides point of sale solutions with very low barriers to entry for 30 000 vendors across South Africa (www.getsnapscan.com)

GoMetro: is a public transport information app downloaded more than half a million times. It enables users to update information about delayed services and can enable employees to notify workplaces with validated messages about late trains and buses. (www.getgometro.com)

Afta Robot: is a platform that uses advanced wireless technology combined with cloud support that will improve the safety and efficiency for the minibus taxi operators and commuters. The minibus taxi industry in South Africa is 'private sector public transport' system accounting for 65 per cent of all public transport services, operated by approximately 331 taxi associations overseeing over 300 000 mini busses that operate an estimated 10 billion trips per annum. The app aims to increase the efficiency of this system using geo-aware smart devices and backend cloud software.

Afta Robot is an excellent of innovative app development based on a particular national context. South Africa's unique and extensive minibus transport system could achieve very large increases in efficiencies based on the use of such an app.

4.2 Ghana

4.2.1 Phone/app use

With a national population estimated in 2014 to be just over 27 million, Ghana's mobile phone penetration rate rose to 127.63 per cent after the voice subscriber base climbed to over 35 million in December 2015 from 34 million registered in the previous month.

The National Communications Authority (NCA) mobile voice and mobile data market share trends for December 2015 also reported the number of mobile data subscribers rose from about 17.73 million to 18.03 million, an access rate of 65.74 per cent. The main catalysts for the rise in the number of people who have access to mobile phones and Internet usage have been the recent push for telecommunication companies to expand their network coverage, the availability of cheap smartphones from China and a robust legal regime.[55] According to the Internet company, Opera, 31 per cent of the population in Ghana use mobile applications.[56]

4.2.2 App import and export

Only 11 developers from Ghana, or 0.42/million on a per capita basis, were captured in the sample for the Caribou Digital *Winners and Losers in the Global App Economy* report 2016, which sampled Ghanaian developers based on their appearance in App Annie's 'Top Ranked' and 'Top Grossing' categories for the nation. The ratio of those sampled developers who were constrained to their domestic market was 100 per cent, meaning that Ghanaian app developers do not sell their apps overseas. The inability of Ghanaian developers to export their apps has a double impact: primarily, being limited to one market is generally less lucrative than being able to enter additional markets; but secondly, these producers are in a low-revenue market, such that even if they are very highly ranked domestically, the revenue may not be sufficient for sustainable businesses.

[55] www.theafricareport.com/West-Africa/ghana-mobile-phone-penetration-soars-to-128.html
[56] www.africanews.com/2016/11/11/safrica-ghana-nigeria-africa-s-top-mobile-app-users-internet-survey/

The role of English as the global lingua franca of business, and especially ICT, is no doubt a driver of the widespread popularity around the world of apps produced in the United Kingdom and United States. Unsurprisingly, these apps are most popular in markets where English is the only or primary official language. A less predictable finding of the Caribou Digital report was that the region with the next-highest ratio of United Kingdom and United States based apps was sub-Sahara Africa, where Ghana, Kenya, Nigeria, South Africa, and Tanzania all showed over 50 per cent market share of United Kingdom and United States based apps. Market share of United States based apps sits just below 60 per cent in Ghana.

4.2.3 App developer revenue

The path to app monetization in Ghana is extremely challenging. Globally, advertising and app purchases are the dominant mechanisms for revenue generation. Developers in Ghana have, in principle, the same choices as anywhere else, but they are constrained by various market factors that limit their choices and their ability to raise revenues when products and services are targeting local audiences. Several app developers have needed to supplement their income through contract work in order to cross-subsidize app development. There are several revenue sources potentially available, but few are practically possible because of the lack of payment facilities within Ghana. The challenge remains the ability to match revenue sources with available payment facilities.[57]

Competitions for app developers, such as the App Developer Competition from MTN, are one tool to increase the supply of apps, but one-off competitions are unlikely to be the basis for a dramatic change in the availability of apps and the number of downloads. The challenge is that too few apps are using the available payment facilities, such as premium SMS, because of the perceived inequity in revenue share. The universal complaint among app developers was that revenue share was unfair and that payment, when it did take place, was often delayed for many months. Operator app stores suffer from the archetypal causality dilemma: if app developers have a viable business model, then MNOs will offer good terms; if MNOs offer good terms, then app developers will develop apps. MNOs are preoccupied with the app business model and require the app developer to submit a business plan to even get the API (Application Programming Interface). App developers distrust MNOs and feel that they are not being treated fairly. The net result is inaction.[58] This is a good example of how the absence of a payment system that is perceived to be fair and equitable can impede the development of new industries.

4.2.4 App discovery and distribution

By far the most attractive platform for Africa region app developers is the Google Play store: its revenue split is 70/30 in favour of developers and the procedures for registering an app are relatively straightforward and transparent. Google Play's API is available on the Web, easily accessible, and easily understood with few conditions. Though the Google Play store is popular, Google prohibits developers in Ghana from monetising directly through its app store. This means that developers are either restricted to free apps on Google Play or have to work through partners registered as merchants on another continent.[59]

Notably, in less economically developed countries such as Ghana, where high data costs and lower disposable income constrain web browsing and download behaviour, much app discovery and distribution takes place via alternative channels. Research published in the Caribou Digital report has shown that in Ghana, users often access third-party stores such as Opera app store (because they are familiar with the data-saving Opera browser) as well as third-party aggregator sites such as Waptrick. But offline channels are also very common, with many users in the study installing apps provided by friends, or buying apps from offline vendors who then transfer the app (or music, or video) locally.

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57 www.infodev.org/infodev-files/mobile_apps_at_the_base_of_the_pyramid_ghana_0.pdf
58 Ibid
59 https://support.google.com/googleplay/android-developer/table/3539140?hl=en .

GetJar is the major third-party OS store available to the Ghanaian market. GetJar is a third party because it is independent of handset operators (such as Nokia) and the OS stores (such as iTunes, Google Play, and BlackBerry World). Uploading apps onto GetJar is free and there is no revenue share requirement. From a revenue share perspective, this is an attractive app store, but its awareness among BoP consumers is reportedly low. There are also websites that act as content aggregation platforms to which users can log on to get apps, music, games and videos. Examples include www.waptrick.com and www.sefan.ru.

Vodaphone Ghana, in an effort to bring visibility to more Ghanaian app developers, has launched the Vodaphone App Store. It is described as a developer friendly app store with a focus on local, relevant content while giving subscribers the opportunity to still have access to a global range of popular apps. An advantage of this store is its low barrier to entry: the removal of the USD 50 – USD 100 cost on hosting apps on the major app stores will help developers host their apps more easily and possibly faster.[60]

4.2.5 Regulatory developments for the app economy in Ghana

Online news source BuzzGhana[61] published a story headlined *Ghanaians might say goodbye to Internet calls including WhatsApp, Skype.* This story was in response to a press release by the National Communications Authority (NCA)[62] on *The regulation of over-the-top (OTT) services.* This release did not actually oppose banning OTT services. It emphasised that OTT services were negatively impacting operator revenues and that the NCA was "*concerned with the fact that most of these OTT players are generally not bound by regulations in many countries which orients market dynamics in their favour"* and that the "*challenges posed by OTT services from a national perspective warrants the need for the authority to ensure proper regulatory balance and a level playing field in terms of regulatory compliance as well as the need to address the issues pertaining to security*". The NCA also noted that consumers benefited from being able to access OTT services. A little over a week later, the NCA announced that it was further reviewing the OTT market[63] but the next day Ghana Deputy Minister of Communication, Ato Sarpong, told key industry players in Accra that the government had no intention whatsoever of regulating the operations of over-the-top (OTT)[64]. The Chairman of the NCA Board, Eugene Baffoe-Bonney, speaking at a conference on the theme *The Growth of OTTs and the Role of Mobile Operators and Regulators*, emphasised that the NCA had no intention to ban OTT services, encouraging mobile network operators to rather embrace the technologies considered by many as disruptive.[65]

These developments appear to indicate a more liberal attitude to app driven disruption within the Ghana Government and regulators. This would seem to be reinforced by the announcement in June 2016 of the signing of a Statement of Understanding between Uber and the Ghana Transport Ministry.[66]

Ghana becomes one of the first countries on the continent to sign the Statement of Understanding (SoU) with Uber, whose operations in other parts of the continent have received resistance from traditional taxi drivers. Fiifi Kwetey, Minister for Transport signed the SoU along with Alon Lits, Uber General Manager for sub-Sahara Africa at the launch of Uber operations in Accra. Uber launched in Accra with free rides over the last week. The SOU is a fantastic first step for Ghana to become a smart city of the future and shows the critical role technology will play in creating thousands of economic opportunities for Ghanaians. The SOU also provides for Uber to partner with the Ministry to develop a regulatory framework that allows for ride sharing technology and also regulate its use and adoption by riders, drivers, and companies that use it to source business.

60 https://gharage.com/2015/09/21/vodafone-ghana-launches-the-vodafone-app-store-for-local-app-developers/
61 http://buzzghana.com/nca-restrict-internet-calls/
62 www.nca.org.gh/assets/Uploads/Press-Release-OTT-Services-v2.pdf
63 www.itwebafrica.com/telecommunications/338-ghana/236228-ghana-initiates-review-of-ott-services
64 www.biztechafrica.com/article/government-rules-out-ott-regulation-ghana/11345/
65 https://asokoinsight.com/news/embrace-over-the-top-services-national-communications-authority-tells-telcos-ghana
66 www.africanews.com/2016/06/14/uber-enters-agreement-with-ghana-s-transport-ministry/

These developments seem to indicate that the Ghana Government is focused on the consumer and economic benefits arising from app economy services and is taking a proactive approach to ensuring that these services are integrated sooner rather than later and that resisting the evolution of the app economy is not in the interest of Ghanaian citizens or the domestic economy.

4.2.6 App companies in Ghana

Ghana is home to The Meltwater Entrepreneurial School of Technology (MEST) and the MEST Incubator programme. Founded by successful Norwegian entrepreneur, Jorn Lyseggen, in 2008, MEST:

"… offers aspiring African entrepreneurs a fully sponsored intensive twelve-month program. Sourced from top graduates in Ghana, Nigeria, Kenya and South Africa, these Entrepreneurs-In-Training (EITs) are selected each year to receive comprehensive training across the spectrum of skills required to build successful tech businesses, including computer programming, software development, product management, finance, marketing, sales and leadership best practices.

After completion of the program, the EITs have the opportunity to pitch a business concept. Winning teams receive a seed round from the MEST Incubator to pursue their idea.[67]

MEST now has multiple businesses that have graduated from its program that are currently operating in Ghana and throughout Africa.

An outstanding example of a successful app company from Ghana that graduated from MEST is Saya. Saya was founded in August 2011 by Ghanaian entrepreneurs Robert Lamptey and Badu Boahen, both graduates of the Meltwater Entrepreneurial School of Technology (MEST) in Accra.

Saya is an excellent example of how a start-up app economy company can flourish by designing a product that is suited to local conditions. Saya built an app which was a replacement for text messaging much like WhatsApp, but built for feature phones which were much more prevalent in Africa than in more economically advanced countries where smartphones dominate. The app attracted millions of users in over 30 countries including India, Syria, Indonesia and Bangladesh."[68]

Saya was acquired by New Jersey-based Kirusa, a developer of Voice SMS based Mobile Value Added Services (MVAS), for an undisclosed amount in August 2014.

4.3 Conclusion: The state of telecommunications/ICT and the app economy in case study countries

4.3.1 Short-term pressure, long-term gains

There are a number of positive developments in the telecommunication markets of both South Africa and Ghana: coverage is improving both in extent and in terms of a shift to more advanced technologies such as 4G and LTE, mobile subscriptions are relatively high, and a shift from feature phones to smart phones is underway. On the negative side, particularly in Ghana, mobile broadband subscriptions are underrepresented, usage of mobile broadband is relatively low and, perhaps most importantly, mobile broadband prices are high in terms of GDP per capita.

The chicken and egg problem is that per capita incomes in Africa are low relative to the cost of providing mobile broadband services. The cost of smart phones has now fallen so much that smart phone ownership is no longer a real barrier to enjoying the benefits of mobile broadband. If operators are under margin pressure because of OTTs then this may make them less willing to invest in the near

[67] http://meltwater.org/about/about-mest/

[68] www.forbes.com/sites/mfonobongnsehe/2014/08/20/u-s-company-acquires-african-mobile-messaging-startup-saya/#47e30b676358

and medium term. Perhaps there is some opportunity for policy innovation in terms of creating incentives for operators to achieve increased numbers of subscribers and/or additional infrastructure expenditure.

Governments face difficult trade-offs in creating such incentives for operators. Where governments own, or part own, operators they experience falls in revenue as operators come under competitive pressure from OTTs. In addition, the increasing popularity of OTT services means a loss in the tax revenue base within national jurisdictions. These pressing concerns must, however, be balanced against the long-term interests of consumers and national economic development. Modern economies are increasingly communications and information technology driven for efficiency and economic development. Impeding the ongoing development of the communications sector in the interests of short to medium term revenue raising will likely create a deficit in future economic growth.

4.3.2 Measures of the app economy

Governments are also seeking to understand the extent of the progress of the app economy within their own jurisdictions. This is difficult to ascertain from existing statistical collections because these have typically focused on telecommunications and broadband rather than the app economy per se. Existing collections could be used, however, to construct measures of app economy progress or some form of an 'app economy engagement index' based on how the nature of communications use changes as the app economy progresses in a particular jurisdiction. For example, the number of smart phones compared with feature phones within a particular market will be one indicator of the progress of the app economy. Another would be the proportion of all subscribers with some form of mobile broadband service. Another measure would be the cost of a standardised broadband account subscription (specified in terms of Mbit/s per month of data allowance) as a proportion of GDP per capita compared with the price for more advanced jurisdictions.

Such components could be combined into an 'app economy engagement index' that would enable jurisdictions to compare progress and use this as an input to the formation of policy and regulation. ITU would have much useful data collected on a national basis but, in addition, operators could provide additional useful data such as relative usage of voice and data services of various categories of customers, trends in mobile data packages preferred by consumers and other types of detailed consumer data.

5 Summary: regulating the app economy in Africa

5.1 The importance of app economy regulation in Africa

One of the central conclusions of this report is that, following the emergence of the app economy, the ICT sector is more economically significant and more important than ever for the economic and social development of the Africa region nations. This is not only because of the traditionally cited reasons such as improved efficiency and productivity, reduced transactions costs, improved social inclusion and enhanced economic growth, but also because of a less visible but no less important potential for the app-powered ICT sector to foster the development of markets and institutions in Africa at lower cost and more quickly than has happened in more economically advanced nations. This potential did not exist until the arrival of cheap mobile phones, and increasingly, cheap smart phones along with much greater mobile broadband coverage that together will bring unprecedented and transformative capabilities to the majority of people living in Africa in less than a decade.

To the extent that the app economy will play a critical role in the economic development of Africa and given the importance of regulation in influencing the evolution of the app economy, the stakes

are indeed high for the numerous regulatory decisions now confronting governments and regulators in Africa.

There has been extensive discussion regarding the need for flexible regulation, a regulatory light touch, innovation in regulation and, perhaps, most importantly, the need for collaborative regulation. The need for collaborative regulation emerges from the general phenomenon of convergence and, with respect to the app economy in particular, the many ways in which app driven innovation crosses traditional industry boundaries, disrupts existing business models and challenges long-standing regulatory parameters.

5.2 Opportunities and challenges for the app economy in Africa

The opportunities and challenges described in this report may at first seem insurmountable but it should be recalled that in Africa, the real shift into the app economy is just moving into full swing. It is not surprising that, coming late to the party, having relatively small markets and low income per capita, the nations of Africa do not rate highly in the global app development stakes.

Nonetheless, there are reasons to be optimistic about the future of app development in Africa. These reasons include:

- the next five years will see extremely rapid increases in smart phone ownership and mobile broadband subscriptions throughout Africa;
- there is an enormous number of niche markets based on its economic circumstances and linguistic uniqueness – apps will most certainly be developed to meet intrinsically Africa region needs, and could be leveraged on a regional or global scale;
- there is an enormous willingness to adopt useful mobile app technologies based on simple feature phones with M-PESA probably being the leading example. The functionality and usability of such apps are contained by the relative primitiveness of feature phone interfaces – all this will change with the shift to smart phones and apps will become more feature-rich, usable and attractive to users;
- there is a need to develop customised and productivity-enhancing apps that will enable it to leapfrog many of the institutional and market development processes.

5.3 General policy guidelines to encourage the development of the app economy

The following general policy settings are recommended as initiatives that could be undertaken by governments in the Africa region to encourage the development of the app economy:

- develop a policy that encourages the creation of app start-ups that are targeted at both global markets and niche markets in Africa;
- encourage the rollout of high-speed mobile broadband networks throughout the region including high capacity fibre backhaul and backbone links;
- endorse policies that support net neutrality rules similar to many global markets subject to reasonable network management;[69]
- promote fiscal incentives to encourage operators to lower tariffs, including the elimination or reduction of customs duties on telecommunication/ICT equipment for infrastructure providers as well as on consumer devices;
- encouraging the development of app economy skills throughout national education systems including coding, business, marketing and entrepreneurship;

[69] As a minimum, this could be similar to Article 14.10 of Trans-Pacific Partnership Agreement (TPP). Available at www.mfat.govt.nz/Treaties-and-International-Law/01-Treaties-for-which-NZ-is-Depositary/0-Trans-Pacific-Partnership-Text.php

- work with national financial system regulators and taxation authorities to ensure that app developers can fully participate in global app store payment systems;
- encourage collaborative regulation among all sectors and between regulatory agencies for the industries affected by app-based and other relevant agencies such as competition regulators, financial regulators, etc.;
- facilitate the establishment of in country and inter-region Internet exchanges in order to reduce tromboning and secure lower interconnectivity costs for domestic ISPs;
- Support the liberalisation of international gateways to increase international capacity, reduce the costs of international data capacity (which is a rapidly growing cost to providing broadband services) and to guarantee a higher quality of service by having multiple redundant submarine cables and/or terrestrial links where possible, with a view to reducing the cost of connectivity;
- adopt innovative licensing regimes to encourage new business models for covering remote and rural areas;
- design flexible, incentive-based and market-oriented policy and regulatory frameworks with regard to allocation and assignment of spectrum, in particular for broadband services;
- make as much as possible spectrum available in the IMT bands as soon as possible this may require governments to lower their expectations about the revenue they can raise from spectrum sales.

Not all of these recommendations concern policy and regulatory issues that relate directly to the app economy, but they are all designed to foster its long-term development. It is true that some of these recommendations are concerned with policy and others with regulation and, some policy innovations will have regulatory implications while others will not.

Acronyms and abbreviations

ACMA	Australian Communications and Multimedia Authority
ADSL	Asymmetric Digital Subscriber Line
API	Application Programming Interface
AR	Augmented Reality
ASEAN	Association of South East Asian Nations
CAGR	Compound Annual Growth Rate
Capex	Capital expenditure
CITC	Communications and Information Technology Commission of Saudi Arabia
DSL	Digital Subscriber Line
EU	European Union
FCC	Federal Communications Commission of the United States
FDI	Foreign Direct Investment
FTTB	Fibre-To-The-Building
FTTC	Fibre-To –The-Curb
FTTH	Fibre-To-The-Home
FTTx	includes FTTH, FTTB, FTTC, etc.
GDP	Gross Domestic Product
GNI	Gross National Income
GSMA	GSM Association
GSR	ITU Global Symposium of Regulators
ICTs	Information Communication Technologies
ICT4D	ICT for Development
IMT	International Mobile Telecommunication
IoT	Internet of Things
ITU	International Telecommunication Union
ITU-D	ITU Telecommunication Development Sector
ITU-T	ITU Telecommunication Standardization Sector
ITU-R	ITU Radiocommunication Sector
LDCs	Least Developed Countries
LTE	Long-Term Evolution
LTE-A	Long-Term Evolution Advanced
MDGs	Millennium Development Goals
M2M	Machine-to-Machine
MNO	Mobile Network Operator
NBN	National Broadband Network

NBP	National Broadband Plan
NGN	Next-Generation Network
OECD	Organisation for Economic Cooperation and Development
Opex	Operating Expenditure
PPP	Public-Private Partnership
QoS	Quality of Service
RCEP	Regional Comprehensive Economic Partnership
SAARC	South Asian Association for Regional Cooperation
ROW	Right of Way
SDGs	Sustainable Development Goals
SMEs	Small- and Medium-Sized Enterprises
STEM	Science, Technology and Mathematics
TPP	Trans-Pacific Partnership
UN	United Nations
UNESCO	
USF	Universal Service Fund
USOs	Universal Service Obligations
VoLTE	Voice over Long Term Evolution
WDR	World Development Report
WRC	World Radiocommunication Conference
xDSL	Refers to different variations of DSL, such as ADSL, SDSL, VDSL
2G	Second-generation mobile
3G	Third-generation mobile
4G	Fourth-generation mobile
5G	Fifth-generation mobile

Annex 1: Telecommunication markets in South Africa and Ghana

A1 South Africa

A1.1 Market share of mobile operators

By the end of 2015, Vodacom held 37.7 per cent of the South Africa market, followed by MTN at 35.9 per cent and Cell C at 23 per cent. Telkom Mobile (former incumbent – government now has 40 per cent stake) is the smallest mobile network operator, with 2.6 per cent of the market.[70]

Figure A1: Mobile operator market shares

Mobile operator market share		
Operator	**Number of subscribers**	**Market share**
Vodacom	32.12 million	37.7%
MTN SA	30.55 million	35.9%
Cell C	19.6 million	23.0%
Telkom	2.19 million	2.6%
MVNOs	650,000	0.8%

MTN's financial year end is 31 December, therefore its market share is overestimated.

Source: http://www.researchictafrica.net/polbrf/Research_ICT_Africa_Policy_Briefs/2016_Policy_Brief_2%20South_Africa_mobile_operators_wake_up_as_2020_draws_closer.pdf

A1.2 Regulator

The South Africa ICT sector is regulated by the Independent Communications Authority of South Africa (ICASA). The authority now falls under the purview of the newly created Department of Communications (DoC) following a 2014 decision to split various government ICT responsibilities into two bodies: the DoC and the Department of Telecoms and Postal Services (DTPS).[71]

A1.3 Growth in data usage

The largest mobile operators in South Africa have all reported rising data demand and revenues as low-cost smartphones become more widely adopted. Smartphones now account for more than half of all mobile users in the country, rising from just under 5 million active devices in 2010 to nearly 24 million in 2015. This means that 37 per cent of the population own a smartphone.

Mobile Internet now accounts for more than 97 per cent of all Internet connections, and with almost two thirds of the population able to access LTE services, this sector will continue to see strong growth into 2017.[72]

Current trends indicate that mobile data traffic could grow at an annual rate of 63 per cent between 2014 and 2019, eventually accounting for 32 per cent of all data traffic by 2019, versus just 13 per cent

[70] https://mybroadband.co.za/news/cellular/172592-vodacom-vs-mtn-best-and-worst-mobile-network-in-south-africa.html
[71] https://www.oxfordbusinessgroup.com/overview/down-wires-rising-popularity-data-sparking-heavy-investment-fibre
[72] https://www.budde.com.au/Research/South-Africa-Mobile-Infrastructure-Operators-and-Broadband-Statistics-and-Analyses

in 2014.[73] In line with this trend, mobile operator Vodacom saw 23.4 per cent data revenue growth to reach ZAR 15.54 billion (USD 1.34 bn) in 2014/15. Data now comprises 28.8 per cent of Vodacom revenues in South Africa, while active data customers rose 9.4 per cent to reach 16.6 million in the 2014/15 financial year. MTN South Africa reported that its data growth was supported by 'attractive data promotions', including data bundles, with data revenues rising by 17 per cent during the fourth quarter of 2013.[74]

This shift away from traditional voice and SMS services into the realm of data services is prompting telecommunication operators to invest heavily in new fibre-optic and next-generation infrastructure, although the country's delayed digital TV migration and lack of available frequency spectrum, which is critical for the roll-out of 4G long-term evolution (LTE) mobile broadband services, has slowed progress.[75] Mobile operators are able to reduce the cost of data to consumers only as much as they have excess spectrum. As operators are faced with an increasing shortage of spectrum, consumers may feel the impact on mobile data services.[76]

A1.4 Delay in allocation of spectrum

ICASA planned to sell five blocks of spectrum (700 MHz, 800 MHz and 2.66 Ghz) starting at ZAR 3 billion (USD 220 million) each to help extend Internet access across South Africa in 2016. The High Court in Pretoria ruled at the end of 2016, however, that ICASA could not go ahead with the auction, deciding that an orderly process for the auction must be followed that involves both the regulator and the government formulating a policy for the allocation of the spectrum. The telecommunication ministry was against the sale, arguing that South Africa's biggest phone companies, including MTN Group Ltd and Vodacom Group Ltd, would benefit at the expense of smaller competitors. This means that the auction will be pushed back to May 2017. This dispute risks further delaying South Africa's move to 4G broadband Internet, with many countries in the rest of Africa now pulling ahead of South Africa in the allocation of spectrum.[77]

A1.5 Cost of data

The South Africa market is facing challenges in terms of affordability and quality of service, with the average monthly price of broadband being ten times more than in the United Kingdom, yet Internet speeds in the United Kingdom are five times greater than in South Africa.[78] In addition, while the effective prices of data may be well below the advertised price of the 1 GB measure used internationally, mobile users in South Africa, especially those in the lower income category, are spending significant portions of their income (around 20 per cent), on relatively small amounts of data (1 GB). South Africa is ranked 16th out of 47 Africa region countries in relation to the average cost of 1 GB of data.[79] South Africa also has the second highest data contract prices among the BRICS countries (Brazil, China, India and Russia), once prices were converted to Rand and re-based for the cost of living.[80] ITU rates South Africa 71st out of 184 countries in terms of the cost of the 'Mobile-cellular sub-basket' with a cost of 1.25 per cent per month of GNI per capita.[81]

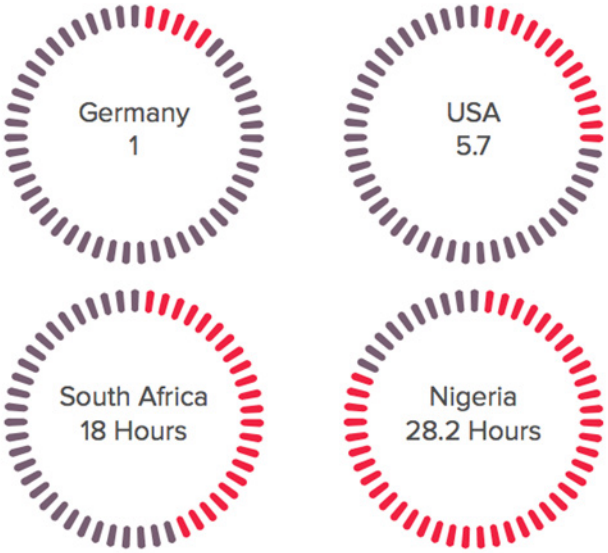
The high cost of data can be partially attributed to the high demand for data, which is forcing operators to build out NGNs, increase their international and local capacity, whilst maintaining the quality of their networks. As a result, operators are collectively investing billions (over ZAR 20 billion between

73 https://www.oxfordbusinessgroup.com/overview/down-wires-rising-popularity-data-sparking-heavy-investment-fibre
74 Telecoms & IT pdf.
75 https://www.oxfordbusinessgroup.com/overview/down-wires-rising-popularity-data-sparking-heavy-investment-fibre
76 www.fin24.com/Tech/Gadgets/SA-mobile-data-growth-to-surge-63-per-year-20150226
77 http://ewn.co.za/2016/09/30/High-Court-sets-aside-Icasas-planned-spectrum-auction
78 Telecoms & IT pdf.
79 www.sowetanlive.co.za/news/2016/10/20/why-data-must-fall-too
80 www.fin24.com/Tech/Multimedia/data-prices-how-sa-compares-to-the-rest-of-the-world-20160930
81 ITU, Measuring the information society report, 2016

Vodacom and MTN in the current financial year alone) in network extension and upgrades, which they need to justify to shareholders with robust rates of return.[82]

Some critics argue that the government has not done enough to legislate on prices, with its current stance of allowing market forces to drive prices down through increased competition regarded as not adequate, primarily because of the barriers to entry for new entrants into the market. Critics argue that without legislation, the current oligopolistic stranglehold on the market cannot be broken, and the existing operators have no incentive to aggressively cut data prices, particularly as they aim to offset their losses in voice revenue.[83]

Figure A2: Hours of work to pay for 500 MB of mobile data



Source: McKinsey Global Institute 2015

A1.6 Major infrastructure investment programmes

Although 4G LTE services remain concentrated in wealthy suburbs across Johannesburg, Cape Town and Durban, some operators have begun rolling out innovative 4G LTE services to expand access and availability in under-served areas. The 4G LTE network technology offers an improved responsiveness that makes a range of voiceover Internet protocol applications, such as Skype and Facebook, function with minimal latency. This has attracted the attention of mobile operators adapting to a growing customer preference for data services.

In April 2015, Cell C announced plans to invest 691 million over the next three years to establish 4G LTE services in metropolitan areas. The company also plans to build an additional 1353 3G sites, largely within areas outside and between the metropolitan centres that will comprise its 4G LTE network. Telkom also moved to launch its own next-generation mobile broadband, announcing in November 2014 that it will roll out a 4G LTE-Advanced network connecting more than 50 suburban communities. Over the longer term, the company hopes to increase Internet speeds to more than 200 Mbit/s.[84]

82 http://researchictafrica.net/publications/Other_publications/2016_South%20Africa_Cost%20to%20Communicate%20Submission_RIA%20.pdf
83 http://www.sowetanlive.co.za/news/2016/10/20/why-data-must-fall-too
84 Telecoms and IT pdf.

A1.7 National broadband/telecommunications development plans

The Minister of Communications gazetted a new broadband policy for South Africa in December 2013. The policy and its associated strategy and plan have been collectively dubbed 'South Africa Connect' and outline a number of activities to improve broadband in South Africa, which run until 2030. In particular, the overall vision of the policy is to give everyone in South Africa access to a broadband connection at a cost of 2.5 per cent or less of the average monthly income. ICASA will supplement these targets by specifying quality of service standards, download and upload speeds, latency, waiting time for installation and fault clearance. South Africa Connect has ambitious targets, including achieving 50 per cent Internet coverage with speeds of 5 Mbit/s by 2015, 90 per cent coverage at the same speeds by 2020, 50 per cent coverage with speeds of 100 Mbit/s by 2020 and universal 100 Mbit/s coverage by 2030. To meet the national objective of more affordable broadband access for all, South Africa Connect allows for both demand and supply-side policy interventions. These are reflected in a four-pronged strategy that will close the gap between the currently poor status of broadband in the country, and the country's vision of a seamless network of networks that by 2030 will make broadband universally accessible at a cost at a quality that meets the needs of citizens, formal and informal business and the public sector.[85]

A2 Ghana

A2.1 Market share of mobile operators

The Ghanaian market has six mobile operators, five operating GSM and one CDMA. All of the mobile operators are associated with international telecommunication companies. As of June 2015, the dominant player in the mobile market was MTN, with a 46 per cent market share. MTN was followed by Vodaphone, with 22.55 per cent, Tigo with 13.87 per cent, Airtel with 12.71 per cent, Glo with 4.47 per cent and Expresso with 0.41 per cent.

Vodaphone entered the market in Ghana as part of the privatisation process. Ghana Telecom was the incumbent national operator, and Vodaphone acquired a 70 per cent stake (the remainder still held by the government) in 2008.[86]

A2.2 Regulator

The National Communications Authority (NCA) was established by Parliamentary Act 1996 as a central regulatory body to regulate the telecommunication sector and to promote a stable operating environment for all participants, while also promoting fair competition and efficiency. The main task of the NCA includes the licensing and regulation of telecommunication system operators and assigning or allocating systems frequencies.[87]

The government policy towards the telecommunication sector is guided in part by two over-arching policy documents: the National Telecoms Policy (NTP), and the Information and Communications Technology for Accelerated Development (ICT4AD). The NTP broadly aims to make telephone and Internet connectivity available and affordable to all Ghanaians. The related ICT4AD sees ICT as an important catalyst for economic growth and the development of a range of economic sectors.[88]

85 www.gov.za/sites/www.gov.za/files/37119_gon953.pdf
86 www.africantelecomsnews.com/resources/Ghana_mobile_subscribers.html
87 www.itu.int/osg/spu/ni/3G/casestudies/ghana/ghanafinal.pdf
88 https://www.oxfordbusinessgroup.com/overview/calling-shots-liberalisation-and-mobile-demand-are-driving-strong-market

A2.3 Broadband access

The six licensed mobile network operators currently compete mostly in the 10 administrative regions of Ghana and other major towns, with the competition fierce in the two most-wealthiest and populous regions: Greater Accra and Ashanti region, which has a combined population of about 10 million.

Mobile network operators in Ghana have a universal licence that mandates them to roll-out services throughout the country, but policy makers and the industry may sometimes have different priorities. The operations of the Ghana Infrastructure Fund for Electronic Communication (GIFEC), which is funded from the one per cent revenue contribution of all the network operators, has largely failed to connect many underserved and economically challenged communities. The decision by some network operators to ignore underserved areas and concentrate on the cities, where subscription is nearly at saturated levels, is based on the fact that the cost of extending services to deprived communities will not be met with the right compensation required to break even in an economy in which the cost of doing business is always rising amid the fact that affordability is still a challenge and out of reach of many people. According to ITU latest price research, mobile broadband costs 1-2 per cent of monthly income in developed countries, compared with 11-25 per cent of monthly average income in developing countries.

Based on these findings, some critics argue that the raft of tax policies introduced by the government needs to be relaxed to bring down the cost of operations and give breathing space to mobile network operators to commit more resources to investment and deployment of mobile services to unconnected areas. In particular, it is argued that the 20 per cent import tax on mobile phones needs to be scrapped to put broadband-enabled devices in people's hands.[89]

A2.4 National broadband/telecommunications development plans

The Ghana ICT4AD launched in 2003 aimed to promote adequate supply of broadband infrastructure, universalization of broadband, private sector interest in investment in broadband networks and to stimulate demand to ensure efficient take-up of broadband services .[90] Some specific government actions/announcements to date include the following:

- The government has created a national backbone network that is run by the National Communications Backbone Company (NCBC), a subsidiary of Vodaphone Ghana. This network is intended to be managed on an open access basis, encouraging competition, transparent pricing, interoperability with other infrastructure, devolved local applications and solutions and increased access to an usage of broadband. However, questions have been raised about the effectiveness of open access to date, partly because operators have invariably chosen to develop their own fibre-optic networks.
- The creation of the Ghana Investment Fund for Electronic Communications, the Ghana universal service fund.
- Announcement of intention to create a more efficient tax regime – where the burden of taxation on the total cost of mobile phone ownership is more than 22 per cent (in stark contrast to close neighbour Nigeria, where only 5.4 per cent of the total cost of mobile ownership is represented by tax).[91]

In addition, the national broadband strategy was launched to ensure the uptake of broadband in Ghana as an economic stimulus by making it accessible and affordable.

89 http://businesstimesafrica.net/index.php/telecoms/1552-ghana-mobile-broadband-growth-deceptive.html?showall=&start=1
90 https://cdn.modernghana.com/images/content/report_content/ICTAD.pdf
91 https://a4ai.org/wp-content/uploads/2014/07/Ghana-Case-Study_FINAL.pdf

The national broadband strategy sought to achieve by 2015:

- 50 per cent broadband penetration for Ghanaians by 2015;
- reduce broadband cost by 80 per cent;
- reduce customer-premises equipment and PC costs by 90 per cent.[92]

A2.5 Attempted removal of smartphone tax

As of 2015 in Ghana, 21 per cent of the population owned a smartphone. This is compared to a median of 37 per cent in emerging and developing nations, and a global median of 43 per cent.[93] The Ghana Government announced plans in the 2015 budget to eliminate the 20 per cent import duty to reduce the cost of handsets in Ghana, where taxes make up approximately 35 per cent of the cost of a smartphone. This was the first step in an innovative government drive to enable affordable Internet access through policy reform. However, this plan was withdrawn in 2016, with the government confirming that it will not cancel the tax but instead reduce the rate from 20 per cent to 10 per cent.[94] It is worth noting when Kenya scrapped VAT on handsets in 2008, devices in circulation quadrupled and overall mobile penetration rose from 50 per cent to more than 70 per cent.[95]

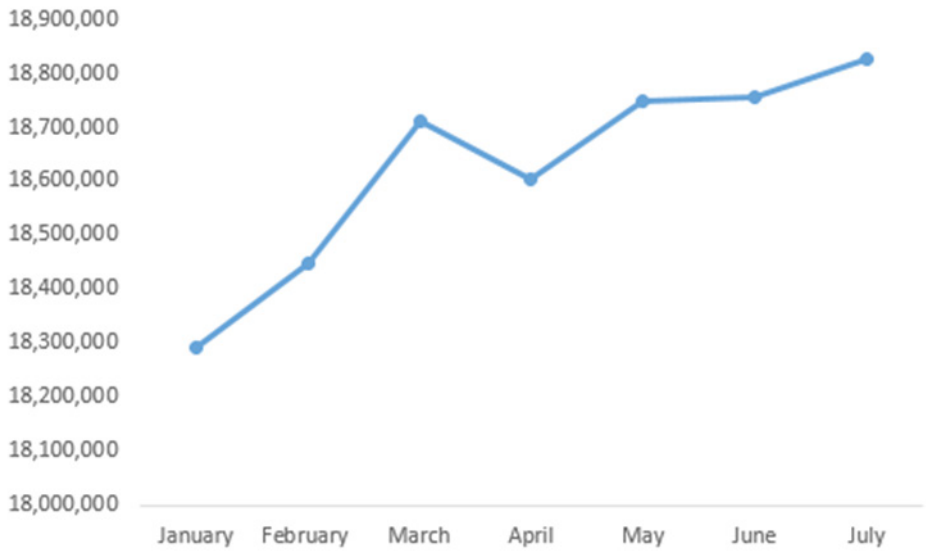
A2.6 Data use

A 15-month report on SMS and mobile data use in the country indicates SMS use declined year-on-year as mobile data consumption more than doubled in the same period. The report shows a 25.2 per cent decline in the number of SMS sent both on-net and off-net, between and within the six telecommunication operators, over the period between the second quarter of 2015 and the second quarter of 2016. Meanwhile, the gigabytes of mobile data consumption within the same six telecommunication operators rose by more than 100 per cent over the same period.[96] Notably, Ghana is third highest country in Africa based on active mobile-broadband subscriptions, with 66.82 per 100 inhabitants.[97]

The National Communications Authority of Ghana mobile voice and mobile data market share trends reported the number of mobile data subscribers rose from about 17.73 million to 18.03 million in December 2015, an access rate of 65.74 per cent. The rise in the number of people with access to mobile phones and Internet usage has been attributed to the recent push for telecommunication companies to expand their net (see Figure A3) work coverage, the availability of cheap smartphones from China and robust legal regime.[98]

92 http://1e8q3q16vyc81g8l3h3md6q5f5e.wpengine.netdna-cdn.com/wp-content/uploads/2014/03/Ghana_Broadband_Strategy_v8.pdf
93 www.pewglobal.org/2016/02/22/smartphone-ownership-and-internet-usage-continues-to-climb-in-emerging-economies/
94 https://www.telegeography.com/products/commsupdate/articles/2016/02/05/ghana-cancels-plans-to-scrap-20-smartphone-tax/
95 www.balancingact-africa.com/news/telecoms-en/32292/alliance-for-affordable-internet-welcomes-ghanaian-governments-moves-to-cut-mobile-phone-taxes
96 https://asokoinsight.com/news/report-sms-declines-as-mobile-data-use-doubles-ghana
97 www.broadbandcommission.org/Documents/reports/bb-annualreport2016.pdf
98 www.theafricareport.com/West-Africa/ghana-mobile-phone-penetration-soars-to-128.html

Figure A3: Total Mobile Data Subscriptions from January to July 2016



Source: www.theafricareport.com/West-Africa/ghana-mobile-phone-penetration-soars-to-128.html

A2.7 Major infrastructure investment programmes

Competition is heating up in the Ghana telecommunication market, with growing demand for data prompting operators to roll out large-scale investment programmes in order to expand network capacity. With the bulk of Internet access in Ghana now coming via mobile handsets, the pressure on network infrastructure has increased dramatically. In the two years to March 2015, mobile data penetration nearly doubled, from around 8.8 million people to 16.1 million, with a total penetration increasing from 34.8 per cent to 59.7 per cent, according to the National Communications Authority (NCA), the sector regulator.

To keep pace with growing demand, several of Ghana's top mobile operators have announced sizeable investments to boost capacity and position themselves to offer a wider portfolio of services. MTN Ghana announced USD 103 million worth of investments in 2015 to expand, optimise and maintain its network. This comes on top of more than 2.4 billion already invested between 2006 and 2014. Tigo announced in July that it would channel 24 million into its own network expansion efforts, to be completed by the first quarter of 2016. The company aims to open 275 new base stations, in addition to the 1050 already in operation across the country. This should help improve network quality and geographical coverage, while also easing bottlenecks in areas known for heavy usage, boosting Internet speeds and call quality. In a similar move, Airtel Ghana announced plans to expand its network with a view to improving data services, with 51.7 million earmarked for the build out.[99]

[99] http://www.oxfordbusinessgroup.com/news/ghana's-telecoms-operators-eye-expansion

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SOCIAL AND ECONOMIC IMPACT OF DIGITAL TRANSFORMATION ON THE ECONOMY

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Executive Summary

Digitization refers to the transformations triggered by the massive adoption of digital technologies that generate, process, share and transfer information. Digital transformation is not a one-time event. It proceeds in waves driven by technological progress and diffusion of innovations. The first wave of digitization is associated with the introduction and adoption of what today are considered "mature" technologies, such as management information systems aimed at automating data processing and applied to monitoring and reporting of business performance, telecommunications technologies such as broadband (fixed and mobile) and voice telecommunications (fixed and mobile) which allow the remote access of information. The second wave of digitization entails the diffusion of the Internet and its corresponding platforms (search engines, marketplaces), which enable the networking of enterprises to consumers and enterprises among themselves for purchasing of supplies, and distribution of output. The third wave of digitization entails the adoption of a range of advanced technologies, such as big data/analytics, Internet of Things, robotics, sensors, and artificial intelligence, and is aimed at enhancing information processing and the quality of decision making, while further automating routine tasks within business enterprises and governments. These technologies are not typically adopted in a stand-alone fashion but are integrated with the mature technologies characteristic of the first and second waves.

Each digitization wave has a specific set of social and economic impacts. Computing, broadband and mobile telephony networks have been instrumental in relaxing industry scalability constraints, thereby allowing traditional sectors of the economy to grow more rapidly. The alleviation of the resource constraint has led to increased demand for labor in service industries, (e.g., financial services, education, health care, etc.) although it also had a positive effect in manufacturing. Finally, the first wave appears to have had an impact on the growth of household income, and the facilitation of social inclusion (access to information, government services, and entertainment content).

The second wave of digitization has led to the introduction of new services and applications such as Internet information searches, electronic commerce, distance education and a whole range of collaborative businesses that characterize the digital economy (Uber, airbnb, etc.). This "innovation effect" has yielded enhanced demand for labor in certain occupations linked to the development of digital services or the emergence of collaborative business models, coupled with the disappearance of repetitive low and middle-skilled jobs resulting from task automation.

The third wave of digitization has significant implications for productivity improvements. It also promises to have significant benefits on social welfare, more particularly on several Sustainable Development Goals, associated with the delivery of public services. The

evidence so far with regards to the disruptive labor effects of the third wave are quite speculative, unless once believes that third wave disruption is merely an extrapolation of the second digitization wave effects. However, there is almost universal agreement that, similarly to the prior waves of innovation, automation will tend to favor those workers with more education and training. In this context, it is relevant to consider the policy remedies that could propel the benefits of automation and limit the negative outcomes:

- Implement labor market policies focused on workers being able to either retain their current jobs or move to the new areas of demand. These policies comprise job placement services, special labor market programs and wage subsidies to lessen the transition cost;
- Deploy policies focused on increasing geographic mobility, which would allow workers residing in areas affected by automation to move to high job creation cities.
- Accelerate the creation of clusters of industries and universities around high quality of life locations that stimulate high-skilled labor demand in under-developed areas.
- In particular, emerging countries need to actively promote the digitization of production and digital transformation. This requires emphasizing policies focused on accelerating the digitization of production of small and medium enterprises, by reducing the cost of technology acquisition, training of employees, and the provision of consultancy services to support companies in their process of digital transformation.
- Launch changes in educational and training systems to address the human capital gap (implement tracking systems aimed at sorting out top performers; introduce short term technology careers; structure two-tier university systems);
- If ICT deployment leads to job destruction in certain areas or sectors, governments should be ready to implement retraining programs and temporary safety net mitigation initiatives.

The policy challenge going forward is that the digital transformation resulting from all three waves of digitization is so all-encompassing that sector-specific strategies developed within institutional silos are not applicable any more. Governments need to build cross-institutional links fostering the collaboration among education, ICT, industrial promotion, science and technology to devise and jointly implement policies. In addition, the future public policy scope has to be significantly expanded beyond traditional domains such as taxation, competition, and digital literacy to include new areas such as privacy protection, cyber security, and the fostering of digital adoption such as trust and enhanced customer experience. As it is clear, the challenges for policy makers are significant, but so are the benefits for citizens and the need to mitigate any potential disruptions.

1. Framing the issue

The purpose of this paper is to provide an understanding of the social and economic impact of automation and digital transformation, and its potential benefits in developing technology applications with a fundamental positive contribution to our quality of life. At the same, as it is the case with all major technological innovations, automation and digitization may result in some social. In this context, the paper outlines policies aimed at maximizing benefits and controlling for any potential negative outcomes associated with these changes.

Digitization refers to the transformations triggered by the massive adoption of digital technologies that generate, process, share and transfer information. Unlike other innovations driven by a single innovation, digitization builds on the evolution of multiple technologies: telecommunications networks (mobile or fixed broadband networks), computer technologies (computers/laptops, wireless devices/tablets), software engineering (operating systems, machine learning and artificial intelligence) and the spillover effects resulting from their use (common platforms for application development, electronic delivery of government services, electronic commerce, social networks, and availability of online information in fora, blogs and portals). The gradual adoption of these technologies has led to a massive technological discontinuity, similar to the introduction of steam engines, electricity and railways, sweeping across economies, affecting our societies, and leading to spillover effects within the local, regional and global communities.

Digital transformation impacts society at several levels. On the production side of the economy, digital transformation enables the automation of business operations, yielding operational efficiencies, such as reduction of transaction costs, with an impact on productivity. Similarly, digital transformation provides new business opportunities, impacting employment and entrepreneurship. Regarding the delivery of public services, digital transformation enhances the provision of health and education, while improving the way citizens interact with their governments. Finally, digital transformation has an impact on human relationships and individual behavior, facilitating social inclusion and communication. It should be noted, however, that digital transformation could also result in potential negative effects, such as workforce disruption, the disappearance of companies, cybercrime and social anomie.

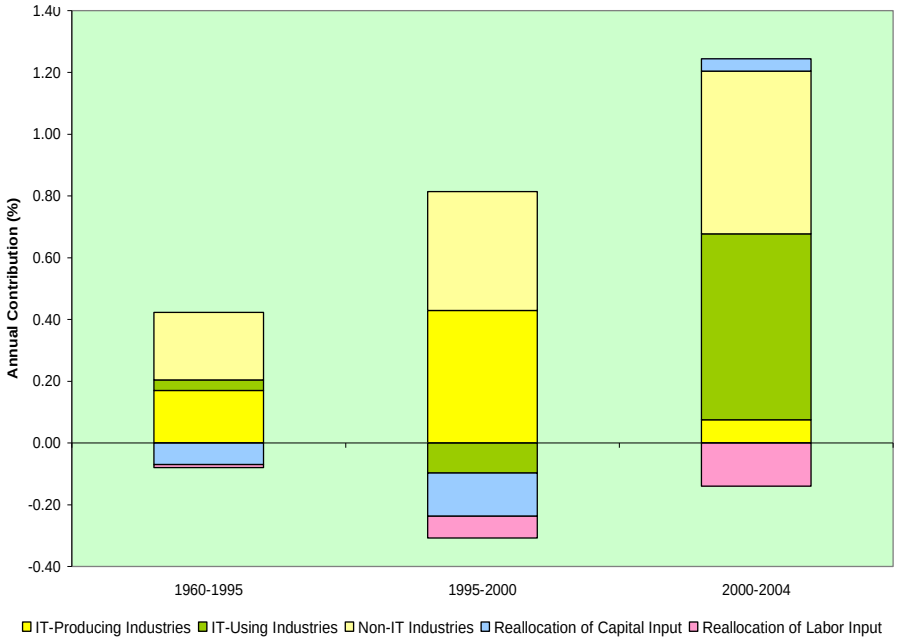
Regulators and policy makers need to consider that digital transformation is not a one-time event. It proceeds in waves driven by technological progress and diffusion of innovations. In understanding these processes, ICT regulators and policy makers can not only anticipate the changes to come as a result of each wave but also be capable of projecting the time it will require for some of these innovations to be fully adopted. Along those lines, digitization should be understood as two simultaneous processes: technology

evolution through innovation as well as R&D, and technology adoption among enterprises, governments, and consumers. It is important to differentiate between both processes because technological progress (the first process) is well ahead of diffusion (the second process), meaning that there could be a significant lag between product availability and impact. As an example, the introduction of computing resulting from R&D conducted in the 1940s and 1950s did not yield a significant impact on business productivity until well in the 1990s. The reader might recall Robert Solow's famous statement published in 1987:

> *"One of the central beliefs is that there has been a Revolution in manufacturing, its name is Programmable Automation, (….) (We) are somewhat embarrassed by the fact that what everyone feels to have been a technological revolution, a drastic change in our productive lives, has been accompanied everywhere, including Japan, by a slowing-down of productivity growth, not by a step up. You can see the computer age everywhere but in the productivity statistics."*[1]

The lag between technology development, adoption and impact was clearly shown by Dale Jorgensen et al. (2005) in their study of ICT impact on multifactor productivity in the United States (see exhibit 1).

Exhibit 1. United States: Sources of Aggregate Total Factor Productivity Growth



Source: Jorgensen, D. et al. (2006) Productivity Growth in the New Millennium and its Industry Origins

[1] Solow, R. "We'd better watch out", *New York Times*, July 12, 1987, p. 36

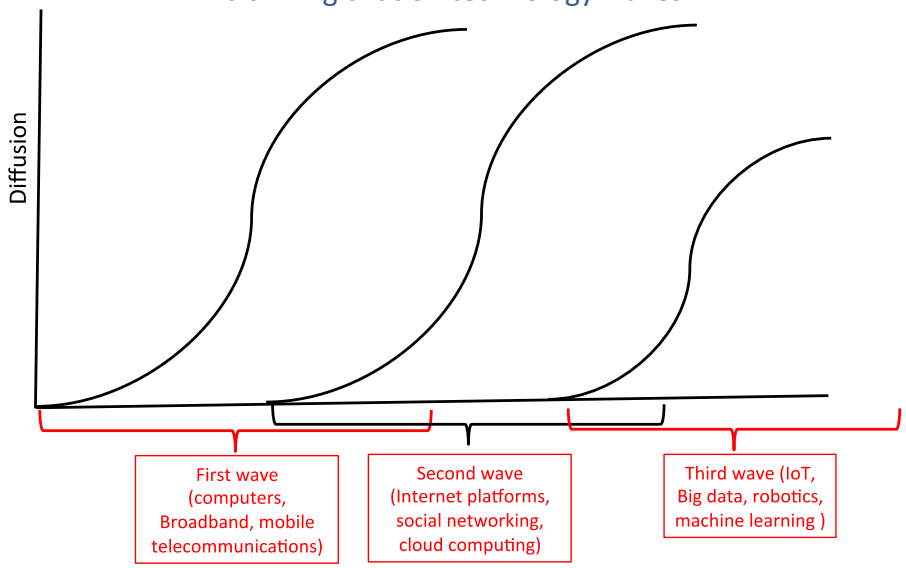
As exhibit 1 indicates, despite its early development and consistent adoption in the 1970s and 1980s, it is only in 1995 that ICT begins to have a sizable impact on productivity. Moreover, despite the downturn in the early 2000, the contribution of ICT to productivity continued increasing.

Along these lines, it is important to start this paper by conceptualizing the different digitization waves while determining how long each of these waves is lasting and understanding how much time current technological innovations, such as artificial intelligence and machine learning, will take to have a significant and measurable social and economic impact. This last point is critical because a clear determination of adoption lags and impact will help anticipating any potential workforce disruptions and devise the proper policy remedies to deal with them.

2 Definition of digitization technology waves

The same way earlier waves of technological change, such as the steam engine, railroads, telegraph and automobiles have transformed society, technological innovation linked to digitization proceeds along "waves" (see exhibit 2).

Exhibit 2. Digitization technology waves



Source: author

The first wave of digitization is associated with the introduction and adoption of what today are considered "mature" technologies, such as management information systems aimed at automating data processing and applied to monitoring and reporting of business performance, telecommunications technologies such as broadband (fixed and mobile) and voice telecommunications (fixed and mobile) which allow the remote access of

information. Computers were introduced in business environments in the 1960s and reached 92.61% penetration among businesses in OECD countries only in 2014[2]. Mobile telephony was launched in 1985 and achieved 99% worldwide penetration by 2015. Personal computers, introduced in 1982, were adopted by 80.29% of OECD households in 2015[3]. Similarly, fixed broadband was introduced approximately in 1995 and has reached 80.07% adoption within the same universe, while mobile broadband networks (3G and above) reached 84% of the global population in 2016.

The second wave of digitization entails the diffusion of the Internet and its corresponding platforms (search engines, marketplaces), which enable the networking of enterprises to consumers and enterprises among themselves for purchasing of supplies, and distribution of output. In addition to adoption of the Internet, this wave led to the diffusion of cloud computing[4]. These technologies are supported by equipment, ranging from servers and routers to mainframes and switches. Despite its early development in the late 1960s through 1980s, the popular introduction of the Internet can be situated in 1995[5]. By 2015, 77.2% of the OECD population accesses the Internet in a regular fashion, while 45% of the emerging world population has reached the same level.

Diffusion cycles of digital technologies are becoming faster with each generation. For example, while Facebook, the dominant worldwide social networks, was launched in 2005, by 2015, 48.05% of the OECD population accesses the dominant social network in each country on a regular basis. In emerging countries Facebook penetration has reached even higher levels (Argentina: 62.19%, Malaysia: 59.35%, United Arab Emirates: 68.80%)[6].

The third wave of digitization, whose diffusion start point can be somewhat arbitrarily placed around 2010, entails the adoption of a range of technologies aimed at enhancing information processing and the quality of decision making, while further automating routine tasks within business enterprises and governments. They comprise:

[2] Source: UNCTAD (2016).
[3] Source: http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2016.pdf
[4] Cloud computing is defined as an architecture of computer systems whereby a network of remote servers connected through the Internet fulfils the fouction of hosting, managing, and processing data. This configuration allows for sharing of hosting infrastructure and accessing resources. Most common applications include webmail, data hosting and back up, and shared remote software platforms. This market is segmented across software as a service (SaaS), infrastructure as a service (IaaS), outsourced business processes (Business Process as a Service), and applications services (Platforms as a Service). Cloud computing most important benefits are cost reduction, reliability, and usage scalability. However, this technology is dependent on fast and reliable broadband access.
[5] Having started as a research project of the Advanced Research Projects Administration (ARPA) of the US Department of Defense, its management was transferred to the National Science Foundation in the mid-1980s and limited to academic locations. In 1995, NSFNET was shut down and only for-profit organizations were left running the commercial backbone. At this point, the diffusion process was driven exclusively by market forces (Greenstein and Prince, 2006).
[6] Source: Owloo.

- **Big data/analytics** is defined as the capability of processing extremely large data sets to identify patterns of relationships (correlation, causality) among data to be used in detecting market trends, consumer behavior and preferences. Most common applications range from epidemiological and climate change research (in the public domain), as well as marketing and business process design (within the private sector).



- **Internet of things** entails platforms that link multiple sensors and data devices in order to generate a complete vision of the behavior of an organization, a system, a business operation, or a phenomenon. The most common applications are precision agriculture (which controls fertilizers, monitors rain and determines the most appropriate harvest), smart cities (which allow the control of traffic flows or manage energy use in public places), and telemedicine (which monitor hospital patients health). The adoption of Internet of Things is directly linked to vertical applications, and while these platforms are different from machine to machine applications, they are based on common components. Machine to machine applications are generally conceived as point solutions that link similar devices, such as thermostats, connected via a cellular network, a flow sensor in a refinery, a vehicle location system for fleet management, or home appliances monitoring. On the other hand, an Internet of Things system is a platform that interconnects a variety of discrete devices (including Machine to Machine sensors) to provide a holistic vision of certain phenomena. In that sense, M2M devices are a component of an Internet of Things network.



- **Robotics** entails the application of digital technology to the performance of repetitive manual tasks, such as those required in car assembly, agricultural harvesting, and exploration in dangerous environments.



- **3D printing** is a technology that allows the creation of objects by means of successive printing of adhesive materials such as polymers. While applications of 3D printing are widespread, its use is fairly common in product design (medicinal prosthetics, architectural models, textile design) as well development of spare parts (in consumer electronics and industrial products)



- **Artificial intelligence/machine learning:** these two technologies are not equivalent, although they share some common concepts. Machine learning is an artificial intelligence application consisting in the development of programs that allow a computer to learn routines without being necessarily pre-programmed. In that sense, the machine learning program transforms itself once it starts processing information. The most common machine learning applications are self-driving cars, product recommendations, Internet platforms like Amazon and Netflix, fraud detection in credit card usage, and calculation of consumer credit profile.



These technologies are not typically adopted in a stand-alone fashion. In order to be incorporated within an industry 4.0 digitization context, they are integrated with the mature technologies characteristic of the first and second waves. Along those lines, industry 4.0 represents the assembly of mature and advanced technologies to respond to new requirements in the configuration of value chains in order to yield higher efficiencies and new capabilities in product development and delivery (which naturally leads to an increase in consumers' willingness to pay). As an example of changes in business operations:

- Collaborative development of products and services among different firms;
- Optimization of production chains in order to reduce transactions costs between functions;
- Reduction in production sizes and decrease in response time to allow for higher product personalization;
- Optimization of logistics chains to reduce supply intervals;
- End to end multidimensional traceability in order to increase monitoring and management of the production chain;
- Flexibilization and efficiency in the management of production means; and
- Transformation of distribution in order to optimize market reach (better signalling, better prices, improved segment coverage).

The interaction between matured and advanced technologies is oriented towards meeting the requirements discussed above (see exhibit 3).

Exhibit 3. Technologies and applications of Industry 4.0

	DIGITAL TECHNOLOGIES										
	Hybridization of physical and digital worlds			Communications and data processing			Management applications				
	Sensors/M2M/IoT	3D Printing	Robotics	Cyber-security	Cloud computing	Broadband	Platforms	Big Data/analyticss	Artificial Intellgence/ machine learning	Applications (ERP, CRM)	Financial flows
Collaborative development of products and services				✓	✓	✓	✓		✓		
Industrial chain (re) configuration				✓	✓	✓	✓			✓	✓
Reduction of production series and response time		✓	✓					✓			
Optimization of lpogistics chains			✓					✓	✓	✓	
End-to-end multidimensional traceability	✓			✓	✓			✓		✓	
Flexibility and efficiency of means of production			✓					✓		✓	
Distribution transformation	✓			✓		✓	✓	✓	✓		✓

Source: adapted from Indra (2015)

The third digitization wave entails further embedding of the more advanced technologies, such as artificial intelligence, machine learning, and deep learning in production. While some discrete applications are starting to be developed, we still lack widespread assimilation as it is in the case of the second wave. Part of this delay is related to the complexities and high investment required for developing these applications. Furthermore, development in some areas is related to ethical and/or privacy concerns, where industry seeks guidance from regulators and policy makers[7]

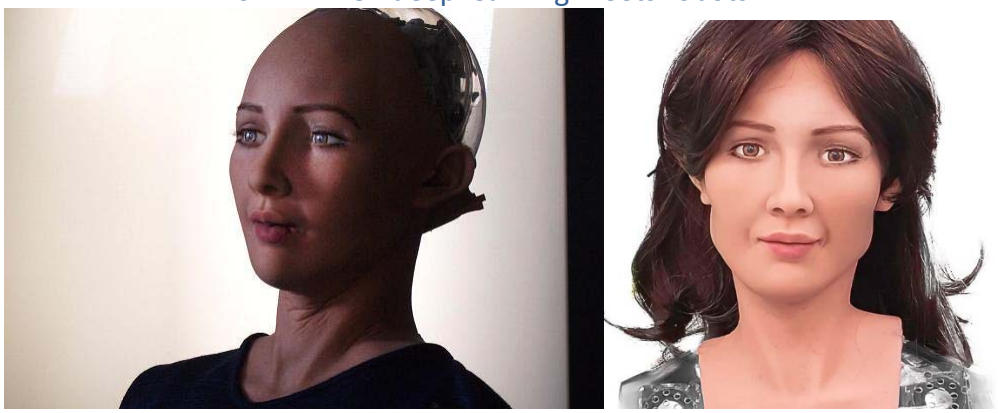
The assessment of third wave of digitization is constrained by the lack of statistics, particularly in the developing world. That being said, preliminary data indicates that adoption of third wave digitization technologies is advancing as a fast pace. For example, the installed base of machine-to-machine devices reached 9.58 per 100 populations among OECD countries in 2015[8]. This trend is not restricted to developed countries. In

[7] A common policy issue pertains to data sharing across applications and its privacy implications. Another one is whether an AI platform can have the potential to deliver biased recommendations, such as credit approval in loan applications or crime prevention.

[8] Source: GSMA Intelligence.

Latin America, for example, penetration in 2015 reached 3.10 per 100 populations. Similarly, robot density (a measure of the installed base per 10,000 employees) was 531 in South Korea, 398 in Singapore, 305 in Japan, 301 in Germany, and 176 in Germany. As expected, density is highest in the automotive industry, with a density of 1,276 in Japan, 1,218 in South Korea, 1,218 in the United States, and 1,218 in Germany[9].

Box 1: When deep learning meets robots



Sophia is Hanson Robotics' latest and most advanced robot. Sophia is a "social robot" using AI software developed at Hanson Robotics. She can process visual data to see people's faces, she can process conversational data and emotional data and use all them to converse with people. She has given numerous interviews to multiple media outlets, sang in a concert, and has been featured on the cover of a top fashion magazine. She has also appeared onstage as a panel member and presenter in high-level conferences, covering how robotics and AI will become a prevalent part of people's lives.

Source: Hanson Robotics, at www.hansonrobotics.com/robot/sophia/

To sum up, we have reviewed three waves of digitization and differentiated innovation versus adoption and social and economic impact cycles (see exhibit 4).

Exhibit 4. Technological Innovation, Adoption and Impact

Technological Innovation	Development	Adoption	Social and Economic Impact
Computers, broadband, mobile telecommunications	1950-1975	1960-2000	1990-2010
Internet platforms, cloud computing	1970-1990	1995-ongoing	2005-ongoing
Internet of Things, Robotics, Artificial intelligence, Machine Learning	1980-ongoing	2010-ongoing	2020-ongoing

Source: Author

[9] Statistics sourced from World Industrial Robotics 2016.

Having conceptualized and provided some basic statistics of the three digitization waves, it is pertinent to review the evidence regarding their social and economic impact. This will allow defining what role should be assumed by ICT policy makers and regulators in fostering innovation and adoption, while controlling for potential social disruptions.

3. Social and economic impact of the first wave of digitization

3.1 Impact on economic growth

At the highest level, computing, broadband and mobile telephony networks have been instrumental in relaxing scalability constraints, thereby allowing traditional sectors of the economy to grow more rapidly. It is common to observe that many traditional sectors of the economy are growth constrained by limited access to resources such as raw materials or distribution channels. In this context, digitization based on mature technologies has provided a way to allow businesses to scale further, addressing additional final demand and thereby creating increased need for factor inputs, namely labor. The initial push for alleviating the scalability constraint has been identified in several pieces of research:

- Improved productivity as a result of the introduction of more efficient business processes supported by ICTs, and marketing of excess inventories and supply chain optimization [10] (Atkinson et al., 2009)

- Revenue growth resulting from extended market coverage (Varian et al., 2002, Gillett et al., 2006, and Jonscher and Tyler, 1982)

- Impact on the composition and deployment of industrial value chains. First wave digital technologies can attract jobs from other regions as a result of the ability to process information and provide services remotely. The services most greatly impacted are outsourcing and the deployment of virtual customer care centers. Abramovsky et al. (2006) analyzed an extensive dataset of UK firms and found that broadband Internet use increases the probability of a firm offshoring business processes and services between 6% and 12%, thereby reducing its overall costs.

- Growth of some industries within the services sector (Crandall et al., 2007): for example, growth in software development and business process outsourcing.

In particular, with regards to revenue growth, Clarke (2008) studied the impact of broadband access on exports of manufacturing and service firms. The analysis was

[10] Efficient telecommunications make it possible to reach a broader market, facilitating business processes. They also result in reduced input costs as the capacity to search for lower prices increases.

performed for countries of medium and low levels of development in Eastern Europe and Central Asia. The study controlled for variables such as firm size, industrial sector, foreign ownership, firm performance, level of domestic competition, international trade organization affiliation, progress in privatization, and telecommunications infrastructure. The author found that in the manufacturing sector firms with Internet access enabled by broadband generated 6% more foreign sales than the rest.

This particular effect has been well researched in the microeconomics literature. The opportunity provided by broadband to increase market reach and seek out the highest possible selling price in open economies is essential in the development of a vibrant manufacturing sector. In the service sector, broadband enabled firms generate between 7.5 % and 10 % more sales. In this case, the impact is primarily driven by enhanced access to foreign markets. In both cases of manufacturing and service industries, broadband improves export performance by facilitating the communication with foreign buyers, improving information on overseas markets, consumers and standards, and by ultimately linking the enterprise to consumers, and by allowing bidding for contracts or participating in business-to-business platforms.

At an aggregate level, Katz and Callorda (2017) estimate that 1% increase in a digital ecosystem development index, which corresponds mainly to the first and second waves of digitization (including all telecommunications technologies and digital services such as e-commerce, e-government, e-health) yields 0.13% increase in per capita GDP growth, meaning that a ten-point increase in the index yields 0.26% increase in per capita GDP (which includes direct and secondary effects). The coefficient is higher for OECD countries than emerging economies[11].

In particular, ICTs have been found to have a positive impact on the development of new businesses. This results from the network effects of connectivity. When a large enough number of households are connected to broadband, the incentive to develop new businesses around information search, advertising and electronic commerce increases. For example, Crandall et al. (2007) estimated that the network effects of universal broadband access could have a multiplier of 1.17 on the investment in infrastructure. Similarly, as a result of 40% lower broadband penetration in the United Kingdom, Liebenau et al. (2009) estimated the multiplier to be somewhat lower (0.33) for the British economy.

3.2. Impact on job creation

Beyond job creation as a result of the construction and deployment of telecommunications networks, the first wave of digitization has already had significant

[11] An increase of 1% in the Digital Ecosystem Development Index yields an increase on 0.14% in per capita GDP for OECD countries, while the impact of a similar change in non-OECD countries will be 0.10%. In other words, the higher the economic development, the stronger the contribution of the digital ecosystem on economic growth.

employment contribution. Research has allowed extending the positive impact of the first wave of digitization from alleviation of the resource constraint mentioned above to increased demand for labor. According to Crandall et al. (2007), the job creation impact of broadband tends to be concentrated in service industries, (e.g., financial services, education, health care, etc.) although the authors also identified a positive effect in manufacturing as well. In another study, Shideler et al. (2007) found that, for the state of Kentucky in the United States, county employment was positively related to broadband adoption in multiple sectors, including manufacturing and certain services. This specific effect has also been analyzed by Katz et al. (2010) for rural economies of the United States. In this research, the author found that, within rural counties, broadband penetration contributed to job creation in financial services, wholesale trade and health sectors. This is the result of enterprise relocation enabled by broadband, which benefits primarily urban communities in the periphery of metropolitan areas (Katz et al. 2010).

At the aggregate world level, Katz and Callorda (2016) also show that between 2004 and 2015 an increase of 1 percent in the digitization of consumption index results in a 0.07% reduction in the unemployment rate. Furthermore, Goos et al. (2015) estimate that across locations in Europe the local high-tech job multiplier is around five. Some research estimates that those jobs are compensated at 30% rate higher than average (therefore, they are high-skilled).

That being said, research also found that certain industries undergoing digitization of their production, contrary to creating jobs, were prone to reduce their workforce. For example, Katz et al. (2010) found that the lodging and food services industry undergoing broadband adoption in the United States was found to reduce its number of jobs. This was the result of a particularly strong capital/labor substitution process taking place, whereby productivity gains from broadband adoption yielded reduced employment. Similarly, Thompson and Garbacz (2008) concluded that, for certain industries, "there may be a substitution effect between broadband and employment"[12].

3.3 Impact on social welfare

In recent years, the implementation of national household surveys that now include ICT modules has allowed to research the impact on social welfare of the first wave of digitization. For example, using information from Peruvian households between 2007 and 2009, De Los Rios (2010) found that, during this time period, Internet adopters experienced significant income growth relative to those households that did not have the service. Similarly, Katz and Callorda (2014) have estimated through analysis of household data in Ecuador that the introduction of broadband yielded an increase of 3.67% increase in average household monthly income (increasing to 5.01% among households equipped with a personal computer).

[12] This effect was also mentioned by Gillett *et al.* (2006).

While the causes for this increase can vary, broadband appears to have an impact on the growth of household income through four effects. First, broadband deployment requires infrastructure construction in order to provide the service (the "construction" effect referred to above), additional workers for the operator's new commercial offices, and technical personnel for the installation and maintenance of the new infrastructure. The new demand for labor in a market with an unemployment rate that is already below 5% generates a shift in the demand curve for workers, which leads to an increase in equilibrium wages. In other words, at full employment, additional demand for workers tends to result in an increase in compensation. Furthermore, the rise in wages through this channel may reflect a need for better compensation for those workers who, given the low unemployment rates, should receive better wages to meet or exceed their reservation wage.

A second explanation for the income increase is that, as seen in Katz (2012a), broadband has a positive effect on worker productivity. Classic labor economics literature shows that wages in competitive markets equal marginal productivity. As a result, higher labor productivity should yield higher wages. This is labeled the "productivity effect".

Third, research results also show that the effect of broadband deployment is greater for computer and Internet users. In this sense, the introduction of broadband at the county level allowed workers with digital literacy skills to signal their computer knowledge to potential employers and then use those skills in the workplace in return for a higher wage. We call this impact the "skill signaling effect".

Finally, the introduction of ICT can also help to reduce the time otherwise required for an effective job search, allowing underemployed workers to look for full-time work using broadband services. This increase in efficiency leads to a reduction in unemployment periods and generates an increase in the migration of underemployed workers to full-time positions, which, in turn, results in higher labor income. In other words, reduced transaction costs related to finding employment can ultimately result in higher income (with less search time required, the underemployed can find full-time work).

* * * * *

In summary, research on the social and economic impact of the first wave of digitization indicates significant contribution to business growth and cost optimization. On the other hand, job creation effects appear to differ by industry sector. The first wave of digitization may have simultaneously caused labor creation triggered by unlocking scalability in certain sectors while enhancing productivity in other labor-intensive industries, resulting in job destruction. In other words, while triggering job creation by alleviating scalability constraints in certain sectors, the productivity impact of broadband can cause capital-labor substitution and may result in a net reduction in employment in other industries. In any case, research on the first wave indicates that job creation far outpaces workforce reduction in certain labor-intensive sectors. Exhibit 5 summarizes the evidence regarding the social and economic effects of the first digitization wave.

Exhibit 5. Social and Economic Effects of the First Wave of Digitization

Area	Positive Contributions	Negative Effects
Economic growth	• Improved productivity as a result of the introduction of more efficient business processes supported by ICTs • Revenue growth resulting from extended market coverage • Impact on the composition and deployment of industrial value chains • Growth of some industries within the services sector (software development and business process outsourcing)	
Employment	• Job creation impact of broadband tends to be concentrated in service industries, (e.g., financial services, education, health care, etc.) although a positive effect was detected in manufacturing as well • In the United States, county employment was positively related to broadband adoption in multiple sectors, including manufacturing and certain services • For rural economies of the United States, broadband penetration contributed to job creation in financial services, wholesale trade and health sectors, as a result of enterprise relocation, benefitting primarily urban communities in the periphery of metropolitan areas • Between 2004 and 2015 and increase of 1 percent in the digitization of consumption index results in a 0.07% reduction in the employment rate • In Europe the local high-tech job multiplier is around five	• Certain industries undergoing digitization of their production, contrary to creating jobs, were prone to reduce their workforce as a result of result of a particularly strong capital/labor substitution (for example, lodging and food services industry)
Social inclusion	• Increase in average household income as a result of broadband access	• Reinforcement of social divide patterns as a result of technology have's and have not's

Source: Author

As indicated in exhibit 5, while the first wave can elicit some negative effects, they are vastly outpaced by the positive contributions. Moreover, the negative effects can be mitigated through well-proven targeted policy remedies described below.

4. Social and economic impact of the second wave of digitization

Moving on to the second wave of digitization, empirical evidence on social and economic impact can be grouped into three categories: 1) innovation triggered economic growth, 2) labor force impact, and 3) social welfare negative effects. Each category will be reviewed in turn.

4.1 Business innovation as a driver of economic growth

In the beginning of the second wave of digitization, economic growth was fueled by the introduction of new services and applications such as Internet information searches, electronic commerce, distance education and social networks (Atkinson et al., 2009). This initial move has achieved considerable impact. For example, in countries with high broadband penetration, by 2015 the percentage of total retail trade conducted through electronic commerce had already exceeded 10% (South Korea: 15.09%, Denmark: 12.63%, United Kingdom: 13.41%).

Beyond this initial spur, empirical evidence supports the existence of a second "innovation" effect triggered by the combined adoption of platforms, broadband, and cloud computing. This results in the development of new products and services, such as the whole range of collaborative businesses that characterize the digital economy (Uber, airbnb, etc.). In addition, the development of Internet platforms has resulted in the emergence of a large market for creating local Internet content and applications in native languages. In addition to creating jobs in the production, distribution and management of a local content digital industry, its development has multiple benefits, including helping to strengthen national cultural identities, reducing foreign trade imbalances, and promoting demand for local ICT infrastructure services (e.g., domestic ISPs and cloud services to support domestic content). The development of local digital content entails enormous opportunities not only to develop a vibrant domestic content and applications industry but also to meet the needs of population that would only adopt broadband if they were to find a product that is culturally relevant to its needs. For example, research conducted by Katz and Callorda (2011) for the Colombian Digital Plan Vive Digital indicated that 1 percentage point increase of local e-Government applications yields an increase of 0.55 percentage points in broadband penetration.

Similarly, on-line B2B and B2C platforms have allowed domestic businesses to address international markets, which in turn, yield an increase in employment. As an example, as of 2015, the videogame industry in Latin America comprised 418 companies employing approximately 7,000 developers, while developers of applications in the same region relying on Facebook platform amounted to approximately 20,000 (Katz, 2015). In the case of Latin America, *Mercado Libre*, the most important e-Commerce platform has triggered the creation of approximately 120,000 registered users offering their goods through the network[13]. This amount vastly exceeds the direct jobs created by the platform (2,635). Additional new jobs created by the "new" digital economy could include support services for these businesses, which include advertising, platform maintenance and management, and the like.

[13] Mercado Libre (2015). *Business Overview*.

On the other hand, the increased use of digital technologies associated with the second digitization wave has raised the potential negative economic effect of an Internet disruption, as a result of natural emergency, cybercrime, technological failure, or politically motivated blackout. World economies are increasingly reliant on the Internet, while, as explained above, the Internet is vital for economic development. In this context, it is reasonable to consider what the economic impact might be of a disruption of the Internet as a result of either natural or man-made causes. These appear to be fairly common as documented by Howard, Agarwal, and Hussain (2011). The authors identified 606 government-imposed shutdowns of the Internet between 1995 and the first part of 2011, for a total of 99 countries. In 2010 alone, the number of man-made shutdowns reached 111. Between July 2015 and June 2016, West (2016) counted 81 government-imposed disruptions, of which 36 affected the national broadband network and 22 impacted subnational mobile networks. Beyond government-initiated downtime, the Internet is constantly affected by localized downtimes. According to the disruption tracking platform Pingdon, at any hour period worldwide, the Internet is affected by approximately 16,000 outages. Man-made and technology disruptions have an economic impact. The economic impact per day varies by the type of disruption, ranging, according to West (2016), from US$ 3,816,000 for a national platform (such as Twitter or Google) to US$ 14,968,000 for the national Internet[14].

4.2 Labor force impact

The other stream of social and economic impact research of the second wave of digitization has focused on the restructuring of labor markets in certain sectors of the economy. Along these lines, the extensive evidence can be categorized along three clusters:

- Disappearance of jobs resulting from task automation
- Job creation resulting from enhanced demand for labor in certain occupations linked to the development of digital services or the emergence of collaborative business models
- Labor force polarization resulting from “hollowing out” of middle-skill jobs

4.2.1 Elimination of jobs

The same way that technology fostered capital labor substitution in agriculture and manufacturing, the primary assumption of this body of research, as reported by Brynjolfsson and McAfee (2014), is that new digital technologies have an adverse effect on low and middle-skilled workers. This is supported, according to the authors, by stagnant median wages and the falling labor share of income.

[14] This impact only looks at GDP, and excludes lost tax revenues, impact on worker productivity, barriers to business expansion, and loss in investor or consumer confidence.

However, this body of research is not completely endorsed. For an example, in an opposing view, Gordon (2012) argues that automation linked to the second wave of digitization is not significantly affecting labor markets in the aggregate, and that sluggish productivity growth in the United States indicates slow technological progress. In support of this statement, some sectors such as health care and personal services continue to create jobs at a fast pace. Furthermore, despite what one could assume in terms of the disappearance of some repetitive occupations, the fact is that there are still 3,000,000 cashiers in the United States, although a large percentage is likely to be replaced by automated registers over a period of time driven by the adoption of innovation timeline (Frey and Osborne, 2013).

In response to this finding, both Brynjolfsson and McAfee (2014) and Summers (2015) argue that productivity statistics do not accurately capture fundamental changes in labor markets. First, the negative effects of automation are primarily concentrated at the low-skill level of occupations (Sachs and Lawrence, 2012). Second, the job creation contribution of the second digitization wave cannot completely cancel out the disappearance of jobs.

4.2.2 Creation of jobs

The consensus of research regarding job creation as a result of the second wave of digitization is that, while new employment has emerged, the effect has not been sufficient to counterbalance the disappearance of jobs discussed above. For example, Berger and Frey (2016a) reported that the emergence of new technology- related industries throughout the 2000s —including online auctions, video and audio streaming, and web design—had negligible effects on aggregate employment patterns, employing less than 0.5 percent of the US workforce. In a similar vein, Spence and Hlatshwayo (2012) report that between 1990 and 2008, technologically progressive sectors of the US economy, accounting for more than 34 million jobs in 1990, grew by a negligible 0.6 million jobs, while technologically stagnant sectors, experiencing slow productivity growth accounted for 98 percent of total job creation.

A more nuanced view of this effect has been presented by Lin (2011). According to this researcher, job creation resulting from digitization was strong as a result of the first digitization wave (reported in the section above) but has decreased as a result of the second wave. For example, during the 1980s, some 8.2 percent of US workers shifted into jobs that appeared for the first time during that decade, while by the end of the 1990s that share had almost halved to 4.4 percent. Given the recent occurrence of this trend, evidence of this trend in emerging countries is still not available.

Research has also been able to identify the clusters of employment growth resulting from the second digitization wave. As digital technologies have diffused across a wider range of occupations and industries, the demand for workers with analytical, interactive, and problem-solving skills has surged (Autor et al, 2003). In this context, Acemoglu and Autor

(2011) estimate that the supply of skilled human capital is not keeping up with demand triggered by technological change; this, in turn, has driven an increase in wages of high-skilled occupations. Coincidentally, Spitz-Oener (2008) reports that computer use in jobs is associated with an increase in wages by some 8-15 percent.

Simultaneously, the surge in low-skill service jobs is driven by increase in demand from higher income occupations combined with the fact that manual non-routine tasks that are prevalent in service occupations are not substitutable by computers (Autor and Dorn, 2013). Similarly, Moretti (2010) showed that the indirect contribution of new technology jobs is still significant as they create additional demand for local services. For example, one additional job in the tradable high-technology sector generates about 4.9 new jobs locally in the non-tradable sector, as skilled workers with higher incomes create additional demand for local services.

4.2.3 Labor force polarization

Labor polarization is defined as the disappearance of medium-skilled jobs combined with the growth of employment at the high-end and more routine service end. Based on research by Goos et al., (2007; 2009; 2014), labor markets throughout the OECD economies have experienced a reduction of routine jobs with significant expansions of employment at both ends of the skill spectrum. Coincidentally, Akerman et al. (2015) report that digital technologies and automation are the primary drivers of job polarization in most developed countries. Part of this effect can be linked to limited digital skills in those sectors of the population that have little access to education beyond secondary schooling.

* * * * *

In summary, the difficulty in assessing the combined negative and positive effects of the second digital wave of digitization on labor markets is due to three factors. First, as pointed in the first wave of digitization, the job creation/job destruction effects vary by industry and occupations. So far, research indicates that adverse effects on labor markets are concentrated on low and middle-skilled jobs, which are more prone to being replaced by technology. Second, the speed at which capital – labor substitution is proceeding is conditioned by the pace at which firms implement the necessary organizational and business process changes to assimilate the new technologies. Katz (2015) research in Latin America indicates, for example, that despite the high adoption of digital technologies among all industries, their contribution to productivity is almost negligible. This finding is consistent with Basu and Fernald (2007) who point out that productivity growth follows investment in digital technologies with lags of between five and 15 years. This means that steep changes in job destruction take some time to materialize, particularly in emerging economies. Third, while hypothetically, some jobs could be easily replaced by automation, the fact is that we still have limited knowledge of the “non repetitive”, intuition-based tasks that are part of these occupations.

That being said, researchers agree on three conclusions:

- Automation effects will have a significant change on the occupational profile of labor markets, particularly in sectors that are labor intensive with an emphasis in repetitive tasks
- The main impact will concentrate at the low-skilled levels
- These effects will accelerate over time fueled by the accumulation of intangible capital of firms (organizational changes, reengineering of business processes due to digital transformation) and the increasing potential of digital technologies linked to the third digitization wave

4.3. Welfare impact

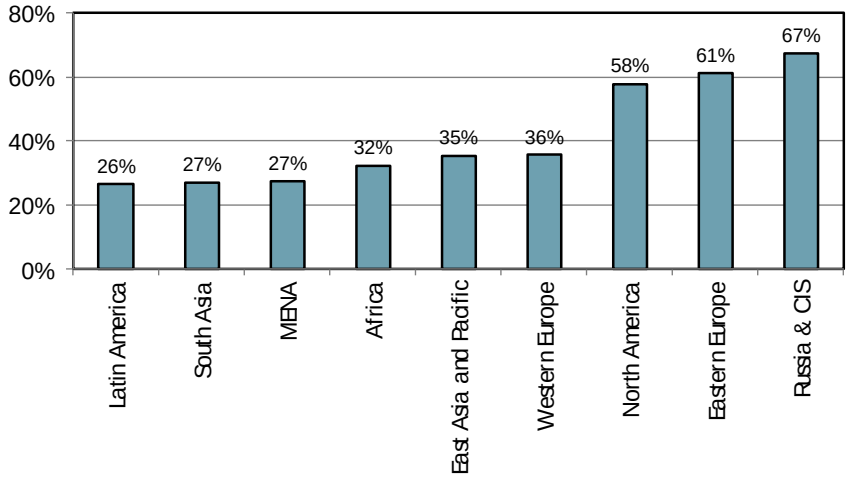
The second wave of digitization has also been found to trigger a number of negative effects. The first risk is the degradation of human relationships resulting from intense digital consumption. Americans spend an average of five and a half hours a day with digital media, more than half of that time on mobile devices, according to the research firm eMarketer. Moreover, users check their phones 221 times a day—an average of every 4.3 minutes—according to a UK study. This number actually may be too low, since people tend to underestimate their own mobile usage. Research by Turkle (2015) argues that the digital revolution, by its intensity, is degrading the quality of human relationships. Turkle finds the roots of the problem in the failure of young people absorbed in their devices to develop fully independent selves. She argues that digital devices disrupt the ability of children to separate from their parents, and raise other obstacles to adulthood. Because they aren't learning how to be alone, Turkle contends, young people are losing their ability to empathize. Along these lines, social media offer respite from the awkwardness of unmediated human relationships.

The second risk, particularly among adolescents, is the decline in conducting other knowledge gathering activities such as reading. In a research by this author (Katz, 2012), high school students in the United States spend on average 554.80 minutes (or 9.25 hrs.) a day using technology devices during the week. Of these, 279 minutes are spent in front of a PC and 191 in front of a cellphone. Given the increasing capability of cellphones, it is expected that future studies would yield a much higher time allocation to smartphones at the expense of the PC. Conversely, the study found that teenagers read for leisure an average of 5.6 books per year. Along these lines, girls tend to read more than boys (6.6 vs. 3.9). The higher levels of video game playing amongst boys could partly explain this trend. Furthermore, when it comes to human interaction, most adolescents prefer texting to calling on their cellphones.

A third risk that has been studied particularly in developing countries is cultural uprooting. An analysis conducted by this author of the most popular Internet sites accessed by region

indicates that in MENA countries, only 27 of 100 most popular sites, measured by number of visitors and time spent on the site are produced locally, while the remaining are either produced overseas or developed overseas and translated to local language (see exhibit 6).

Exhibit 6. Percentage of Local Internet Content by Region (2013)



Source: Katz (2013) based on Alexa data

The data in exhibit 5 indicates two important patterns. First, developed regions appear to have a higher percentage of the most popular Internet sites to be local. Second, regions with linguistic specificities (such as Russia) appear to have a higher percentage of local content. Conversely, developing regions with use of one of the world languages (Latin America for Spanish, South Asia for English, MENA and Africa for French and English) tend to have a lower percentage of local Internet content. The implications of these data are that as result of limited local content production, the Internet could act as vehicle for cultural uprooting. This situation raises the importance for ICT policy makers to promote the development of local Internet content and applications.

A related risk of 'opportunity cost' has to do with the fact that a portion of the population does not gain access to the benefits implied by digitization due to concerns related to data privacy, trust, and cybercrime. ICT regulators and policy makers need to devise the right initiatives to address these adoption barriers.

4.4 Compilation of social and economic impact of the second digitization wave

As demonstrated in the research reviewed in this section, the second wave of digitization can be linked to a number of positive contributions and negative effects. Exhibit 7 summarizes the evidence regarding the social and economic effects of the first digitization wave.

Exhibit 7. Social and Economic Effects of the Second Wave of Digitization

Area	Positive Contributions	Negative Effects
Economic growth	• Development of new products and services, such as the whole range of collaborative businesses that characterize the digital economy • Emergence of a large market for creating local Internet content and applications in native languages, which strengthens national cultural identities, reduces foreign trade imbalances, and promotes demand for local ICT infrastructure services (e.g., domestic ISPs and cloud services to support domestic content) • On-line B2B and B2C platforms allow domestic businesses to address international markets	• Negative economic impact related to Internet blackout as a result of technological failure, cybercrime, or political shutdown
Employment	• Create jobs in the production, distribution and management of a local content digital industry, its development has multiple benefits • Creation of indirect employment as a result of multi-sided Internet platforms (social networks, search engines, etc.) • Additional new jobs created by the "new" economy could include support services for these businesses, which include advertising, platform maintenance and management, and the like.	• While job creation resulting from digitization was strong as a result of the first digitization wave, it has decreased as a result of the second wave • Adverse effect on low and middle-skilled workers • Negative effects of automation are primarily concentrated at the low-skill level of occupations • These effects will accelerate over time fueled by the accumulation of intangible capital of firms (organizational changes, reengineering of business processes) and the increasing potential of digital technologies linked to the third digitization wave
Social welfare	• The development of local digital content entails enormous opportunities to meet the needs of population that would only adopt broadband if they were to find a product that is culturally relevant to its needs	• Degradation of human relationships resulting from intense digital consumption (failure of young people absorbed in their devices to develop fully independent selves, digital devices disrupt the ability of children to separate from their parents, and raise other obstacles to adulthood. Because they aren't learning how to be alone) • Decline in children and adolescents conducting knowledge-gathering activities such as reading. • Developing regions with use of one of the world languages (Latin America for Spanish, South Asia for English, MENA and Africa for French and English) tend to have a lower percentage of local Internet content. As result of limited local content production, the Internet could act as vehicle for cultural uprooting.

Source: Author

As is self-evident in the data on positive and negative effects, while the second wave of digitization is still driving significant number of social and economic benefits, the number of negative effects appears to be increasing: job creation resulting from innovation does not seem to compensate for job losses at the medium and low-skilled level, the economic risk linked to disruption associated to the increased reliance on the Internet are rising, and there are some potential negative social effects related to human relationships, learning capability, and cultural uprooting.

The policy implications are clear. First, it is imperative to maximize the application of levers that accelerate innovation. This could have an impact not only in the creation for additional labor demand, but also regarding the supply of local Internet content and applications. Second, workforce retraining would appear to be a natural requirement to mitigate the disruptions associated with low-skilled jobs. This policy intervention will be addressed in detail below. Third, there is an urgent need to approach education in an integrated, holistic manner where the value of technology is properly integrated with more traditional approaches to teaching.

5 Social and economic impact of the third wave of digitization

As mentioned above, the third wave of digitization is still in its inception. Along these lines, research on social and economic impact is substantiated by either anecdotal evidence or technology forecasting that assessing past effects.

5.1. Impact on economic growth

The expanding scope of the third wave of digitization has significant implications for productivity improvements. The advances in robotics, big data analysis and machine learning have already yielded applications that, when adopted on a mass scale, should have a significant impact on operating costs (see exhibit 8).

Exhibit 8. Examples of economic impact of advances in third wave digitization technologies

Application	Technology	Impact
Medical Diagnosis conducted by IBM's Watson	• Big data (cancer: 600,000 medical reports and 2 million pages of medical papers • Machine learning	• Match patient symptoms and genetics to deliver tailored treatment • Reduction in health care costs
Google Translate	• Machine Learning	• Improve accuracy in translation services • Reduction in delivery time of translated content
Smart Action call automation	• Speech recognition • Natural Language processing	• Reduce call center costs by 60-80 percent
Workfusion software	• Machine learning	• Splits job streams between routine ones that can be automated and those that cannot • Platform learns from humans as to how they execute tasks and routinizes / codifies them
Rethink Robotic (Baxter) Workday software	• Robotics • Sensors • Big data • Artificial Intelligence • Big data	• Robot can be instantly reprogrammed to perform different tasks ranging from line loading and machine tending to packaging • Identify most promising job candidates by scanning CVs • Accelerate recruiting time by reducing paper data analysis

Source: compiled by the author

As these applications are still moving from the lab to adoption, it is not feasible yet to quantify their impact at a macro-economic level. Moreover, turning back to the distinction between technological innovation, diffusion and economic impact, it is fairly difficult to forecast the speed at which they will undergo adoption. For example, it is likely that some of these platforms will be adopted only by some large companies in industries more likely to be affected by high operating costs. Thus, beyond firms such as Amazon, Wal-Mart (with high fulfillment costs), and the big telecommunications operators (affected by high call center costs), it is unlikely that adoption will proceed at a rapid pace. Moreover, the adoption of these platforms will require a massive change in operating processes and organization structure, as well as employee training (accumulation of intangible capital), which will have an impact on timing to adoption. Finally, many of these platforms raise fundamental issues regarding employee resistance, lack of management awareness and even ethical considerations. For example, the CV scanning platform mentioned above might push managers to abdicate judgment in recruiting talent or push the boundaries with regards workers' privacy[15]. All these factors might delay for some time the actual economic impact to be yielded by the third wave of digitization.

Assuming that mass adoption of the third digitization wave will occur within a decade or two, it is fair to conclude that the economic impact will be significant. First, if operating

[15] Greenwald, T. "How AI is transforming the workplace". The Wall Street Journal. April, 9, 2017.

costs diminish substantially, at least part of this reduction will be transferred to consumers, which they will also benefit by increase efficiency. Second, the third wave of digitization could reverse the offshoring trend of multinational corporations and dramatically alter the global production chains. For example, it is projected that the operating cost of a welding robot in an automobile assembly line will be lower than that of a welder in an emerging country factory. At that point, the incentive towards globalization of the automobile value chain lessens and the geographic division of labor could undergo a significant change. The third impact pertains to labor force disruption, which is addressed in the next section.

5.2. Impact on labor force

The factors regarding time of adoption notwithstanding, the third wave of digitization promises to have an impact on employment. That said, research is clustered around two bodies: one that forecasts a dramatic disappearance of jobs as a result of automation, and a second one that establishes that negative disruption effects are overstated.

The primary assumption supporting the first body of research is that automation of repetitive tasks, linked to robotics, and combined with enhanced power of technology in areas such as artificial intelligence and speech recognition, is linked to the disappearance of jobs. For example, Frey and Osborne (2013) estimate that nearly half of jobs in the United States are susceptible to automation over the forthcoming decades, while jobs requiring creativity and complex social interactions are at low risk of automation. According to this research, three key bottlenecks that ultimately set the current boundaries for the application of machine learning and AI to occupations: (i) creative intelligence; (ii) social intelligence; and (iii) perception and manipulation. Coincidentally, McKinsey (2015) estimates that 45 percent of tasks undertaken by US workers are automatable with existing technology. In the same vein, Bruegel (2014) estimates that 45 percent of EU jobs are at risk of automation, ranging from 47 percent in Sweden to 62 percent in Romania.

The primary premise of the second body of research is that not all jobs can be replaced by automation and that second-order job creation derived from either new innovation and/or increased productivity and spending can actually cancel out any disruption effects. It should be noted that some research acknowledges that innovation-driven job creation will never compensate for automation-driven job losses, but that new jobs will be triggered by an increase in purchasing power of consumers (Atkinson and Wu, 2017). Along those lines, the concern of these researchers is that if productivity does not increase, living standards will not improve and, consequently, second order effects will not materialize.

5.3. Impact on social welfare

The third wave of digitization promises to have significant benefits on social welfare, more particularly on several Sustainable Development Goals, such Good health and Well Being (SDG 3), Affordable and Clean Energy (SDG 7), Decent Work and Economic Growth (SDG 8), and Sustainable Cities (SDG 11). Applications, particularly those related to health, and e-government services, have a potential for providing the population for information regarding environmental sustainability. On the other hand, the same applications should contribute to a reduction in traffic of vehicles, particularly in urban and suburban environments. Similarly, e-Government applications reduce travel time needed to conduct transactions in public administrations. In fact, introduction of some of these applications is fairly routine around the world (see exhibit 9).

Exhibit 9. Examples of welfare impact of advances in third wave digitization technologies

Application	Technology	Impact
Horizon Scanning Center (United Kingdom)	• Big data	• Platform forecasting the impact of climate change on food and water availability, among other factors
Prediction of vacant residential property (United States	• Big data	• Help predict and prevent vacant residential property
ATISMART	• Big data • CAS mathematical core	• Traffic flow simulation platform based on the use of smart traffic lights, network sensors, and signals
Foot and mouth disease syndrome prevention (South Korea)	• Big data	• Analysis of data streams coming from animal disease overseas, customs/immigration records, breeding farm surveys, livestock migration, and workers in the livestock industry
Fraud detection in Social benefits payment (United States)	Machine Learning (Unsupervised Learning performing anomaly detection using unlabeled data)	• Fraud reduction in Medicare payments
Public transportation management	• Machine Learning	• Provide just-in-time access to public transportation • Expected to be faster, cheaper and more accessible to the public
Criminal Justice System (United States)	• Machine Learning	• Improve crime reporting, policing, bail, sentencing, and parole decisions (Data Driven Justice, Police Data Initiative) • Aid for decision-making in the criminal justice system

Source: compiled by the author

Diffusion of third wave digitization technologies in the public sector with impact on citizen welfare is proceeding at a fast pace. A recent survey in nine countries completed by Accenture indicated that 70% of interviewed agencies are considering the implementation of an advanced technology, while 25% are moving beyond pilot into full implementation[16].

[16] Accenture. *Emerging Technologies in Public Service*. February 2, 2017.

6. Policy implications

So far, the evidence points out that the first wave of digitization has yielded significant social and economic benefits, coupled with very limited disruptions in labor markets restricted to labor intensive sectors. Secondly, the second wave of digitization has, so far resulted in increased business efficiencies, coupled with job destruction in low-skilled categories (although it is likely that this trend will accelerate once firms accelerate the accumulation of intangible capital and they become more adept at substituting capital for labor). Thirdly, the evidence so far with regards to the disruptive effects of the third wave are quite speculative, unless once believes that third wave disruption is merely an extrapolation of the second digitization wave effects. That being said, it is relevant to consider the policy remedies that could propel the benefits of automation and limit the negative outcomes.

6.1. Promoting innovation and addressing workforce disruption in developed countries

Despite the lack of consensus around the ultimate effects of digitization, there is almost universal agreement that, similarly to the prior waves of innovation, automation will tend to favor those workers with more education and training. Those with limited education (which implies no digital skills) tend to either shift to lower paid occupations or drop out of the workforce entirely. In this context, it would seem obvious, as Sachs (2016) says that,

> *"the most important policy response is to ensure that students stay in school long enough to achieve the skills needed for the new jobs".*

The problem is, however, that training alone might not be a sufficient remedy. In fact, the average number of years in school for populations around the world has been consistently increasing in the last ten years [17](see exhibit 6).

Exhibit 6. Education years expectancy (2006-2015)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
OECD	15.38	15.47	15.54	15.64	15.83	15.94	15.98	16.32	16.37	16.36
North America	16.05	16.22	16.34	16.44	16.58	16.69	16.62	16.54	16.54	16.54
Western Europe	16.05	16.08	16.18	16.27	16.45	16.53	16.59	17.13	17.20	17.21
Latin America	13.26	13.32	13.61	13.69	13.81	13.92	13.96	14.40	14.42	14.42
Asia Pacific	11.17	11.50	11.78	11.90	12.16	12.52	12.74	12.92	12.98	12.98
Eastern Europe	13.79	13.94	14.02	14.06	14.39	14.61	14.74	15.42	15.47	15.47
Africa	10.95	11.16	11.36	11.56	11.68	11.77	12.01	12.19	12.19	12.19

Source: UNESCO; analysis by the author

[17] While the number of school years is increasing, this might not be resulting in more courses focused on digital skills.

As data in exhibit 6 indicates, the average number of education years has been consistently increasing particularly for industrialized countries. However, the OECD countries trend is worrisome insofar that the increase in schooling suggested by Sachs has not been enough to keep up with the shift in occupations triggered by automation. In other words, the first and second digitization waves have reduced the need for low skilled workforce and, despite increasing demand for more educated workers, there were not enough jobs to absorb the supply of more educated population. Two factors appear to be at work that need to be dealt with proactively: capital-labor substitution for low skilled workers, coupled with not enough demand for the highly educated. The relevant question is then, can an increase in the number of school years or non-formal digital training be enough to cancel the trend already observed in developed countries? For this question to happen, the shift towards a supply of high skilled labor (more education) needs to be matched by increasing demand: more education needs to be matched with more job opportunities for the high skilled. This requires an acceleration of the rate of innovation. If this does not occur, a portion of the highly educated will find themselves without job opportunities. This trend is already occurring in advanced economies, which has prompted a debate around what can governments do to lessen the disruption effect.

At the highest level, two policy options are at play. From a proactive standpoint, it is argued that with the loss of international comparative advantage, job destruction/disruption is going to be so significant that governments need to anticipate the wave and proactively intervene (see Pisano and Wheelwright, 2012). Alternatively, from a 'laissez faire" perspective, given the uncertainty in anticipating the occupational shifts, and, recognizing the importance of digitization in enhancing productivity, governments need to focus on reducing the cost of capital and regulation to enable companies to acquire new technologies and let the private sector address the "creative destruction" challenge (Crafts and Toniolo, 2010; van Ark, 2014; Nicoletti and Scarpetta, 2005).

The proactive camp endorses labor market policies focusing on workers being able to either retain their current jobs or move to the new areas of demand. These policies comprise job placement services, special labor market programs and wage subsidies to lessen the transition cost. In particular, the German government has been quite active in promoting apprenticeship programs aimed at training young workers on the new digital skills. On the subsidy side, tuition-free higher education, a temporary cut in payroll taxes are some of the policy initiatives. Many OECD countries (in particular, France and Belgium) have reduced the amount of taxation among low income workers as a way of lessening the negative income effect of low-skilled workers. More radical policy initiatives to address job disruption effects comprise the introduction of a basic income guarantee

for low skill workers. Others raised the option of taxing robots to compensate for the jobs being taken over by robots as a way to ensure the viability of the social security systems[18].

A different set of proactive policies aimed at addressing workforce disruption focus more on the demand side of skilled jobs, aiming at fostering the growth of poles of innovation that would need more workers. This approach is supported by two types of evidence. First, under the first and second wave of digitization conditions, job creation tends to be focused on cities that concentrate new industries, while employment declines in locations with industries more susceptible to automation (Berger and Frey, 2016; Fey, 2015; Duranton and Puga, 2001). Second, high technology secondary job multipliers appear to be around five (Goos et al., 2015). Under these premises, policies focused on increasing geographic mobility would allow workers residing in areas affected by automation to move to high job creation cities. For example, these policies should focus on reducing high relocation costs such as housing. On the negative side, these policies could risk stimulating the "hollowing out" of certain areas and accelerating the divergence between innovation-prone poles and backward regions. This is where proactive policies aimed at creating clusters of industries and universities around high quality of life locations will stimulate high-skilled labor demand in under-developed areas. The cross-sectorial/cross-institutional nature of these initiatives imply the importance of implementing them through collaborative approaches built among government entities and the ICT regulator. These initiatives are quite popular across developed, and even emerging, countries.

Moving to the policies focused on creating conditions for development of industries in need of skilled labor, they tend to focus on lowering the barriers to enterprise development (time needed to launch a new business, access to capital) or reducing tax burdens. They tend to be prevalent in advanced countries, although in certain geographies they are implemented with the more proactive interventions, discussed above.

6.2. Promoting Innovation and addressing workforce disruption in emerging economies

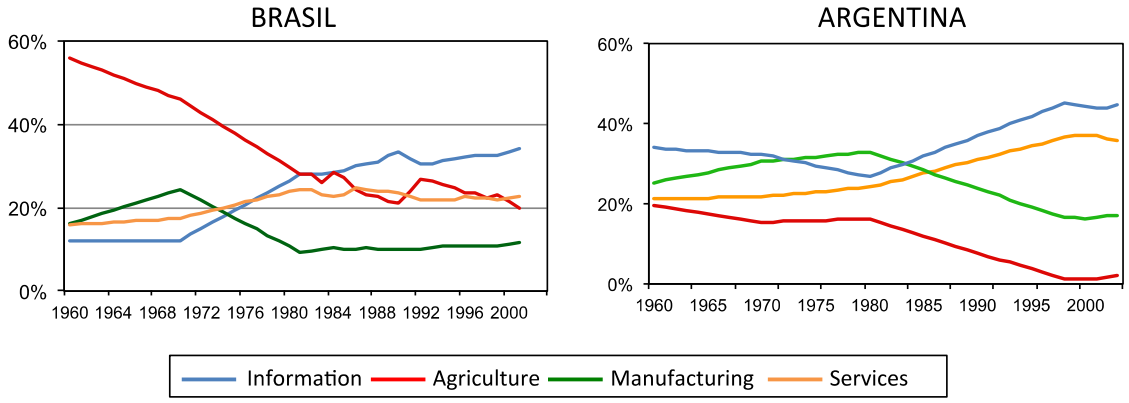
As expected, the policies discussed above to prevent workforce disruption have been more prevalent in the advanced economies, since they have been more affected by the combination of automation and international trade. To what extent will these trends, particularly automation, affect emerging economies? And, if so, when will this happen? The policy premise underlying these questions is that, if emerging countries are likely to soon follow the labor disruption trend of developed economies, the urgency of putting in place policy remedies becomes apparent. Moreover, if emerging countries face the imperative to foster the digitization of industries in order to increase their

[18] See the draft Report to the European Parliament by MEP Mady Delvaux which was in the end rejected by the legislators: http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//NONSGML%2BCOMPARL%2BPE-582.443%2B01%2BDOC%2BPDF%2BV0//EN

competitiveness, they will sooner or later have to deal with the implied labor disruption effects.

Berger and Frey (2016) argue that the labor force shift trend is already affecting emerging economies through an effect that has been labeled premature deindustrialization (Rodrick, 2015). According to the authors, it would appear that, even at lower wage levels that characterized emerging economies, automation of production chains has become cost-effective and that capital labor substitution is occurring not only in agriculture but also in manufacturing. Thus, the automation of manufacturing jobs triggered by the first and second waves of digitization has resulted in a reduction in manufacturing jobs, which have shifted to occupations that manage information (not necessarily in an automated fashion), such as government bureaucracies. Exhibit 7 displays the composition of employment for two emerging economies after 1960, isolating four occupational categories: information (comprising professional, technical and related workers, administrative, executive and managerial, and clerical works), agriculture (farmers, fishermen, hunters), industry (craftsmen, production process workers), and service sector (workers in transport and communication, sales workers, service, sport and recreation workers)[19].

Exhibit 7. Employment shifts and Premature Deindustrialization



Source: ILO Laborstat; analysis by the author

In addition to showing the widely acknowledged shift away from agricultural employment as a result of a wide range of innovations that resulted in productivity growth, exhibit 7 shows a secular decline in manufacturing employment, coupled with an increase in service and information employment. The decline in manufacturing employment could be attributed to automation. However, research by this author would indicate a lag in assimilating digital technologies in production processes (Katz, 2017). An alternative explanation of the reduction of manufacturing employment is that, being exposed to international trade, emerging economies become non-competitive and, therefore, undergo a «premature» deindustrialization trend (Rodrik, 2015).

[19] A first version of this approach was utilized by Katz (1985).

As to the increase in the share of «information» occupations, this would be the result of the expansion of state expenditures triggered by new needs poor public, regulatory and protective roles, combined with the capacity of the State to absorb a high-skilled workforce that cannot be employed within the private sector.

What are the policy prescriptions suited for this situation? In the first place, in order to tackle the international competitiveness challenge, emerging countries do not have a choice but to actively promote the digitization of production and digital transformation. This requires moving along the industrial digitization path, emphasizing policies focused on accelerating the digitization of production of small and medium enterprises. This entails the need of policies aimed at reducing the cost of technology acquisition, training of employees, and the provision of consultancy services to companies that would want to initiate a process of digital transformation. For example, the European Commission is implementing the Smart Use of ICT for SMEs, a program focused on promoting digital transformation among small and medium companies through innovation promotion vouchers, guidebooks for regional authorities, and innovative financing solutions.

Secondly, emerging economies should address human capital gaps in driving the second and third waves of digitization. These gaps are not related to the overall supply of skilled labor. In fact, as shown above, educational systems might be training more resources than what the private sector can absorb. The gaps are related to technical and engineering skills. This includes launching changes in educational and training systems introduced to address the gap (introduce tracking systems aimed at sorting out top performers, launching short term diplomas, structuring two level university systems, etc.).

Additionally, governments in emerging countries need to stand ready to help reduce the costs of disruptions and adjustments. If ICT deployment leads to job destruction in certain areas or sectors, governments should be ready to implement retraining programs and temporary safety net mitigation initiatives. The experience of deployment of the technology in emerging regions such as Chile and Saudi Arabia has highlighted the fact that once digitization increases, job creation is directly a function of human capital availability. Studies in digital economy development tend to underscore the fact that once the infrastructure gap has been addressed, human capital becomes the stumbling block. To rapidly tackle this barrier, governments are implementing short training programs focused on creating the necessary digital skills to innovate utilizing the technology in the development of new businesses.

7. Conclusion

This paper has raised the question that in order to assess the social and economic of digitization, it is necessary to differentiate three “waves” of digitization and understand where societies stand in terms of the technological innovation and adoption cycles.

Research evidence has clearly stated the productivity, economic growth, job creation, and welfare resulting from the first wave of digitization associated with the diffusion of computers, broadband and mobile telephony.

The second wave of digitization, linked to the diffusion of the Internet, its corresponding platforms and cloud computing has resulted in an extensive "innovation" effect resulting in the emergence of digital industries, which have absorbed high-skilled labor. However, automation has also resulted in the disappearance of jobs in certain low and medium-skilled occupations. On the other hand, the increase in high-skilled employment has triggered an increase in demand for low-skilled workers at the local level. Trends linked to the second wave of digitization are still difficult to measure in a consistent manner because of the lag existing between technology adoption and its social and economic impact. That being said, researchers agree on the fact that automation effects will have a significant change on the occupational profile of labor markets, affecting primarily low-skilled workers. These effects will accelerate over time fueled by the accumulation of intangible capital of firms (organizational changes, reengineering of business processes) and the increasing potential of digital technologies linked to the third digitization wave.

Research on the third wave of digitization, linked to innovations such as robotics, 3D printing, machine learning, and big data among others, is still at its infancy. There is research that posits that automation of repetitive tasks, linked to robotics, and combined with enhanced power of technology in areas such as artificial intelligence and speech recognition, is linked to the disappearance of jobs. On the other hand, other researchers consider that not all jobs can be replaced by automation and that second-order job creation derived from either new innovation and/or increased productivity and spending can actually cancel out any disruption effects. Yet, these researchers concede that if productivity does not increase, living standards will not improve and, consequently, second order effects will not materialize.

In this context, considering the advantages and risks entailed in the three waves of digitization, governments need to devise the right policy instruments that could maximize its benefits, while limiting the disruption risks. In particular, this paper has highlighted policies aimed at promoting innovation in advanced technologies while mitigating workforce disruption in developed economies:

- Increase public expenditures in education to increase the skills (including digital skills) acquired through formal training;
- Implement labor policies focused on workers being able to retain their current jobs or move to new areas of demand (job placement services, special labor market programs, apprenticeship programs);
- Put in place subsidies to lessen job disruption of low-skilled workers (tuition-free education, temporary cut in payroll taxes, basic income guarantees);
- Implement policies aimed at increasing geographic mobility (reduction of relocation costs, subsidized housing; and

- Promote demand for skilled workers by accelerating the rate of innovation in areas likely to be affected by job disruption effects.

The evidence of labor disruption effects in emerging economies is still not conclusive. Yet, the evidence points at a "premature deindustrialization" as a result of an erosion of manufacturing competitiveness (trend which excludes China and other Asian economies) and a growth of "information processing workers", which are being absorbed by expanding state governments. In this context, emerging countries do not have a choice but to actively promote the digitization of production and digital transformation. This requires putting in place policies, which combine the expansion of innovative capacity, "learning capacity" and human capital generation:

- Implement policies aimed at reducing the cost of technology acquisition, training of employees, and the provision of consultancy services to companies that would want to initiate a process of digital transformation;
- Launch changes in educational and training systems introduced to address the gap (implement tracking systems aimed at sorting out top performers, introduce short term diplomas, structure two level university systems); and
- If ICT deployment leads to job destruction in certain areas or sectors, governments should be ready to implement retraining programs and temporary safety net mitigation initiatives.

The policy challenge going forward is presented by the fact that the digital transformation resulting from all three waves of digitization is so all-encompassing that sector-specific strategies developed within institutional silos are not applicable any more. Governments need to build cross-institutional links fostering the collaboration among education, ICT, industrial promotion, science and technology to devise and jointly implement policies. In addition, the future public policy scope has to be significantly expanded beyond traditional domains such as taxation, competition, and digital literacy to include new areas such as privacy protection, cyber security, and the fostering of digital adoption such as trust and enhanced customer experience. As it is clear, the challenges for policy makers are significant, but so are the benefits for citizens and the need to mitigate any potential disruptions.

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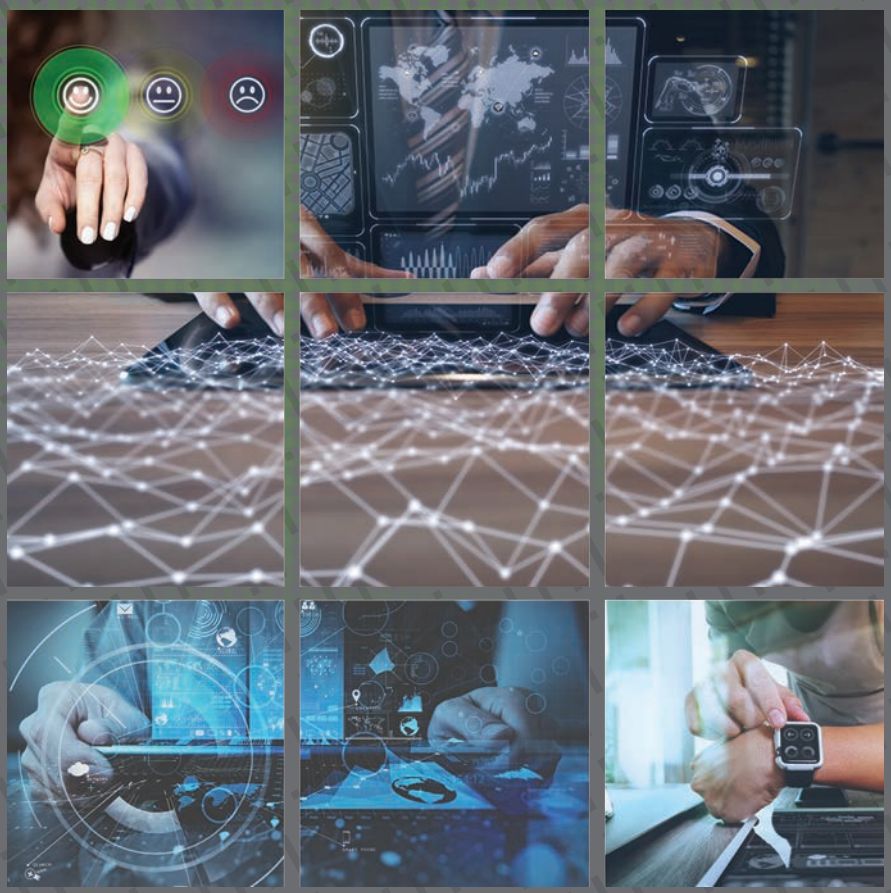
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REGULATORY & MARKET ENVIRONMENT

Quality of Service
REGULATION MANUAL

Manual



Telecommunication Development Sector

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2017

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Foreword



I am pleased to present the Manual on Quality of Service (QoS) Regulation published to serve as a reference and guiding tool for regulators and policy makers in dealing with QoS and Quality of Experience (QoE) matters in the ICT sector.

Regulation and management of QoS are increasingly important and complex in today's highly competitive, challenging and globalized digital environment. Ensuring fairness and high quality user experience requires effective regulatory frameworks. The profusion of ever-evolving technologies, networks, services and devices with different QoS capabilities further adds to the complexity of regulation in this area. Quality can be impacted by many factors at the network level and along the value chain. In this regard, a common approach to regulating QoS can enable greater quality prospects irrespective of the locations of the consumer and service provider.

This manual builds upon ITU-T recommendations and extends the ITU regulation guidelines further by introducing hands-on information and practical approaches in regulating QoS for telecommunication/ICT services. It provides a 360 degree assessment of QoS regulation, ranging from the technical and regulatory perspectives to issues such as traffic management, network neutrality, consumer protection, economic principles and enforcement mechanisms.

This manual is a key resource to advance QoS regulation in the fast changing digital world. Its recommendations and the sharing of good practice will provide useful guidance in addressing QoS to ensure that both individual and business consumers benefit from quality ICT services, an essential element in this fast-paced transformational digital environment.



Brahima Sanou

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1 Introduction

In this digital, globally connected world where all functions and aspects of life are being transferred to communication networks and services, citizens everywhere rely on ICTs to conduct their everyday socio-economic activities. Telecommunication networks are interconnected on a national, regional, and global basis, and the quality of telecommunication services applied in one network or one country influences the end-to-end quality of that service, so the quality cannot be considered only at national or regional level, but also needs to be considered globally.

Ensuring quality of service (QoS) in this ever-changing environment is increasingly critical. A harmonized and common approach to regulating QoS would enable greater quality prospects irrespective of the locations of the consumer and service provider.

This manual refers to different standards and regulatory practices from different regions and countries worldwide noting that each region and each country has its own specificities. It is intended to be used as a guiding tool for telecommunication national regulatory agencies (NRAs) or government ministries in charge of QoS and QoE (quality of experience) parameters and measurements as defined by ITU-T, as well as enforcement mechanisms. It extends ITU regulation guidelines further by introducing more hands-on information regarding the QoS and QoE big picture, as well as outlining practical approaches in QoS regulation for telecommunication/ICT services. It puts forth the case that NRAs should have the appropriate skill-set to carry out QoS regulation, and how continuous capacity building is key to adapting to market and regulatory changes. NRAs can benefit greatly by learning from each other. The argument for cooperation between regulators is strong, bringing substantive benefits through the sharing of good practice and mutual learning.

1.1 The ICT sector today

The ICT world is increasingly broadband, as illustrated in Figure 1.1. Twenty years ago, only one per cent of the global population had a mobile cellular subscription, and 11 per cent had a fixed telephone subscription. Today, mobile cellular penetration is approaching saturation with more than 7.5 billion subscriptions worldwide. Globally, 3.57 billion people are expected to be using the Internet by end 2017. Mobile broadband is the most dynamic market segment – globally, mobile broadband penetration is expected to reach 56.4 per cent with fixed broadband access expected to reach more than 979 million fixed broadband subscriptions by the end of 2017. The number of Internet users is growing, reaching 48 per cent of the world population.

Broadband provides access bit rates in downstream and upstream that support all available types of services offered through good quality Internet access. A decade ago, broadband access was mainly offering hundreds of kbit/s, today it provides access within Mbit/s or tens of Mbit/s (i.e. speeds), enabling such things as the provision of high-definition (HD) video as well as ultra-HD videos.

Fixed broadband access technologies can be provided either by copper (twisted-pairs) by reusing local-loops for fixed telephony, cable access (by reusing coaxial cable networks, primarily developed for television distribution, for IP-based access via asymmetric digital subscriber line (ADSL), very high bit rate digital subscriber line (VDSL or generally xDSL where DSL stands for digital subscriber line), and FTTH (fibre-to-the-home or more generally FTTx), which is the long-term future for fixed broadband access in all regions (Figure 1.2). For example, almost all transport networks are now fibre based, and the differences shown in Figure 1.2 refer mainly to the last mile.

Figure 1.1: Global ICT developments, 2001-2017

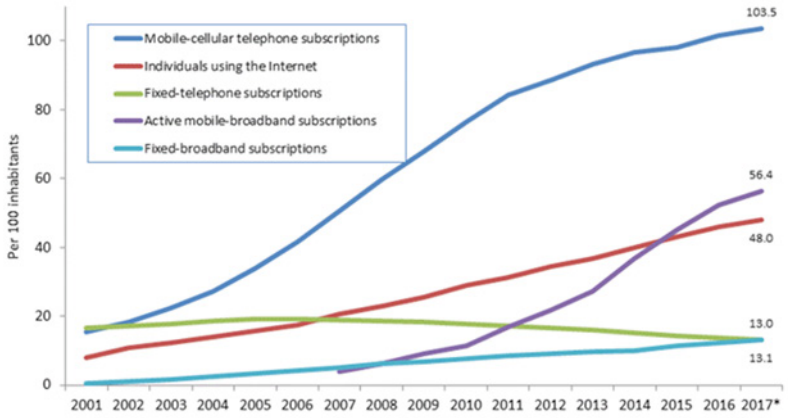
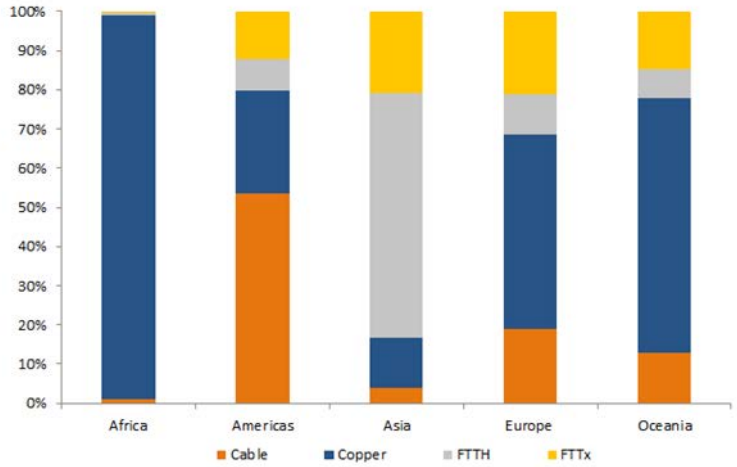
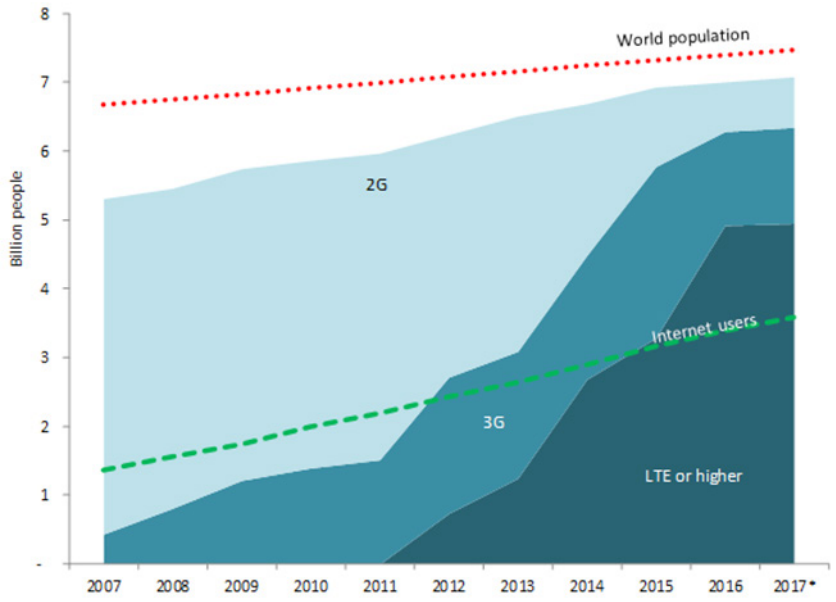


Figure 1.2: Fixed broadband access, technology market share by region (Q1 2017)



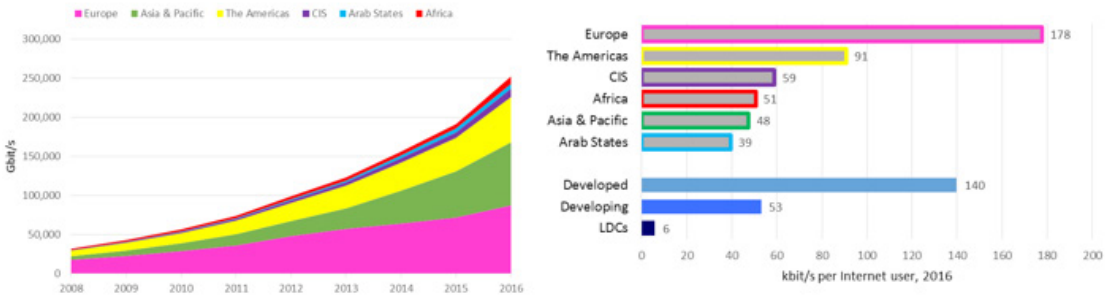
Mobile broadband access is provided currently with 3G (e.g. Universal Mobile Telecommunications System/High Speed Packet Access (UMTS/HSPA)) and 4G mobile technologies (e.g. Long-Term Evolution (LTE) / LTE-Advanced). In 2016, LTE networks were offered in at least 165 countries world-wide. Figure 1.3 shows mobile broadband network deployment trends. Seven billion people (95 per cent of the global population) live in an area that is covered by a mobile-cellular network. Mobile broadband networks (3G or above) reach 85 per cent of the global population. LTE networks have spread quickly over the last three years and reach more than 4.9 billion people today (66 per cent of the global population), enhancing the quality of Internet use for many.

Figure 1.3: Mobile broadband network deployment trends



Source: ITU World Telecommunication/ICT Indicators database (* Estimate)

Figure 1.4: Internet bandwidth distribution in the world in 2016



Source: ITU World Telecommunication/ICT Indicators database

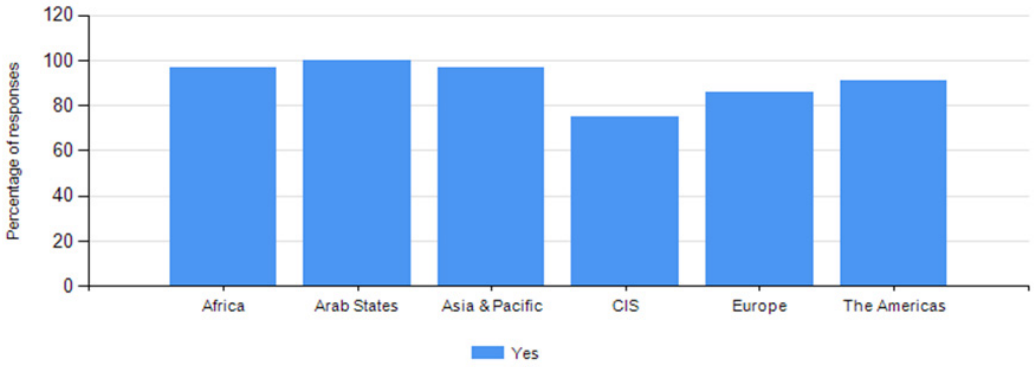
By the end of 2016, total international Internet bandwidth had reached more than 250 000 Gbit/s, up from 30 000 in 2008, which shows remarkable growth in speed (Figure 1.4). However, the Africa region has the lowest international connectivity of all regions: there is twice as much bandwidth per inhabitant available in the Asia-Pacific region, four times as much in the Commonwealth of Independent States (CIS) region, eight times as much in the Americas region, and more than twenty times as much in Europe. Mobility, always on access, and the massive adoption of broadband enabled devices have irreversibly changed consumer social and economic behaviour and their quality of service expectations as well.

Quality of service and quality of experience measuring is becoming more and more complex. Quality can be impacted by many factors at the network level and along the value chain, including the device, hardware, infrastructure, service and applications. In addition, differences may arise between perceived and assessed QoS.

QoS is important for both customers and service providers. Specific QoS policies should be established in each country by the appropriate authority (e.g. NRA, ministry or other government authority), based on QoS standards. QoS provisioning should be monitored as well as encouraged and enforced when needed.

1.2 Quality of service regulatory trends

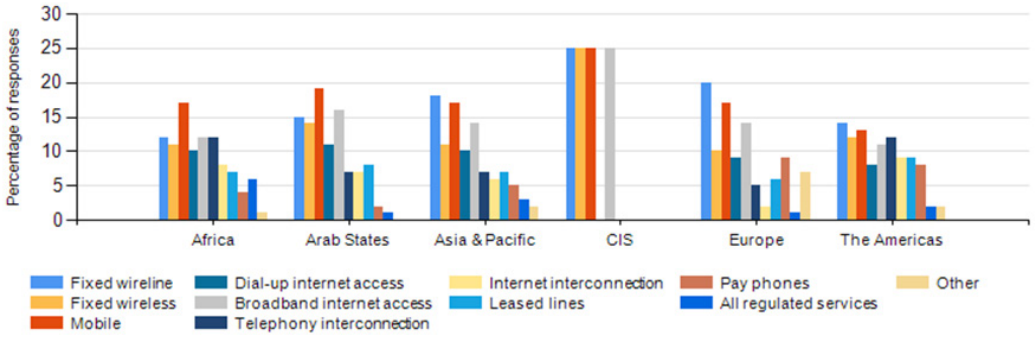
Figure 1.5: Monitoring QoS in different regions in the world, 2016



Source: ITU Telecommunications/ICT Regulatory Database (total country responses: 171)

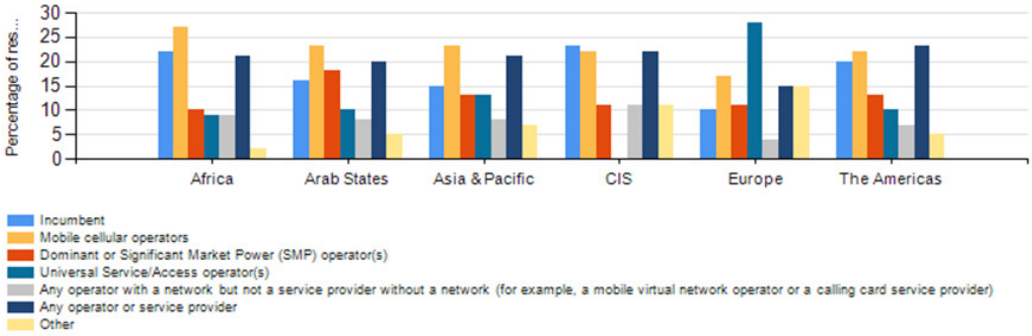
Today, QoS is being monitored in at least 158 countries (Figure 1.5). Historically speaking, QoS requirements have been applied to voice services (provided by telecommunication operators), but more recently regulators have been incorporating minimum QoS requirements for data services (through Internet access service (IAS)). These requirements can vary from high level transparency guidelines on how the information on traffic management techniques is disclosed to end-users, to requiring actual indicators for data network performance for fixed and mobile broadband providers. QoS monitoring is required in 82 per cent of the 193 ITU Member States. There are some differences when looking at which services and who is subject to QoS monitoring between regions. In Africa, mobile services are subject to monitoring in 32 countries, followed by fixed wireline (26 countries), telephony interconnection (15 countries) and broadband Internet access (23 countries). Services subject to QoS monitoring by region in 2016 are presented in Figure 1.6.

Figure 1.6: Services subject to quality of service monitoring, 2016



Source: ITU Telecommunications/ICT Regulatory Database (total country responses: 145)

Figure 1.7: Operator/service providers subject to quality of service monitoring, 2016



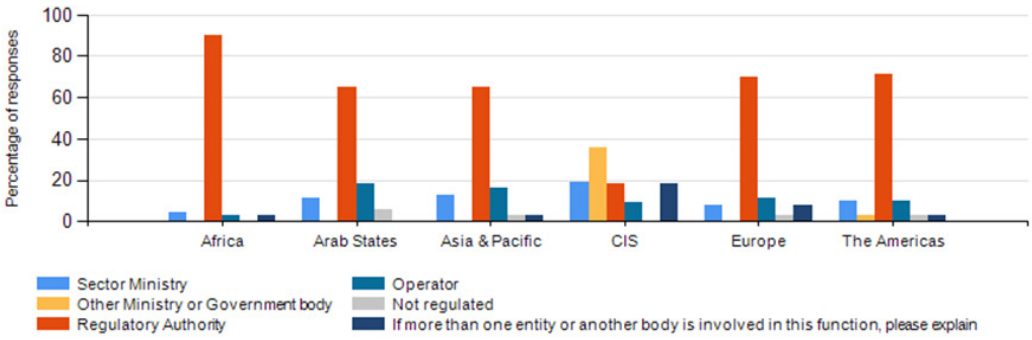
Source: ITU Telecommunications/ICT Regulatory Database (total country responses: 158)

Figure 1.7 shows which operators and service providers are subject to QoS monitoring. In most countries, QoS monitoring targeted incumbent and mobile operators. For example, for various reasons most countries in Africa have little fixed infrastructure, and the focus on QoS monitoring is mostly on mobile operators, which typically provide broadband access in that region.

In most countries, the NRA monitors QoS as shown in Figure 1.8. However, in some countries, QoS monitoring is performed by the sector ministry or another ministry or government body (e.g. CIS region countries).

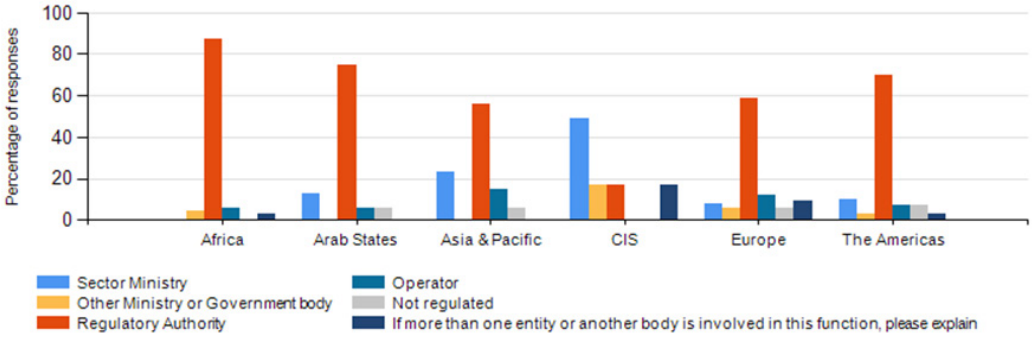
In most countries, if QoS standards are defined, it is the NRA that defines them (Figure 1.9) although other arrangements are possible, but generally, the authority that sets QoS standards also carries out QoS enforcement (Figure 1.10).

Figure 1.8: Agency responsible for monitoring QoS standards, 2016



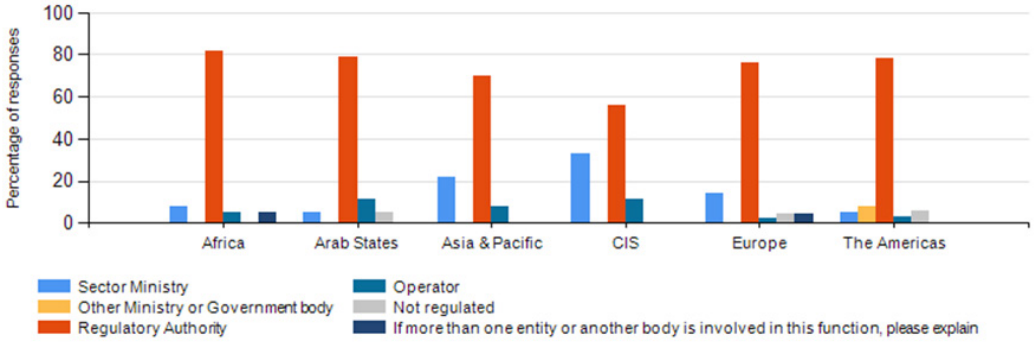
Source: ITU Telecommunications/ICT Regulatory Database (Total country responses: 140)

Figure 1.9: Agency responsible for setting QoS standards, 2016



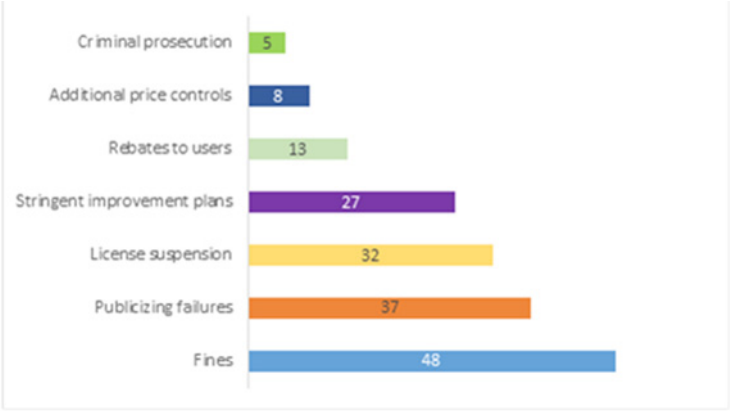
Source: ITU Telecommunications/ICT Regulatory Database (Total country responses: 127)

Figure 1.10: Agency responsible for enforcing QoS, 2016



Source: ITU Telecommunications/ICT Regulatory Database (Total country responses: 170)

Figure 1.11: Types of sanctions regulators can impose, 2016



Source: ITU Telecommunications/ICT Regulatory Database (total country responses 77 countries)

Regulators may impose different types of sanctions to operators not meeting their QoS obligations, ranging from publicizing failures, fines, licence suspension, to criminal prosecution in some cases (Figure 1.11). In terms of sanctions that have been most commonly used, 22 countries indicated they had imposed fines, required operators to publicize failures and provided rebates to users. The kind of sanctions applied will depend on national circumstances and market maturity (see Chapter 10).

1.3 Structure of the manual

The manual is divided into the following chapters:

- Chapter 2: QoS framework from a technical perspective, drawing from the work by ITU-T on QoS standardization.
- Chapter 3: QoS regulatory framework and the role of national regulatory authorities in addressing QoS.
- Chapter 4: Traffic management.
- Chapter 5: QoS parameters and key performance indicators.
- Chapter 6: Broadband QoS measurement, and different measurement tools and platforms.
- Chapter 7: Economic principles for QoS regulation.
- Chapter 8: Network neutrality and its regulation worldwide.
- Chapter 9: Consumer protection and privacy aspects.

- Chapter 10: QoS enforcement.
- Chapter 11: Concluding remarks.

2 Quality of service framework: Technical aspects

The section will:

- examine the technical aspects of quality of service (QoS);
- define the concepts to better understand how migration from public switched telephone (PSTN) to IP networks has impacted QoS; and
- explore the difference between Internet and next generation networks (NGNs) in order to identify the QoS regulatory framework needed in a broadband digital environment.

Standards developing organizations (SDOs), such as ITU-T, the European Telecommunications Standards Institute (ETSI), or the Internet Engineering Task Force (IETF) have collective QoS knowledge and expertise related to the change of paradigms in networks and terminals in terms of planning and possible regulation of end-to-end QoS. The basis for setting quality parameters for publicly available electronic communication services should include technical recommendations, standards, technical specifications and guidelines published by different SDOs in the telecommunication/ICT sector globally.

ITU has a long standing history of QoS work, which includes the following cornerstones:

- Since 1957 the ITU has been conducting expert work in the fields of transmission planning, subjective testing and standards for telephone sets.
- Since 1986 the Speech Quality Experts Group (SQEG) has provided coordination of the quality requirements and subjective testing methodologies for speech coding algorithms.
- Since 1997 the Video Quality Experts Group (VQEG) has provided coordination of quality requirements and subjective testing methodologies for video coding algorithms.

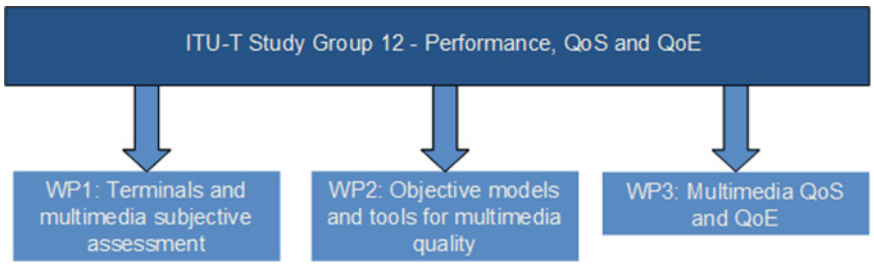
In ITU-T, Study Group 12 (SG12) is responsible for performance, QoS, and QoE. SG12 is developing recommendations on performance, QoS and QoE for the full spectrum of terminals, networks, services and applications ranging from speech over fixed circuit-based networks to multimedia applications over networks that are mobile and packet based. Included in this scope are the operational aspects of performance, QoS and QoE; the end-to-end quality aspects of interoperability, and the development of multimedia quality assessment methodologies, both subjective and objective. SG12 works proactively to help bridge the standardization gap in the area of QoS/QoE, in particular through its Regional Group on QoS for the Africa Region (SG12RG-AFR) and the Quality of Service Development Group (QSDG).

Recommendations under the responsibility of SG12 include:

- ITU-T E.420 – ITU-T E.479, ITU-T E.800 – ITU-T E.859
- ITU-T G.100-series, except ITU-T G.160- and ITU-T G.180-series
- ITU-T G.1000-series
- ITU-T I.350-series (including ITU-T G.820/I.351/Y.1501), ITU-T I.371, ITU-T I.378, ITU T I.381
- ITU-T J.140-, ITU-T J.240- and ITU-T J.340-series
- ITU-T P-series
- ITU-T Y.1220-, ITU-T Y.1530-, ITU-T Y.1540-, ITU-T Y.1560-series

Each Study Group (SG) of ITU-T has working parties (WPs), as shown in Figure 2.1. Each WP has one or more Question under its jurisdiction. Each Question is related to one or more ITU-T Recommendations. The current structure of SG12 and the Questions under study are listed at http://itu.int/net4/ITU-T/lists/loqr.aspx?Group=12&Period=16.

Figure 2.1: Organization of work within ITU-T SG12



Source: ITU-T SG12

Among other series of recommendations of great interest to regulators and policy-makers, the E.800 series (Quality of telecommunication services: concepts, models, objectives and dependability planning) primarily refers to QoS. Some important recent ITU-T Recommendations on QoS include the following:

- ITU-T Rec. E.800 (09/2008): Definitions of terms related to quality of service
- ITU-T Rec. E.801 (10/1996): Framework for Service Quality Agreement
- ITU-T Rec. E.802 (02/2007): Framework and methodologies for the determination and application of QoS parameters
- ITU-T Rec. E.803 (12/2011): Quality of service parameters for supporting service aspects
- ITU-T Rec. E.804 (02/2014): Quality of service aspects for popular services in mobile networks
- ITU-T Rec. E.807 (02/2014): Definitions, associated measurement methods and guidance targets of user-centric parameters for call handling in cellular mobile voice service

At a global level, the importance of QoS is acknowledged in the Final Acts of the World Conference on International Telecommunications (WCIT-12), and Resolution 95 on ITU Telecommunication Standardization Sector initiatives to raise awareness on best practices and policies related to service quality of the World Telecommunication Standardization Assembly (WTSA-16).

The following subsections introduce the definition of QoS and QoE, give an overview of the Internet QoS mechanism, and cover QoS parameters in IP networks and end-to-end QoS provisioning. QoS requirements apply not only to traditional telecommunication and broadcast services, but increasingly to broadband, wireless/mobile and multimedia services as well. In general, communications services from 2010 onwards are increasingly delivered through IP-based networks, including:

- IPbased networks (access, core/backbone, and transit); and
- IP-based services, including QoS-enabled (i.e. managed services); and OTT (over-the-top) services, which are provided in best effort manner, without end-to-end QoS, and based on the principle of network neutrality in current Internet use.

QoS is moving from its initial definitions targeted to traditional telecommunication networks (e.g. public switched telephone network/integrated services digital network (PSTN/ISDN), broadcast networks) to QoS in IP networks and services.

Networks and systems are gradually being designed according to the end-to-end performance required by user applications. However, the term QoS is usually not well-defined, is used loosely and even misused. Depending on what aspects of quality are examined and what kind of services/technologies

are involved, different definitions and concepts of quality are used. The variety of different definitions demonstrates the difficulties in assessing all aspects related to the term QoS.

In many industry standards, reports and specifications, either QoS is not clearly defined or reference is made to ITU-T Rec. E.800. Therefore, a first step is to define QoS and have a clear understanding of general QoS terminology.

2.1 Definition of quality of service

ITU-T Rec. E.800 defines quality of service as:

Totality of characteristics of a telecommunications service that bear on its ability to satisfy stated and implied needs of the user of the service.

In its technical report[1], ETSI defines QoS from the network perspective as: "*Quality of Service (QoS): the ability to segment traffic or differentiate between traffic types in order for the network to treat certain traffic differently from others*", and in the ISO definition, quality is defined as "*the totality of characteristics of an entity that bear on its ability to satisfy stated and implied needs*" **(ISO** 8402).

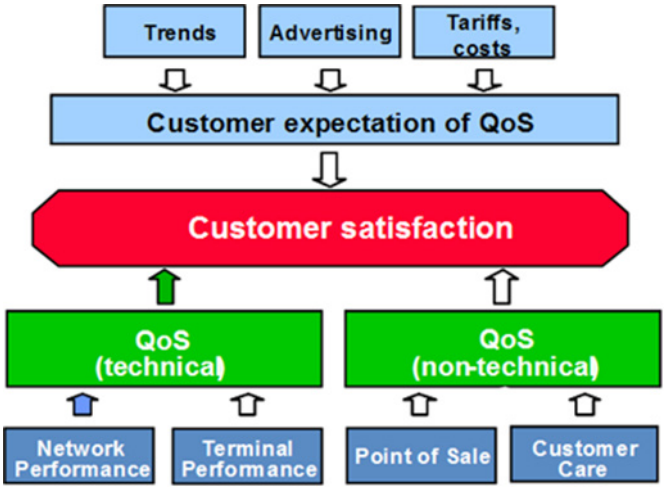
In this manual, the ITU definition of QoS is used, which is consistent with the ISO definition of quality of a service. Compared to the ETSI definition from a network perspective, the ITU and ISO definitions focus on the service as the entity under consideration. It is important to note however, that the various definitions tend to reflect views on the telecommunication/ICT systems, networks, and services/applications from user and network perspectives.

Traditionally, QoS was mainly addressed from the perspective of the end-user being a person (e.g. telephony), with abilities to hear and see and be tolerant to some degradation of services (e.g. low packet loss ratio is acceptable for voice, while end-to-end delay for voice should be less than 400 ms). But with the advent of new types of communications where services may not require real time delivery and where the sender or the end-user may not be a person but a machine, it is important to keep in mind that not all services are the same (e.g. Internet of Things (IoT)). Even similar services can be treated in different ways depending on whether they are used by machines or by humans on one or both ends of a given communication session or connection.

The end-user perception of a telecommunication/ICT service is also influenced by different factors such as social trends (in terms of popular devices, services, applications, social networks, etc.), advertising, tariffs and costs, which are interrelated to the customer expectation of QoS. The user perception of quality is not limited to objective characteristics at the man-machine interface. For end-users, the quality that they personally experience during their use of a telecommunication service also counts.

[1] **ETSI**-TR102157: www.etsi.org/deliver/etsi_tr/102100_102199/102157/01.01.01_60/tr_102157v010101p.pdf This definition is from the perspective of broadband satellite.

Figure 2.2: QoS technical and non-technical point of view, and customer satisfaction



Source: ITU-T Supplement 9 to Rec. Series E.800 (12/2013)

As illustrated in Figure 2.2, QoS depends on end-to-end technical aspects, which include network performance and terminal performance, and on non-technical aspects (not directly related to the equipment), such as point of sale, customer care, etc.

QoS terminology

General QoS terminology, as defined in ITU-T E.800, includes the following:

QoS requirements of user/customer (QoSR): A statement of QoS requirements by a customer/user or segment/s of customer/user population with unique performance requirements or needs.

QoS offered/planned by service provider (QoSO): A statement of the level of quality planned and therefore offered to the customer by the service provider.

QoS delivered/achieved by service provider (QoSD): A statement of the level of QoS achieved or delivered to the customer. These parameters should be the same as specified for the offered QoS so that the two can be compared to determine what was actually achieved in order to assess the level of performance obtained.

QoS experienced/perceived by customer/user (QoSE): A statement expressing the level of quality that customers/users believe they have experienced. Perceived QoS is assessed by customer surveys and from a customer's own comments on levels of service.

Characteristic: A property which helps to differentiate between the individuals of a given population.

Criterion: Collections of characteristics or a single characteristic, as appropriate, to describe benefit to a user of a product or a service.

Parameter: A quantifiable characteristic of a service with specified scope and boundaries.

Objective (quantitative) parameters: Parameters that are measurable (with instruments or observations) and a performance value assigned quantitatively may be classified as objective parameters.

Subjective (qualitative) parameters: Parameters that can be expressed using human judgment and understanding may be classified as subjective or qualitative parameters.

Measure: A unit by which a parameter may be expressed.

Metric (also called *Indicator***):** Value calculated from observed attribute/s of a measure.

Service: A set of functions offered to a user by an organization.

Item: Any part, device, subsystem, functional unit, equipment or system that can be individually considered.

User: A person or entity external to the network, which utilizes connections through the network for communication.

Customer: A user who is responsible for payment for the services.

Network performance: The ability of a network or network portion to provide the functions related to communications between users.

Network provider: An organization that owns a telecommunications network for the purpose of transporting bearers of telecommunication services.

Service provider: An organization that provides services to users and customers.

2.2 Definition of quality of experience

According to ITU-T Recommendation P.10/G.100, quality of experience (QoE) was initially defined as the overall acceptability of an application or service, as perceived subjectively by the end-user.

ITU-T Study Group 12 replaced the QoE definition developed in 2007 with a new definition in 2016, although the on-going research on this topic means that this is a working definition and it is expected to evolve for some time…

Quality of experience (QoE) is the degree of delight or annoyance of the user of an application or service.

The same ITU-T recommendation defined two new terms:

1. *QoE influencing factors: This includes the type and characteristics of the application or service, context of use, the user expectations with respect to the application or service and their fulfilment, the user cultural background, socio-economic issues, psychological profiles, emotional state of the user, and other factors* whose number *will likely* expand *with further research.*

2. *QoE assessment: This is the process of measuring or estimating the QoE for a set of users of an application or a service with a dedicated procedure, and considering the influencing factors (possibly controlled, measured, or simply collected and reported). The output of the process may be a scalar value, multi-dimensional representation of the results, and/or verbal descriptors. All assessments of QoE should be accompanied by the description of the influencing factors that are included. The assessment of QoE can be described as comprehensive when it includes many of the specific factors, for example a majority of the known factors. Therefore, a limited QoE assessment would include only one or a small number of factors.*

Source: ITU https://www.itu.int/rec/dologin_pub.asp?lang=e&id=T-REC-P.10-201607-I!Amd5!PDF-E&type=items

QoE includes complete end-to-end system effects (end-user equipment, as well as network and service infrastructure). Overall acceptability may be influenced by user expectations and the context. QoE takes into account additional parameters:

- user expectations;
- user context (e.g. personal mood, environment, work/home/outside, etc.);
- potential discrepancy between the service offered and individual user awareness of the service and additional features (if any) for that service.

One may conclude that QoE is different from QoS as it is based on customer perception of the given service. QoE includes the complete end-to-end system elements (client, terminal, network, services infrastructure, etc.) and may be influenced by user expectations and context. In principle, QoE is measured subjectively by the end-user and may differ from one user to another.

The most used measure for QoE is the mean opinion score (MOS). Initially, the MOS scale referred to voice service only (ITU-T P.800), but is now used for other services such as video (e.g. Internet Protocol Television (IPTV)). MOS is expressed as a single number in the range from 1 to 5, where the value of 1 corresponds to the lowest quality experienced by the end-user and 5 is the highest quality experienced (as shown in Table 2.1).

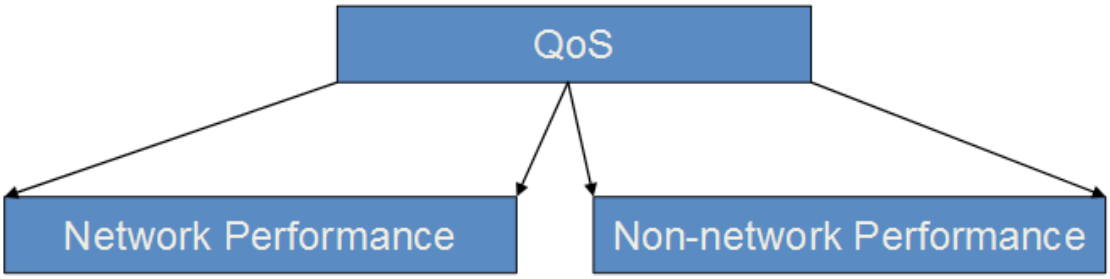
Table 2.1: Mean opinion score

Mean Opinion Score	Quality
5	Excellent
4	Good
3	Fair
2	Poor
1	Bad

2.3 Definition of network performance

Network performance is determined by the performances of network elements one by one, or by the performance of the network as a whole, i.e. the combination of the performance of all single elements. However, network performance has an influence on QoS, and it represents a part of it. Simply said, QoS consists of network performance and non-network performance, as shown in Figure 2.3.

Figure 2.3: Network performance and QoS



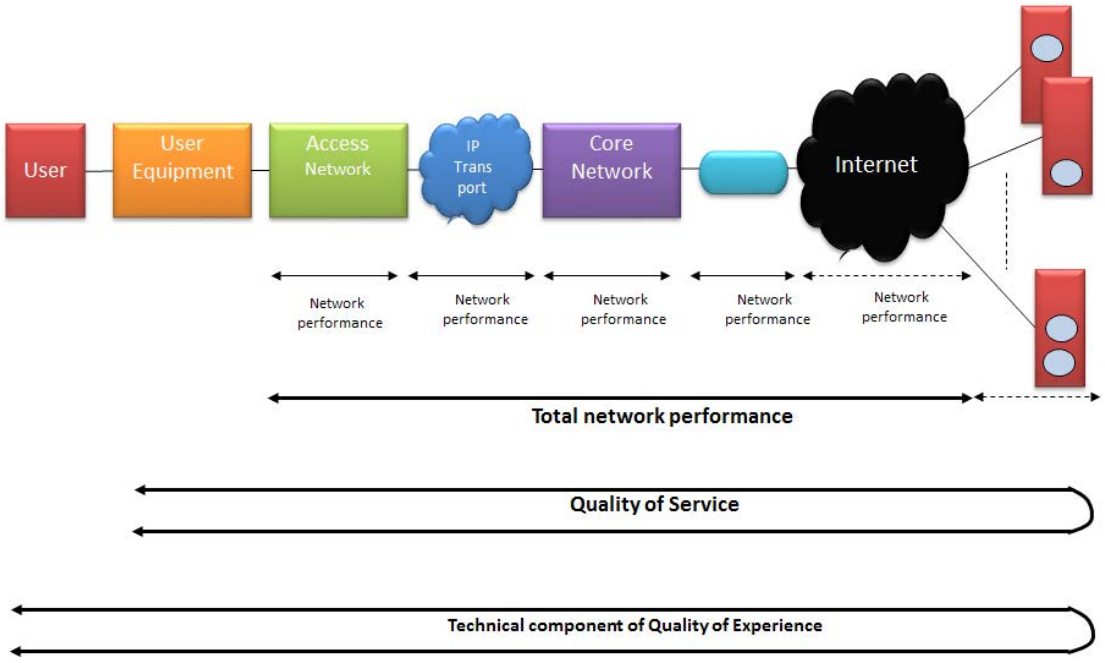
Source: ITU

2.4 The relationship between quality of service, quality of experience, and network performance

QoE is different from QoS and network performance as it has a subjective feature in its definition. QoE depends on the end-user perception in addition to features of services that may result in quite different ways of specifying the value. It is clear, however, that QoE is impacted by QoS and network performance.

Network performance applies to network provider planning, development, operations, and maintenance. As illustrated in Figure 2.4, total network performance is the detailed technical part of the QoS offered. As indicated in ITU-T Rec. G. 1000, it contributes to QoS as experienced by the user. The functions of a service depend on the performance of the network elements and the performance of user terminal equipment. QoS is always end-to-end, i.e. user-to-user or user-to-content. Therefore, QoS measurements are also carried out end-to-end. End-to-end QoS depends on the contributions made by the components as described in Figure 2.4, including user, user equipment, access network, IP transport, core network, and the rest of the path end-to-end (e.g. through the Internet). QoE has a broader scope as it is impacted by QoS as well as by user expectations and context.

Figure 2.4: Network performance, QoS and QoE



Source: ITU

To provide QoS support for a given service, QoS criteria and parameters are required. ITU-T Rec. G.1000 defines these terms, which provide the general QoS framework. Seven QoS criteria are specified:

- speed (refers to all service functions);
- accuracy (e.g. speech quality, call success ratio, bill correctness, etc.);
- availability (e.g. coverage, service availability, etc.);
- reliability (e.g. dropped call ratio, number of billing complaints, etc.);
- security (e.g. fraud prevention);
- simplicity (e.g. ease of software updates, ease of contract termination, etc.); and
- flexibility (e.g. ease of change in contract, availability of different billing methods such as online billing, etc.).

The seven service quality criteria are mapped on a set of service functions by using a given matrix, as illustrated in Table 2.2 where the example provided is a matrix for mobile telephony service. Such mapping is also referred to as a performance model in ITU-T E.802. It is one of the three possible models for identification of user QoS criteria that is needed before defining QoS parameters (one must specify criteria used for definition of QoS parameters).

1. **Universal model:** A generic and conceptual model. In this model, all QoS criteria may be grouped under four categories: performance, aesthetic, presentational and ethical. Each functional element of the service is cross-checked against the four predefined quality components and criteria.
2. **Performance model**: This model is more suited for determining the performance criteria of a telecommunication service, as illustrated in Table 2.2 for mobile telephony service.
3. **Four-marked model**: This model is especially suited for multimedia services (as most services nowadays) since the separation between the transport and service layer is taken into account.

In general, QoE is influenced by all seven QoS criteria. For example, speed influences the available throughput and latencies and it is of crucial importance for QoE. That is why in moving towards broadband access and higher access bit rates (including fixed and mobile broadband), overall QoE improves. Availability and reliability are also very important, which depends upon the capability of the network to recover from a failure (e.g. self-organizing networks (SON) solutions in 4G, resilience solutions in optical networks, etc.) as well as appropriate planning and dimensioning of the network (to suit to the expected number of users for a given service or services). For example, typical quality metrics for network availability from the era of synchronous digital hierarchy (SDH) onwards are so-called 'five nines', i.e. service to be available 99.999 per cent of the time to end-users, and which requires certain survivability mechanisms to be implemented in the network (e.g. re-routing of traffic in a case of failure over alternative or reserved paths in the network). Security aspects, accuracy, flexibility regarding the services, and user friendliness of the service further influence QoE.

Table 2.2: Performance model for a mobile telephony service with matrix of mapping service quality criteria and service functions (Source: ITU-T E.802.)

		Service quality criteria						
		Speed 1	Accuracy 2	Availability 3	Reliability 4	Security 5	Simplicity 6	Flexibility 7
Service function								
Service management	Sales & pre-contract activities 1	Processing time						
	Provision 2	Supply time		Coverage				
	Alteration 3	Response time						Ease of change in contract
	Service support 4	Response time		Availability of call centre			Professionalism of help line	
	Repair 5	Processing time						
	Cessation 6	Call set-up time					Ease of contract cessation procedure	
Connection quality	Connection establishment 7	Call set-up time		Service availability				
	Information transfer 8	One-way delay			Dropped call ratio within a specific time period			
	Connection release 9	Release time						
Billing 10		Billing frequency			Number of billing complaints within period	Fraud protection/ prevention		Availability of different billing methods (e.g. online billing)
Network/Service management by customer 11							Ease of software updates	

The management of QoS can be divided into four viewpoints, as described in ITU-T Rec. G.1000, which covers QoS from both the customer and service provider viewpoints (see Figure 2.5).

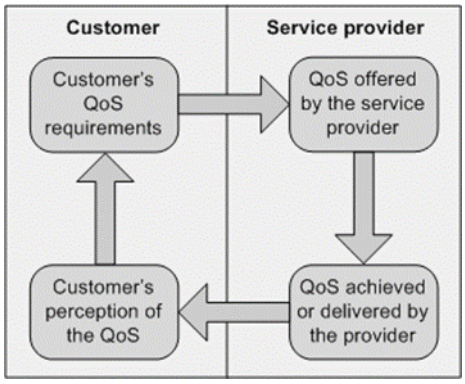
The customer viewpoints are:

- Customer requirements: This is the QoS level required by the subscriber.
- Customer perception: The QoS level obtained by user ratings of the provided QoS by the service operator, which can be used for comparison purposes among QoS levels provided from different service providers, as well as for corrective actions (e.g. when perceived QoS level is below the QoS offering by the provider).

The service provider viewpoints are:

- QoS offered by the service provider (or planned/targeted QoS): This includes QoS criteria or parameters offered by the service provider (which includes network providers that provide access to the Internet as a service), which may be used for several offerings:
  - Service level agreement (SLA) as a bilateral agreement between the customer and the service provider.
  - Public offering (i.e. declaration) of the service level that can be expected by the subscriber.
  - Planning and maintaining the service to a given performance level.
  - For subscribers to make the best choice from the given service provider offerings.
- QoS achieved: the actual level of QoS achieved or delivered by the service provider, which can be used as a check for delivered QoS (e.g. according to a given SLA) or as a basis for any corrective action regarding QoS.

Figure 2.5: QoS four viewpoints concept



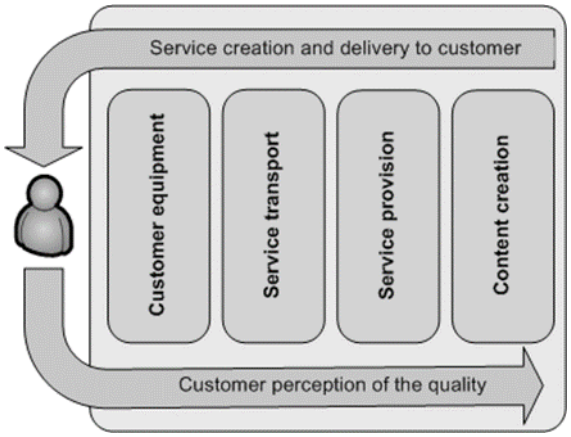
Source: ITU-T (Rec. G.1000)

The four-market model (see Figure 2.6) is better suited for multimedia services. It defines the chain of action from content creation towards service provision, service transport and customer equipment. There are four elements, content, service provision, service transport, and customer equipment, which are generally supplied and which work independently of each other. Different parties may be in charge of installation, operation, and maintenance. Different services have different QoS requirements. The four-market model provides the possibility to identify QoS criteria for one or more components in the model. For example, for file download service (e.g. download of music contents), the following criteria can be applied in the four-market model:

- Content creation: Suitability of the content, its popularity, codec format and its quality, piracy aspects, etc.
- Service provision: Ease of navigation to requested music files, fair contract, security of personal data, pricing, customer care, etc.

- Service transport: Bandwidth (in bits/s), latency, (i.e. delay), jitter (i.e. delay variation), error rate, contention, round-trip delay (including delay budget of server, application and network), distortion, etc.
- Customer equipment: Quality of playback, required storage capacity (in bytes), easy of selection and playback, easy of navigation and downloading, ergonomic aspects of the user device, etc.

Figure 2.6: Four-market model



Source: ITU-T (Rec. E.802)

The ITU-T QoS framework, including the four viewpoints as well as four-market model, provides the basis for the definition of QoS and further QoS regulation. QoS regulation can be targeted to NGN services regulation and to Internet services regulation. In particular, QoS regulation may apply:

- between operators at the interconnection level, and
- between operators and end-users.

However, regulation of QoS in these instances raises a number of questions[2]:

- Which QoS issues for certain services (e.g. voice, television) have to be changed when transitioning from the public switched telephone network/public land mobile network and broadcast networks to all-IP based networks, such as NGN?
- Which QoS criteria should be included for services regulated and monitored by national regulatory authorities when differences exist between countries (e.g. differences in the quality of the network infrastructure, network capacity or server capacity, human resources, etc.)?

In addition, the specificities of the networks need to be taken into consideration, such as the best effort nature of the Internet and its architecture, which although not suited well for QoS provision (e.g. voice over IP (VoIP)) that can evolve accordingly by adding certain functions in the network nodes and the service platforms, as standardized for NGN. The technical parameters for QoS are also different between packet-switched Internet and circuit switched traditional telecommunication networks. However, the differences in terms of regulatory implications are related to the multi-service and multi-operator environment of the Internet and to its fundamentally global character. Regulation may be required to ensure/enforce interconnection service level agreement (SLA) between Internet dominant players in a given market (e.g. dominant network providers in a given country). QoS for certain services such as voice (e.g. latency for QoS-enabled voice delivery) in any IP-based network infrastructure should not be lower than the delay experienced in circuit switched plain old telephone services. In general, the Internet environment is mostly competitive due to its openness to new services and applications either locally (provided in a given network) or globally (e.g. websites), hence

[2] ITU and InfoDev *ICT Regulation Toolkit: Key Points and Recommendations on QoS Regulations* www.ictregulationtoolkit.org

regulatory intervention should be limited. However, in cases where markets for Internet access service are not sufficiently competitive, then there is a need for regulation.

3 QoS regulatory framework and role of national regulatory authorities

Policy-makers want consumers to have services of good quality and to develop appropriate QoS regulation. In defining the QoS regulatory framework, a number of questions need to be addressed by policy-makers and regulators. These include:

- What level of QoS do consumers want and need? (This is the job of the ITU-T SG-12.)
- Which national policies and laws, country benchmarking and practices are relevant to QoS matters?
- What QoS are consumers willing to pay for? Provision of services with higher quality tends to have higher costs for both operators and customers when compared to the same services with lower quality (e.g. Internet access service with 1-2 Mbit/s in downlink or uplink direction will provide lower QoS than Internet access with bit rates of 50-60 Mbit/s, respectively).
- Which policy measures if any are conducive to consumers having services available at the levels of QoS they want and need? In the absence of policy interventions, would network operators be motivated to provide services with good QoS at prices that are reflective of cost? If so, might policy interventions make things worse for consumers? If not, what kind of policy interventions might make things better?
- Should the regulatory authority impose QoS standards? Are market forces alone sufficient to ensure appropriate QoS? This is a longstanding debate among policy-makers.

Countries have taken different approaches to answer these questions depending on their national circumstances (e.g. existing infrastructure, national targets, etc.). There is no global consensus as to a single, best way; different approaches are needed. The answer to this question obviously has to do with the degree of competition in the market in question; for this reason, the approach in mature markets is, in principle, different from the approach in less mature markets.

If a national regulatory authority imposes QoS standards, the delivery of services in excess of what many consumers strictly require can result (e.g. some users may prefer low price for lower quality). In countries where competition is weak or non-existent, this may not be a concern as there might not have been any low price lower quality offerings in any case. In countries with little or no competition, QoS standards and higher prices may be preferable to low quality and nonetheless high prices. In countries with competition, however, it is often the incumbent that promotes QoS regulatory standards since they limit the ability of other network operators to compete aggressively on price.

In countries with greater competition, or at least with strong prospects of competitive entry, it is often preferable to leave QoS to market forces that may lead to different levels of quality, with correspondingly different prices. Different consumers have different willingness to pay (WTP) for different levels of quality, or even different WTP for QoS for different conversations. Price and quality differentiation benefit the network operators overall as they can capitalize on these differences and extract more revenue. Consumers also benefit from differentiated services that match their preferences. Aggregate consumption tends to be higher, benefiting broader society.

These questions are relevant to many aspects of QoS, and are equally relevant to traditional networks and to IP-based networks.

Developed countries tend to adopt a light touch approach when enforcing QoS standards. Some developed countries (including all of those in the European Union) require network operators to publish statistics on the QoS that they offer and/or the QoS that they achieve. In other countries, persistent failure to achieve committed levels of QoS can be actionable, not as a matter of telecommunication regulation, but rather as a matter of truth in advertising.

A key advantage of this light touch approach to QoS regulation is that it encourages network operators to tailor the QoS of their offerings to meet the requirements, and the corresponding WTP of customers.

The possible approaches for QoS regulation in these countries include:

- Neither monitoring nor enforcement: A minimal role for the regulator.
- Passive monitoring without enforcement: Typically a watching brief.
- Self-regulation: Possible monitoring and a watching brief.
- Co-regulation: Market participants play a key role, but the regulatory authority oversees the process and steps in if needed.
- Regulation: The regulatory authority is typically involved not only in setting standards and monitoring compliance, but also when enforcement is needed.
- Publication of QoS commitments, and enforcement via truth-in-advertising legislation: The division of responsibilities could vary, but primary responsibility is a matter of consumer protection.

Overall, countries can address QoS through different means which include:

- development of standards;
- licence regulation;
- monitoring, measurement techniques through survey and test;
- enforcement.

In this fast changing ICT environment, the NRA needs to keep pace with technology, market and business innovations, while ensuring consumers make informed decisions and benefit from reasonable quality services. In most countries, the regulatory framework sets out QoS regulation by setting minimum QoS standards, defining minimum value of QoS parameters, monitoring QoS, defining measurement methods and setting targets, reporting and publication procedures. QoS obligations can be found in different legal forms such as telecommunication laws and consumer protection laws, universal service directives (e.g. in the European Union), licence regulation, QoS regulations, etc.

Analysis of the contributions of QoS monitoring toward achieving regulatory targets is provided in Table 2.3.

Table 2.3: Direct contributions of QoS monitoring to achieving regulatory targets

QoS area	Monitored operators	Regulatory targets							
		Checking claims by operators	Helping customers make informed choices	Improving user experience	Understanding the state of the market	Maintaining or improving quality in competitive markets	Maintaining or improving quality in the absence of competition	Helping operators to achieve fair competition	Making inter- connected networks & platforms work well together
Setting targets	Dominant traditional operators only						+	+	+
	Dominant operators, incl. OTTs/ OSPs						+	+	+
	All traditional operators				+				
	All service providers, incl. OTTs and OSPs				+				
Making measurements	Dominant traditional operators only								
	Dominant operators, incl. OTTs/ OSPs								
	All traditional operators	+			+				
	All service providers, incl. OTTs and OSPs	+			+				
Publishing measurements	Dominant traditional operators only						+		
	Dominant operators, incl. OTTs/ OSPs						+		
	All traditional operators	+	+	+	+	+			
	All service providers, incl. OTTs and OSPs	+	+	+	+	+			

Note: A '+' occurring in an entry in this Table indicates that the activity contributes to achieving regulatory targets. Making measurements is assumed to be required by publishing measurements and setting targets, but making measurements is not awarded '+' just because publishing measurements or setting targets is awarded '+'.

Source: ITU: www.itu.int/ITU-D/treg/Events/Seminars/2006/QoS-consumer/documents/QOS_summary.pdf

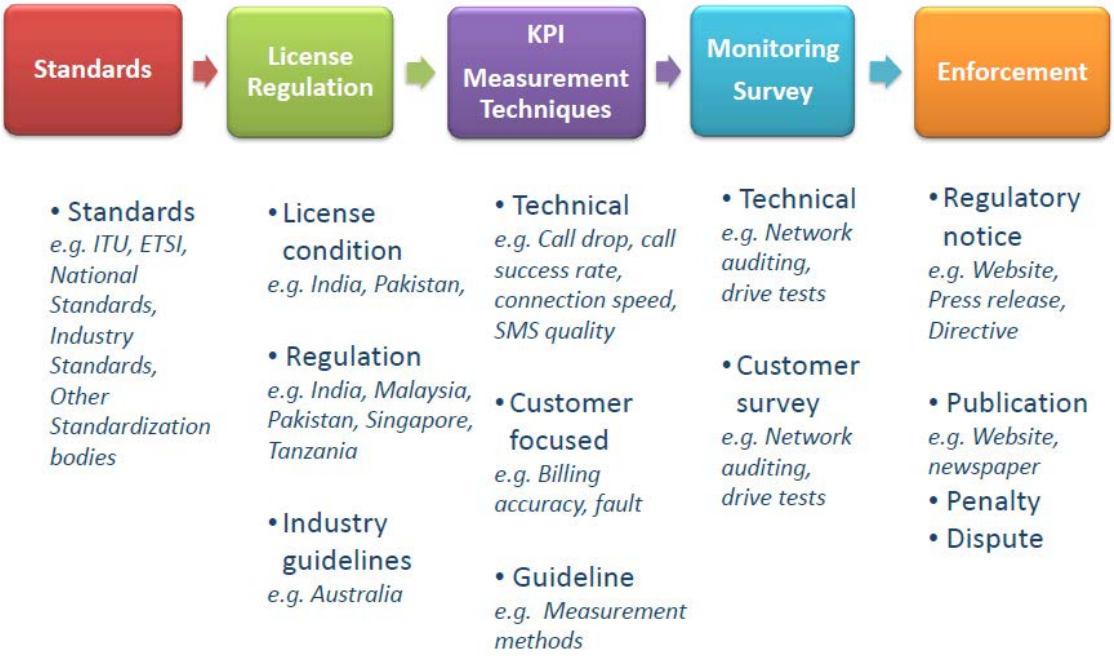
QoS has to be defined based on requirements given to the network and/or service providers. Typically, such a role falls under the jurisdiction of the regulatory authority that implements the QoS regulatory framework; the same can be considered by other authorities in charge of telecommunication/ICT regulations (e.g. NRA, ministry or other government body). The role of NRAs regarding services can be summarized as follows:

- Impose special obligations on operators of publicly available services concerning the provision of availability of services to all users, including users in sparsely populated areas as well as users with disabilities.
- Keep an updated database of prices, conditions of access and use (including limitations), and the quality of public communications networks and services (including voice, messaging, television, data services, etc.). The NRA shall update this data and make it publicly available on its website.
- Monitor, measure and ensure that networks are professionally designed and of a satisfactory quality, and that they provide the desired QoS for different services offered through the given network operator which delivers broadband access.
- Ensure and enforce the quality of the communication services and Internet access service. For that purpose, the NRA should set minimum QoS requirements on Internet access providers and other appropriate measures to enforce QoS to ensure that all end-users enjoy an Internet access service of good quality.
- Ensure and enforce the quality of QoS enabled services (e.g. carrier grade VoIP, IPTV, business services, etc.) according to the service level agreements (SLAs) concluded between the provider and the end-users.

3.1 The quality of service regulatory framework

The QoS regulatory framework is outlined in Figure 3.1. It starts with setting standards, developed by global standard developing organizations (SDOs) such as the ITU-T, as well as by regional SDOs (e.g. ETSI in Europe, etc.). QoS standards can be implemented as part of licence conditions (e.g. India, Pakistan, etc.), ICT regulation (e.g. India, Malaysia, Pakistan, Singapore, Tanzania, etc.), or industry guidelines (e.g. Australia, etc.). QoS is defined through a given set of parameters that are measurable. Such quality parameters that are defined for QoS measurements in a given country (or globally) are referred to as key performance indicators (KPIs.) KPIs can be technical and non-technical. Examples of technical KPIs include call success rate, call drop rate, connection speed (downstream and upstream), SMS delivery time, etc. Non-technical KPIs are customer focused, and may include parameters such as billing accuracy, fault, etc. Once defined, KPIs will serve for monitoring purposes. Different measurement methods can be used; this may differ from one country to another. KPI monitoring is done by the NRA as well as by operators (network providers and/or service providers) or independent organizations. Different approaches exist in the monitoring of technical and customer focused KPIs.

Figure 3.1: QoS regulatory framework



Source: ITU

For example, technical monitoring of KPIs can be performed by network auditing, drive tests (in mobile networks), probe stations on selected locations, etc. The customer focused KPIs are monitored by customer surveys. The purpose of monitoring the values of the defined KPIs (used to define the required QoS in a given country) is to detect degradation of the QoS when it appears, and to apply appropriate actions to enforce QoS. Such QoS enforcement can be performed through a regulatory notice (e.g. publishing KPI monitoring results on a public website, through press releases, via directives, etc.) with the aim of informing customers. However, if such enforcement approaches are not enough to enforce QoS, then more drastic QoS enforcement should be undertaken through financial penalties (to non-conforming telecommunication operators or service providers) or through dispute resolution mechanisms.

The first step of a QoS regulatory approach is to obtain appropriate information on the level of QoS and identify problematic areas. The next step is to publish the information on QoS performances in order to inform customers. The following step is to impose regulations on minimum required performances on a selected set of KPIs (e.g. bit rates). Enforcement measures include imposing fines and compensation for non-conformant operators. Finally, in all steps, constructive dialogue between the authority for ICTs (ministry, NRA, etc.) and the operator concerned is encouraged to foster QoS implementation and improvements.

3.2 Principles for quality of service regulation

As stated in Supplement 9 to ITU-T E.800-series Recommendations, there are four main elements in a regulatory approach to QoS:

1. Obtaining appropriate information on the level of QoS and identifying problem areas. This is essential, without the appropriate information, the other elements cannot be undertaken.
2. Undertaking a constructive dialogue with the operator concerned to encourage and foster improvements.
3. Publishing information on QoS performance so that customers can be better informed.

4. Imposing regulations on performance, such as required minimum levels and fines or compensation.

There are basically two alternative approaches:

1. Regulation-oriented approach, where reporting is to the regulator; performance targets are set in regulations; fines are payable to the regulator if targets are not achieved.
2. Customer-oriented approach, where reporting is to the customer; targets and minimum performance levels are provided in contracts; compensation for poor performance is payable to the affected customer.

QoS regulation has a cost and the costs should be assessed against the benefits. Efforts should be focused where there are known problems. In addition, problem areas can change so there needs to be a degree of flexibility. The following clause provides an overview of the fundamentals of QoS regulation (ITU-T Rec. E.800):

Quality of service regulation is part of customer protection. However, customer protection is broader than quality of service regulation and covers, for example, sales activities, complaint resolution procedures and disconnection policies. Furthermore, as explained earlier, QoS is not the same as network performance, which is concerned with standards for network design.

The main purposes of QoS regulation are (ITU-T Supp. 9 of E.800 Series):

- helping customers be aware of the QoS provided by telecommunication operators/ ISPs through networks (mobile and fixed), so that they can make their own choices;
- checking claims made by operators;
- understanding the state of the market;
- maintaining / improving QoS in the presence of competition;
- maintaining / improving QoS in the absence of competition;
- helping operators to achieve fair competition; and
- making interconnected networks work well together.

QoS regulation is based on a selection of so-called QoS parameters, which can be technical (examples in ITU-T Rec. 804) and non-technical (examples in ITU-T Rec. E.803). Standard developing organizations, such as ITU, standardize QoS parameters for different services. For example, ITU-T Rec. E.804 defines QoS parameters for popular mobile services. ITU-T Rec. 803 defines parameters for supporting aspects of QoS. Not all QoS parameters are subject to regulation. The selected QoS parameters that are important to users, operators and the regulator are referred to as KPIs. Different countries have specific characteristics regarding their QoS parameters and therefore their target values may vary from country to country for a number of reasons (e.g. low penetration of certain services, early years of development of certain services in that country, etc.). Some variations of standard parameters may be necessary, depending on the specific situation in a given country or sector. The measurements of a parameter might need to distinguish between:

- Market segments: QoS may be different for private consumers, small and large businesses or for wholesale and retail offerings.
- Reporting areas: Areas likely to have differences in quality, such as rural and urban areas.
- Operators: Who have few customers, that resell services from other operators, or that are not dominant in the market might be exempted from monitoring parameters or publishing measurements.

- Services: Parameters may be specific to services such as voice, text messages and Internet, television and radio broadcasting, as well as leased lines, as the main services that have most impact on users.

3.3 Service level agreements

This section draws largely from ITU-T Rec. E.860 to describe what a service level agreement is, how it can help enforce QoS, and the role of the regulator.

According to ITU-T Rec. E.860, a service level agreement (SLA) is a formal agreement between two or more entities that is reached after a negotiating activity, with the scope of assessing service characteristics, responsibilities and priorities of each part. An SLA may include statements about performance, tariffing and billing, service delivery and compensations. It is a commercial agreement that is typically monitored by the NRA.

In a multi-provider environment, the relationships that exist between service providers may be very complex. For example, a primary service provider that wants to deliver a service to a customer often uses service elements provided by other service providers, and consequently it becomes much more complex to ensure the QoS level as stated in the SLA. It is therefore necessary to define the responsibilities of all entities involved in service delivery, and, above all, to coordinate all activities in order to reach the agreed QoS levels end-to-end.

This is when the concept of *one stop responsibility* can come into play. The concept is based on the SLA agreed by two entities that stipulates the QoS conditions, among others. This is called QoS agreement or service quality agreement (ITU-T E.800). An illustration of SLA content is provided in Figure 3.2.

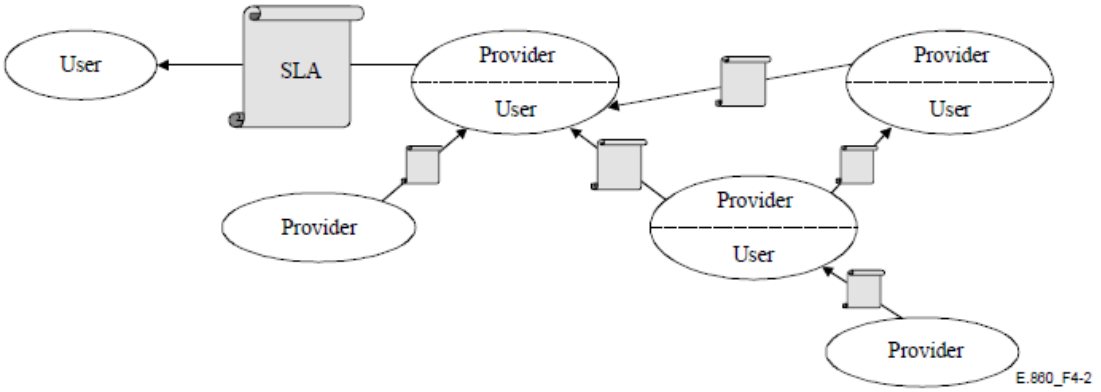
Figure 3.2: SLA between service provider and end-user



Source: ITU

As explained in ITU-T Rec. E.860, one stop responsibility, as agreed between a provider and a customer under an SLA, allows a user to retain a primary service provider, with whom the user signed the SLA, as the sole responsible party for the overall QoS received. In turn, the primary provider can apply the same one stop responsibility to its sub-providers. This however is not obligatory considering the SLA toward the end-user (e.g. there can be peering or transit agreements between the Internet service provider (ISP) i.e. the provider with other ISPs, which are not directly related to the end-user SLA. They can, however, indirectly influence the end-user SLA, as discussed in Chapter 5 on end-to-end QoS provisioning.

Figure 3.3: One-stop responsibility concept for the SLA



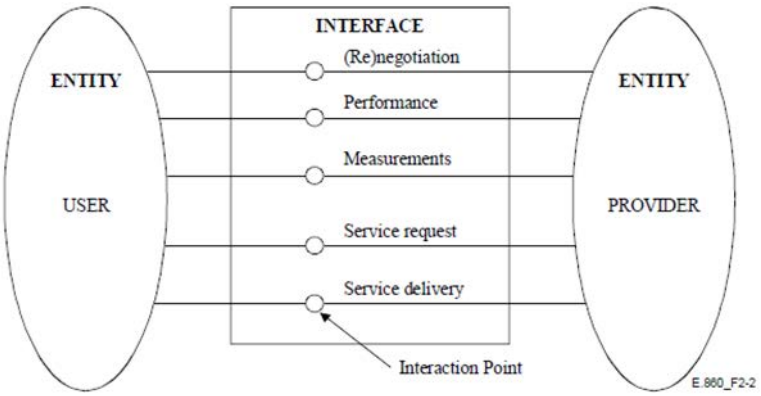
Source: ITU

According to E.860, by applying the one stop responsibility in a recursive manner to all entities (provider and sub-providers) taking part in the provision of the service (Figure 3.3), the service agreed with the end-user is then guaranteed. Again, in practice there are possible variations in this regard since the ISP (i.e. the provider) may use different peering or transit for the traffic to/from the user in different times or locations.

The terms defined in ITU-T Rec. E.860 related to the SLA that are used in the remaining part of this section (Figure 3.4) include the following:

- **Entity** is a generic unit involved in using/delivering a service. It is characterized by its states and its transitions from a state to another. An entity that delivers a service to another entity is called **provider** while the entity that receives the service is called **user**.
- **Interaction point** is where two entities can exchange information. Sometimes an interaction point between user and provider may not belong to their logical interface although this point remains under the control of the provider.
- A group of interaction points at the logical boundary between two entities constitutes an **interface**.

Figure 3.4: Definition of entities and interfaces for SLA



Source: ITU

3.3.1 Quality of service agreement

The part of the SLA that refers to QoS is called a QoS agreement and includes a formal programme mutually agreed by the two entities for choosing, measuring and monitoring QoS parameters. The

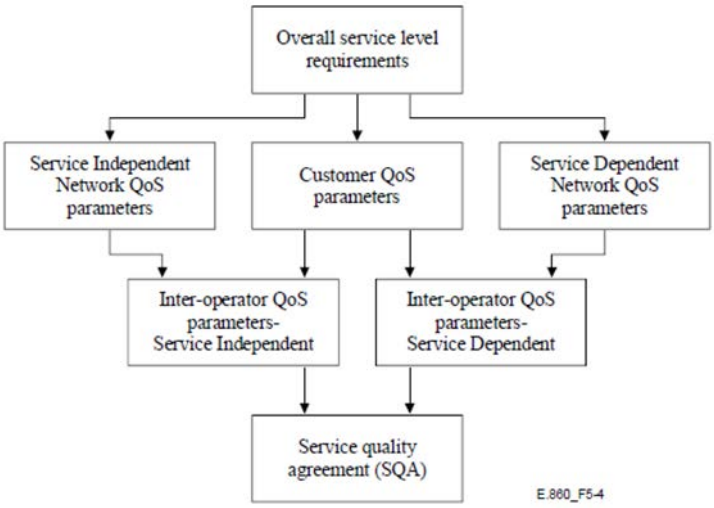
goal is to reach the QoS agreed upon with the end-user and thus obtain end-user satisfaction. The definition of QoS parameters is an essential stage in developing an SLA and, in particular, its corresponding QoS agreement. QoS parameters need to be expressed in a clear and accessible way, in simple language for the end-user and more technical language for service providers. Regarding the type of information exchanged, the following interface descriptions are included in ITU-T Rec. E.860:

- Business interface: This interface is composed of interaction points always located between the user and service provider, used for specific QoS agreement functions as well as (re)negotiation, performance reporting and reaction patterns that are triggered when the agreed QoS level is not provided.
- Technical interface: This interface exchanges service specific information and allows measurements from which QoS parameters are derived.

In order to manage its own resources properly, every entity must know the **characteristics of traffic** that it receives from other entities (traffic at the entry points). Outgoing traffic for one entity is incoming traffic for another entity, for application and management flows.

The conditions (thresholds) that enable the activation of reaction patterns from the receiving entity have to be specified. The description of traffic patterns should be clearly understood by the entities on both sides of the interface. In this way, any possible reaction can be clearly justified to the penalized entity involved in using or delivering a service (e.g. network or service provider). One way to individuate QoS parameters in an interconnection between two entities is provided in ITU-T Rec. E.860, and described in Figure 3.5, where both customer and network parameters are taken into consideration.

Figure 3.5: Determination of QoS parameters for service quality agreement



Source: ITU

A telecommunication service is defined as a group of functions whose realizations are observed through direct or indirect analysis of corresponding events. If we are considering all possible types of functions, a useful categorization of primary QoS parameter is the Timeline Model approach defined by the European Telecommunications Standards Institute (ETSI).

In ITU-T Rec. E.860, the Timeline Model identifies three possible scenarios (levels) on the basis of a temporal scale, and each scenario is then divided into three phases:

- First level: Service scenario, refers to design and realization of a given service by the service provider in a range of years or decades.

- Second level: User scenario, has the focus moved from the totality of the users to the service utilization of each single user (the end points are the start and end of the subscription period) in a range of months or years.
- Third level: Session scenario, attention is focused on the single call/session. End points are the setup and the release of a given call or session, so time intervals are referred to in a range of seconds, minutes or hours.

In all three of these scenarios, quality of service depends on the accuracy of the service functions provided, which is valued on three criteria (I.350):

1. Speed
2. Accuracy
3. Reliability

QoS is assessed by assigning proper values to QoS parameters, which can be divided into two groups:

- Direct parameter refers to a specific service element and is determined by collecting direct observations of events in correspondence with its interaction points.
- Indirect parameter is defined as a function of other direct parameters. Indirect parameters are defined as functions either of values of primary QoS parameters or of decisions taken on the basis of the latter. A good example of an indirect parameter is service availability.

Example from ITU-T Rec. E.860:

Service availability (SA%) is often derived from measurements of service unavailability (UA%) applying the formula: SA% = 100% – UA%

The expression that allows calculating UA% is the following:

UA% = (Σ outage interval / Active time) x 100%

3.3.2 Service level agreements for end-to-end quality of service

To achieve end-to-end QoS, SLA agreements are needed between end-users or end-entities and service providers, as well as between all providers along the path between the end-points of the given call or session. Several service providers are often involved in a service provision and collaborate together in realizing the various service elements forming a multi-provider environment.

Using one stop responsibility, the end-user will rely exclusively on the agreed QoS with the service provider from their negotiated SLA, while the service provider will have to guarantee that QoS by signing, in turn, suitable SLAs with its sub-providers. Such an approach assures that end-to-end QoS of connections, which pass through several service providers, will fulfil QoS agreed with the end-user in the SLA.

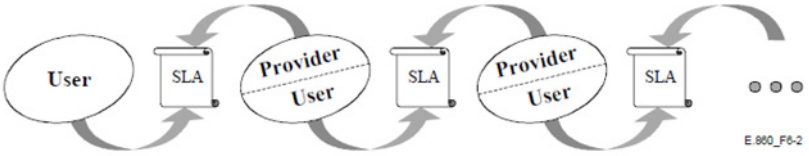
Another method consists in making a chain of SLAs between each user/provider pair involved in the provisioning of the same service. The chain starts with an end-user and primary provider SLA that states the end-to-end QoS. In turn, the primary provider – bearing in mind the promised performance – contracts SLAs with sub-providers recursively to make a chain (as presented in ITU-T Rec. E.860 and reported in Figure 3.6). A general procedure for end-to-end SLA includes:

- The input includes the service description, the entities involved, the description of their roles and their relationships (business model).

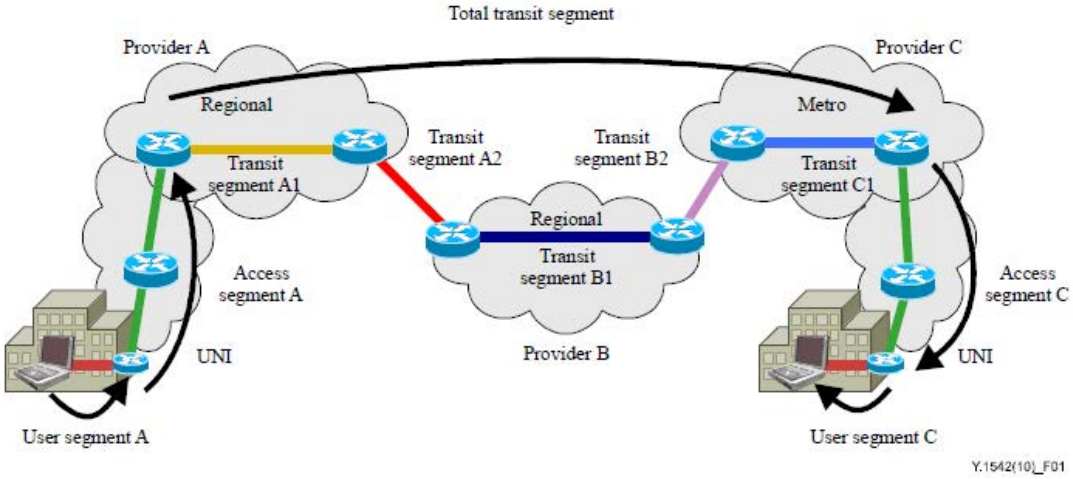
- The procedure individuates the service elements provided to the primary provider by its sub-providers and both business and technical interfaces that will be used.
- The outputs are the service delivery configurations with the description of an SLA for each user/provider pair identified during the procedure.

Figure 3.6: Theoretical chain of SLAs for end-to-end QoS (a) and practical framework for achieving end-to-end IP performance objectives (b)

a) Chain of SLAs for end-to-end QoS



b) Practical framework for end-to-end QoS



Source: ITU

3.3.3 Service level agreements, quality of service regulation and legal aspects

The inclusion of an SLA in contracts has become popular but such agreements are not always effective as their formulation may be vague, and compensation terms may not be stated. Furthermore, the process for claiming compensation may be made excessively complex to deter claims. To be effective, the SLA should state:

- The minimum level of performance offered to the customer, not the average level to be achieved for all customers.
- The compensation payment, if the minimum level is not achieved with the sum at least proportional to the degree of failure.
- The mechanism for claiming compensation. In most cases compensation should be paid automatically and the customer should not be required to make a claim.

It is possible to enforce penalty clauses for failing to meet QoS service levels under relevant domestic laws. Ideally, the goal of the penalty portion of the contract should be oriented less toward punishing the service provider and more toward providing incentives. However, penalties may be charged in a certain amount of money proportional to the interruption period for defined QoS parameters in the SLA. There are cases when penalties are avoided with certain negotiations between the parties (e.g.

the ISP and the client), which may result in the release of the SLA and the option to change providers before the expiration of the SLA.

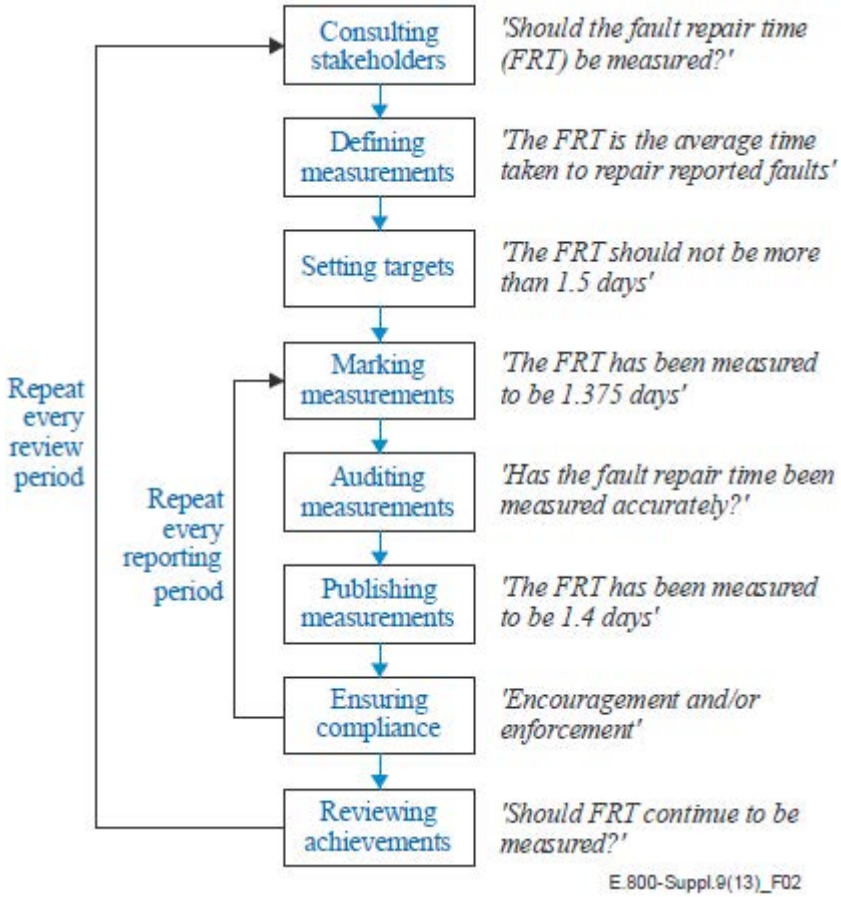
Regarding QoS regulation and especially QoS enforcement, the SLA can play an important role. Typically the NRA is the authority that monitors the format of agreements between telecommunication operators (as service providers) and end-users. Selected QoS parameters as KPIs may be a part of the SLA, such as bit rates in downlink and uplink. For example, by requiring the SLA to specify minimum bit rates in downlink and uplink (where that is technologically feasible, such as in fixed access networks), the NRA can ensure operators provide a certain level of broadband access to the end-users in the country and take enforcement measures if they fail to do so. However, there can be different targets specified for differently priced services, such as different prices for different access bit rates in downlink and uplink direction. The offers for the end-users should be market driven (in mature markets), while the NRA can specify the minimum bit rates that can be offered to the end-users (e.g. to stimulate the uptake of broadband access in the country, which is of higher importance to society in general, and avoid it being just a market battle between telecommunication operators as service providers).

3.4 Activities in quality of service regulation

Quality of service regulation requires the regulator to perform the following activities, as provided in Figure 3.7. Some of these may also be performed by the operator, consumers or even third parties in some cases (contracted or independent). These activities will be examined in greater detail in the following sections:

- defining parameters;
- setting targets;
- making measurements;
- auditing measurements;
- publishing measurements;
- ensuring compliance.

Figure 3.7: Activities in QoS regulation



Source: ITU

3.4.1 Defining quality of service parameters

When defining QoS parameters, the involvement of operators is beneficial and desirable. However, there is a risk that they may exercise undue influence and that the consultation process could be lengthy. The regulator needs to exercise strong leadership while ensuring that stakeholders are consulted. The following factors, among others, should be taken into consideration:

- the practicability for operators to make the required measurements;
- the practicability for regulators or any independent entity to audit the results;
- the measurement being made should retain the customer experience aspect.

QoS regulation is based on the definition of QoS parameters that will be monitored for the purposes of QoS enforcement. A target is defined as a potential value (or a range of values) for a parameter that must be reached if quality is to be regarded as satisfactory. Three classes of parameters determine the user experience:

1. Customer interface parameters.
2. Network infrastructure parameters.
3. Service functionality parameters.

Service functionality parameters are organized according to service type (such as voice, SMS, etc.) rather than by operator type (fixed wireless, wireline, mobile, etc.) to help with comparability between countries and consistency in the treatment of operators.

Parameters are named according to the same conventions irrespective of how they are named in different countries. As such, *rate*, which defines the frequency of actions, *ratio*, which stands for the proportion of actions that succeed, and *time*, which means the average time taken by actions that succeed. A list of proposed QoS parameters is provided in Table 3.1.

Table 3.1: List of proposed parameters

Customer interface	Network infrastructure	Service functionality
1 Customer complaint submission rate	4 Coverage	8 Call set up ratio
2 Customer complaint resolution time	5 Service supply time	9 Call retention ratio
3 Customer service call answer ratio	6 Fault report submission rate	10 Listening voice quality
	7 Fault repair time	11 Value added service call answer ratio
		12 Message transmission ratio
		13 Packet transmission ratio
		14 Packet transmission rate
		15 Data transmission capacity

Source: ITU-T Supplement 9 to ITU-T E.800-series

3.4.2 Setting target levels

Targets are normally set by the regulator based on consultation and prior monitoring of operator data. An operator can also set targets and be required to publish them. Aggregated performance targets, for example, involving a number of different observations can be formulated in two different ways:

1. The percentage of events that exceed or fail to meet a target level of performance (e.g. % lines delivered in more than X days). In this case, X indicates a target level.
2. The number of days within which 90 per cent of lines were delivered. In this case, no target level is indicated.

If compensation is going to be given, then the measure must have a simple pass or fail criterion for each individual customer.

3.4.3 Making measurements

As Table 3.1 shows, for customer interface and network infrastructure parameters, these measurements can be easily made by operators. Many service functionality parameters are best made by external measurement agencies or by use. Measurement methods, if possible, should be objective. For some issues – such as the effectiveness of call centres and help lines – it may not be possible to specify a parameter that can be measured objectively, and subjective user assessments are used, e.g. the caller is asked at the end of the call to assess its effectiveness on a scale of 1-5. While this does give some measure of performance, it is not suitable for the application of penalties or compensation. Measurement may be taken by third parties or reported by the operator itself. They may be based on sampling or include all events. Where measurements can be built into the network or support systems

and be automatic, then self-reporting covering all events is normally the best approach. Regarding measurements, there are two methodologies for measuring QoS:

1. Passive measurement (using test packet): Test packets are sent from management systems, and performance metrics such as delay, jitter, and packet loss are measured along the way. This method is also often used for troubleshooting.
2. Active measurement: Probes in the form of software agents or network appliances are deployed on network elements and user devices (for the software agent case). Measurements based on these probes provide a very accurate status of the devices at any time. The sources and sinks of probes may be either dedicated measurement devices, routers that are dedicated to measurement tasks, or routers that support both data traffic and measurement probes. The main drawback of this measurement is that it doesn't scale for large networks.

Regarding international practices, active testing (i.e. active measurement) is the mostly commonly adopted methodology by NRAs to measure QoS of broadband Internet provided by ISPs. Active testing allows regulators to regularly produce benchmarking reports. However, the active testing methodology faces implementation challenges, including:

- The cost of implementing this methodology is high.
- For benchmarking/comparison of QoS performance of various ISPs, the sampling methodology is very critical; therefore, QoS monitoring tools (probes) have to be deployed to replicate a like-for-like QoS performance comparison of ISPs.
- It requires very close collaboration with ISPs and Internet consumers.
- The results from the measurements should be reported for the purpose of auditing the QoS. Reporting normally involves aggregated results. The question is whether they should be aggregated over:
  - all parts of the network or aggregated separately for different areas;
  - all customer types or reported separately for business and residential customers.

This can only be decided on a case-by-case basis taking local circumstances and quality problems into account.

3.4.4 Audit of quality of service

The purpose of QoS auditing is to verify QoS experienced by customers and to compare the results (from audit exercises) against licence obligations. The methods of auditing telecommunication operators include:

- Drive test (performed on a quarterly basis or as required)
- Consumer survey
- Data submitted on a monthly or quarterly basis by telecommunication operators, etc.

For example, consumer surveys can effectively pinpoint the weakest elements of service quality, giving operators good feedback, while allowing customers to compare their views on the various operators with other people. It is also a good addition to the indicator-based method of measurement. Contrasting the two sets of data can determine whether a weakness identified by consumers also falls among the low-levels of relevant indicator data.

3.4.5 Publishing measurements

Measurements should be published by the regulator to help carry out comparisons between operators. To simplify the task, the number of measurements to be published could be reduced. The main purpose of publishing information on QoS is to better inform customers.

Regulators should publish information on performance on their websites and also require operators to send the information periodically to subscribers with their bills. QoS information examples that should be published include the QoS results from the audit campaign (drive test, consumer survey, etc.).

This information should be made available as soon as possible.

3.4.6 Ensuring compliance

Ensuring compliance is highly recommended in QoS regulation. There are two approaches in implementing QoS regulations:

1. The encouragement approach.
2. The enforcement approach.

For the regulator to proceed with the enforcement approach, it may start with recommendations and move towards obligations. The regulator can adopt a range of techniques, starting from naming-and-shaming strategies to tighter regulation, financial penalties and finally more drastic legal enforcements. However, doing so can involve extensive legal processes and may take a long time. A schedule of penalties may be announced publicly to ease implementation.

As a general principle, it is recommended that both encouragement and enforcement should be graduated and proportional. Whenever feasible, the regulator should engage in constructive dialogue with operators on quality problems. This should not be seen as a process of telling the operator how to run their business, but of asking targeted questions that can trigger the operators to review and reconsider their approach in areas with specific problems.

4 Traffic management

4.1 Convergence of telecommunications and Internet

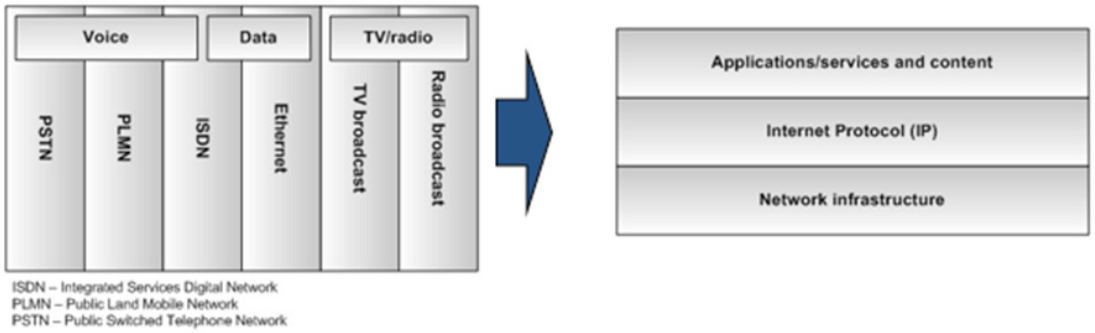
The network layer of the Internet is the IP (Internet Protocol). Version 4 (IPv4) is currently present in every host, router and gateway of every network. As it stands, it does not contain mandatory QoS mechanisms. However, it does have the ability to identify the type of service field and specify QoS requirements on precedence, delay, throughput and reliability. In a similar manner, IPv6 has a differentiated service code point field and can support QoS per flow on the network layer (e.g. by using flow label and next header options). However, both IPv4 and IPv6 do not guarantee the actual end-to-end QoS as there is no reservation of network resources, something that should be provided by other mechanisms in IP networks. Internet is built on autonomous systems, where each system is identified by a 16-bit or 32-bit number. This number is allocated by the Internet Assigned Numbers Authority (IANA), a department of ICANN (Internet Corporation for Assigned Names and Numbers) that currently governs the Internet in terms of domain naming and IP addressing, as well as other well-known numbers from various standardized protocols for IP networks, such as port numbers used by transmission control protocol (TCP) and user datagram protocol (UDP). The system is autonomous because it can apply traffic management schemes and routing protocols in its administrative domain independently from other systems. Internet and global telecommunication networks are based on IP networks, consisting of 50 000 to 100 000 active systems, which are interconnected between

each other. Each system is interconnected with one or more neighbouring systems, not with all of them, thus creating the global telecommunication network of today, completely based on Internet networking technologies. This is crucial in understanding why the traditional way of enforcing QoS (same approach in all countries, e.g. for digital telephony, i.e. PSTN/ISDN) is no longer possible in an IP-based environment due to the heterogeneity of the various IP networks, applied management techniques, and the plethora of services and applications that are constantly being offered (e.g. in OTT applications/services ecosystems). QoS as an end-to-end characteristic is becoming more complex in a telecommunication environment based on Internet technologies.

The traditional telecommunication approach by default includes end-to-end QoS support in the network. The main purpose of the NGN standardization framework is to standardize the end-to-end QoS support in all-IP networks (including all needed functions in transport and service stratums) that is essential for real-time services, such as VoIP and IPTV. Such services have strict requirements regarding QoS (e.g. guaranteed bit rates, losses, delay, and delay variation). Therefore, NGN provides a standardized implementation of QoS (instead of proprietary case-by-case implementation) that is mandatory for the transition from PSTN and PLMN to all-IP networks.

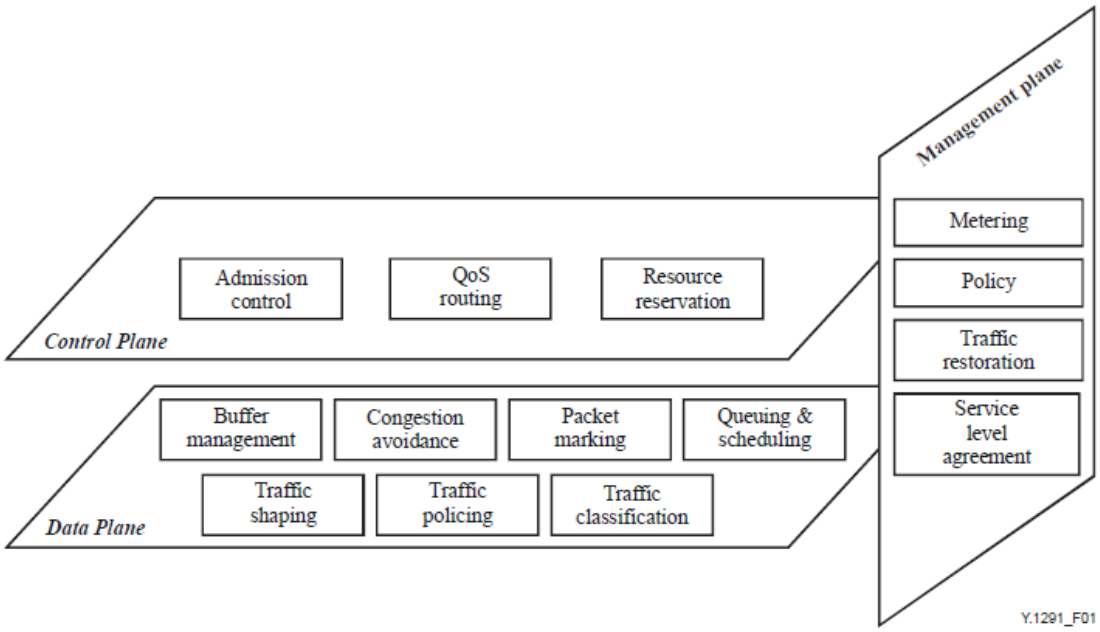
In an all-IP telecommunications/ICT world, Internet technologies should be considered for traffic management and for QoS standardization, monitoring and enforcement. The transition from the vertical silo approach to a horizontal layered approach in an IP environment is illustrated in Figure 4.1.

Figure 4.1: Transition from vertical separation of networks and services (the old way) to horizontal separation of services/applications and broadband IP networks (the new way)



Source: Dr Toni Janevski, NGN Architectures, Protocols and Services, 2014

Figure 4.2: QoS architectural framework



ITU has defined an architectural framework for the support of QoS in packet networks. Although there are unified packet switched networks, different packet switched networks also exist that are standardized, including the SS7 signalling as well as asynchronous transfer mode (ATM). The QoS framework defined by ITU-T (Figure 4.2) is organized into three planes (ITU-T Y.1291):

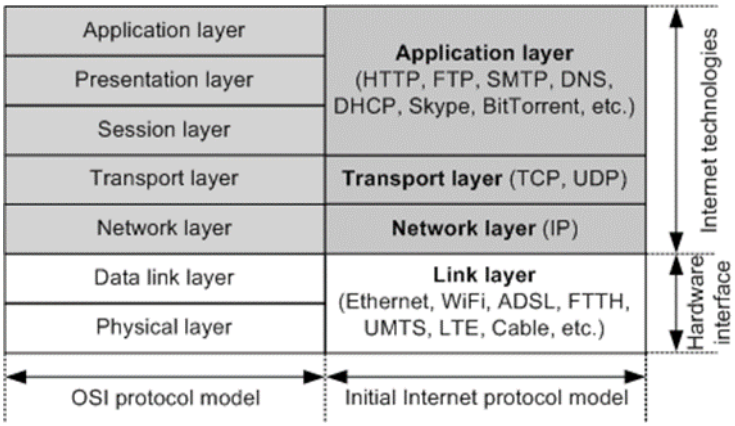
1. The control plane: admission control, QoS routing, and resource reservation.
2. The data plane: buffer management, congestion avoidance, packet marking, queuing and scheduling, traffic classification, traffic policing and traffic shaping.
3. The management plane: SLA, traffic restoration, metering and recording, and policy.

4.2 Internet technologies: the basics

To regulate QoS, regulators need to understand how traffic management applies in telecommunication networks. Because telecommunication networks are becoming all-IP, understanding Internet technologies is key. This section examines the basics of Internet technologies.

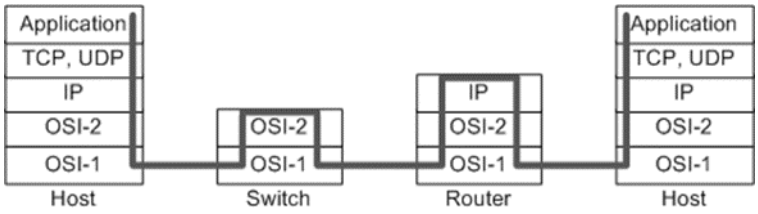
Figure 4.3 shows the Internet protocols layering model mapped with the open systems interconnection (OSI) protocol layering model.

Figure 4.3: Internet protocols mapped to OSI protocol layering model



Source: Toni Janevski, *Internet Technologies for Fixed and Mobile Networks*

Figure 4.4: Comparison of information processing in Internet host, switch and router



Source: Toni Janevski, *Internet Technologies for Fixed and Mobile Networks*

Internet networks consist mainly of two entities: the end hosts (e.g. personal computers, lap-tops, smartphones, modems, etc.) and network elements (switches and routers). The main network elements are the routers that process the network layer packet header (i.e. IP headers), while switches process only protocol layers 1 and 2, and therefore are typically used for the design of IP-based access network architectures, either on the end-users' side or on the servers' side. The end hosts typically have protocols on all layers, from physical layer, at the bottom, up to the application layer, at the top (Figure 4.4).

How packets are classified depends on the approach as different options exist, such as:

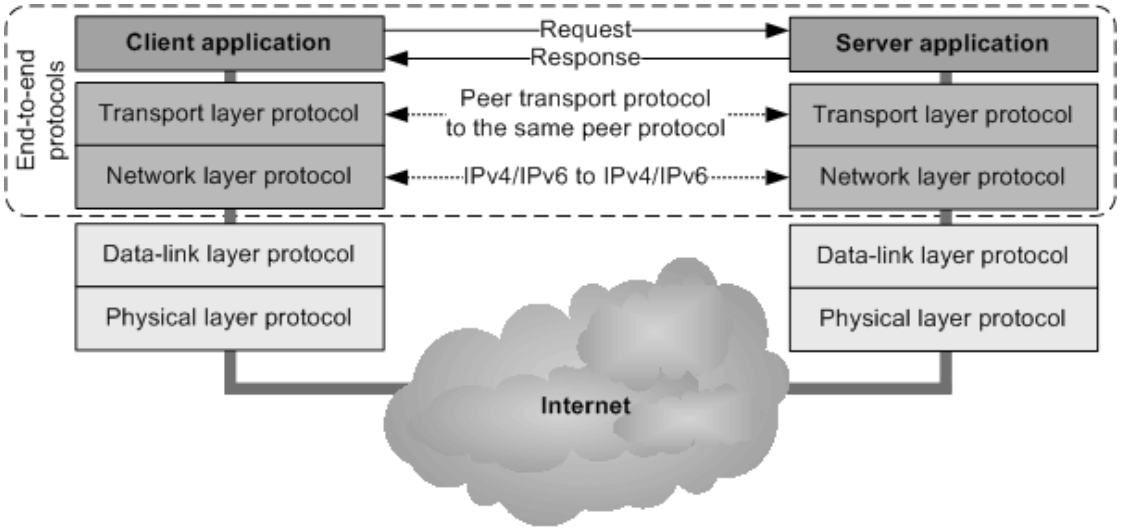
- Classification can be based on ports (ports are used by transport layer protocols such as TCP and UDP to identity applications on the top). For example, port 80 (HTTP, i.e. the web) takes precedence over port 21 (FTP).
- Classification can be based on application type. For example, carrier grade VoIP takes precedence over HTTP, BitTorrent.
- Classification can be based on user type. For example, home and business users get normal service, but hospitals/police/fire departments get highest priority service.
- Classification can be based on subscription. For example, USD 50 for high speed Internet (guaranteed maximum access bit rates in downstream and upstream) compared to USD 10 for fair-usage policy-based Internet (e.g. bit rate is proportionally downgraded with higher usage).

To understand packet classification and traffic management, one needs to know that the main networking principle in the Internet is the client server, where:

- A client requests a service from the server through a well-defined client interface (e.g. web browser).
- The server provides a service through a well-defined server interface (e.g. web server).

Typical examples of standardized client-server protocols are file transfer protocol, hypertext transfer protocol used for the web; all e-mail protocols; video streaming protocols; as well as mainly all non-real-time OTT services (e.g. video sharing such as Youtube, picture sharing such as Instagram, social networking such as Facebook or Twitter, cloud computing (e.g. Google Drive, Amazon cloud, etc.), web search engines (e.g. Google, Yahoo, Bing, etc.), etc.

Figure 4.5: Client server communication



Source: Toni Janevski, *Internet Technologies for Fixed and Mobile Networks*, 2015.

Both endpoints (i.e. hosts) communicating over the client-server network architecture must use the same transport protocol (e.g. TCP, UDP). For each communication, the peer applications on both end hosts must be of the same type (e.g. web clients communicate with web servers, FTP clients communicate with FTP servers, etc.), as shown in Figure 4.5.

When both end host entities (which are also referred to as hosts in Internet literature) can act as both a client and a server, then the communication is referred to as peer-to-peer (P2P). For example, conversational VoIP is an example of peer-to-peer communication – either it is being provided by telecommunication providers with guaranteed end-to-end QoS (i.e. telephony) or it is being provided by OTT voice providers (e.g. Skype, Viber, etc.). Another example of peer-to-peer communication is peer-to-peer file sharing (e.g. BitTorrent).

Packet classification is needed to sort packets into flows (per class). Usually the following fields are used for classification (5-tuple):

- source address (from IP header);
- destination address (from IP header);
- protocol number (from IP header);
- source port (from transport protocol header, e.g. TCP, UDP);
- destination port (from transport protocol header, e.g. TCP, UDP).

In IPv6 networks classification can be performed with 3-tuple (if flow label in IPv6 header is used) source address, destination address, flow label (all from IPv6 header).

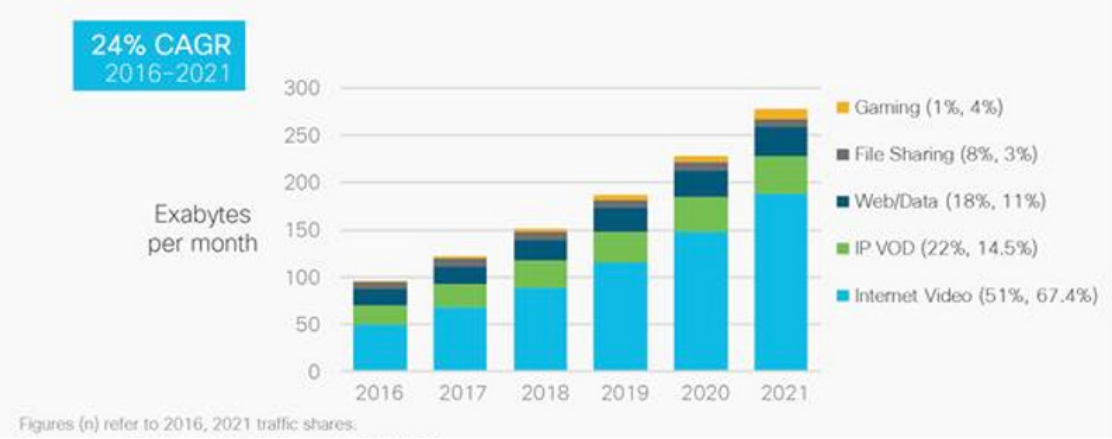
Typically packets are classified at the edge router, then the core routers check the given mark. Due to the autonomous nature of each Internet administrative domain (autonomous system), the marking in one network domain is rewritten at the edge of another network domain. Therefore marking is not the same throughout as the IP packet travels through several different operator networks on the end-to-end path.

4.3 Traffic management aspects

Nowadays, traffic management currently follows a *fair use* paradigm that is intended to limit excessive or unfair use. Until recently, users generating the most traffic have been running P2P applications, and ISPs have therefore mainly targeted P2P in their policies.

With broadband access, users do not need to download a movie to watch it, they can do so online. Today the greatest traffic growth is in video streaming and video is widely expected to grow further as broadband Internet penetration over fixed and mobile networks increases (Figure 4.6).

Figure 4.6: Internet traffic forecast



Source: Cisco VNI Global IP Traffic Forecast, 2016-2021.

Without a managed response (e.g. more capacity, traffic management), there is a risk of congestion and a reduction in many users' QoE. In the future, there will certainly be new killer applications that could put even more pressure on Internet capacity.

Traffic management is therefore targeted to the management of different types of traffic (voice, video, data, messages, etc.) in different parts of the networks (access, core, transit) to ensure the provision of the desired QoS and QoE.

Traffic management is influenced by:

- the type of traffic, such as voice (it is low rate) or video (high bit rates and bursty by nature) or data (variable data rates and bursty by nature);
- the number of users attached to a given network;
- the capacity of the network which is installed (measured in bits per second (bit/s or bps);
- the type of network equipment and its capabilities (e.g. switches, routers, gateways, base stations, etc.);
- business plans (by the ISP, i.e. telecommunication operator) and regulatory legislation (e.g. national regulation);
- capacity of employees at the ISPs and regulators.

4.3.1 The principles of traffic management

Telecommunication operators, i.e. ISPs, may differ in their traffic management practices, however the basic techniques of traffic management are the same. In all cases, a traffic management decision is made that is implemented in the network as an intervention. A traffic management decision can take into account the type of traffic, the user profile and cumulative usage relative to any caps or limits

that are in place. A traffic management intervention can either be to modify the traffic priority or to change the bandwidth allocated (e.g. a guaranteed minimum or to impose a maximum speed cap). Traffic management technologies enable the identification of different types of traffic. Two main types of traffic management can be found, implicit and explicit. Explicit traffic management is done through packet prioritization and bandwidth management, and implicit traffic management derives from the network design itself, which affects traffic differentially and can also be regarded as a form of traffic management. The dimensioning of networks, the partitioning of access pipes and the use of content distribution networks all affect QoS, and can do so in ways that discriminate between traffic types. Some of these issues can be resolved through market competition, but others may need regulation.

Traffic management can be viewed in different terms, such as:

- Implementation across different access network types (e.g. xDSL, cable, mobile).
- Where it is controlled and enacted within particular layers of the protocol layering model for ICTs (from the physical layer at the bottom, up to the application layer on the top).
- Where it is controlled and enacted in the physical, geographic network (e.g. core network, access network).
- The impact it has on different traffic types (e.g. voice, peer-to-peer traffic, web browsing, streaming video, etc.).
- The impact it has on different users, or types of users.
- The type of traffic management intervention that is used, and the decision basis for enacting the intervention.

4.3.2 Traffic management: Intervention

While implementation of traffic management is far from trivial, there are relatively few underlying techniques available. All traffic management involves a decision basis and an intervention. For example, exceeding a monthly usage allowance is a decision basis, and the response of cutting the data rate according to policy is an intervention. Three common decision inputs are:

1. The user identity (or profile), specifying a QoS package for that user.
2. Whether or not a usage cap has been exceeded (these caps are often set by the user tariff).
3. The particular traffic type (e.g. VoIP, IPTV, OTT, etc.).

Regarding traffic management interventions, there are two main types:

- Packet prioritization: Wherever queues occur in a network, higher priority traffic will get through whereas lower priority traffic may be delayed or suffer packet loss. This is typically applied today in the core network, but may in future migrate closer to the access network to increase the effectiveness of traffic management in maximizing network utilization while minimizing the effect on most users.
- Bandwidth allocation: The bandwidth (or data rate) offered to a user or a type of traffic can be actively controlled. Users can be offered a minimum guaranteed rate or can be limited or capped at a maximum rate. Bandwidth allocation does not cause packet loss unless it reduces data rate to below that required for a particular application.

Table 4.1 presents a matrix for traffic management approaches, and Table 4.2 provides the characteristics of different intervention types.

Table 4.1: Matrix for traffic management approaches

Decision Input / Intervention type	1. User identity	2. Usage cap	3. Traffic type
A. Packet prioritization	A1	A2	A3
B. Bandwidth allocation	B1	B2	B3

Source: Ofcom, United Kingdom, *Traffic management and quality of experience*, 2011

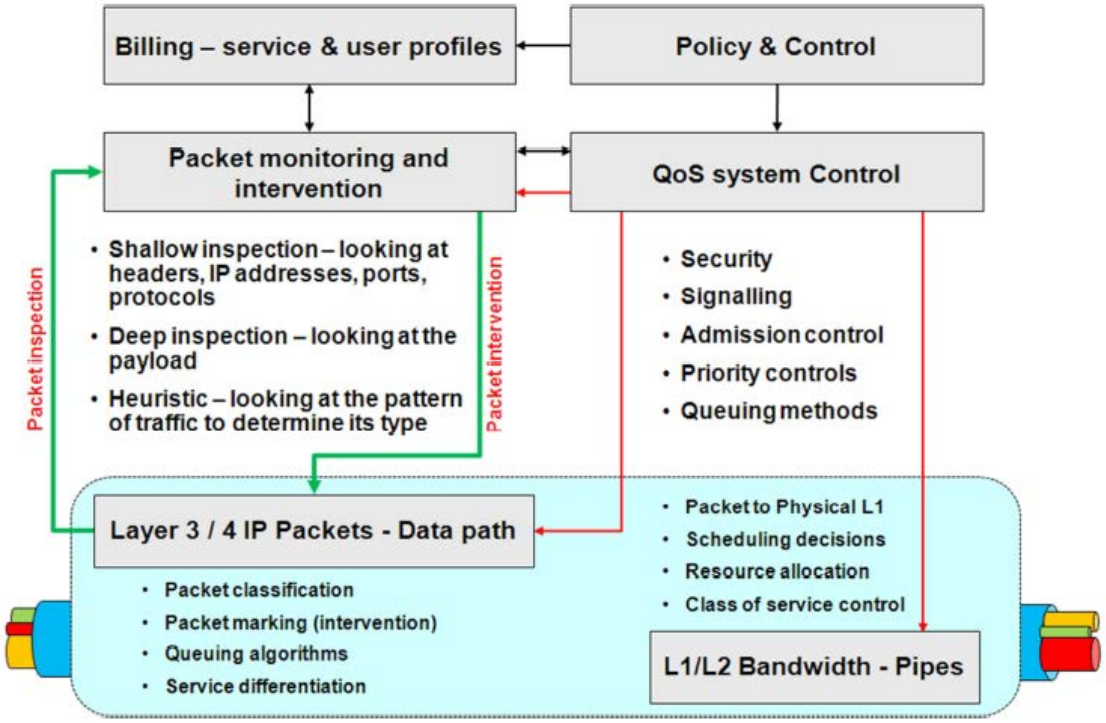
Table 4.2: Characteristics of intervention types

Inter-vention type	Characteristic					
	Possible actions	Applied in	ISO Model Level	Impact of negative intervention on data type		Comments
				TCP/IP FTP	UDP RTP	
A. Packet prioritization	Prioritize or De-prioritize	Core network	Layers 3 and 4	Retransmission of packets	Data loss	TCP/IP traffic can be effectively managed by de-prioritizing this traffic type
B. Bandwidth allocation	Guarantee or Cap	Access network	Layers 2 and 3	Reduced throughput (Service maintained, but at lower speed)	Reduced quality (Codec may drop to a lower rate)	Video is best managed by prioritizing or giving guaranteed bandwidth in the access network

Source: Ofcom, United Kingdom, Traffic management and quality of experience, 2011

The majority of IP interventions are dealt with by inspecting IP packet headers and marking them accordingly for transmission across the network. The inspection equipment will investigate the header information being transmitted across protocol layer 3 and, based on the criteria set in the policy and control unit, will implement IP header manipulation. Generic traffic management architecture is shown in Figure 4.7.

Figure 4.7: Generic traffic management architecture

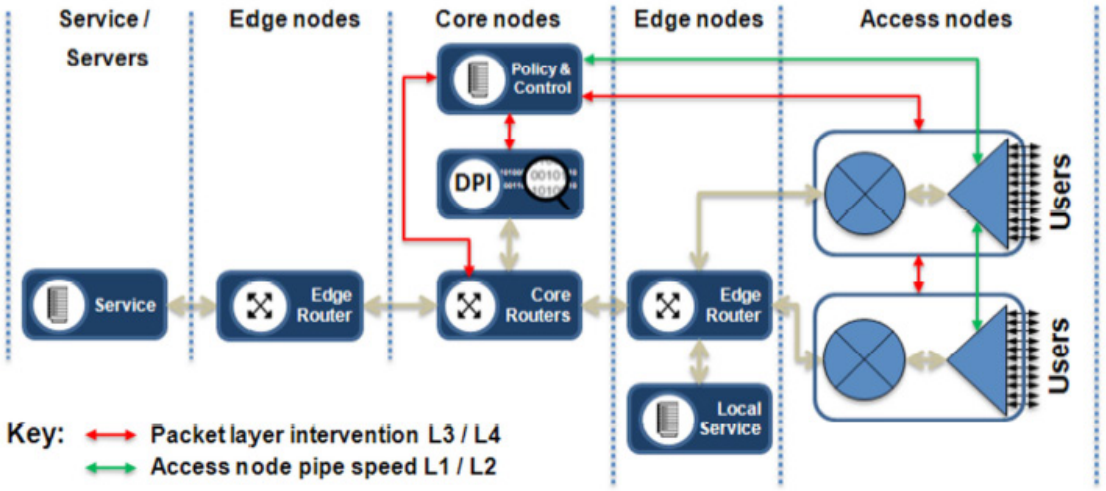


Source: Ofcom, United Kingdom, *Traffic management and quality of experience*, 2011

4.3.3 Network agnostic traffic management example

In telecommunication operator networks, deep packet inspection (DPI) boxes are deployed in the core network nodes to inspect the packets to determine traffic types. The DPI inspects all contents from all headers and information in the packet, which can be done by using the 5-tuple (pairs of source and destination IP addresses, source and destination port numbers, and used transport protocol). An example of how the DPI functions is presented in Figure 4.8.

Figure 4.8: Network agnostic traffic management example



Source: Ofcom, United Kingdom, *Traffic management and quality of experience*, 2011

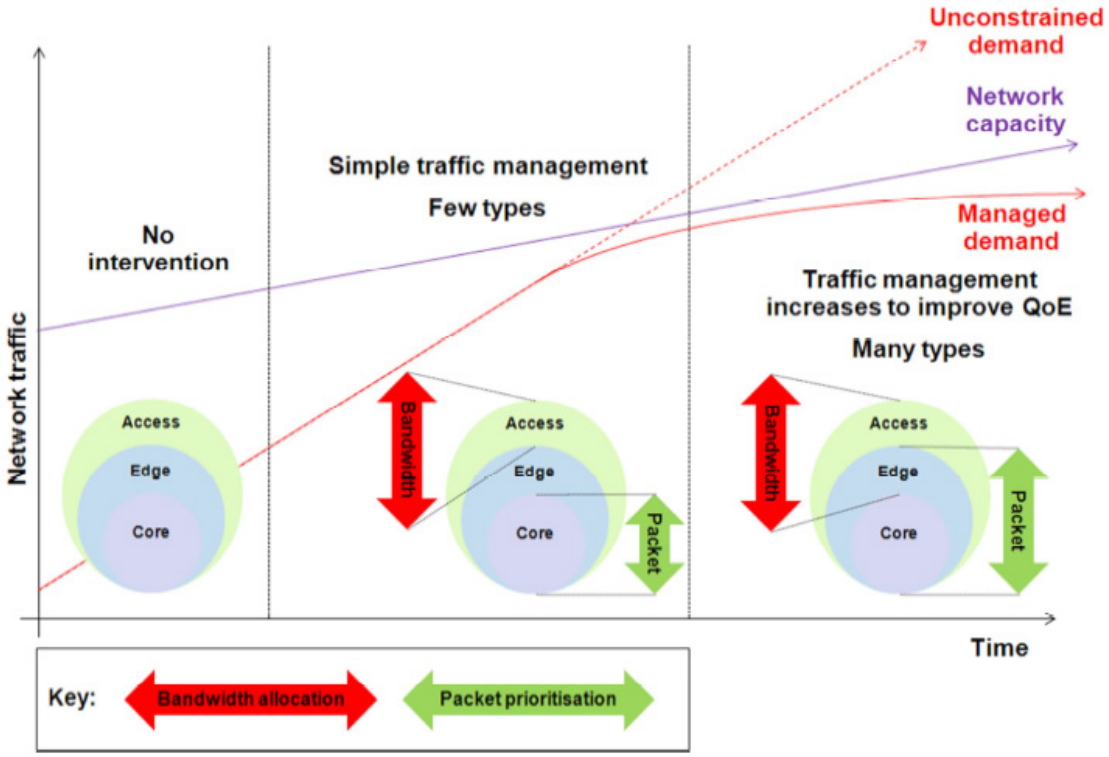
The information from DPI boxes is passed to the policy and control node. The policy and control units typically contain the traffic management policies and, based on the information received from the

DPI box, send control signals to the respective nodes on how to deal with the traffic. The red lines indicate the packet-based intervention where the core nodes re-label packets based on the priority decided by the traffic management policy, and the access nodes then treat them accordingly. The green line indicates control of the access node Layer 1 and Layer 2. For example, the DPI box could monitor a monthly usage cap and when the limit is reached could apply a reduction to the pipe speed by allocating less resource to the end-user in the access node.

4.3.4 Traffic management vs. network capacity

The extent and complexity of traffic management depends on how much congestion is being experienced, or how close network traffic is to the limit of the **network capacity**, as shown in Figure 4.9.

Figure 4.9: Traffic management as a function of network capacity



Source: Ofcom, United Kingdom, *Traffic management and quality of experience*, 2011

When traffic demand is much lower than the installed network capacity then no intervention is needed. When there is moderate space between demand and network capacity, simple traffic management is needed, including bandwidth allocation and packet prioritization. When traffic demand approaches network capacity, the probability for congestion significantly increases. In this case, traffic management is required to improve QoS.

In the future and from a technical point of view, traffic management will remain a response to congestion and a mechanism to maintain the highest level of QoS. The most important changes will be that packet inspection capabilities will migrate out of the core, enabling a more finely graded and user-specific form of traffic management. Table 4.3 illustrates the positive and negative effects of traffic management.

Table 4.3: Positive and negative effects of traffic management

	Positive effects on QoS	Negative effects on QoS
Traffic management applied to a user's own traffic	Can guarantee or prioritize data for sensitive applications	Can restrict or block certain applications
Traffic management applied to other people's traffic	Can reduce congestion to manageable levels, allowing fair use for all	Other people's traffic may take priority

Source: Ofcom, United Kingdom, *Traffic management and quality of experience*, 2011

5 Quality of service parameters and key performance indicators

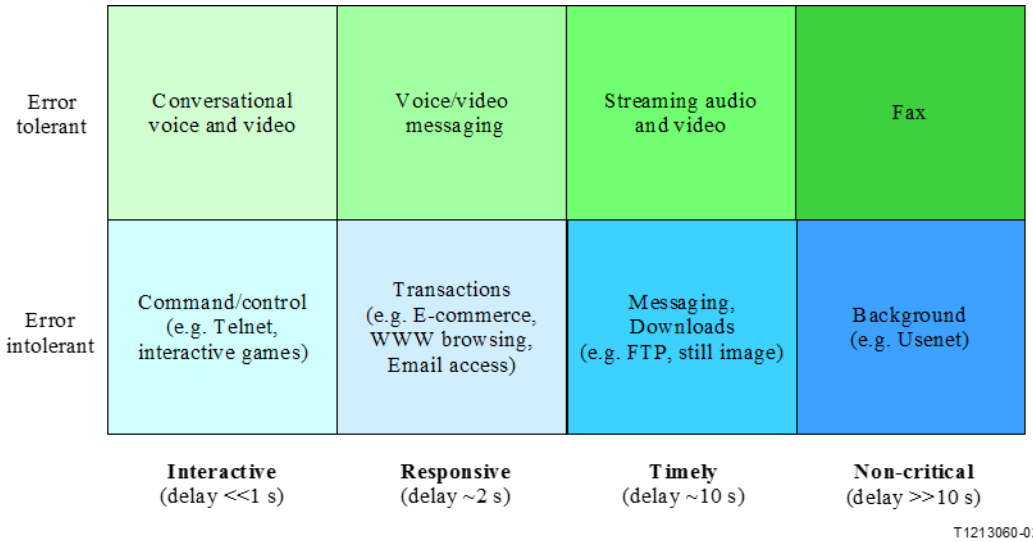
5.1 Quality of service, quality of experience, and application needs

The relationship between **QoS** (at the IP network level) and **QoE** is strongly dependent on the application, for example:

- E-mail is tolerant of high delay or loss as users do not expect instant delivery.
- The QoS of voice conversations (such as in IP telephony) mainly depends on packet delay, delay variation (jitter), and packet loss. In addition to these parameters, QoE of voice is also impacted by terminal capabilities, user-related aspects (e.g. mood, tariffs, etc.) and many more elements that can influence service delivery and the user.

A well-known criterion for ensuring proper experience is that one-way delay through the network should not exceed roughly 150 milliseconds. Longer delays may cause users on both sides of the connection to begin speaking at once (as with telephone conversations using geosynchronous satellites, where round trip delay is 270 milliseconds). For interactive gaming, delay, and delay variation can also be important.

Figure 5.1: Model for user-centric QoS categories



Controlling QoS does not make the transmission links any faster. Network designers and engineers can, however, control:

- the relative priority with which each router processes the IP packets/datagrams waiting to be sent over each transmission link; and
- which packets are to be dropped during periods where more packets are waiting than a given router is able to store or buffer.

Effects similar to prioritization can be achieved by caching (storing frequently used static data close to the user) and by replication (where the same dynamically generated results can be produced in more than location in the network – cloud services can represent an example of this kind of distribution or replication of function). The use of caching content delivery networks represents an increasingly common and important means of improving QoE. For example, locating Youtube video servers closer to the end-users reduces delay and jitter, and hence gives higher QoE. The same approach refers to all services that are based on principle user to content (i.e. Internet native client-server networking approach).

How prevalent is delay sensitive application traffic? It is clear that:

- Real-time bidirectional speech benefits from bounded **delay**. The traffic load associated with VoIP is negligible.
- Real-time bidirectional video (e.g. video conferencing) benefits from bounded delay.
- For streaming one-way speech or video, delay plays a minor role (as long as the user is prepared to accept a second or two of delay at the outset while the jitter buffer is filled). Streaming video is a huge and growing segment of Internet traffic.

5.2 Quality of service parameters

Quality of service parameters (alternatively called QoS metrics, QoS indicators, QoS measures or QoS determinants) characterize the quality level of the service being offered and the level of customer satisfaction. QoS parameters represent subjective and abstract user perception of quality in terms of numeric (quantified) values. QoS parameters can be obtained from objective and/or subjective measurement methods. QoS parameters may also be interrelated.

If QoS parameters characterize the quality level of a certain aspect of a service being offered, then this should lead to customer satisfaction. QoS parameters can be used by service providers to manage and improve how they offer their services, as well as by customers (end-users or partner providers) to ensure that they are getting the level of quality that they are paying for. They have now been used to support commercial contracts such as service level agreement formulation and verification.

QoS parameters can be obtained from objective or subjective measurement methods:

- Objective QoS parameters are obtained from measurement of physical attributes of circuits, networks and signals.
- Subjective QoS parameters are obtained by conducting well-designed customer opinion surveys.

QoS metrics can be primary parameters that are determined by direct measurement of call characteristics or events, such as circuit noise, echo path loss, or signalling release cause. QoS metrics can also be derived from a collection of primary parameters such as:

- statistical calculation (e.g. call completion rate for calls to a given destination for a day);
- rating factor to estimate customer opinion (e.g. E-model rating according to ITU-T Rec. G.107); and
- decision thresholds.

Specific QoS metrics can be defined to serve different applications and service types, such as:

- QoS metrics for different signal types, e.g. voice, fax, video;
- QoS metrics for one signal type (voice), but different service types, e.g. telephony conversational voice, voice-mail and streaming audio, which have different requirements for delay;
- QoS metrics for the same signal type and service type, but different classes of commercial offering, e.g. premium-price high-quality telephone voice service, as opposed to toll-free best effort telephone service with advertisements.

5.2.1 Comparable performance indicators

Comparable performance indicators refer to agreed QoS values that enable customers to be aware of the actual variety of service quality so that they can make informed decisions when choosing a service provider. Examples of comparable performance indicators are provided in Table 5.1.

Table 5.1: Comparable performance indicators

Telecommunication activities	Objective QoS Indicator	Subjective QoS indicator
Service provision	Supply time for initial network connection, percentage of orders completed on or before the date confirmed	Satisfaction with this parameter
Restoration/repair	Fault-clearing of reported faults on or before the date confirmed	Satisfaction with this parameter
Service reliability	Number of reported faults, number of customers touched by a cut connection	Satisfaction with service reliability
Billing	Number of billing complaints received per 1 000 units	Satisfaction with this parameter
Complaint handling	% Complaints, resolved within 20 working days	Satisfaction with this parameter

Source: Geza Gordos et al, Telecommunication Networks and Informatics Services

5.2.2 Survey of ITU standardized quality of service parameters

Quality of service parameters or metrics are essential for effective QoS management. They should be simple to use, provide accurate representation of customer perception, and be commonly accepted as standards. It is possible to distinguish between parameters for specific service types. For example, there are a number of standards that relate to conversation or voice quality (ITU-T Recs. G.107, G.108.2, G.109 and P.862/P.863).

- Subjective evaluation of voice calls is dealt with in ITU-T Recs. P.800, P.800.1, P.831 and P.832 that provide specifications on a 5-point mean opinion score (MOS) for voice quality assessment (1 = bad, 2 = poor, 3 = fair, 4 = good, 5 = excellent).
- ITU-T Rec. G.109 defines five categories of speech transmission quality that can be used as guidance in establishing different speech transmission quality levels in telecommunication networks.
- ITU-T Rec. P.561 In-service non-intrusive measurement device – voice service measurements, defines the scope of measurement and accuracy objective of voice grade parameters, such as

speech level, noise level, echo path loss and echo path delay, based on non-intrusive monitoring of live calls.

- Call clarity index (CCI) uses a two-way conversational opinion model and maps measured INMD parameters for a given call based on predictions of customer perceived mean opinion scores (1 to 5), as detailed in ITU-T Rec. P.562.
- The E-model provides a scalar rating of transmission quality, but this can be transformed to provide estimates of customer opinion (ITU-T Recs. G.107, G.108, P.833, and P.834). The E-model requires knowledge of the end-to-end configuration, i.e. networks and terminals, and is intended for network planning purposes.

Perceptual evaluation of speech quality (PESQ) is a one-way listening model. It estimates user-perceived MOS by comparing the transmitted reference speech signal and the received degraded signal. The model takes into account impairment effects due to voice compression and IP network parameters (e.g. jitter and packet loss), in addition to conventional circuit switched network impairments, such as noise and echo (ITU-T Rec. P.862). ITU-T Rec. P.863 (also known as perceptual objective listening quality assessment (POLQA)) incorporates current industry requirements and allows for assessment of super-wideband speech, as well as networks and codecs that introduce time warping. It includes different test factors and different existing coding technologies for voice such as G-series ITU voice codes, 3GPP codecs such as GSM and AMR, Skype codecs, etc.

In addition to voice, other standardized QoS parameters are referred to in this section.

- Fax transmission quality is covered in ITU-T Rec. E.437.
- Comparative metrics for alternate routes are part of ITU-T Rec. E.437, which recommends these metrics in comparing the performance of different routes from one origin to the same destination, as well as in assessing the effectiveness of services being offered on direct or alternative routings.
- Video transmission quality is mainly covered by the ITU-T recommendations currently being developed by ITU-T SG 12. The main ITU-T recommendations on video quality belong to the J-series (J.140-series, J.240-series, and J.340-series for measurement of QoS for multimedia video including television and HDTV); the P.900-series on audio-visual quality in multimedia services; and the P.1200-series covering models and tools for quality assessment of streamed media.
- The recent list of QoS parameters is provided in ITU-T Rec. E.803, which lists 88 different QoS parameters (see the 2011 version), while QoS parameters for popular mobile services are defined in ITU-T Rec. E.804.

Below are different types of QoS parameters defined in ITU-T Rec. E.803:

- **Preliminary information on ICT services** (Parameter 2) Pricing transparency: is characterized by clarity, conciseness and unambiguity in every tariff structure for all usage conditions for every service provided by the service provider. Measured as: opinion rating.
- **Contractual matters between ICT service providers and customers** (Parameter 5) Integrity of contract information: true and fair view of pertinent information on supply, maintenance and cessation of a telecommunication service provided by a service provider. Measured as: opinion rating.
- **Provision of services** (Parameter 9) Meeting promised provisioning date: successful completion of provisioning of service on the date promised in the contract in relation to the total number of signed contracts with promised service provisioning dates. Measured as: ratio or percentage.
- **Service alteration** (Parameter 17) Time for alteration of service: time elapsed from the instant alteration notification is received by the user to the instant the alteration is completed. Measured as: time.

- **Technical upgrade of ICT services** (Parameter 26) Time for technical upgrade of a service: time elapsed from the instant the technical upgrade period was announced to the user to the instant the technical upgrade was carried out. Measured as: time.
- **Documentation of services** (operational instructions) (Parameter 36) Documentation of delivery time: time taken from the instant a service is provided to the instant documentation for the commissioning and use of the service is delivered to the customer. This parameter measured as: time.
- **Technical support provided by service provider** (Parameter 42) Accessibility to technical support: ratio of the number of successful attempts to technical support to the total number of attempts to reach this support. Measured as: ratio or percentage.
- **Commercial support provided by service provide** (Parameter 49) Commercial solution delivery time: time elapsed from the instant the customer raised a problem with commercial support to the instant a solution was achieved. Measured as: time.
- **Complaint management** (Parameter 54) Accessibility of the complaint management: ratio of the number of successful attempts to the total number of attempts to reach complaint management (CM) in a specified period. Measured as: ratio or percentage.
- **Repair services** (Parameter 62) Successful repairs carried out within a specified period of time: ratio of the number of repairs successfully carried out to the total number of repair requests accepted by the service provider within a specified period. Measured as: ratio or percentage.
- **Charging and billing** (Parameter 68) Accessibility of tariff information: ratio of the number of successful attempts to the total number of attempts to reach this facility located as indicated in the contract or regulations (access details to this facility to be provided by the service provider). Measured as: ratio or percentage.
- **Network/Service management by customer** (Parameter 78) Outage duration: the total time a network/service management facility is not accessible to the customer during a specified reporting period. Measured as: time.
- **Cessation of service** (Parameter 85) Cessation acknowledgement time: time elapsed from the instant of sending the cessation request to the instant of receipt by the customer of the acknowledgment from the service provider. Measured as: time.

5.2.3 End-to-end network performance parameters for IP-based services

The characteristic of telecommunication/ICT services is the end-to-end QoS. With the transition of telecommunication networks and services from PSTN to IP network and IP-based services, the most important QoS metrics (for any service) for the provision of traditional telecommunication services (voice, TV and leased lines) along with traditional Internet services (web, e-mail, FTP, and all other OTT services) are the end-to-end QoS parameters in IP-based networks.

ITU-T Rec. Y.1540 defines network parameters that may be used in specifying and assessing IP network performance. The most important performance parameters are:

- IPTD (IP packet transfer delay): The time difference between the occurrences of two corresponding IP packet reference events (an IP packet reference event is a packet transmission via a given measurement point in the network). There are several types of IPTD, such as:
  - minimum IPTD (smallest IP packet delay among all IP packet transfer delays);
  - median IPTD (50^{th} percentile of the frequency distribution of IP packet transfer delays);
  - average IPTD (arithmetic average of IP packet transfer delays).
- IPDV (IP packet delay variation, or jitter): The difference between the one-way delay of IP packet and reference IP packet transfer delay (e.g. average IPTD as a reference delay).

- IPLR (IP packet loss ratio): The ratio of total number of lost IP packets to the total number of transmitted IP packets in a given measurement.
- IPER (IP packet error ratio): The ratio of the total number of errored IP packets to the total number of transmitted IP packets in a given measurement.

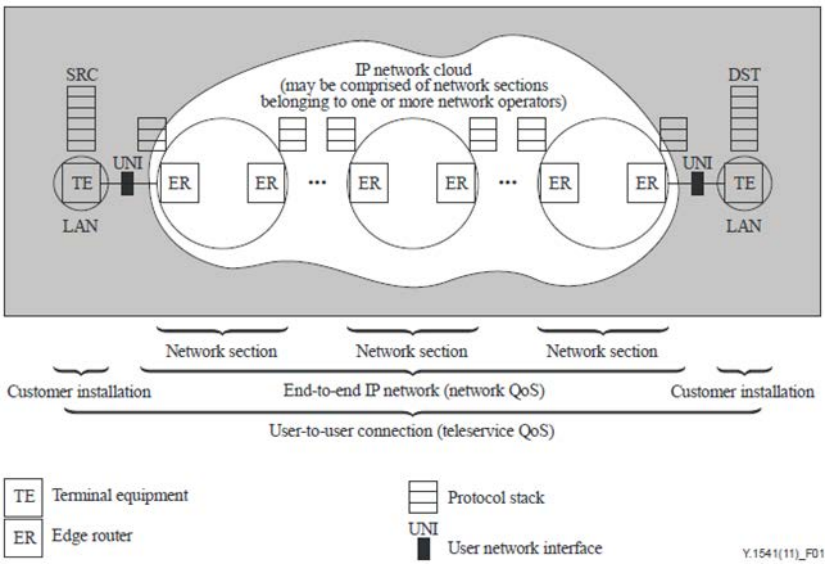
The values of the defined performance parameters vary, depending upon different so-called network QoS classes. The classes might not be used in certain network environments.

Transfer capacity (in bit/s) is the performance parameter that has the highest impact on the performance perceived by the end-user. Higher bit rates (i.e. broadband access and transport) are normally better for all services, including real-time and non-real-time. However, the theoretical capacity of a given system (e.g. xDSL, WiFi, GPON, LTE, etc.) is always larger than the bit rate perceived by end-user applications. In practice, the error ratio is not constant, congestion may occur, terminal equipment may have different processing and storage capacities, as well as a different operating system (where network and transport layer protocols are implemented at the end hosts).

ITU-T Rec. Y.1541 provides target values for different QoS classes, where these network performance parameters are useful for supporting SLA management at the wholesale level as well as at the end-user level.

The end-to-end network model is also referred to as UNI-to-UNI (user network interface). IP clouds may support user-to-user connections, user-to-host connections, and other endpoint variations. Network sections may be represented as clouds with edge routers on their borders, and a number of interior routers with various roles. The number of network sections in a given path may depend upon the class of service offered, along with the complexity and geographic span of each section. The scope of ITU-T Recommendation Y.1541 allows one or more network sections in a path. The network sections supporting the packets in a flow may change during its lifetime. IP connectivity spans international boundaries but does not follow circuit switched conventions (e.g. there may not be identifiable gateways at an international boundary if the same network section is used on both sides of the boundary).

Figure 5.2: UNI-to-UNI reference path for network QoS objectives



The UNI-UNI performance of a path can be estimated if the performance of sub-sections is known, covered in ITU-T Y.1541 (Figure 5.2). The main standardized QoS parameters for IP-based services include:

- Mean transfer delay (ITU-T Y.1541): For the mean IP packet transfer delay (IPTD) performance parameter, the UNI-UNI performance is the sum of the means contributed by network sections.
- Delay Variation (ITU-T Y.1541): The relationship for estimating the UNI-UNI delay variation (IPDV) performance from the network section values must recognize their sub-additive nature. It is difficult to estimate this accurately without considerable information about individual delay distributions. This detailed information will occasionally be shared among operators, and may not be available in the form of continuous distribution. Therefore, the UNI-UNI IPDV estimation may have accuracy limitations.
- Error packet ratio (ITU-T Y.1541): For the IP packet error ratio (IPER) performance parameter, the UNI-UNI performance may be estimated by inverting the probability of error-free packet transfer across *n* network sections loss ratio (ITU-T Y.1541): For the IP packet loss ratio (IPLR) performance parameter, the UNI-UNI performance may be estimated by inverting the probability of successful packet transfer across *n* NS, as follows:

$$IPER_{UNI\text{-}UNI} = 1 - \{ (1 - IPER_{NS1}) . (1 - IPER_{NS2}) . (1 - IPER_{NS3}) . \ldots . (1 - IPER_{NSn}) \}$$

- **Loss ratio (ITU-T Y.1541)**: For the IP packet loss ratio (**IPLR**) performance parameter, the UNI-UNI performance may be estimated by inverting the probability of successful packet transfer across *n* NS, as follows:

$$IPLR_{UNI\text{-}UNI} = 1 - \{ (1 - IPLR_{NS1}) . (1 - IPLR_{NS2}) . (1 - IPLR_{NS3}) . \ldots . (1 - IPLR_{NSn}) \}$$

The units of IPLR values are lost packets per total packets sent, with a resolution of at least 10^{-9}.

5.2.4 ITU quality of service classes

Network QoS classes are specified by ITU-T (Rec. Y.1541), based on the requirements of key applications – conversational telephony, reliable data applications based on TCP (e.g. WWW, e-mail, etc.), and digital television. They are shown in Table 5.2.

Table 5.2: ITU QoS classes

QoS Class	Upper bound on IPTD	Upper bound on IPDV	Upper bound on IPLR	Upper bound on IPER
Class-0	100 msec	50 msec	10^{-3}	10^{-4}
Class-1	400 msec	50 msec	10^{-3}	10^{-4}
Class-2	100 msec	Unspecified	10^{-3}	10^{-4}
Class-3	400 msec	Unspecified	10^{-3}	10^{-4}
Class-4	1 sec	Unspecified	10^{-3}	10^{-4}
Class-5	Unspecified	Unspecified	Unspecified	Unspecified
Class-6	100 msec	50 msec	10^{-5}	10^{-6}
Class-7	400 msec	50 msec	10^{-5}	10^{-6}

QoS classes specified in ITU-T Y.1541 define upper bounds on key performance parameters (besides the transfer capacity) for end-to-end IP services (end-to-end means from one UNI to another UNI, i.e. UNI-UNI performance is defined for each class). For example:

- Class-0 and Class-1 are targeted to real-time jitter-sensitive applications (e.g. VoIP, video conferences) where class-0 provides higher interactions due to a lower bound on the IPTD parameter.
- Class-2 and Class-3 are targeted to transaction data, from which class-2 is intended for signalling traffic, while class-3 is for interactive applications.
- Class-4 is targeted for short transactions, video streaming or bulk data.
- Class-5 is unspecified (regarding all performance parameters) and is targeted to traditional best effort Internet applications.
- Class-6 and Class-7 are provisional in the given table. However, such QoS classes are needed for new emerging applications with strict performance parameters. They also introduce in their definition a new parameter named IP packet reordering ratio (IPRR) that has the same upper bound as IPER for these two classes.

The specified upper bounds on IP-network performance parameters refer to end-to-end QoS provisioning – not an easy task to implement in the existing Internet.

5.3 Interconnection and quality of service regulations

Interconnection is an important part of QoS. Interconnection for voice traffic over PSTN and PLMN networks is based on traditional QoS voice parameters, such as limited end-to-end delays, bit rates guarantees for each direction of the voice connection, etc.

Interconnection is also important for best effort Internet traffic. This type of interconnection is harder to consider than traditional interconnection for voice traffic due to the fact that bit rates, end-to-end, are more variable and depend on different network segments over which best effort traffic travels end-to-end.

5.3.1 Quality of service norms for TDM interconnection between telecommunication networks

Although the ICT world is progressing toward all-IP networks, there are still many TDM (time division multiplexing) telecommunication networks that use circuit-switching for voice (i.e. telephony) and therefore SDH (synchronous digital hierarchy) in the transport networks with which they interconnect for such legacy (i.e. TDM) voice services.

To ensure effective TDM interconnection between networks, the network-related parameters to measure the quality of telecommunication services relate to (ITU-T E.847):

- network availability;
- connection establishment (accessibility);
- connection maintenance (retainability);
- optimal point of interconnection (POI) capacity provisioning and its effective utilization;
- POI congestion (number of POI not meeting the benchmark).

Interconnection in TDM networks can be considered relatively simple and well established since all legacy telephone networks usually use the same signalling system (i.e. SS7 signalling), media transport as in TDM, and numbering scheme (such as that of ITU-T Rec. E.164). Interfaces such as E1 and T1 links are also well used depending on the region or network equipment provider.

From a regulatory point of view, the purpose of interconnection is to ensure end-to-end network service connectivity and enable consumers of interconnected operators to establish connections with one another. Access also enables service providers to utilize facilities of other providers to further influence their own business plans for providing service to customers.

Table 5.3 shows some parameters and their thresholds that aim to help network operators set measurable and realistic KPIs to ensure effective compliance of regulations and help them in negotiating interconnection agreements to mitigate unforeseen disputes. An interconnection agreement should ensure fair, reasonable and non-discriminatory terms and conditions of interconnection between telecommunication service providers, and take into consideration technological, market, licensing, regulatory and legal developments in the telecommunication sector.

While interconnection is purely a matter of mutual agreement between interconnecting parties, any interconnect capacity creation, augmentation and/or disconnection of the interconnect capacity may have to be mutually agreed upon. However, it is desirable for administrations to have ex-ante regulatory guidelines for establishing a proper environment to facilitate effective and expeditious interconnection in the interest of consumers. For this purpose, they may prescribe broad guidelines based on fair, reasonable and non-discriminatory principles and leave the details of the interconnection agreement to be mutually decided by the interconnecting telecommunication operators (i.e. telecommunication service providers) in a time-bound manner. Alternatively, if they are unable to mutually agree upon terms and conditions of the interconnection agreement between themselves in a specified time-frame, a standard interconnection agreement – which must be entered into between interconnecting telecommunication service providers – may be prescribed.

Table 5.3: QoS norms for TDM interconnection between telecommunication networks

Key Performance Indicators (KPI)	Benchmark threshold and/or KPI information
Subscriber attempt success ratio for a POI	It should discourage intentional deterioration in QoS of a particular POI.
POI congestion	This refers to failed total number of call requests over a POI. The benchmark threshold for POI congestion may be set at <0.5%.
Subscriber attempts-seizure success ratio	This is the ratio between actual seizures at the POI and the total call attempts meant for that POI. It reflects the performance of a particular POI.
Inter-operator POI efficiency	Gives comparative performance of any particular inter-operator POI with respect to the other inter-operator POIs.
Time-frame for activation of a new POI	The prescribed time limit benchmark for providing POI connectivity is 90 days, counted from the date of confirmation or acceptance of demand for POI connectivity.
Time-frame for POI capacity enhancement	Where POIs between networks already exist, POI capacity enhancement may be possible within 60 days from the date of acceptance or confirmation of demand.
Interconnection route utilization parameter	The prescribed benchmark for the route utilization parameter is 70 per cent.
Mean time to repair for POI ports	POI port failure should not be greater than 72 hours.
Time to repair interconnection route	Interconnection route should not be more than one hour from the time the fault occurred.
Dual seizure ratio	This should not exceed 40 per cent of handling capacity in case of a failure condition (ITU-T Q.780).

Key Performance Indicators (KPI)	Benchmark threshold and/or KPI information
Signalling link utilization	This should not exceed 40 per cent of handling capacity in case of a failure condition (ITU-T Q.780); and sufficient number of signalling links provided between POIs to avoid any signalling congestion.
Unit of time measurement and recordings in CDRs (call data records)	The unit of time measurement should either be in seconds or milliseconds in CDRs in order to avoid any inter-operator billing disputes.
Clock synchronization and accuracy of switch time	Synchronization with reference to the clock of the interconnection provider or another operator is recommended.
Acceptance testing and monitoring	A uniform testing procedure (which should be reviewed from time to time) with a regular monitoring mechanism, by a governmental agency or accredited third-party is recommended.

Source: ITU-T Rec. E.847

The broad guidelines suggested above (describing, among other things, the technical and commercial conditions for interconnection) are a sort of model Reference Interconnect Offer (RIO), which may form the basis of all interconnection agreements.

In order to resolve problems relating to bilateral interconnection issues and to ensure effective interconnection, one option is to establish an interconnect exchange. The interconnect exchange could provide interconnection ports to all types of telecommunication service providers and, in turn, it could reduce the number of POIs. Under such a scenario, the existing peer-to-peer interconnection may continue as before; however, any increase in the number of ports would be carried out through the interconnect exchange. There is a need to establish a framework and explore options on operating such an interconnect exchange.

5.3.2 Internet interconnection and quality of service

The majority of Internet traffic exchange is carried-out under peering and transit agreements. Peering is an agreement in which two interconnecting ISPs carry each other's traffic. Peering does not include the obligation to carry traffic of third parties. Transit is an agreement where an ISP agrees to carry traffic on behalf of another ISP or end-user. Transit is usually a bilateral business and technical arrangement, where one provider (the transit provider) agrees to carry traffic to third parties on behalf of another provider or an end-user (the customer). In most cases, the transit provider carries traffic to and from its other customers, and to and from every destination on the Internet, as part of the transit arrangement.

Peering thus offers a provider access only to a single provider's customers. Transit, by contrast, usually provides access at a predictable price to the entire Internet. Historically, peering has often been done on a bill-and-keep basis, without cash payments.

There are credible claims that new forms of peering and transit are emerging that are making the Internet vastly more complex. Many of these claims emphasize the emergence of paid peering and partial transit. While it may be true that these forms are becoming more common than in the past, these claims should be interpreted with caution.

Paid peering is not technically different from settlement-free peering. Both paid peering and partial transit were already well established when the Internet was privatized in the 1990s – they are not new. There is little or no publicly available data on the prevalence of paid peering, partial transit, mutual transit, or other variants of peering and transit.

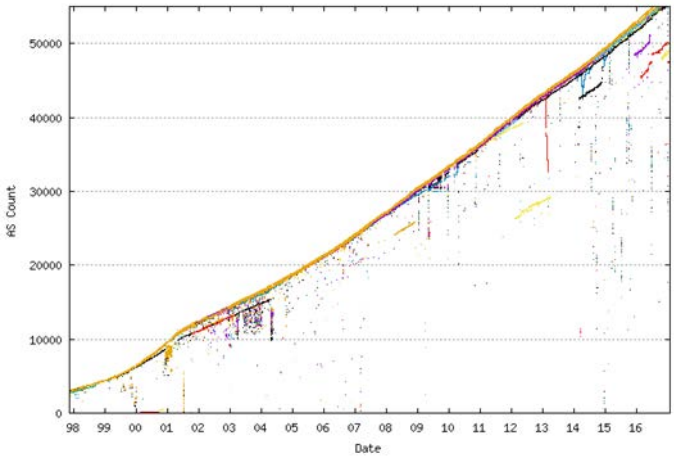
The Internet has become more widespread, intricate and interlinked over time, while dependence on the largest ISPs has decreased. The number of independent IP-based networks (autonomous systems)

continues to grow (Figure 5.3); the average path length, expressed as a number of autonomous system hops (not router hops), is stable (Figure 5.4). This implies that the autonomous systems are more richly connected than in the past.

In 2017, the entire Internet consisted of approximately 55 000 active autonomous systems with the average path length (end-to-end) span across three to five such systems. Each autonomous system on the path of the IP packets (i.e. the traffic) adds more delay and a higher probability of bottlenecks somewhere on the path between the two end points of a communication call/session. This shows that Internet has good scalability, despite its increase in size, the number of autonomous systems that the traffic passes end-to-end remains almost the same, which directly influences the end-to-end QoS is a positive manner.

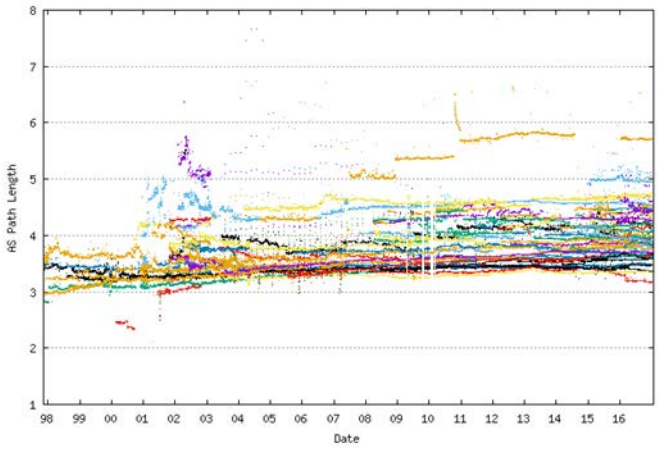
Large network operators typically exchange traffic with comparably large network operators through private peering arrangements that are direct connections between network operators. Generally, they are subject to contracts and to nondisclosure commitments. In terms of the amount of Internet traffic carried, these connections are highly significant, both individually and collectively.

Figure 5.3: Number of active autonomous systems in the world (1998-2016)



Source: http://bgp.potaroo.net/

Figure 5.4: Average autonomous system path lengths (1998-2016)



Source: http://bgp.potaroo.net/

Two significant interconnection trends are:

1. the growing importance of content delivery networks; and

2. the growing tendency of large content and application providers to operate their own global networks and their own content delivery systems.

Traffic forecasts in the Cisco VNI (2017) claim that 71 per cent of all Internet traffic will cross content delivery networks by 2021 globally, up from 52 per cent in 2016. Meanwhile large content and application providers such as Google and Apple operate some of the largest data networks in the world (although they typically lack local distribution), and negotiate peering arrangements in their role as network operators.

5.3.3 End-to-end quality of service in an IP environment

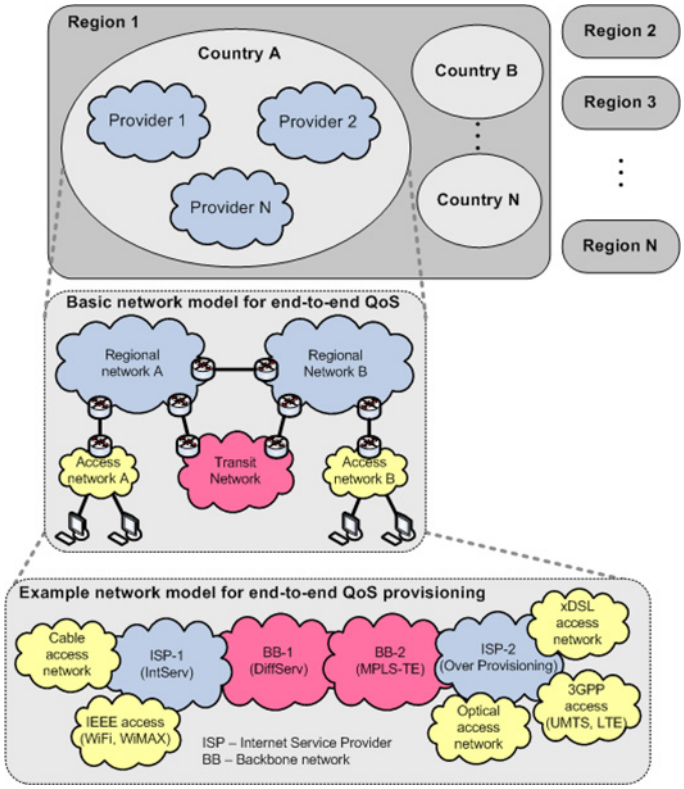
The whole concept of QoS is attractive to the end-user if the presentation at the user interface satisfies their needs and expectations. This means that an overall approach to QoS provisioning is necessary (i.e. end-to-end QoS provisioning).

As previously mentioned, in the end-to-end network model across the Internet (UNI-to-UNI), IP network sections may be represented as clouds with edge routers on their borders, and a certain number of interior routers with various functionalities. Such IP clouds may support user-to-user connections, user-to-host connections, and other variations of the endpoints. In general, there can be one or more network sections in a path. Also, network sections that support the packets in a flow may change during its lifetime. Additionally, IP connection may span national or regional boundaries. In all cases, UNI-UNI performance of a given path can be estimated knowing the performance of its sub-sections across different networks.

Generally, providing end-to-end QoS in IP-based platforms and networks is difficult due to their heterogeneity. In other words, using IP as a transport technology does not mean networks and platforms are the same or compatible. An extreme case of configuration among different IP networks is a scenario where each network has a different mechanism, level of performance control and QoS provision (e.g. ISP-1 uses IntServ, Backbone-1 uses DiffServ, Backbone-2 uses MPLS-TE, ISP-2 uses over provisioning, as shown in Figure 5.5). In this case, it is hard to provide services with guaranteed end-to-end QoS level because each network has a different QoS mechanism.

A basic network model (consisting of access, backbone and transit networks) should be applied commonly by providers, but the technologies that compose such a network model would be different depending on the providers and countries. In addition, differences exist between national regulatory frameworks and how they address SLAs, as well as QoS and QoE frameworks (Figure 5.5).

Figure 5.5: End-to-end QoS provision and basic network model

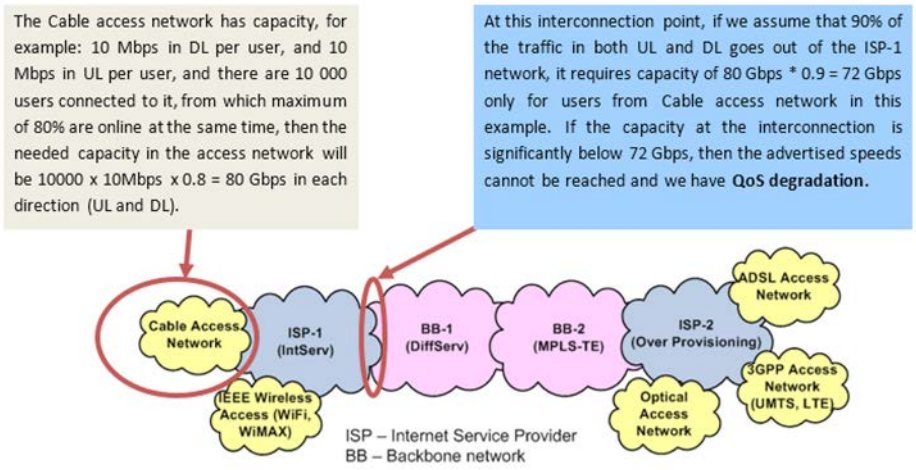


Source: ITU-T, *How to increase QoS/QoE of IP-based platform(s) to regionally agreed standards*, March 2013

Finally, end-to-end performance assessment and evaluation are essential in order to provide end-to-end QoS for fixed and mobile networks.

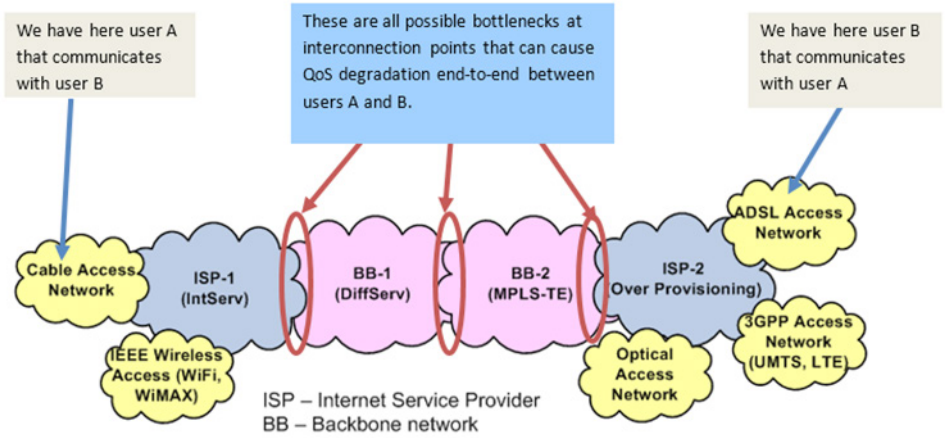
Issues of QoS and interconnection points are shown in Figures 5.6 and 5.7. As illustrated, interconnection points are possible bottlenecks for end-to-end traffic. The interconnection points of a given operator (i.e. ISP) should be able to transfer the demanded traffic in all access networks (of the given ISP) during peak time (e.g. the time of the day with the highest volume of traffic to/from end-users). In this regard, peering and transit agreements of a given operator (i.e. ISP) influence end-to-end QoS and may require regulatory attention to ensure end-to-end QoS performance of services.

Figure 5.6: Interconnection and QoS: required bit rates at the interconnection point dependent upon the aggregate access bit rates from/to end-users



Source: ITU-T, *How to increase QoS/QoE of IP-based platform(s) to regionally agreed standards*, March 2013

Figure 5.7: Interconnection and QoS: possible bottleneck at interconnection points in end-to-end view



Source: ITU-T, *How to increase QoS/QoE of IP-based platform(s) to regionally agreed standards*, March 2013

5.3.4 Interconnection, quality of service and end-to-end regulation

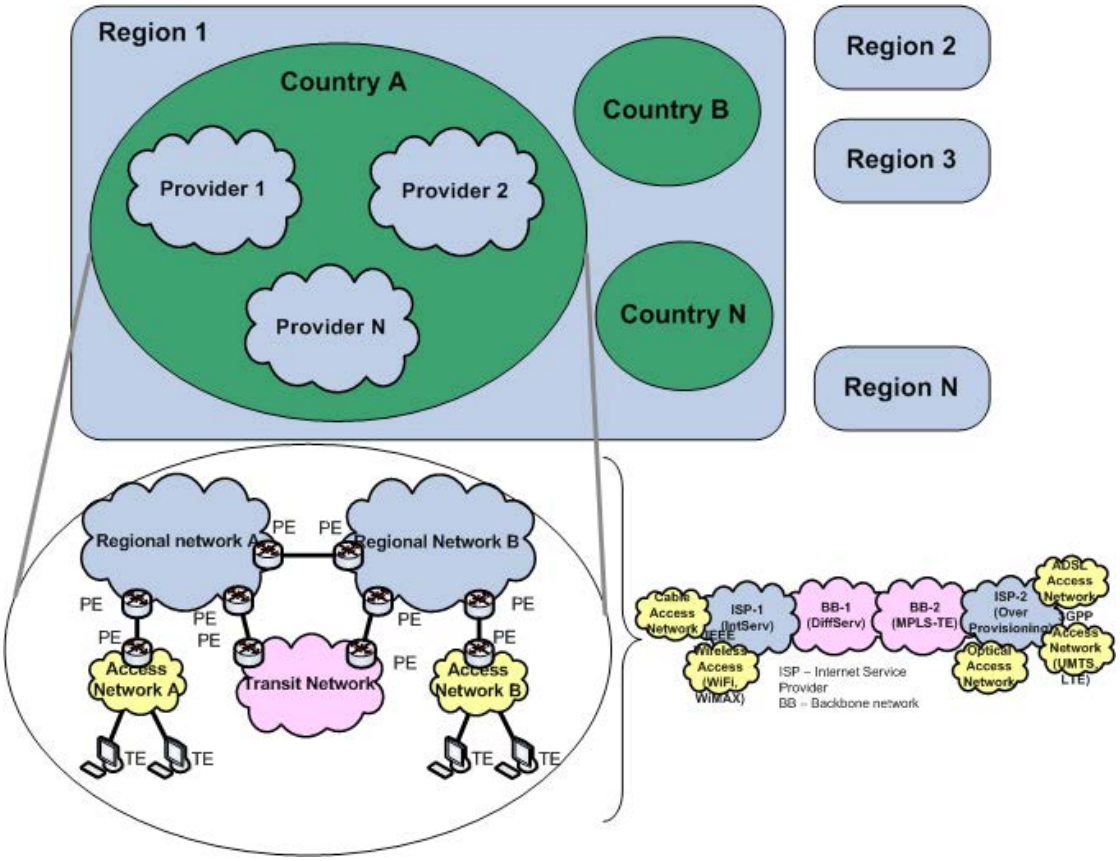
Interconnection is well regulated for carrier grade telephony. There are now IP exchanges (IPXs) in many countries. However, QoS regulation at the interconnection points is typically not present. The QoS parameters for the interconnection points can be regulated within a country by the NRA (e.g. interconnection bit rates) and monitored at IPXs. End-to-end QoS/QoE provisioning can be achieved only through regional and global harmonization, which must include QoS regulation between each pair of IPXs and the networks attached to them.

In the telecommunication world, PSTN and PLMN interconnection has been easier to implement because circuit switched voice uses 64 kbit/s in each direction (globally). Interconnection today is also related to peering and transit in IP networks:

- IP networks carry heterogeneous traffic, put more simply, this consists of QoS-enabled VoIP (including signalling) and IP traffic from/to Internet access service (IAS) as well as to/from content delivery networks.

- IP packets are transferred via interconnection points aggregated in VPN (virtual private network) tunnels established between the two peers (peers are the gateway nodes/routers on the border of each of the two networks that interconnect).
- There are different VPNs for QoS-enabled traffic such as operator provided VoIP (as PSTN/ISDN replacement), for signalling traffic (e.g. Session Initiation Protocol (SIP)), for network neutral traffic (traffic from IAS and content delivery networks).

Figure 5.8: End-to-end QoS regulation



Source: ITU-T, *How to increase QoS/QoE of IP-based platform(s) to regionally agreed standards*, March 2013

For end-to-end QoS, interconnection (Figure 5.8) should be regulated at the national and international levels, currently, this is not the case. In IP-based networks, the most appropriate place to enforce end-to-end QoS is at the interconnection points (e.g. IPXs). Of course, the need for QoS encouragement and enforcement at the broadband access level remains.

5.4 Key performance indicators

Key performance indicators are based on network counters and are essential for operation and maintenance, and for business models, and which can help in other actions such as reporting and auditing. QoS is experienced, required or expected by end-users. The QoS level planned by service providers may not always match the delivered level of QoS, and despite efforts from service providers to provide higher QoS levels, the level experienced by end-users may still be low, even much lower than expected. From the end-user point of view, QoS depends a combination of indicators ranging from network and terminal performance, to retail channels and customer care.

5.4.1 Key performance indicators, targets and measurement methods

KPIs can be formulated with *implied* targets, for example, the percentage of faults repaired in one day. This implies that one day is the target. This approach has been discussed in depth by standard developing organizations with the conclusion that it is better to formulate parameters without implied targets, but to set a target level separately, if appropriate. For example, a formulation without an implied target would be the time within which the fastest 80 per cent of faults are repaired. A target could then be two days. Generally, such parameters without implied targets are preferred.

How to set targets varies very much from one parameter to another. The performance level achievable may be affected by the type of access. It may be necessary to specify different target values for the same service over fixed access and over mobile access. The level of performance considered to be minimally acceptable may increase over time as technology develops and users demand more. Past practice has been to treat fixed and mobile services as distinct services. Hence fixed voice telephony was a separate service to mobile voice telephony, although only if viewed from the perspective of the calling party.

With the development of next generation networks (NGNs), however, there has been a change in the approach. Fixed and mobile are viewed as different forms of access to a common core network. This is the objective behind the IP multimedia subsystem (IMS) standardization, which is being followed by many traditionally mobile and some traditionally fixed service providers. It is also the approach taken by some countries in moving towards unified licensing, where services are provided over both fixed and mobile networks under the same licence.

In order to make formulation of QoS parameters as future proof as possible, the parameters have been grouped in accordance with their usage domains. This means that wherever possible the parameter definition applies to services over both forms of access (mobile or fixed). In terms of measurement and targets, however, there may be differences because of differences in access.

It is possible to measure mobile access using drive tests from stationary or moving vehicles. For fixed access, such tests would require either connection to the local loops at the roadside cabinet or access to the subscriber premises, which is less practicable. Consequently, for measurements over fixed access, techniques that can run from distribution frames or exchange sites have been developed to assess the performance that is being delivered to the subscriber. As a result, and in most cases, different measurement methods have had to be specified for the same service provided over fixed and mobile access, but they are, wherever possible, measurements of the same service parameter.

5.4.2 Key performance indicators for data services

Data includes all Internet-based services that are provided through Internet access, based on the network neutrality principle and by applying a best effort approach for packet delivery. Over-the-top (OTT) service may be treated equally with the term data. Both terms are used interchangeably in this manual.

What belongs to the OTT service space?

It covers all data services as everything that a telecommunication operator charges as data is in fact Internet traffic due to OTT services. OTT services include (but are not limited to):

- FTP (file transfer protocol) standardized by IETF (Internet Engineering Task Force www.ietf.org).
- E-mail, with standardized protocols by IETF.
- Web services, which use HTTP as the communication protocol, standardized by IETF, and above HTTP is typically HTML (HyperText Markup Language). Web services offered through open Internet access are considered as data (i.e. OTT) services. For example, all public websites on

the Internet (e.g. www.itu.int, etc.) are data services (either provided by a third party or hosted by the same operator which provides Internet access to the user).

However, HTTP can also be used in the provisioning of certain QoS enabled services (as enabler, e.g. for IPTV) by the telecommunication operator, and in such a case it is not considered as data (i.e. OTT) service:

- Proprietary (not standardized) services and applications, such as Skype, Viber, BitTorrent, etc.
- Web-based proprietary services, such as video sharing and streaming (e.g. Youtube, Netflix), social networking services (e.g. Facebook, Twitter), cloud computing services (e.g. Google docs), etc.
- Everything else that uses network neutral Internet access, either through fixed or mobile/wireless network.

All services provided via network neutral Internet access service (IAS) are referred to as data services.

What are the requirements of different data services offered through IAS?

As defined by the Body of European Regulators for Electronic Communications (BEREC): "*Internet access service means a publicly available electronic communications service that provides access to the Internet, and thereby connectivity to virtually all end points of the Internet, irrespective of the network technology and terminal equipment used.*"[3]

Data services are provided by using the network neutrality principle (see Chapter 8). Network neutrality refers to the way that Internet service providers manage the data or traffic carried on their networks when data is requested by IAS subscribers/end-users from various providers of content, applications or services available on the Internet (e.g. YouTube, various websites, Instagram, Facebook, Twitter, BitTorrent, Google Docs, various cloud services, video streaming and sharing sites, and so on), including traffic exchanged between end-users (e.g. VoIP using Skype, Viber, WhatsApp, etc., or file sharing with BitTorrent, etc.). The best effort Internet is about the equal treatment of data traffic being transmitted over the Internet, i.e. that the best efforts are made to carry data, no matter what it contains, which application transmits the data (application-agnosticism), where it comes from or where it goes. The benefits of best effort Internet notably include the separation of applications running over the Internet and underlying access and transport technologies (either via copper, fibre or wireless/mobile). This separation enables innovation of applications independent of the ISP, enhancing end-user choices.

In the context of network neutrality (net neutrality), the performance of individual data applications is also important as it can be used to detect potential degradation of individual applications. Table 5.4 illustrates popular applications by non-professional users and the relevance of quality parameters on the performance of those applications. In Table 5.4, the relevance goes from "–" (less relevant) to "+++" (very relevant). When evaluating quality aspects of IAS in the context of net neutrality, it is essential to evaluate potential degradation of individual applications based on such considerations.

Table 5.4: Popular types of OTT applications and quality parameters

Application	Data transmission speed		Delay	Delay variation	Packet loss
	Downstream	Upstream			
Browse (text)	++	-	++	-	+++
Browse (media)	+++	-	++	+	+++

[3] BEREC, *Guidelines on the Implementation by National Regulators of European Net Neutrality Rules*, http://berec.europa.eu/eng/document_register/subject_matter/berec/regulatory_best_practices/guidelines/6160-berec-guidelines-on-the-implementation-by-national-regulators-of-european-net-neutrality-rules

Application	Data transmission speed		Delay	Delay variation	Packet loss
	Downstream	Upstream			
Download file	+++	-	+	-	+++
Transactions	-	-	++	-	+++
Streaming media	+++	-	+	-	+
VoIP	+	+	+++	+++	+
Gaming	+	+	+++	++	+++

Source: ITU-T Rec. G.1011, and ITU-T Rec. E.800

What are the main parameters that define QoS for data services?

First is the bit rate of the IAS, which provides access to data services. Second is the availability of the given data service. Third (when service is available), the QoS for data is influenced by the delay experienced for the data services by the end-users. Based on this discussion, if the given data service is available, then the KPIs for each hop of an IP-based network will be:

- Bandwidth: The maximum number of bits that a transmission path can carry.
- Propagation delay: The time that a packet requires, as a function of the combined length of all transmission paths and the speed of light through the transmission path.
- Queuing delay: The time that a packet waits before being transmitted. Both the average delay and variability of delay (jitter) matter, since the two together establish a confidence interval for the time within which a packet can be expected to arrive at its destination.
- Packet loss: The probability that a packet never reaches its destination. This could be due to transmission errors, but errors are quite rare in modern fibre-based fixed networks. More often packets are lost because the number of packets waiting for transmission is greater than the available storage capacity (buffers).

These KPIs correspond closely to parameters defined by ETSI, and they are recommended by BEREC[4]:

- Upload / download speed
- Delay
- Jitter (variability of delay)
- Packet loss ratio
- Packet error ratio

However, individual data applications may have a specific set of KPIs that are dependent on the functional definition. For example, the web is the most used best effort service, which is standardized by the IETF. Standardized QoS parameters in ITU-T E.804 (popular mobile services) for web browsing are:

- HTTP service non-accessibility (%) is the probability that a subscriber cannot establish a PDP (packet data protocol) context and access the service successfully.
- HTTP set-up time(s) is the time period needed to access the service successfully, from starting the dial-up connection to the point of time when the content is sent or received.

[4] BEREC: *Monitoring quality of Internet access services in the context of net neutrality* http://berec.europa.eu/eng/document_register/subject_matter/berec/reports/4602-monitoring-quality-of-internet-access-services-in-the-context-of-net-neutrality-berec-report

- HTTP IP-service access failure ratio (%) is the probability that a subscriber would not be able to establish a TCP/IP connection to the server of a service successfully.
- HTTP IP-service set-up time(s) is the time period needed to establish a TCP/IP (transmission control protocol/Internet Protocol) connection to the server of a service, from sending the initial query to a server to the point of time when the content is sent or received.
- HTTP session failure ratio (%) is the proportion of uncompleted sessions and sessions that were started successfully.
- HTTP session time(s) is the time period needed to successfully complete a PS (packet switched) data session.
- HTTP mean data rate (kbit/s): After a data link has been successfully established, this parameter describes the average data transfer rate measured throughout the entire connect time to the service. The data transfer shall be successfully terminated. The prerequisite for this parameter is network and service access.
- HTTP data transfer cut-off ratio (%) is the proportion of incomplete data transfers and data transfers that were started successfully.

Example of QoS parameter definition (for HTTP) – HTTP mean data rate (kbit/s)

Abstract definition: After a data link has been successfully established, this parameter describes the average data transfer rate measured throughout the entire connect time to the service. The data transfer shall be successfully terminated. The prerequisite for this parameter is network and service access. Trigger points (for the HTTP mean data rate) are provided in Table 5.5.

Abstract equation:

$$\text{HTTP mean data rate}\left[\text{kbit/s}\right] = \frac{\text{user data transferred}\left[\text{kbit}\right]}{\left(t_{\text{data transfer complete}} - t_{\text{data transfer start}}\right)\left[\text{s}\right]}$$

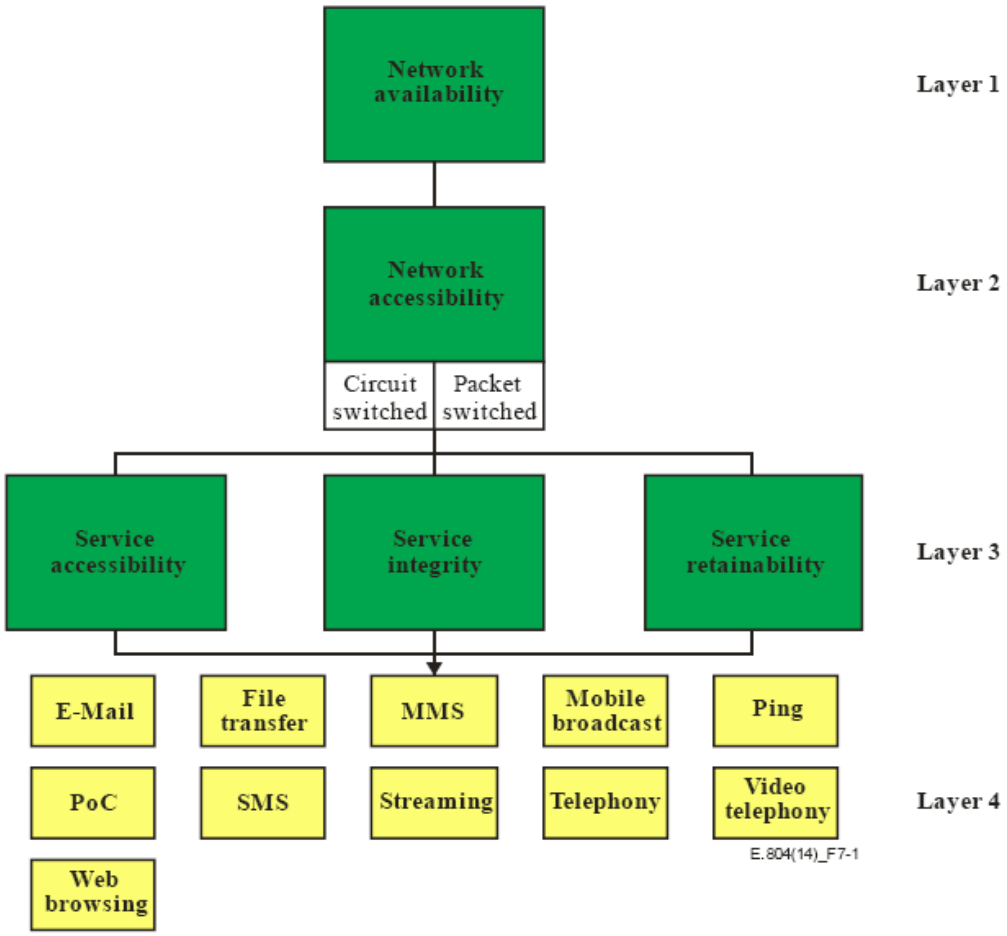
Table 5.5: Trigger points for HTTP mean data rate

Event from abstract equation	Trigger point from user point of view	Technical description/ protocol part
tdata transfer start: Time of successfully started data transfer.	Start: Web page download starts.	Start method A: Reception of the first data packet containing the content. Start method B: Sending of the first GET command.
tdata transfer complete: Time when data transfer is complete.	Stop: Web page download successfully completed.	Stop: Reception of the last data packet containing the content.

5.4.3 Key performance indicators for mobile services

Figure 5.9 shows a model for quality of service parameters in mobile networks. This model includes four layers. The first layer, network availability, defines QoS from the viewpoint of the service provider rather than the service user. The second layer, network access, is the basic requirement for all other QoS aspects and parameters from the service user point of view. The third layer contains the other three QoS aspects, service access, service integrity, and service retainability. The different services are located in the fourth layer. Their outcomes are the QoS parameters.

Figure 5.9: QoS aspects and the corresponding QoS parameters



QoS for mobile services is covered in ITU-T Rec. **E.804** and explained below.

Direct mobile services

QoS parameters are defined for the following direct services:

- FTP (file transfer protocol)
- Mobile broadcast
- Ping
- Push-to-talk over cellular (PoC)
- Streaming video
- Telephony
- Video telephony
- Web browsing (HTTP)
- Web radio
- WLAN (wireless local area network) service provisioning with HTTP-based authentication
- Wireless application protocol (WAP)
- IMS multimedia telephony

- E-mail
- Group call

Each of these direct mobile services is defined with a set of QoS parameters similar to the example for QoS parameters for HTTP mean data rate (provided above).

Store and forward mobile services

These QoS parameters can generally be divided into four groups of parameters:

1. Generic parameters
2. E-mail parameters
3. Multimedia Messaging Service (MMS) parameters
4. Short Message Service (SMS) and Short Data Service (SDS) parameters

Overall, store-and-forward services are typically messaging services that have less stringent demands on QoS parameters.

There are service independent QoS parameters that may be dependent upon mobile or wireless network technology, or may be relevant to all IP-based services (e.g. domain name system (DNS) parameters). Service independent QoS parameters (as defined in ITU-T Rec. E.804) are:

- radio network unavailability
- network non-accessibility
- attach failure ratio
- attach set-up time
- PDP context activation failure ratio
- PDP context activation time
- PDP context cut-off ratio
- data call access failure ratio
- data call access time
- DNS host name resolution failure ratio
- DNS host name resolution time

Regarding service independent QoS parameters that are dependent upon the mobile network, the PDP (Packet Data Protocol) context is used in UMTS/HSPA (Universal Mobile Telecommunications System/high speed packet access) mobile networks (i.e. 3G) and in GPRS/EDGE (General Packet Radio Service/Enhanced Data rates for Global Evolution – i.e. 2.5G), while in 4G mobile networks (e.g. LTE/LTE-Advanced) it is being replaced with EPS (evolved packet system) bearer. Both types of parameters are related to maintaining user call/session information in the mobile core and access network for all data services (provided through mobile Internet access).

For service independent QoS parameters, the DNS parameters refer to all IP-based services, including fixed networks. The DNS connects the two name spaces in the Internet, they are IP addresses (including IPv4 and IPv6) on one side and domain names on the other side. Without the functioning of the DNS, there would be in practice no access to data services over Internet access service, whether the connection is going through fixed or mobile access. DNS QoS parameters are therefore fundamental for all IP-based services, as are their KPIs.

Regarding mobile broadband QoS parameters, currently 3G and 4G mobile networks are typically considered as mobile broadband access. All testing principles and QoS parameters are provided in ITU-T Rec. E.804. A subset or all of them may be chosen as KPIs for mobile services.

From an end-user perspective, there is no difference between a mobile broadband connection with a smartphone and a fixed broadband connection from a laptop. Therefore the same indicators apply, which include (but are not limited to) the following:

- web browsing (HTTP QoS parameters);
- voice-over-IP (both signalling and voice data parameters are important);
- download speed (kbit/s, Mbit/s);
- upload speed (kbit/s, Mbit/s);
- UDP latency (important for real-time services, such as VoIP and IPTV, which typically use RTP/UDP/IP, where RTP is the real-time transport protocol);
- UDP packet loss (important for real-time services, such as VoIP and IPTV, which typically use RTP/UDP/IP);
- DNS resolution (important for all IP-based services, either real-time or non-real-time);
- video streaming (video is one of the most demanding services regarding the bit rates in downlink, where the demands increase with the resolution of the video content).

5.4.4 Key performance indicators for voice over LTE

Regarding voice over LTE (VoLTE), the relevant KPIs are specified in ITU-T Rec. G.1028 on end-to-end quality of service for voice over 4G mobile networks. VoLTE is a managed voice service that benefits from prioritization over the other traffic. OTT applications do not use session initiation protocol/IP multimedia subsystem (SIP/IMS) signalling and are delivered in best effort manner through the Internet access service (with no prioritization). This section examines VoIP over LTE/LTE-Advanced according to ITU-T Rec. G.1028. The quality classification identifiers (QCIs) in use for VoLTE are shown in Table 5.6.

Table 5.6: LTE Quality Classification Identifiers (QCIs) in use for voice over LTE

QCI	Resource type	Priority level	Packet delay budget	Packet error loss rate	Example services
1	GBR	2	100 ms	10^{-2}	Conversational voice
5	Non-GBR	1	100 ms	10^{-6}	IMS signalling

Source: ITU-T Rec. G.1028.

Figure 5.10: Typical degradations of VoLTE communications

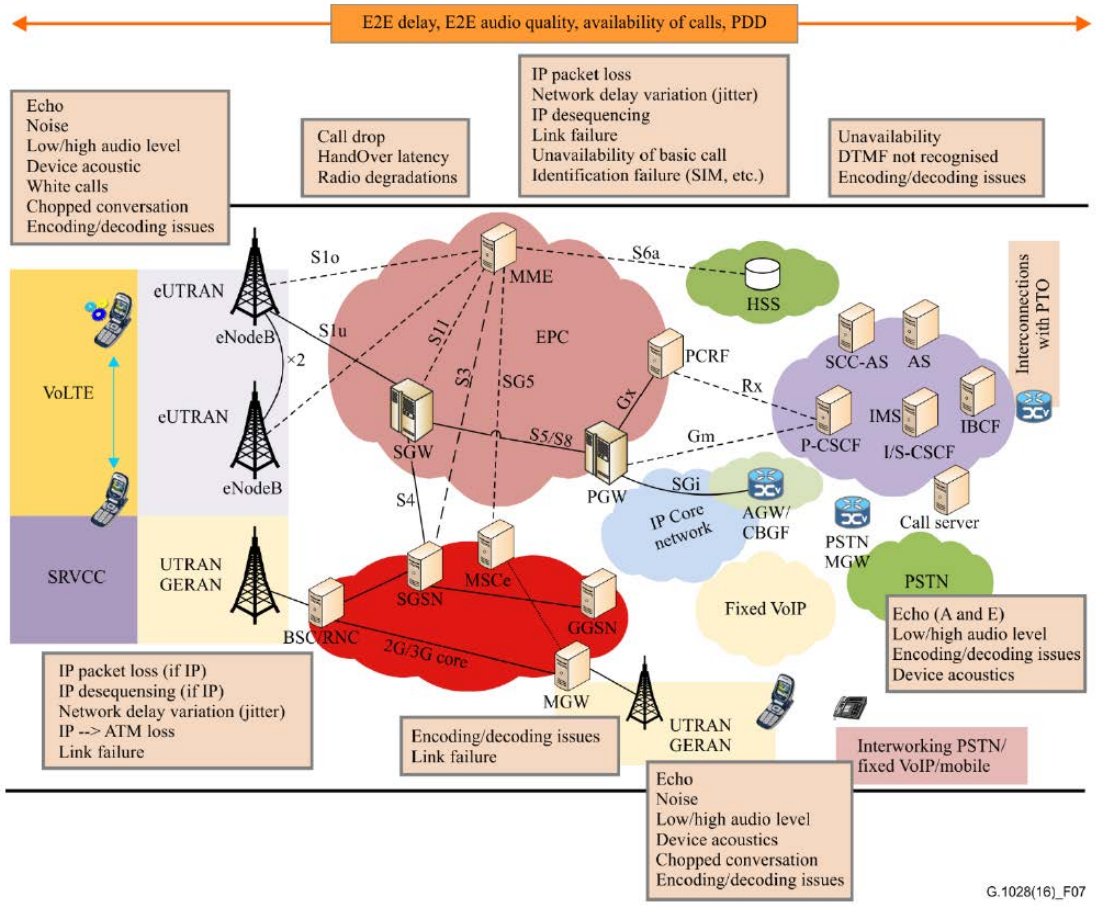


Figure 5.10 shows the QoS degradations that can typically be encountered on a VoLTE call. QoS is understood here as defined in ITU-T Rec. E.800. The main elements of the network are depicted to show the signalling and media elements, as well as connections with PSTN or mobile platforms.

Table 5.7: End-to-end quality indicators and corresponding network KPIs

End-to-end indicators	Definition	IP network KPIs
Registration success rate	Rate of successful registration attempts in the VoLTE service. Equivalent to IMS registration success ratio as defined in (ETSI TR 103 219).	Registration success rate. KPI related to IMS and based on P-CSCF counters. Equivalent to 1 – ineffective registration attempt (IRA) ratio, as defined in (IETF RFC 6076).
Service availability	End-to-end service availability in terms of capacity to establish calls from, and to, a VoLTE customer. Equivalent to 1 – VoLTE session set-up failure ratio as defined in (ETSI TR 103 219). Equivalent to 1 – telephony service non-accessibility as defined in (ITU-T E.804) (clause 7.3.6.1).	Network efficiency ratio. Measures the ability of network, from the service platform point of view, to deliver calls to the VoLTE customer. Based on SIP protocol, network error rate (NER) is equivalent to session establishment effectiveness ratio (SEER), as defined in (IETF RFC 6076).

End-to-end indicators	Definition	IP network KPIs
Post dialling delay	Time interval (in seconds) between the end of dialling by the caller and the reception back by user of the appropriate ring tone or recorded announcement. Equivalent to call set-up time, as defined in (ITU-T E.800). Equivalent to telephony set-up time as defined in (ITU-T E.804) (clause 7.3.I.1).	SIP session set-up time. Interval between sending INVITE message (with SDP) and ACK (180 or 200) message by the originating side. Equivalent to successful session request delay (SRD), as defined in (IETF RFC 6076).
Voice quality (MOS-LQ)	Equivalent to speech quality as defined in (ITU-T P.10). Models like those defined in (ITU-T P.862) and (ITU-T P.863) provide an objective view on the quality of the voice signal as it may be perceived by the customer. Can be seen on a call basis or on a sample basis (see (ITU-T E.804) clauses 7.3.I.2 and 7.3.6.4).	Network quality index ((ITU-T G.107), (ITU-T P.564).) IP packet loss ratio (see definition of Internet packet loss ratio (IPLR) in (ITU-T Y.1540)): several possible measurement points.
Mouth-to-ear delay	The time it takes for the speech signal to go from the mouth of the speaker to the ear of the listener.	IP packet transfer delay (see definition of Internet packet transfer delay (IPTD) in (ITU-T Y.1540)). Round trip time Corresponds approximately to twice the end-to-end delay. Can be measured based on RTCP protocol messages.
Call drop rate	Service continuity in terms of capacity to maintain calls to their normal end. Equivalent to telephony cut-off call ratio as defined in (ITU-T E.804) (clause 7.3.6.5).	Session completion rate KPI related to IMS and based on P-CSCF counters. Equivalent to session completion ratio (SCR), as defined in (IETF RFC 6076).
Speech bandwidth (NB, WB or SWB)	Measurement of the bandwidth used (normal NB or WB, or even partial and unwanted bandwidth limitation).	Codec statistics. Information related to the selection of (AMR and AMR WB) codec and codec modes, as well as switch between them, accessible on SIP protocol messages.

Source: ITU-T G.1028.

From a customer point of view, these degradations are divided into categories based on QoS required and perceived, as defined in ITU-T Rec. G.1000.

Call session performance:

- problems of registration to the service (IMS/SIP);
- call set-up issues (bad accessibility);
- failed continuity (or retainability), including impact of mobility (radio handovers and SRVCC (single radio voice call continuity) events).

Perceived speech quality during the call (integrity):

- Frequency content: This refers to the speech spectrum of signals presented to end-users (NB, WB, or SWB) and its potential distortions.
- Interruptions: Concerns all events resulting in clipping of the speech signal during the conversation:
  - end-to-end delay (impact on conversation interactivity);
  - presence of unwanted noises, from whatever origin.

End-to-end quality indicators and corresponding network KPIs are provided in Table 5.7. All target values for managed VoIP (that is, with QoS guarantees, as replacement of circuit switched telephony in mobile networks) for different scenarios, such LTE-LTE, LTE-3G, and LTE-PSTN, are specified in ITU-T G.1028.

5.4.5 Non-technical key performance indicators

In addition to technical QoS parameters, non-technical QoS parameters are also defined (see ITU-T E.803). Those QoS parameters that are considered as the most important can at certain times become KPIs.

Figure 5.11: Non-technical key performance indicators



Source: ITU

Currently the most commonly used non-technical KPIs include (but are not limited to) the following (Figure 5.11):

- Customer satisfaction
- Service quality
- Service availability
- Provision of service
- Service activation / de-activation / restoration time
- If target value is not reached, further analysis might be necessary
- Network availability
- MDT (mean down time)
- MTTF (mean time to failure)

- MTBF (mean time between failures)
- Billing information
- Clarity of tariff plans
- Ease of switching between plans
- Ease of getting billing information
- Ease of bill payments
- Ease of getting refunds
- Billing accuracy

5.5 QoS measurement

To measure QoS as an end-to-end characteristic of services, the following types of measurements can be used: PE-PE measurements (PE – provider edge router) and CE-CE measurements (CE – customer edge router), even when the PEs or CEs are contained in, or attached to, the networks of different providers. Measurement of QoS along the path between end-to-end customers should be an essential part of monitoring and troubleshooting SLAs. ITU-T introduces objectives, considerations, methodology and protocols for QoS measurement in the case of inter-provider through ITU-T Rec. Y.1543, and Supplement 8 to ITU-T E.800 series of recommendations.

End-user aspects of QoS including QoE should be a set of QoS and performance measurements. The measurements will be taken from each of the segments of the measurement network model and may be combined to form multi-segment, site-to-site, edge-to-edge or terminal-to-terminal metrics. Enhancement of QoS contributes to increasing the level of confidence in the expected service characteristics of the networks. This will enable new applications, services and revenue streams.

The objective of QoS measurements is to provide information to customers, potential customers and service providers, including:

- For **customers** and potential customers:
  - reports to customers of what service has been delivered;
  - reports to potential customers to support marketing claims on service characteristics.
- For **service providers** and third-party delivery assurance entities:
  - reports to design service offerings;
  - reports for troubleshooting;
  - data for marketing collateral;
  - reports to enable capacity planning and service development.

5.5.1 Quality of service measurement system

The QoS measurement system and the statistics obtained from the measurement should:

- be well defined (non-ambiguous) and easily understood by service providers and customers; be relevant to customer applications;
- enable service providers to diagnose issues and anticipate capacity requirements;
- be independently repeatable, that is, multiple service provider measurements over the same time get the same result;

- be independently verifiable by customers, i.e. customer measurements should be close to service provider estimates;
- be widely applicable regarding traffic type, link size, load independent, any IP network;
- be appropriately sensitive to distance and path;
- not significantly impact the forwarding of other data;
- be sufficiently scalable to support enough (e.g. millions) customer sites;
- be sufficiently reliable and accurate to enable SLAs with financial penalties to be administered.

5.5.2 Quality of service measurement methodologies

Two types of methodologies exist for measuring QoS:

- Passive measurement (using test packets): Test packets are sent from management systems, and performance metrics such as delay, jitter, and packet loss are measured along the way. This method is also often used for troubleshooting.
- Active measurement: Probes in the form of software agents or network appliances are deployed on network elements and user devices (for the software agent case). Measurements based on these probes provide a very accurate status of the devices at any time. The sources and sinks of probes may be either dedicated measurement devices, routers that are dedicated to measurement tasks or routers that support both data traffic and measurement probes. The main drawback of this measurement is that it doesn't scale for large networks.

To enable measurement of QoS parameters across multiple provider networks, one of the following methods can be used:

- Each provider agrees to use a common measurement protocol and to make probe points available to other providers, enabling measurements to be made along the end-to-end path.
- Each network provider uses its own methods and probe devices to collect measurements on a per-provider basis, with these measurements being combined to estimate the concatenated end-to-end performance.

In some cases, for example in the Africa region where the level of competition in the communications market is not high enough to influence a significant change in the QoS achieved/delivered, regulatory authorities may find themselves having to enforce specified levels of QoS parameters (see ITU-T E.802 Amendment 1: New Annex A on guidelines on selection of representative samples). To be able to do this, the specified QoS parameters need to be monitored within a legal framework where QoS measurements can be used to hold a service provider accountable for performance.

This may lead to the specification of QoS parameters and the desired targets being tied to penalties, where a service provider may be sanctioned accordingly for failure to comply with such specifications. There is then a need to carry out these measurements in such a way that they reflect a service provider performance. Truly representative QoS measurements are not only critical for regulatory purposes. It is also important for all users of these measurements – be they consumers of telecommunication services or service providers themselves – to have confidence in the accuracy of measurements. Annex A of ITU E.802 recommends that, where samples instead of real traffic are used, QoS measurements should provide a precision of ±10 at a maximum, with a confidence level of 95 per cent. For example, if 96 sample measurements are carried out, there is a 95 per cent confidence level that the true value of the QoS parameter lies within a range of ±10.

5.5.3 Basic network model for measurements

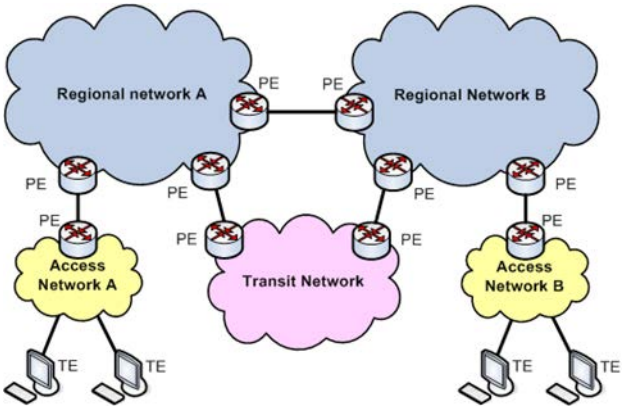
Ideally, measurements would be made between the same endpoints for each customer's traffic. These endpoints are the customer terminal (TE – terminal equipment), customer edge router (CE – customer equipment) or provider edge router (PE – provider equipment).

Providers offer assured delivery services between different endpoints as per the following cases:

- Edge-edge: extend to the edge of a provider's network;
- Site-site: extend to the edge of a customer's premises (also called end-to-end);
- TE-TE for a managed customer network service: extending to a customer's terminal.

To position the measurements points, the network model is partitioned into segments (Figure 5.12), each being monitored independently which is according to the three cases listed above (i.e., edge-edge, site-site, and TE-TE).Typically, there may be a backbone service provider providing transit services between the regional service providers. A specific service provider may act as either, or both, an access provider for some traffic and as a transit provider for some traffic.

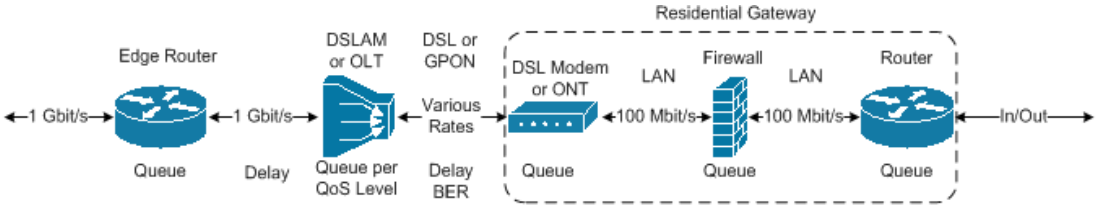
Figure 5.12: The basic network model for QoS measurements



Source: based on ITU-T Y.2173.

Access networks can be fixed or mobile access networks. Examples of fixed access network model with xDSL (digital subscriber line), such as ADSL (asymmetric DSL) and VDSL (very high bit-rate DSL), and FTTH (fibre-to-the-home) technologies are provided in Figure 5.13. In the downstream direction, from the core to the customer premises, a series of network elements and wires are connected: edge router, DSLAM – digital subscriber line access multiplexer (or OLT – optical line terminal for GPON – gigabit-capable passive optical networks), DSL modem (or ONT – optical network terminal for GPON), firewall, and router. This model is bidirectional, so upstream traffic traverses the same elements in reverse order.

Figure 5.13: Access network model



Source: ITU-T, *How to increase QoS/QoE of IP-based platform(s) to regionally agreed standards*, March 2013

5.5.4 Quality assessment methodologies

There are two methodologies for quality assessment:

1. Subjective assessment: With this method, the quality of audio and visual media is evaluated in subjective terms. However, subjective quality assessment, in which human subjects evaluate the quality of various testing conditions, is time-consuming and expensive. In addition, special assessment facilities – such as professional audio-visual devices and soundproof chambers – are required. Thus objective quality assessment is defined as a means for estimating subjective quality solely from objective quality measurement or indices. Mean opinion score is used as a measure of a subjective opinion.
2. Objective assessment: The assessment of QoE must be performed using subjective tests with metrics such as MOS. However, it is also possible and sometimes more convenient to estimate QoE based on objective testing and associated quality estimation models. Objective measurement and automatic calculation using appropriate quality estimation models are generally much faster and cheaper (ITU-T G.1011).

There are three modes of objective testing to evaluate QoE:

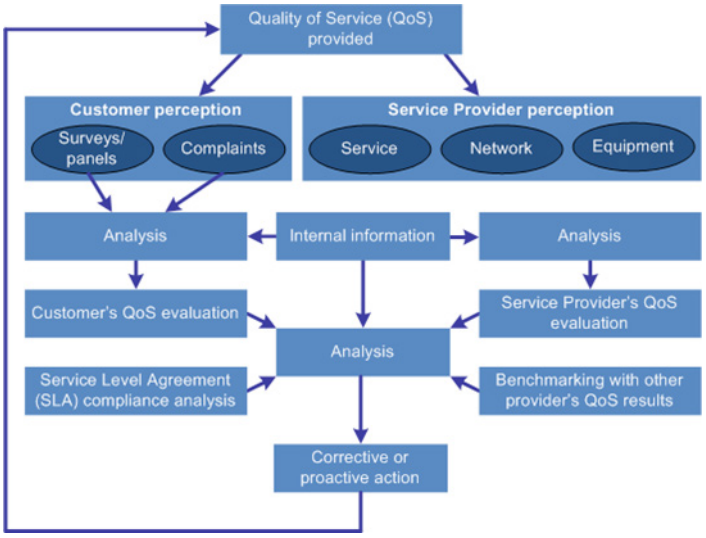
1. Intrusive mode: In this case the quality assessment system requires that a signal be injected into the system under test in order to generate a degraded output signal.
2. Non-intrusive mode: In this case the quality assessment system can be used whilst live traffic is carried by the channel, without the need for any active test signals. This measurement is performed on real customer (live) traffic.
3. Planning mode: It is not used in a real-time environment, but as a tool for the design of systems, and hence does not require any real-time inputs. This type of measurement is performed on artificially generated traffic (established test calls), such as phone calls, fax transactions, videoconference sessions, ISDN calls, website connections, etc., and by measuring relevant end-to-end parameters such as accessibility, transmission reliability, call clarity, etc. To obtain a global view of the service, a large number of connections are needed at different time periods and between several end-to-end points. Exhaustive measurements can only be obtained by using the same measurement unit at each point, since in general these two units need to know the measurement protocol used in the session (e.g. PESQ (perceptual evaluation of speech quality) measurements). Intrusive methods can typically achieve very high correlation with subjective tests. The drawback, however, is the usage of network resources for the assessment.

Criteria like call set-up time, call failures, or interruptions can quite easily be measured via adequate probes in appropriate locations. Measurements can be made either on real traffic or on artificially generated traffic. This can be done either on public traffic or private networks. Intrusive and non-intrusive methods are useful and can be combined.

Another approach in order to assess the quality of a service from a user perspective is through the QoS parameters. These parameters consist of definitions and measurement methods for specific user-perceivable aspects of QoS. However, there are also specific parameters that are strictly related to specific networks and transmission technologies. The main purpose of these parameters is to inform the user on the QoS of the market and to publish QoS statistics. The parameters are therefore defined in a way that is understandable to the average, inexperienced user.

The same service provided by a telecommunication operator can be measured by the service provider and perceived by the customer (two views), as shown in Figure 5.14.

Figure 5.14: QoS perceptions (customer perception and service provider perception)



Source: Author

5.5.5 Quality of service measurement considerations

In addition to definitions and standards regarding QoS parameters and their assessments via measurements, measurements to be defined should be:

- Practical for operators**:** The measurements defined for QoS monitoring by the NRA need to be feasible for implementation by operators at reasonable cost in a reasonable time-frame using consistent measurement and audit procedures. If possible the measurements should be the same as or similar to ones that operators already make for their own purposes.
- Important to customers**:** Measurements must be carried out for the most popular services used by customers. These measurements should be reviewed to see whether they need to be changed as the market evolves and different aspects of services become more important.
- Comparison between operators**:** The details of measurement methods may need to be discussed between operators before they can be settled. The measurement methods should be precise enough that differences in interpretation and implementation should not lead to differences in measurements.

Figure 5.15: Internet (resources) access speed tests

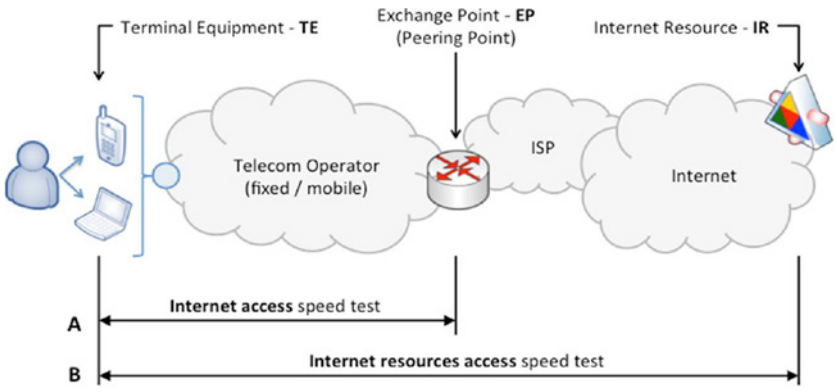


Figure 5.15 presents typical scenario for measurements of the bit rates (i.e. speeds) via Internet access. The OECD categorizes the types of clients that initiate each performance test on the end-user side and examines their characteristics as follow[5]:

- end-user application measurement (EAM);
- end-user device measurement (EDM);
- project self-measurement (PSM); and
- PSM by Internet service provider (PSM-ISP).

Selected examples from the OECD report on Internet access speeds are described in Table 5.8 to illustrate the types of metrics measured and their purposes in different parts of the world. The categories of metrics are the following: DATA, also referred to as Internet speed, is the amount of data transferred within a certain time between a client and a server; DNSR is DNS response time; WEB is length of time to load an webpage from a certain major website to a client; LT is latency; JT is jitter; PL is packet loss.

Table 5.8: List of examples for official measured metrics and their purposes

Country	Client type	Purposes	Measured metrics
Austria	EAM	Consumer protection, competition enhancement, network development (information on network quality), net neutrality (planned)	DATA, LT, JT, PL (DNSR and WEB are planned)
Chile	PSM-ISP	QoS indicators	DATA, DNSR and aggregation rate. (parameters informed by operators, not necessarily verified by SUBTEL)
France	PSM	Verification of licence obligations; consumer protection; competition enhancement; network development	Voice quality, SMS, MMS, data rates (DL and UL), web surfing, video service quality
Germany	EAM and PSM	Consumer protection; net neutrality	Platform measurement: DATA, DNSR, WEB, LT, HTTP response time End user measurement: DATA
Korea	EAM for fixed, PSM for mobile	Consumer protection; network development	Fixed : DATA, WEB Mobile: WEB, rates of successful download and upload that were faster than certain speed, web loading time, (calling quality)
Mexico	EAM	N/A	DATA, LT
Norway	EAM	Consumer protection	DATA, LT

[5] OECD, *Access Network Speed Tests*, www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=DSTI/ICCP/CISP(2013)10/FINAL&docLanguage=En

Country	Client type	Purposes	Measured metrics
United States	Fixed EDM, Mobile EAM	Consumer protection	DATA, WEB, LT (UDP and ICMP), PL(UDP and ICMP), video streaming, VoIP, DNS R, DNS failures, latency under load, availability of connection, data consumption

Source: OECD, Access Network Speed Tests, 13 January 2015

6 Broadband quality of service measurements

In general, QoS measurement methodology, the protocol used – including reporting – should be capable of estimating at least the set of QoS parameters based on packets transmitted between specified measurement points. It is important to know the characteristics of a connectionless service – such as IP and NGN – that deliver user data via standalone packets (IP packets, i.e. datagrams) in each direction. As outbound and inbound traffic routes may differ, targets and measurements for all QoS attributes are in this case practically one-way, reflecting the connectionless nature of the service. Measurement probe packets should traverse as much as possible the same path as customer packets having the same QoS service class and the same QoS mechanisms in routers along the path. The value of probe packets should be appropriately set for the QoS class to be measured. This chapter examines concrete measurement tools and platforms for broadband QoS measurement, and presents selected country case studies on broadband QoS measurement, while tools for measurement are provided in annex to this manual.

6.1 Quality of service measurement system requirements

Requirements identified for quality monitoring systems, as defined by BEREC[6], include:

- Accuracy: The achieved measurement results should be reliable, reproducible and consistent over time. These measurements can be technical indicators characterizing both QoS and QoE. Margins of error should be known and published.
- Comparability: This includes 'plain' comparability of individual sample measurements, as well as comparability at higher levels, depending on the goals set by the NRA, such as comparability between Internet access services. Comparisons of measurements should always be put into context with a wider analysis to clarify the cause of any differences observed.
- Trustworthiness: The system components must be robust and protected against security attacks. They should also ensure availability, integrity and confidentiality. Measurement data must be secured during storage and transmission.
- Openness: Details about the measurement methodology should be made available, and open source code should be considered an option to achieve this requirement. Transparency of collected data (open data) should also be sought, with due respect for the limitations of national legislation. As far as possible, a quality measurement system should be based on state-of-the-art specifications, standards, recommendations and best practices.
- Future-proofness: The system design should ensure flexibility, extensibility, scalability and adaptability. This implies cost-effectiveness. These requirements contribute to the overall accountability of the quality monitoring and should therefore be taken into account when the

[6] *Monitoring quality of Internet access services in the context of net neutrality*

NRA designs a quality monitoring system. The technology chosen and the tools available on the market should also be taken into account when choosing the governance approach.

Regarding Internet access service, which is used for all OTT services, various approaches are taken by different stakeholders. In many European countries, regulators have either suggested or used certain tools that are available, or have engaged certain institution to develop such tools. All measurement tools provide information on the RTT (round-trip time), downlink (DL) and uplink (UL) bit rates (in kbit/s, Mbit/s) averaged over a given time interval of downloading and uploading files.

6.2 Broadband quality of service measurements: Case studies

This section presents country case studies on broadband QoS measurement. Tools used for broadband QoS measurement are provided in the annex to this manual.

6.2.1 Canada

In Canada, the Canadian Radio-television and Telecommunications Commission (CRTC) launched a project to create a community of broadband consumers across Canada. Data is gathered from *Whiteboxes* installed in the homes of participants who expressed an interest in measuring the performance of their broadband Internet services (Figure 6.1). CRTC is collaborating with major ISPs on this project. The data being gathered provides useful insight into network performance, including actual connection speeds, and provides a better understanding of whether certain Internet services from participating ISPs are delivering speeds as advertised. These results also provide data that will enable CRTC to improve its broadband policy-making.

Figure 6.1: Canadian campaign for QoS measurements with *SamKnows*



Source: CRTC

The results of the campaign conducted between March and April 2016 showed that among ISPs, download was consistent between peak and off-peak hours. A majority of ISPs delivered speeds above their advertised rates, regardless of the access technology they used. ISPs also largely met or exceeded their advertised upload speeds. All access technologies met or exceeded the advertised download speed on average. Packet loss was generally very low with some exceptions. All access technologies (FTTH, Cable/HFC, DSL) met or exceeded the advertised download speed on average, demonstrating that the access technologies themselves are capable of supporting the advertised services. Regulators are increasingly providing broadband speed testing open to all on their websites to enable consumers to test their broadband connection and monitor changes.

6.2.2 France

In November 2016, ARCEP (*Autorité de Régulation des Communications Électroniques et des Postes*) submitted a draft proposal and subsequently launched a public consultation in December 2016 for a complete overhaul of its fixed Internet access and telephone service QoS indicators.

To reflect user experience as accurately as possible, ARCEP is proposing to move towards crowdsourcing and make use of new digital tools for the user to obtain a reliable, objective and reproducible measurement of how their individual access is performing. This approach will enable ARCEP to gather a wealth of information collaboratively produced to identify any market failures and to make information transparent. ARCEP also plans to carry out a comparative analysis of the existing different crowdsourcing tools available in the marketplace to better understand these tools and the methodological approaches to best address regulatory objectives. As stated by ARCEP, the objective over time is to reflect the user experience as accurately as possible, as part of a data-centric approach to regulation. This new approach would require an adjustment to be made to the current regulatory framework. Currently ARCEP publishes *scoreboards*, which include:

- Internet access: bit rates, latency, web browsing, streaming video;
- telephone calls: call completion success rate, call set-up time, speech quality;
- customer service: line set-up, reliability, technical support.

Provisions regarding the quality of fixed Internet access and telephone services that have become superfluous will be removed starting in the second half of 2017. Internet access and telephone service scoreboards have been based on tests performed in a controlled environment. ARCEP wants to move to a system that is based on the experience of the user and is as accurate as possible.

6.2.3 Germany

The Federal Network Agency launched its broadband measurement on 25 September 2015. End users can quickly and easily determine the speed of their Internet access using broadband measurement, thereby determining the performance of their fixed and/or mobile broadband connections. A test can be performed free of charge for stationary connections under *breitbandmessung.de*. For mobile connections, a measurement with the free broadband measurement app was made possible with applications for Android and iOS (as the two most used operating systems for smartphones today) in the respective stores.

With this test, customers had the possibility to independently check the performance of their broadband Internet access. Broadband measurement makes it possible to compare the actual data transmission rate of the respective broadband connection with the contractually agreed data transmission rate. Measurement is made to be independent of the provider and the technology. The individual measurement results are electronically storable. This allows customers as end-users to perform various measurements and compare them with each other.

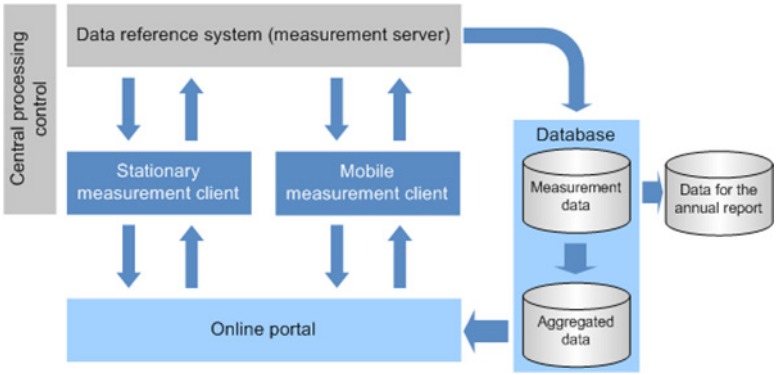
On 27 March 2017, the Federal Network Agency published its first annual report on its broadband measurement, which covers the period from 25 September 2015 to 25 September 2016. For fixed broadband connections, 106 159 valid measurements were taken, while for mobile broadband connections, it numbered 53 651.

Overview of the measurement concept and system

The measuring concept underlying the broadband measurement consists of a measuring system and a measuring method. The measuring system means the combination of measuring point (measuring client) and counter-measuring point (data reference system) and the measuring process in use. The measurement of stationary broadband Internet access services is done on a browser-based basis at https://breitbandmessung.de.

The customer survey was carried out in the reporting period by means of a client measurement using a Java plug-in in the browser of the end-user. An application-based measurement client allows the measurement of mobile broadband Internet access services by end-users via smartphones or tablets, supporting Android (Java) and iOS (ObjectiveC). Measurements were made on the end-user device for all technologies, such as GPRS, UMTS, LTE, and WiFi. The reporting period covers September 2015 to September 2016. At the beginning of the second reporting year, a changeover from Java Plug-in to HTML5 with WebSockets took place.

Figure 6.2: Overview of the measurement concept



Source: Based on Federal Network Agency in Germany, *Broadband measurements - Annual report 2015/16*

The remote end for the measurements consists of the measurement servers (data reference system), as shown in Figure 6.2. A central processing control ensures a controlled sequence of the measuring procedure. In the case of the actual measurement (measuring method), the technical sequence is identical in both cases (stationary and mobile). All measured data are stored and processed in a central database. The data are then validated and processed for a timely, aggregated presentation. On the other hand, a detailed evaluation is carried out for the annual report (Figure 6.2). The data transfer rates as the main KPI in broadband measurements in Germany were split into seven bandwidth classes, as shown in Table 6.1.

Table 6.1: Bandwidth categories for broadband measurements in Germany

Bandwidth classes	Data transfer rates
Class 1	2 Mbit/s to less than 8 Mbit/s
Class 2	8 Mbit/s to less than 18 Mbit/s
Class 3	18 Mbit/s to less than 25 Mbit/s
Class 4	25 Mbit/s to less than 50 Mbit/s
Class 5	50 Mbit/s to less than 100 Mbit/s
Class 6	100 Mbit/s to less than 200 Mbit/s
Class 7	200 Mbit/s to less than 500 Mbit/s

Source: Zafaco GmbH on behalf of Federal Network Agency in Germany

In order to avoid manual entry, the tariff types of the providers (where available) were called up from the provider database of the broadband measurement on the basis of the specified provider and the contractually agreed maximum data transmission rate. In total, more than 130 providers in Germany provided their tariff information during the reporting period, which represents more than 90 per cent of the market volume in the fixed networks segment.

For mobile networks, the measurement was performed by using applications based on Java (Android) or ObjectiveC (iOS) on the end-user device. However, various factors can influence the test result in mobile environments, including tariff-related limitations of the data transmission rate (throttling after exceeding a monthly volume included), the utilization of the Internet access provider and the number of active users in the same mobile cell or the same network segment. In addition, the terminal itself, the mobile radio technology used in the measurement (GPRS, UMTS, LTE), as well as the network coverage and supply quality at the measuring site, can play a role. This also includes the question of whether the mobile radio measurement has taken place inside or outside a building, or in motion (e.g. during a car or train journey).

In all cases, the end customer had to accept the provisions on data protection and the conditions of use before measurement. In particular, consent to the use of the data collected during the measuring procedure should be confirmed.

If it was determined before the start of the measurement that the device would be connected via wireless local area network (WLAN i.e. WiFi), the end customer was informed about this. The subsequent measurement was then recorded as WLAN measurement. The following data, on the connection to be measured, was determined by user dialogue: location (in a building, outdoors, moving), provider, contract-agreed maximum data transmission rate, tariff type, customer satisfaction. During measurement in all environments (fixed and mobile), the following steps were performed:

- querying additional parameters from the router (at the customer end);
- execution of the run-time measurement;
- carry out the download measurement;
- carry out the upload measurement.

At the end of the measurement, tariffs were provided, according to the customer data base or tariff database. Such information is required to determine any limitation of the data transmission rate or throttling after exceeding a monthly data volume included, to check whether the *inclusive volume* had already been exceeded during the measurement.

Mapping the broadband bandwidth across the country

In June 2016, the Federal Network Agency published a map function as part of its broadband measurement. The mapping contains the results of broadband measurements carried out over the tests so far. With the help of the map, anyone can access information on the results achieved, in a given region, in Germany.

The broadband map (https://breitbandmessung.de/) shows the measured data transmission rates as well as the percentage of measured rates compared to the contractually agreed maximum data transmission rate for individual providers. It is possible to use the results according to specific criteria, for example, by provider and/or bandwidth class. The measurement results are displayed in different grids according to the zoom level.

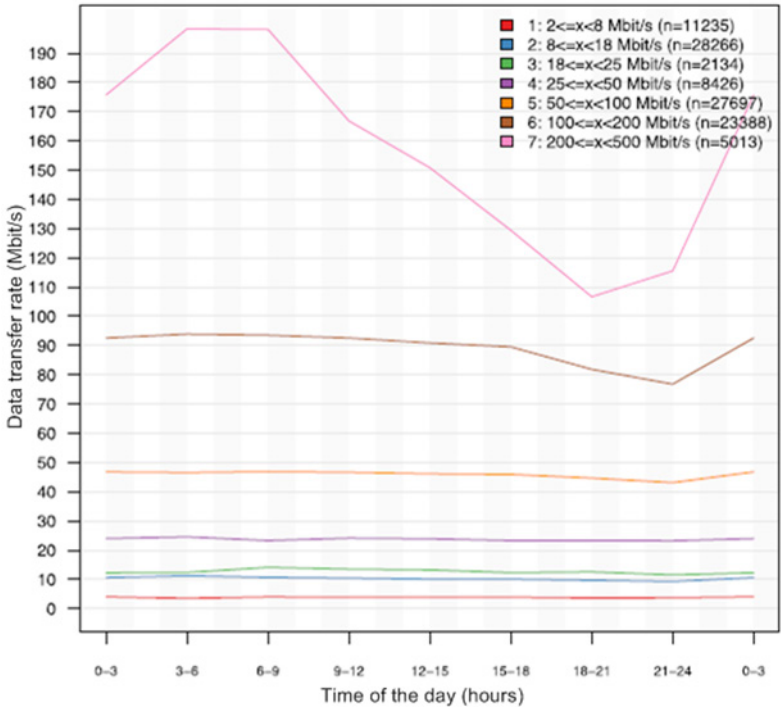
The publication of the measurement results is in accordance with data protection regulations. At least four measurements from different connections in a grid are summarized as a median before the values are displayed in the map. A reference to the respective person cannot be established.

Results in the fixed networks

Depending on the bandwidth class, 4 to about 25 per cent of end-users reached 100 per cent of the agreed maximum data transfer rate. The lowest value was achieved in the bandwidth class of 8 to <18 Mbit/s, which is predominantly characterized by ADSL connections. There were also differences between the providers with regard to reaching the agreed maximum data transmission rate. With regard to providers, the range ranged from 1 to around 35 per cent of the end customers.

For bandwidth class 200 to <500 Mbit/s, the performance fell sharply during evening peak time (as shown in Figure 6.3). This bandwidth class was characterized by products of cable network operators.

Figure 6.3: Download transfer rates in fixed networks in Germany by bandwidth class



Source: Based on Federal Network Agency in Germany, *Broadband measurements - Annual report 2015/16*

Measurement of customer satisfaction was surveyed. About 65 per cent of the customers were satisfied with the performance of their suppliers and rated them: very good, good, or satisfactory. Results also showed that satisfied end-users achieved a better ratio of the actual measured data transmission rate compared to the agreed maximum data transmission rate.

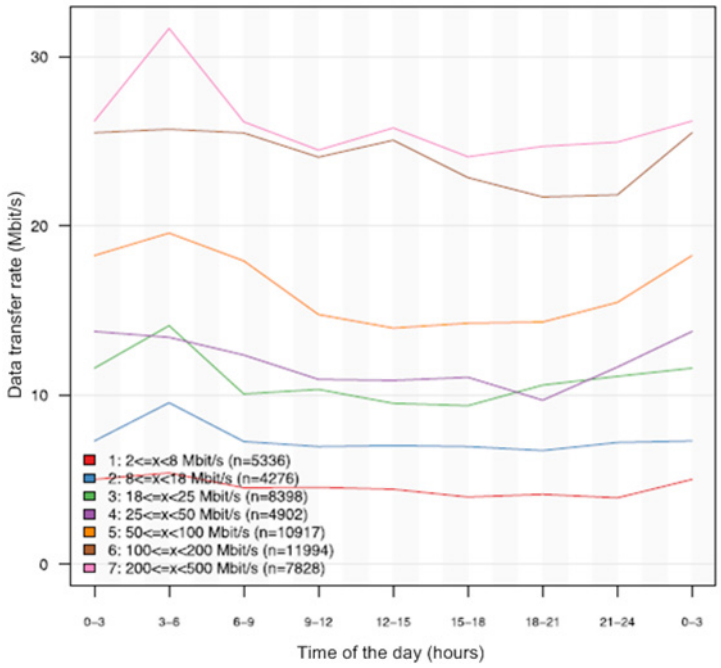
Results in the mobile networks

For mobile broadband connections, the ratio between actual and agreed maximum data transfer rate was below that of stationary connections. The share of end-users reached at least half the maximum transmission rate in the fixed network (just over 70 per cent), however, this figure was only reached by mobile subscribers with less than 30 per cent of users.

However, end customers also rated the very good, good or satisfactory scores (82.8 per cent), even for mobile broadband connections. This suggests that end-users in mobile broadband connections are more likely to rate mobility and availability as performance, rather than reaching expected maximum data transfer rate.

In particular, in bandwidth classes 6 (100 Mbit/s to less than 200 Mbit/s) and 7 (200 Mbit/s to less than 500 Mbit/s), only a small part of end-users reached the corresponding threshold of at least 100 per cent of the contractually agreed maximum data bit rates (as shown in Figure 6.4 for bit rates in the downlink direction).

Figure 6.4: Download transfer rates in mobile networks in Germany by bandwidth class



Overall, the German regulator stated that the measurements do not allow for any conclusions to be drawn regarding broadband supply because the results of broadband measurement depend on the tariff that the user has agreed with the provider. In this respect, no statements can be made on the basis of broadband measurement on the supply situation, or availability of broadband Internet access services.

6.2.4 Italy

The Italian regulator AGCOM (Autorità per le Garanzie nelle Comunicazioni) has an on-going project called *QoS Internet broadband fixed access*. The project seeks to address the issue of misleading Internet offers where ISPs provided only the theoretical maximum speed without providing any minimum guaranteed speed; there is no possibility to withdraw from the contract without penalty; and it is not possible to compare ISP performances because of the lack of transparency.

The AGCOM approach to Internet measurements builds on:

- ISP measurements based on dedicated probes located in the main towns, able to measure performance related to the two most sold offers for each ISP.
- End-user measurements to allow users to measure their own fixed line performances by software called Ne.Me.Sys. The end-point is located in end-user homes. There are four sub-options for the end-user regarding the measurements:
    1. Issue of a complete certificate.
    2. Release of a certificate as soon as 5th percentile target value is violated.
    3. Speed test with registration.
    4. Speed test without registration (one-shot).

All such measurements employ the same network measurement system, based on a software agent running on a standard personal computer.

AGCOM selected the following QoS parameters to measure Internet access performances (Figure 6.5):

- data transmission speed;
- packet delay (RTT);
- packet loss ratio;
- unsuccessful data transmission ratio.

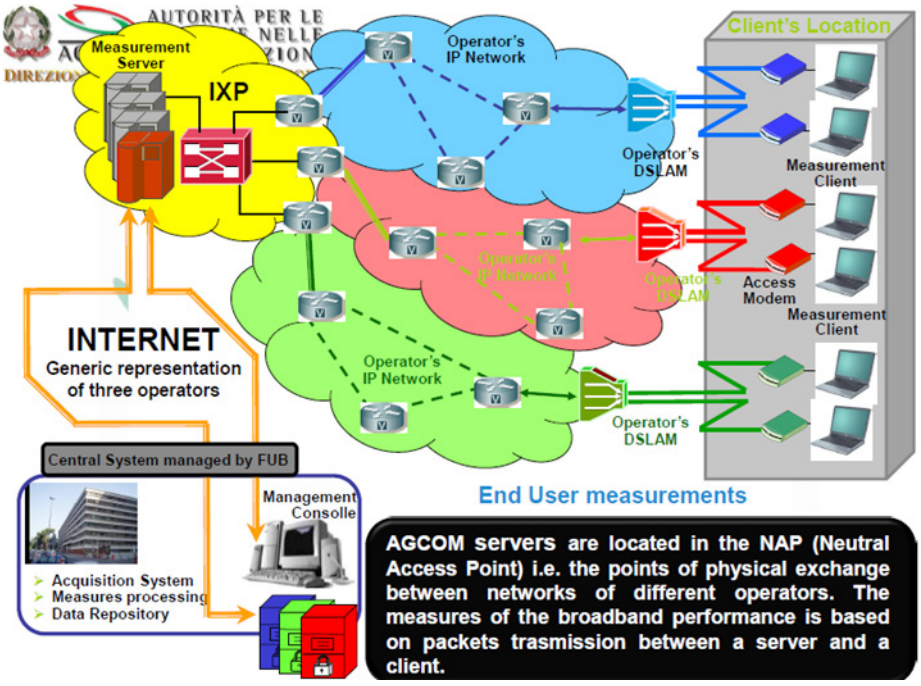
The following four values relevant to data transmission speed are computed for both download and upload direction:

1. 95th percentile in kbit/s;
2. 5th percentile in kbit/s;
3. mean value in kbit/s;
4. standard deviation in kbit/s.

The following two values relevant to delay are computed:

1. mean values in milliseconds;
2. standard deviation.

Figure 6.5: End-user measurement process



Source: AGCOM

The **Ne.Me.Sys**. tool (https://www.misurainternet.it/nemesys.php) measures the quality of the line, making at least one measure per hour throughout the day. To fully characterize the line, the software has to make a measurement in each time slot. This is necessary to evaluate the performance as a function of network load. The evaluation of the line is made by at least 24 independent measurements taken in each time slot. Each measurement is made with: 20 FTP download sessions, 20 FTP upload sessions, and 10 ping sessions. HTTP measurements, instead of FTP, were used in the period 2015-2017.

The outcomes of broadband measurements done by Ne.Me.Sys., and the results obtained, can be used by customers to terminate their contract without penalties, to freely downgrade to a cheaper profile, or to demand that QoS parameter levels be restored.

The results reported in the final certificate, in fact, can be compared with QoS KPI promised values, indicated by the operator for each Internet offer, and will be published on the *misurainternet* site.

If the results are less than the promised values, the user may submit a claim to the operator. If the operator does not improve the quality within 30 days, the user, after a second claim, may terminate the contract without penalties.

Regarding the KPIs for mobile broadband measurements, and in accordance with ETSI technical specifications TS-102-250 and TS-202-057, the following KPIs have been chosen to assess the network performance and quality of mobile broadband service:

- data transmission (DL/UL) throughput;
- data transmission (DL/UL) unsuccessful rate;
- web page download time (HTTP/HTTPS);
- web page download unsuccessful rate (HTTP/HTTPS);
- packet delay;
- packet loss;
- jitter.

For the period 2015-2017, AGCOM has defined measurements for mobile networks that include both static measurements (with probe stations) and dynamic tests (drive tests) for all mobile networks in Italy. These tests include:

- Fixed duration test: DL/UL transfer tests of very large files (e.g. 2 GB), limited to 30 seconds.
- Video streaming test with two possible approaches that have both advantages and disadvantages:
    1. A streaming service could be developed and located at the regulator premises. The advantage is that the test activity is kept within the mobile network under test. The disadvantage is that advanced real-world streaming techniques can hardly be replicated.
    2. The measurement is done using one of the most diffused video streaming service, YouTube. The advantage is that advanced streaming techniques, as experienced by the users, can be taken into account. The disadvantage is that the tests involve sections of external networks.

An example of an AGCOM measurement loop for the measurement of FTP and HTTP (for file download and upload) and ping (for measuring RTT) is presented in Figure 6.6. Figure 6.7 shows the type of tests performed by AGCOM in test campaigns for broadband QoS measurements in the period 2012-2017. HTTP has been the preferred application protocol for file upload and download since 2015 as the majority of Internet users are accessing the web through web browsers, where the web is based on HTTP over a TCP/IP protocol stack. The older FTP is now rarely used by end-users.

Figure 6.6: Measurement loop example

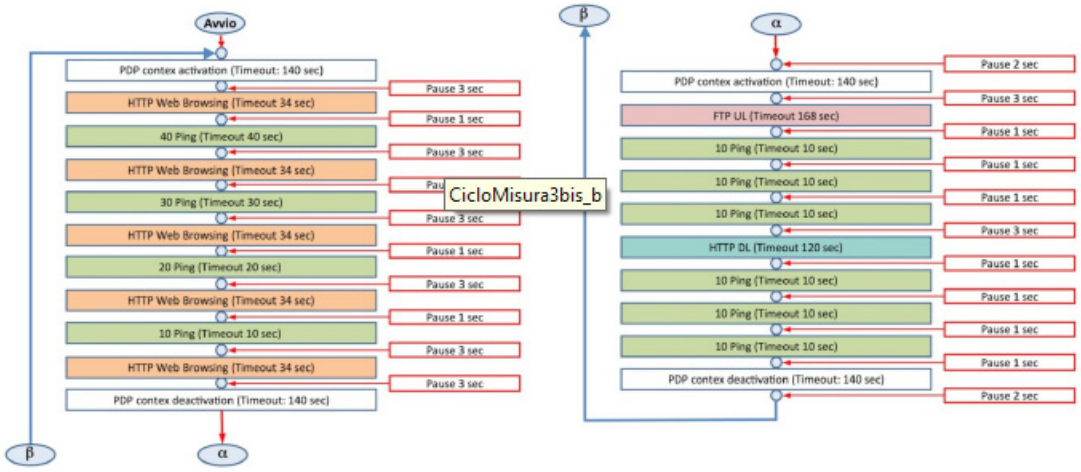


Figure 6.7: AGCOM comparison table for campaigns

AGCOM Deliberation			154/12/CONS				580/15/CONS			
Drive Test Campaigns			2012	2013 - 1	2013 - 2	2014	2015	2016 - 1	2016 -2	2017
Type of tests: Data download	HTTP	FIXED FILE	E	x	x	x	x			
		FIXED DURATION					x	x		
Data upload	FTP	FIXED FILE	E	x	x	x				
	HTTP	FIXED DURATION					x	x		
Web page download	HTTP		E	x	x	x	x	x		
	HTTPS			E	x	x	x	x		
Packet TX/RX			E	x	x	x	x	x		
Videostreaming							x	x		
Test devices		USB dongle	E	x	x	x				
		Smartphone					x	x		
Technology		3G-2G	E	x	x	x	x	x		
		4G-3G-2G					x	x		
Test scenario		Static	E	x	x	x	x	x		
		Dynamic	R	R	R	R	x	x		
		N. of cities	20	20	20	40	40	40		
		N. of static points	1013	1013	1013	1202	1202	1202		

x Official tests for publication
E Experimental test/campaign
R Reserved to AGCOM/FUB

In 3G sub-campaign the fixed-file DL test is carried out for comparison with previous campaigns (historical series)

FTP UL tests are replaced with HTTP UL tests (ref. ETSI ES 202 765-4 V1.2.1)

3G-limited and 4G sub-campaigns (in selected cities) are carried out

6.2.5 New Zealand

Gaming is becoming a popular OTT service which is widely used around the world and has strict delay requirements (on delay and jitter), more stringent than OTT VoIP. Game site latency has been measured by TrueNet commercial measurement tools and platforms in Australia and New Zealand. These results, as illustrated in Figure 6.8, may serve others who do not perform such measurements. RTT delay measurement results on the most popular online games over fibre and cable Internet access (from October 2016) are provided below.

Figure 6.8: Latency measurements on gaming

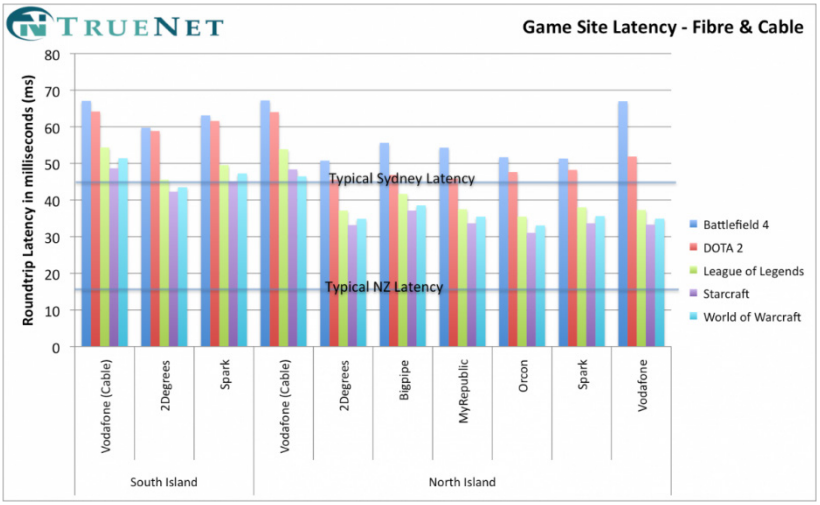
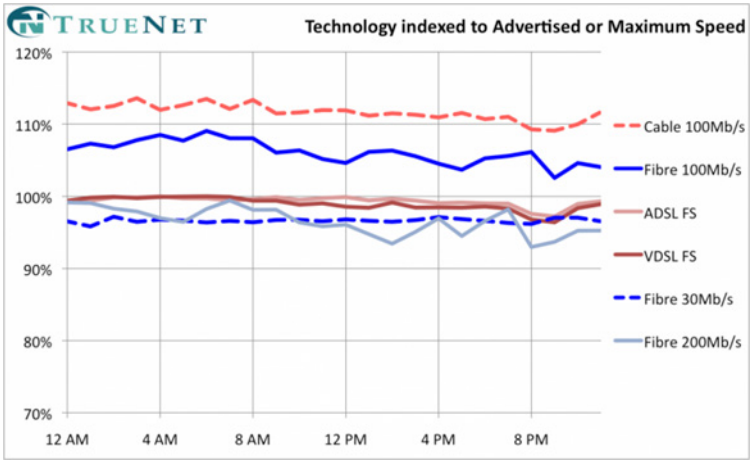


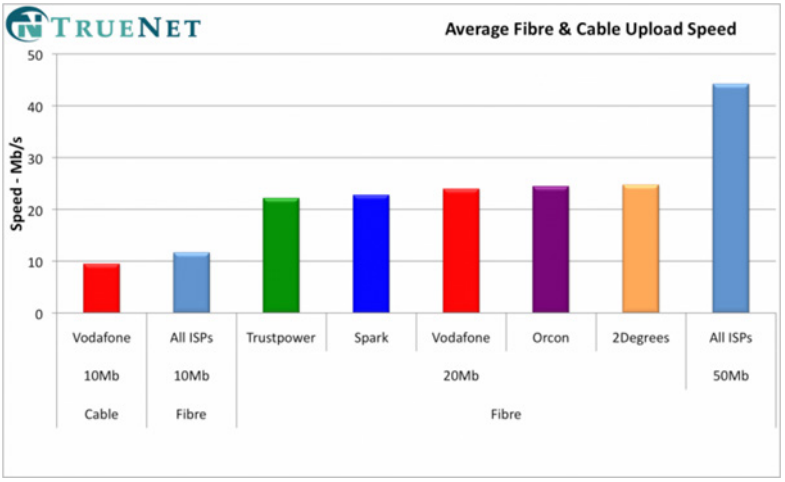
Figure 6.9: TrueNet New Zealand file download speed (measured vs. advertised)



Source: TrueNet. https://www.truenet.co.nz/story/2016/11/october-2016-urban-broadband-report

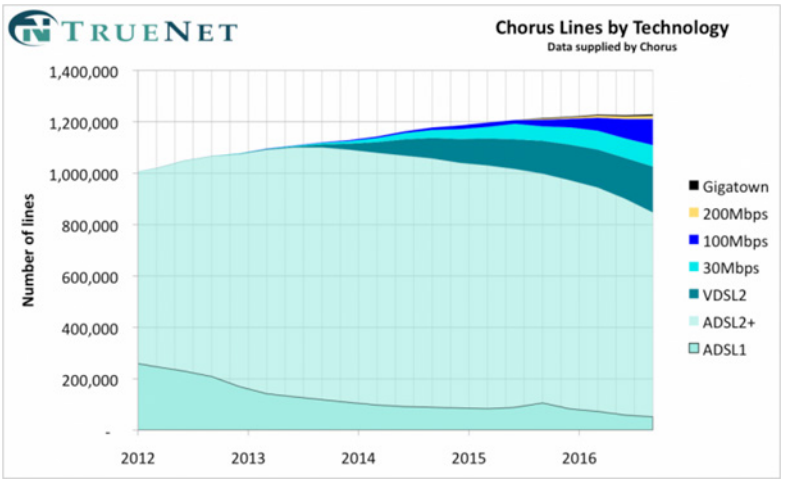
Comparing performance of these OTT services provided via Internet access service by time-of-day (Figure 6.9) is important as it shows service degradation when everyone is using the Internet during the evening peak hours of 8 pm to 10 pm. A poor result typically shows the line drops below 90 per cent, which usually occurs in the busy period between 7 pm and 10 pm, i.e. if this is true, the average customer of that ISP is getting less than 90 per cent of their line capability.

Figure 6.10: TrueNet New Zealand file upload speed (measured vs. advertised)



Source: TrueNet. https://www.truenet.co.nz/story/2016/11/october-2016-urban-broadband-report

Figure 6.11: New Zealand fixed broadband Internet access per technology



Source: TrueNet. https://www.truenet.co.nz/story/2016/11/internet-price-trends

Upload speed (Figure 6.10) is important to users sending large amounts of data through the Internet, or uploading files to the cloud. The TrueNet upload test sends a 1 MB file to the Wellington server and records the results using a similar method to download tests. The penetration of fixed broadband access in New Zealand is shown in Figure 6.11.

6.2.6 Poland

In accordance with the provisions of the Universal Service Directive of the European Union, the Memorandum of Cooperation to improve the quality of services provided to users in the telecommunication market was proposed in May 2012 by the President of the Office of Electronic Communications (UKE), the regulatory authority in Poland, and signed in October 2012, includes:

- contracts for services should be structured in a clear, understandable, easily accessible form;
- published information on the quality of services provided by telecommunications undertakings should be comparable, relevant and up to date;
- the user shall have access to comprehensive, comparable, reliable information presented in a friendly form;

- measurable indicators of quality of service shall be identified, as well as the content, form and method of providing information to be published;
- minimum quality requirements shall be identified in order to prevent deterioration of the quality of service in public networks.

UKE imposed the following technical and administrative QoS indicators (see Table 6.2) as defined in the ETSI Guide (EG 202 057-2, EG 202 057-3 and EG 202 057-4):

- Fixed and mobile services: successful call ratio.
- Mobile services: speech quality ratio, dropped call ratio.
- Internet access (fixed and mobile) services: data transmission speed, delay.
- All telecommunication services: average response time for operator services, bill correctness rate.

Table 6.2: QoS indicators in Poland

Indicator	Range for good quality	Range for satisfactory quality	Range for poor quality
Average response time for operator services	<= 60 s	Longer than 60s but shorter than 120s	120s or more
Bill correctness rate	Above 97.5%	from 95.1 to 97.5% inclusive	Below 95.1%
Efficiency of telephone calls	Above 98%	from 95 to 98% inclusive	Below 95%
Interrupted calls rate	Below 2%	from 2 to 5% inclusive	Above 5%
Quality of speech	Above 90%	from 80 to 90% inclusive	Below 80%

Source: UKE

UKE has concluded that consumers should have the possibility to check the quality of this service for the applications they are using as part of Internet access. The list of services, with assigned threshold values for data transmission speed and delays (according to UKE), is shown in Table 6.3.

Table 6.3: UKE measurements of data transmission speed

Group of applications	Transmission speed not lower than	Delay not greater than
WWW browsing	1 Mbit/s DL	200 ms
SD videos watching	2 Mbit/s DL	200 ms
HD videos watching	6 Mbit/s DL	200 ms
HD videos talks	1.5 Mbit/s DL and UL	150 ms
VoIP telephony	64 kbit/s DL and UL	150 ms
multiroom services (3 x HD video)	18 Mb/s DL	200 ms
On-line real time games	2 Mb/s DL and 1.5 Mb/s UL	30 ms

Group of applications	Transmission speed not lower than	Delay not greater than
Other on-line real time games (chess, ...)	1 Mbit/s DL and UL	200 ms

Depending on the percentage share of samples complying with the minimum criteria of applications, Internet access service is classified by UKE in Table 6.4.

Table 6.4: UKE classification of the quality of Internet access

Result of classification of samples for applications	Quality of IAS
Below 70%	Poor quality
From 70 to 90%	Satisfactory quality
Above 90%	Good quality

Source: UKE

UKE has applied specific rules for measurements in mobile networks as mobile users may be at different locations in the network at different times. The same users may therefore experience different levels of quality within the same network. One of the objectives defined in the Memorandum is to ensure comparability of the measurement results. For this purpose the following rules on mobile network measurements were adopted:

- simultaneity tests (measurements) are conducted at the same time, using the same measurement unit or units in parallel for all operators and all measured services;
- area and time of measurements is the same for all operators;
- measurements will be conducted by an independent entity;
- measurement campaigns will be conducted periodically, in accordance with the adopted reporting period;
- the UKE has monitoring and supervisory functions.

The choice of a measurement route should take into account population distribution patterns, traffic patterns and the area of service provision. The minimum duration of the measurement campaign is 800 hours. At least 80 per cent of the measurements are conducted in motion, with measurements conducted for the following categories of areas: large urban areas; towns with at least 50 000 inhabitants excluding large urban areas; and domestic highways outside administrative borders of large urban areas and towns.

Regarding the publication of measurement results, the telecommunications undertakings have the obligation to publish up-to-date results of QoS measurements for their networks. UKE should publish the summarized benchmarks of QoS indicators for particular reporting periods on its website as submitted by telecommunications undertakings. The first measurement campaign started in 2015 and service providers who have signed the Memorandum must submit the results of their QoS measurements to UKE twice a year.

The Memorandum is open to all interested parties and is unlimited in time. Any telecommunication undertaking in Poland can join the initiative at any time by committing to apply the solutions and standards agreed for the benefit of subscribers and their own companies.

The final report is addressed not only to the Memorandum signatories but is also a public document. The solutions presented in the report may also be used by other telecommunication undertakings when elaborating their own QoS measurement systems.

6.3 Toward the future: Mapping broadband quality of service

Mapping of the existing infrastructure and the broadband QoS allows public authorities to identify the investment gap. It allows for the monitoring of progress towards NGN targets. Mapping is therefore a key element of national broadband plans and of state aid assessment in the European Union. Mapping of broadband QoS helps in reducing investment costs by facilitating higher re-use of existing passive telecommunication infrastructure, avoids duplication of civil engineering works, prevents damages while performing civil engineering works, and facilitates co-investment among sectors.

For example, in Europe, the planned EU integrated monitoring platform will aggregate and benchmark mapping measurements of services through four main steps:

1. Design, development and maintenance of the integrated platform.
2. Two sets of data: quality of service and quality of experience.
3. An interface enabling the pulling/entry, data conversion.
4. A certification and benchmarking function for crowdsourcing apps that comply with a set of qualification criteria.

The final version of the EU broadband measurement platform is expected by December 2017 and will include important QoS and QoE aspects:

- QoS aspects include data based on marketed speeds/quality criteria (on a basis of a number of pre-defined parameters/metrics) gathered within existing national mapping initiatives. Data entities include Ministries/agencies, network operators and National Regulatory Authorities;
- QoE aspects refer to data on actual user experiences pulled from crowdsourcing applications. The qualification process for the data is set by pre-defined parameters/metrics. Data sources include BEREC and the following platforms: M-LAB, Akamai, Ookla, Netradar, Opensignal, Specure, RIPE, PERSOFAR, as well as data collected by consumer organizations, etc.

Regulatory authorities play a key role in promoting competition in the provision of electronic communications, primarily by ensuring the highest benefits for service users in terms of choice, price and QoS; promoting innovation; and encouraging efficient investment in electronic communications infrastructure and associated facilities. Based on this, an operator is entitled to request shared use (including physical co-location) of network elements and associated facilities of another operator or a third party, where necessary, where it is impossible or when it does not make economic sense to construct or install a new electronic communications network and associated facilities. The NRA shall establish and keep an updated database on the type, availability, QoS information, and geographic location of capacities which may be requested for shared use or access. The database has to be made publicly available on the NRA website, offering comprehensive browsing capacity.

Infrastructure mapping enables policy-makers, regulators and operators to identify network availability. Mapping further enables the identification of gaps (underserved areas), supports investors in their planning and decision-making, and helps identify potential areas for infrastructure sharing within the sector and with other utilities. Mapping is also a tool to improve the QoS of communication networks and can provide consumers with access to network availability, coverage and even speeds.

Mapping is therefore a key element of next generation networks (NGN) planning and provides, for example, the basis for state aid assessment in the EU. The results of the EU study on the mapping of broadband and infrastructures (SMART 2012/0022)[7] will help public authorities in Europe to adopt similar criteria to ensure the credibility and reliability of their mapping, thereby helping to speed up the process of planning public interventions under EU funds. The mapping concept is presented in Table 6.5.

[7] http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=8455

During Phase 1, the study reviewed mapping initiatives in Europe and around the world and developed a methodology based on four types of mapping:

1. Infrastructure mapping: Geo-referenced and structured data of physical infrastructure, e.g. ducts/fibre/nodes, antenna towers/masts, and other relevant infrastructures (energy, transport or water supply). A number of European countries perform infrastructure mapping initiatives: Austria[8], Belgium[9], Denmark[10], Estonia[11], France, Poland[12], Switzerland[13], and the United Kingdom[14].
2. Quality of service (supply) mapping: Maps information on the supply side of broadband service provision, including the available bandwidths and the quality of service, technologies, operators/service providers. A number of European countries perform service mapping initiatives: Belgium, Denmark[15], Finland[16], Germany[17], Greece[18], Hungary[19], Ireland[20], Norway[21], Poland[22], Spain[23], Sweden[24], Switzerland[25], and the United Kingdom[26].
3. Demand and quality of experience (demand) mapping: Data on actual latency/speeds experienced by users; data usage (per household); expectations regarding quality of service and experience and willingness to pay by different user groups. Two European countries perform demand mapping initiatives: Sweden[27], and the United Kingdom[28].
4. Investment mapping: Information related to prospective public and private investment of high speed broadband during the next three years (in line with EC broadband state aid guidelines).

In Phase 2, the EU integrated monitoring platform will aggregate and benchmark mapping measurements of services as part of the following steps:

1. design, development and maintenance of the integrated platform; this will include two sets of data: quality of service and quality of experience;
2. development of an interface enabling the pulling/entry, data conversion;
3. inclusion of a certification and benchmarking function for crowdsourcing apps that comply with a set of qualification criteria.

8 www.senderkataster.at/
9 www.bipt.be/
10 http://mastedatabasen.dk/VisKort/PageMap.aspx
11 http://ela12.elasa.ee/elakaart/
12 http://www.uke.gov.pl/mapa/?map_tab=1
13 http://map.geo.admin.ch/?topic=funksender&lang=de
14 http://maps.ofcom.org.uk/broadband/
15 http://dba.erhvervsstyrelsen.dk/file/348160/broadband_mapping_2012.pdf
16 www.ficora.fi/attachments/englantiav/6HdjnUV00/Toimialakatsaus_2012_EN.pdf
17 www.zukunft-breitband.de/DE/Breitbandatlas/breitband-vor-ort.html
18 http://mapsrv1.terra.gr/eettutilities/mapnew.aspx
19 www.vus.sk/broadband/nbbs/hu_nbbs.pdf
20 www.dcenr.gov.ie/Communications/Communications+Development/National+Broadband+Scheme/National+Broadband+Scheme.htm
21 https://www.regjeringen.no/no/dokumenter/bredbandsdekning-2014/id2356922/
22 http://en.uke.gov.pl/report-on-the-coverage-of-poland-with-telecommunications-infrastructure-751
23 http://bandaancha.eu/analisis/mapa
24 http://bredbandskartan.pts.se/
25 http://map.geo.admin.ch/?topic=nga
26 http://maps.ofcom.org.uk/broadband/
27 http://bredbandskartan.pts.se/
28 www.samknows.com/broadband/exchange_mapping

Table 6.5: Mapping concept

Service mapping		Infrastructure mapping	
National level		National level	
Demand mapping		Investment mapping	
Demand for broadband	Quality of service	Rolled-out investments	Planned private investment
According to the national guidelines to justify State aid	Depending on initiative requirements	Integration into service and infrastructure mapping	According to the national guidelines to justify state aid

The national mapping process is very important as it establishes a single information point for broadband service, infrastructure, demand and investment. Infrastructure mapping is the detailed, geo-referenced and structured gathering, processing and visualization of data on infrastructure, which creates transparent access to relevant information. Service mapping describes systems that gather, analyse and present information on the supply of broadband services available in a specific area, and hence provides an insight into the current state of broadband availability in order to assist in decision-making processes. Both service and infrastructure mapping may use several publication formats, such as static or interactive maps in public and other more restricted formats. In both cases the authority in charge should be the NRA.

6.4 ITU framework for monitoring quality of service of IP network services

Through Y.1545.1 (March 2017), ITU has specified a framework for broadband QoS monitoring, i.e. a framework for QoS of IP network services. The rapid increase in the use of the Internet has changed the way we live, and has become an important factor in people's daily life. ITU-T Rec. Y.1545.1 highlights the necessity of testing the QoS of network services offered by ISPs (e.g. fixed and mobile operators), from diagnostic and regulatory points of view. The recommendation also addresses QoS evaluation scenarios, sampling methodology and testing tools for regulators. It also provides guidance to regulators on minimum QoS parameters for evaluating the quality of Internet services.

The minimum set of parameters for evaluating the quality of IP network service, according to ITU-T 1545.1, is defined in Table 6.6. Methods of measuring IP network services provided by ISPs are categorized as active and passive methods of measurement (according to RFC 7799). The advantages and disadvantages of both methods are shown in Table 6.7.

Table 6.6: Minimum set of parameters for evaluating the quality of IP network service

Parameter	Definition
1 IP network service activation time	These parameters apply to a set of individual attempts to access and utilize IP network services, and in one case are supplied by the DHCP server of the service provider. (See Annex A of Y.1546.)
2 DNS response time	Defines a round-trip delay metric for IP networks. (See RFC 2681.)
3 Number of IP network interconnection points	This metric is a count of the number of interconnection points to other autonomous systems (AS), based on creating a diagram of the network being measured according to the procedures specified in RFC 7398.

Parameter	Definition
4 Round-trip delay (RTT to IP network interconnection points)	This metric measures the round-trip delay between subscriber service demarcation points and the interconnection points to ASs. Sometimes these interconnections occur at public Internet exchange points (IXP). (See RFC 2681 for the round-trip delay.)
5. IP delay variation (one-way delay variation to IP network interconnection points)	The one-way delay variation performance parameter is defined in Y.1540.
6 IP packet loss (one-way packet loss to IP network interconnection points)	The one-way packet loss performance parameter is defined in Y.1540.
7 Data rate (download and upload)	Defined with 7.1 and 7.2 in this table.
7.1 Mean data rate achieved: is the average of the data transfer rate achieved for a given number of samples [1)]	This is the average of the data transfer rate achieved for a given number of samples, i.e.: $\text{Mean Data Rate achieved} = \frac{\sum_{i=1}^{N} H_i}{N}$
7.2 Percentage of the mean data rate: denotes the deviation between the data rate contracted / advertised to the achieved data rate [2)]	Denotes the deviation between the data rate contracted / advertised to the achieved data rate, that is equal to: $\frac{Mean\ Data\ Rate\ achieved}{Data\ Rate\ contracted} \times 100\%$
8 Internet IP network service availability	Represents the fraction of time probability that the end-user is able to access IP Network packet transfer Internet services via his/her access to Internet connection. (See Y.1540, Section 7.)
9 Radio coverage availability	Not defined in Y.1545.1 (further study is required).

[1)] The payload stream should consist of incompressible data. This is normally achieved by generating a sequence of random numbers. Another practical solution can be to use a stored stream that is already compressed, e.g. from a zip or jpg file, or to use the digits of the number Pi. The payload stream should have at least twice the length (in kbit/s) of the theoretically maximum data transmission rate per second (in kbit/s) of the Internet access under consideration.

[2)] In this case, a given regulator can set a target of for example 70 per cent, 80 per cent, etc. of the maximum data rate contracted by the subscriber, depending on the country's ICT Market.

Table 6.7: Advantages and disadvantages of active and passive methods of measurements

Measurement method	Advantages	Disadvantages
Active methods	The data (probing packets) is originated from a controlled source with predefined settings and therefore types of services can be fully controlled Easy benchmarking / comparison between measurements obtained from different internet connections provided by different ISPs	– Requires that the line under testing be fully available – Test design must be sure the line is idle before testing

Measurement method	Advantages	Disadvantages
Passive methods	The probe only needs one connection point to the network which means less hardware Does not *take over* the line under test, so it is never an inconvenience to end-users	– Unknown traffic type makes it difficult to test maximum line capability – Difficult to average different tests as the data traffic is not consistent

Source: ITU-T Rec. 1545.1

6.4.1 Testing tools classification by ITU

According to Y.1545.1, testing tools can be hardware-based or software-based. Hardware-based tools can have at least the following options of implementation:

- Option 1: Probes replace completely the end-user equipment and no other equipment can be connected to the Internet access while the probe is performing measurements. This is applicable for both fixed and mobile Internet access.
- Option 2: Probes share the Internet access with ordinary traffic. For example, probes can be connected to the customer residential gateway. Appropriate probes can monitor the end-user traffic behaviour and perform the tests only when there is no traffic being transferred.
- Option 3: A testing application programming interface (API) is embedded into the customer residential gateway, through a firmware update, in order to act as a probe and test the fixed Internet connection.

On the other side, there are at least three kind of software based tools:

- Web-based tool: Download and execution of measurement software is initiated via the end-user web browser by accessing a specific web page.
- Dedicated software client: Measurement software is permanently installed on the end-user terminal equipment. In this case, different versions of software are needed to support different operating systems and terminal equipment.
- Testing API: An API can be included into the code of one popular website in order to perform the test transparently each time users access the website.

No matter what type of test tool is chosen, test tool specifications should be sufficiently detailed so that two independent implementations of the tools should measure statistically equivalent performance (with high confidence) when measuring the same network path under the same conditions.

6.4.2 Quality of service evaluation scenarios by ITU

Scenarios usually applied in order to evaluate the QoS of IP network service (i.e. Internet access services) can be classified into two main types:

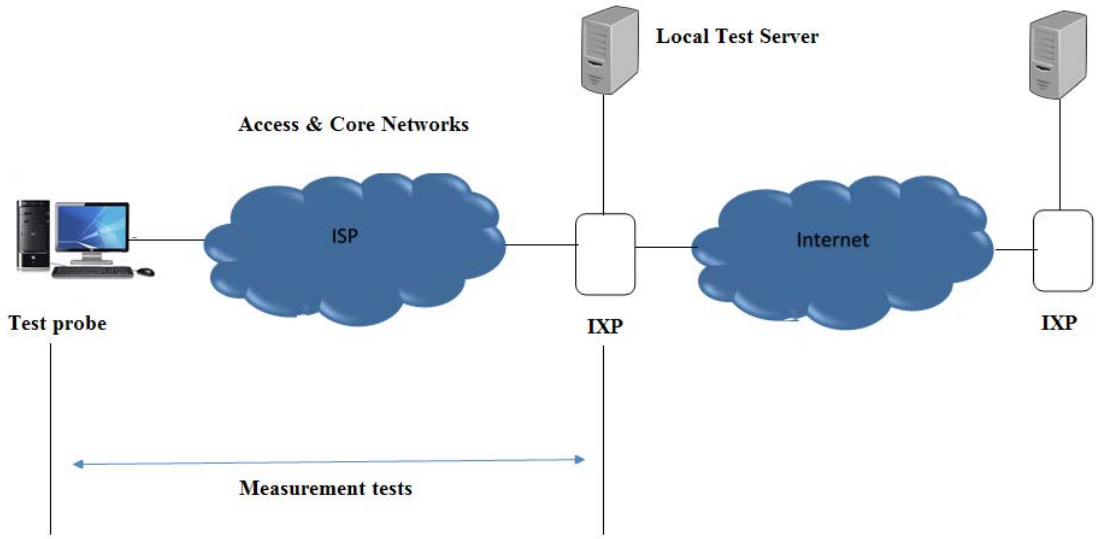
- evaluation scenario at national level (test server located at local IXP);
- evaluation scenario at international level (test server located at an international IXP).

Measurements are conducted on the selected QoS parameters that have an impact on the user experience when utilizing IP network service.

In the evaluation scenario at national level, the test server is located at the local IXP and probes are installed at the end-user point of view. Measurements are carried out by regulators with or without the involvement of ISPs, and the measurement path includes a complete Internet connection from customer to the test server located at the local IXP. ISPs or regulators can use standardized hardware

or software-based probes (when they are available). In this evaluation scenario, tests initiated by probes are directed to the local IXP when testing local KPIs (such as download/upload mean data rate, latency), as illustrated in Figure 6.12.

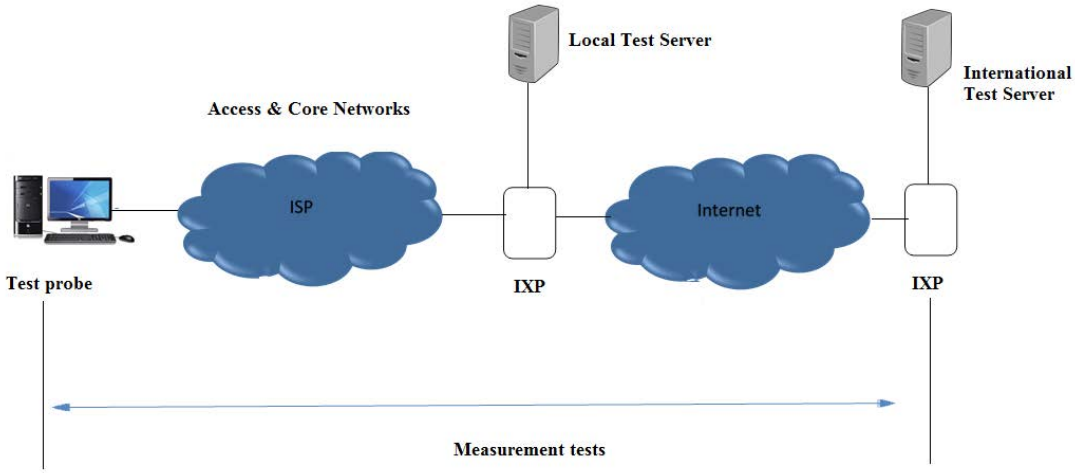
Figure 6.12: Set-up of measurements of Internet QoS at national level



Source: ITU-T Rec. 1545.1

In the evaluation scenario at international level (illustrated in Figure 6.13), the test server is located at an international IXP (e.g. may be installed in another country or even another continent). Usually, the Internet connection that ISPs provide to customers is to the entire Internet. Therefore, the more bandwidth capacity in the ISP connections, the better the quality of Internet connection provided by ISPs will be. This scenario allows regulators to test international data transmission KPIs (such as download/upload data rate, delay). This further allows the comparison between the connectivity of IP-based services inside and outside the country (different countries/continents).

Figure 6.13: Set-up of measurements of Internet QoS at international level



Source: ITU-T Rec. 1545.1

6.4.3 Important considerations about the sampling methodology

The number of probes to be used in testing the QoS of Internet measurements should be enough to guarantee that the data collected are representative for that region and sufficient from a statistical perspective. Further, the data collection plan should be designed in order to ensure that the results sufficiently reflect the QoS as perceived by the user.

It is recommended that the selection of panellists (end-user access points, where to install probes) should take into consideration various factors such as technologies (e.g. xDSL, fibre optic, wireless/mobile networks), Internet data rate packages (depending on popularity), location, and be based on a voluntary process in order to avoid ISP traffic prioritization for those users being tested (which could lead to unrealistic results in favour of ISPs).

Detailed post-processing and statistical methods can be found in ITU-T Rec. E.804 (Chapter 11).

Important considerations regarding Internet QoS measurements include the following:

- Selecting access lines for each speed package: The sampling methodology should have a stable level for the confidence intervals obtained in different regions and for different ISPs. If the final results of the access lines per ISP correspond almost to the market share of the ISP, it is likely to mean that the sampling criteria followed by the national measurement campaign are representative. However, there is a difference between fixed and mobile access to Internet in selecting the access point:
  - *Mobile Internet*: It is possible to measure QoS only where coverage is ensured by selecting a number of hotspots for measurements across the country. This can be calculated depending on the size of the country, geographic coverage percentage, and classification of rural, urban and suburban areas.
  - *Fixed Internet*: Selection of access points for fixed ISPs is quite challenging as in order to perform the measurements, it is necessary to enter the consumer's premises in most cases. This problem is faced by both regulators and ISPs. However, this obstacle may be overcome through the development of cooperation between regulators, consumers and ISPs. Experience in this regard shows that in order to develop cooperation and attract sufficient numbers of volunteers, each attempt should be led by an appropriate advertising campaign and publication of information using different media channels.
- Selecting the measurement moments: The moments for the measurements should in principle cover high and low traffic, including peak hours. However, for simplicity, the measurements may cover only high traffic, including peak hours. If the IAS is working properly in peak hours (or at least in high-traffic hours) the conclusion could be made that quality in low-traffic hours should be even more acceptable. The frequency of the measurements should be based on the number of users participating in the campaign, the option(s) taken for the overall set of measurements, and the level of statistical error and confidence intervals acceptable for the project.

6.5 Issues for consideration

What happens with multiple flows over the same Internet access?

Well, different services or applications that are provided via public Internet access toward end-users share available bandwidth (i.e. bit rates) in the uplink (UL) and downlink (DL). For example, if you have 10 Mbit/s bandwidth in DL, and you download with HTTP or FTP ten files in parallel over that bandwidth, then each connection (download) will have less than 1/10th of the DL bandwidth. That means congestion also occurs on the user side. Most of the non-real-time applications use TCP/IP, where TCP is designed to provide congestion control on the two ends (client and server) by adapting its speed to the available bandwidth and by sharing the available bit rate equally with other TCP flows

over the same connection. However, it is possible (even in the above example) that some TCP flows will have lower bit rates due to some other bottleneck from end-to-end between the client and server, which can be anywhere on the path.

Real-time services (services sensitive to delay) such as VoIP (e.g. Skype, Viber) use RTP over UDP/IP for transfer of the user data (that is voice in the case of VoIP). In such cases, retransmission does not fill the lost packets as TCP does, but results in losses in the given flow (e.g. in VoIP flow). Each user can see the download or upload speed (e.g. via web browser or FTP client software for download/upload). Each user has a certain experience regarding Internet access services (bit rates, delay) at a given time.

Can the end-user be trusted regarding the measurements?

It depends…. If it is about the availability/unavailability of an Internet access, or about significant decrease in the bit rates or increase in the delay, then it may trigger an action toward operation and maintenance on the ISP side (e.g. to repair broken Internet access links or equipment). But, if it is about Internet access QoS on average, then the user cannot make valid measurements by himself/herself (e.g. doing speed tests at certain times). Measurement must be made through certain software (or hardware) installed as an agent (or probe) on the end-user side (with user agreement on that), which will provide periodical measurements on the specified QoS parameters (RTT delay and jitter with ping, downlink and uplink speed with HTTP), taking into account background traffic over the same Internet access and capabilities of the user equipment (e.g. memory, processor, etc.).

Other issues for considerations include the following:

- **Traffic management** is being applied and should be applied in the operator networks, such as ISPs.
- The **network neutrality** based Internet access service must have QoS guarantees on given parameters, such as bit rates in UL and DL, RTT delay, jitter and packet losses (all dependent upon services).
- **QoS for the Internet access service** provided by the ISP should be measured on the end-user side. That requires Internet measurement tools and platforms. There are free available measurement platforms (e.g. M-Lab, RIPE Atlas), and free measurement tools (e.g. SpeedTest, Glasnost, NDT). Many NRAs (e.g. in Europe) have their own tools for Internet QoS measurements on the end-user side.
- **Many factors influence the measured data**, such as other networks on the end-to-end path, background traffic from other applications, type of network (fixed, mobile, and which technology 3G, 4G, etc.), user equipment, traffic management techniques applied by the ISP for the given tariff package, etc. So, this is not a *linear game*. Much knowledge is needed to understand how broadband works in order to regulate it.

7 Economic principles of quality of service regulation

For the purposes of this manual, QoS is directly related to the pricing of services in commercial environments. The focus here is on pricing in an IP environment.

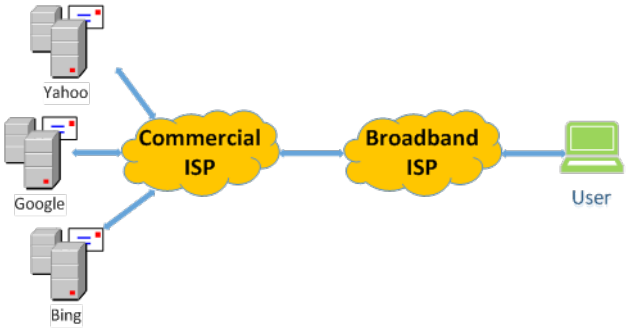
7.1 Two-sided market

Every electronic communications market is in some sense a two-sided market, however, in not every case will a two-sided market analysis provide information that was not available in a conventional analysis. In end-to-end connections, traffic goes through telecommunication operators that provide access to individual end-users (called here broadband ISPs) and commercial ISPs that provide access to the global Internet to telecommunication operators on one side and to content providers (e.g.

Google, Yahoo, Bing, etc.) on the other side. QoS as an end-to-end feature is dependent upon all network players from end-to-end, driven by the market forces on national markets (for broadband ISPs toward end-users) and international markets (for commercial ISPs). Key observations regarding two-sided markets include:

- Promotion of usage is an important societal goal.
- Usage entails two distinct components, characterized by subscription elasticity and usage elasticity.

Figure 7.1: Internet as a two-sided market



Areas where two-sided markets have been considered for electronic communication services include voice call termination payments, network interconnection, as well as arrangements between network operators and content providers, especially in terms of QoS.

The Internet can be thought of as a two-sided market, with the network operators collectively serving as a platform connecting providers of content (e.g. websites) with consumers (Figure 7.1). This interpretation also suggests that quality differentiation is unproblematic. Under this view, some issues are simply about how costs and profits should be divided between the network operators and the two (or more) sides of the market.

When a producer with market power in one market segment attempts to project that market power into upstream or downstream segments that would otherwise be competitive, this constitutes economic foreclosure. Foreclosure should be avoided as it harms consumers, and imposes an overall socio-economic deadweight loss on society. Foreclosure could be a concern in markets where significant market power (SMP) is given free rein.

7.2 Quality of service and pricing

This section is based on ITU report *IP-based networks: Pricing of telecommunication services*. In the past, telephone networks used time-of-day as an element for pricing. Subscription charges are the flat rate charge, with usage being charged on a per-minute (or per-second) basis, and typically varying according to the time of day. The idea with time-of-day pricing is to dissuade callers with low demand from usage during the most congested period, encouraging them to shift their usage to a period when per-minute charges are much lower. This was optimal because the capacity investment costs required to handle the traffic from subscribers with weak demand during peak usage were higher than the present value of their willingness to pay for the capacity needed to satisfy that demand. However, since then, the approaches have changed to mainly flat fee charges regardless of the volume of the voice traffic (on a national basis) since access became broadband (with Mbit/s or tens of Mbit/s per user), and the bandwidth (in bit/s) for voice connections has no changes over time during the connection (i.e. voice requires near constant bit rates in each direction), hence capacity can generally accommodate that. Telephony services with guaranteed QoS provided by fixed and mobile operators have faced competition from OTT voice providers since 2003 (e.g. Skype, Viber, and others). Therefore,

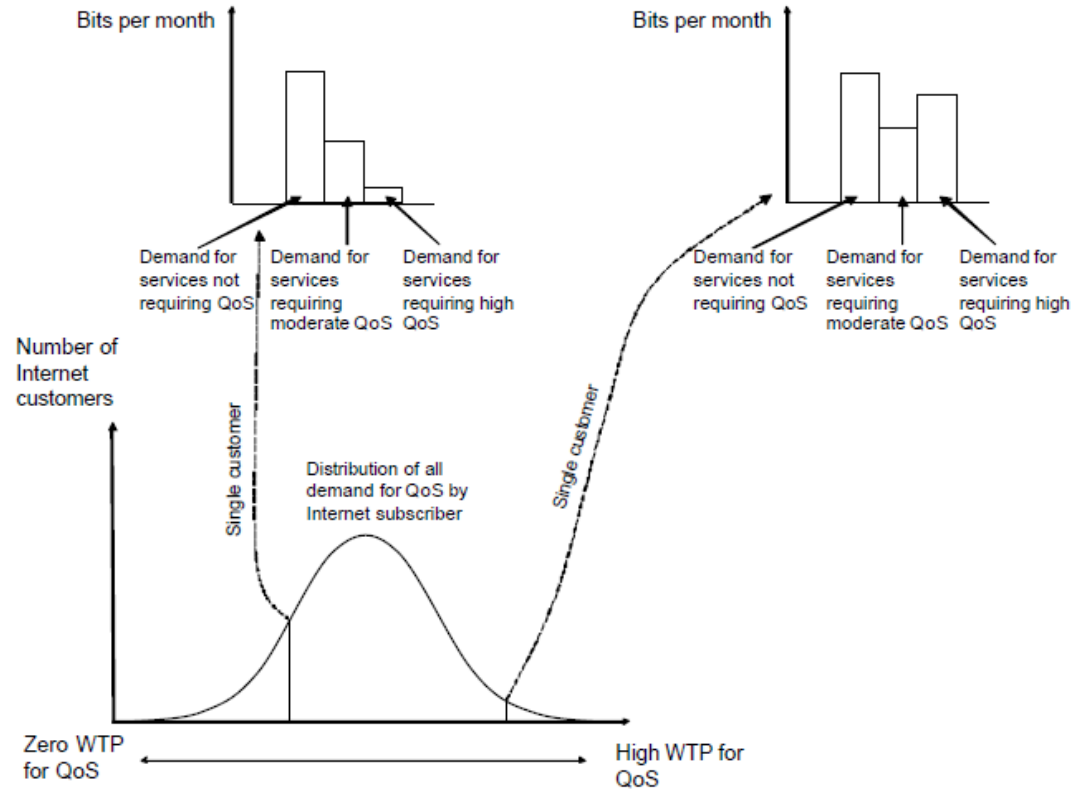
charging per minute or per second is being less applied today (e.g. it is primarily applied for roaming calls on mobile networks).

As further detailed in the ITU report on IP-based networks, the pricing of telecommunication services for Internet access service is also related to QoS as pricing has an influence on the demand for a given service and hence has influence on congestion. For example, a lower price for a service increases the consumption of that service, which in turn increases traffic and hence the probability for congestion. Usage-based pricing can be designed to shift some demand from peak to un-peak periods. It can also signal to ISPs when demand is high enough to make it economically worthwhile for them to increase the capacity of their networks. The idea is that customers should rationalize their own usage during periods of congestion according to the relative strengths of each user's demand. For users with very low demand (say, a willingness to pay for service during a congested period of zero, assuming they can use the service during uncongested periods at no marginal cost), there is little benefit gained in terms of QoS by doing so compared to the costs imposed. At times of congestion, however, the cost of sending extra packets would include the additional delay, packet loss and QoS degradation imposed on other users.

When the Internet is uncongested, experience has shown that usage-based pricing is not helpful; it actually has a detrimental effect on economic welfare as explained in the ITU report. At these times, the cost of sending an additional number of packets is virtually zero. We say that the marginal cost of usage is zero, and it is a demonstrable economic axiom that under these circumstances a usage sensitive price is inefficient – it reduces economic welfare – therefore in those circumstances flat-rate pricing is more appropriate.

Another issue identified with time-of-day pricing in an IP environment is that the Internet is made up of many networks, and even in the same time zone, peak usage may well occur at different times in different places. Moreover, an ISP providing transit to several ISPs, some of which have different peak usage times, suggests that different prices would apply at the same time of day to ISPs that are in the same market competing (on the margin) with other ISPs, even if their traffic/time patterns are not the same. This may raise competition neutrality concerns. Therefore, time-of-day pricing is not suited for Internet services.

Figure 7.2: Demand for Internet service deconstructed



Source: WIK-Consult

Finally, the demand for high QoS for services has an influence on customer willingness to pay for higher QoS (Figure 7.2). If the demand for services that require high QoS is very low (compared to demand for services not requiring QoS), then the willingness to pay for high QoS will be also very low. In such a case, telecommunication operators (which are in fact the ISPs nowadays) will have lower interest in QoS. When the demand for services that require high QoS is comparable with demand for services not requiring QoS, then the willingness to pay for QoS is higher. For example, consumers want and are willing to pay for QoS for IPTV (as replacement for traditional TV), VoIP (as replacement for PSTN/ISDN), business services (e.g. virtual private networks – VPNs, as replacement of leased lines), as well as future smart services (e.g. smart cars, smart homes, smart sustainable cities, etc.).

8 Network neutrality and its regulation

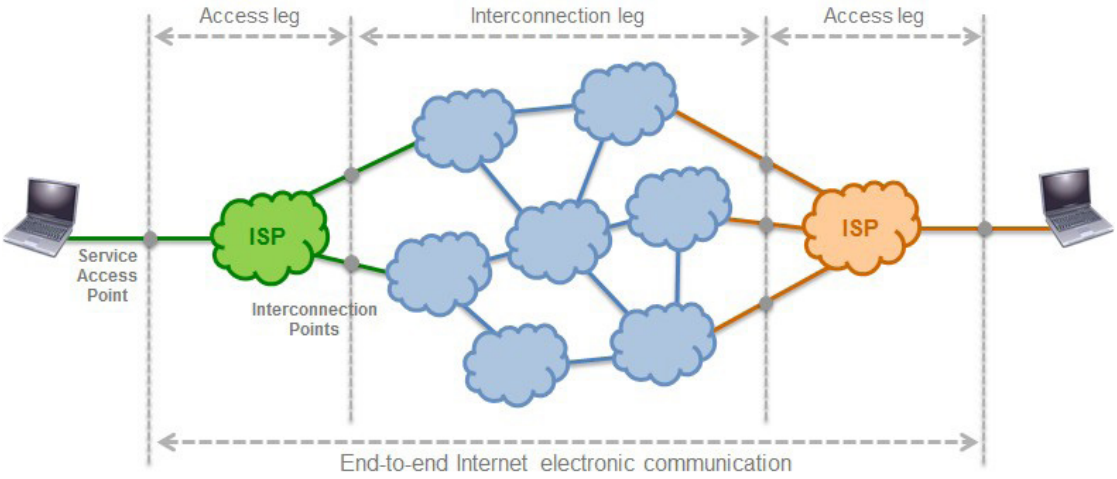
As outlined in ITU Trends in Telecommunication Reform 2013, net neutrality broadly refers to the principle that all Internet traffic should be treated equally. Neutrality proponents claim that telecommunication companies seek to impose a tiered service model in order to control the pipeline and thereby remove competition, create artificial scarcity, and oblige subscribers to buy their otherwise uncompetitive services. Opponents of net neutrality regulation also argue that the best solution to discrimination by broadband providers is to encourage greater competition among such providers, which is currently limited in many areas.

Network neutrality has taken on various meanings, such as in the European Union where it is defined as:

- The ability of all Internet end-users "*… to access and distribute information or run applications and services of their choice*."
- Traffic "*… should be treated equally, without discrimination, restriction or interference, independent of the sender, receiver, type, content, device, service or application*."
- Absence of unreasonable discrimination on the part of network operators in transmitting Internet traffic.

These definitions are not exactly equivalent and do not have the same implications for public policy on the matter. In particular, *all traffic to be treated equally* potentially runs counter (in the more extreme interpretations) to any form of differentiated QoS, while the other definitions do not necessarily prohibit differentiated QoS.

Figure 8.1: Different elements in end-to-end Internet communication



Source: BEREC

Two types of degradation of Internet service(s) were identified by BEREC:

- Degradation of Internet access service (IAS) as a whole: To identify cases of degradation of IAS as a whole, where monitoring the service quality, either proactively or reactively is necessary.
- Degradation of Internet access service with regard to individual applications: In this case individual applications are differentiated in the access part, which may result in congestion and hence require traffic management, and/or network security and integrity protection. In this regard, traffic management mechanisms are used by ISPs to optimize the flow of traffic within their networks. Traffic management can be used to implement both limiting measures (such as blocking and throttling) and enabling measures (such as routing and traffic forwarding). Congestion is the situation met in IP networks when traffic increases to a level at which routers run out of buffer space and are forced to start dropping some IP packets, which typically occurs randomly. Network security and integrity is the protection against externally or internally caused malfunctioning.

To define these cases, BEREC provides the following definitions of the basic concepts:

- Internet: The Internet is the public electronic communications network of networks that use the Internet Protocol for communication with endpoints reachable, directly or through network address translation, via a globally unique Internet address.

- Internet access service: This term refers to a publicly available electronic communications service that provides connectivity to the Internet.
- Specialized services: This term refers to electronic communications services that are provided and operated within closed electronic communications networks using the Internet Protocol. These services rely on strict admission control and extensive use of traffic management in order to ensure adequate service characteristics.
- Internet (electronic) communication: This term is used to refer to the general end-to-end communication provided over the public Internet (Figure 8.1).

When degradation of services by an ISP is noticed, the regulatory authority may intervene and consider imposing minimum QoS requirements. The basic approach to this would be to require the ISP to improve service quality until degradation is eliminated.

8.1 Main regulatory goals of network neutrality by BEREC

Under the framework for quality of service in the scope of net neutrality provided in the BEREC report, and regarding end-user rights, end-users should be able to decide what content they want to send and receive, and which services, applications, hardware and software they want to use for such purposes, without prejudice to the need to preserve the integrity and security of networks and services.

In order to prevent degradation of service and the hindering or slowing down of traffic over networks, countries should ensure that the regulatory authority is able to set minimum QoS requirements on an undertaking or undertakings providing public communications networks. The regulatory authority has the discretion to decide whether to apply any necessary minimum QoS requirements to one, to several, or to all ISPs, and will be able to impose minimum QoS requirements after having identified an instance or a risk of degradation of service, or hindering or slowing down of traffic.

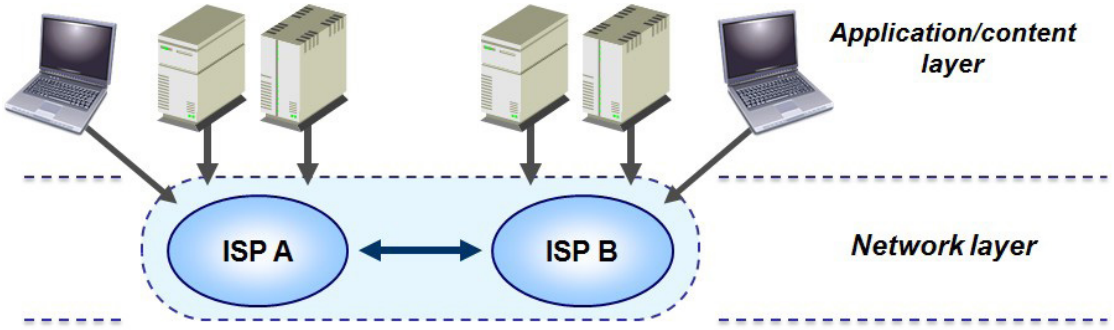
As defined by BEREC, the main regulatory goals of net neutral Internet access services QoS are targeted at:

- achieving the overarching objective of guaranteeing access to content for the interest of citizens;
- ensuring that electronic communications networks run smoothly, in other words to guarantee satisfactory QoS;
- enabling long-term development of the networks and services based on innovation and the development of the most efficient technical and business models; competition plays a fundamental role here, hence the importance of the regulatory authority objective of "*ensuring that there is no distortion or restriction of competition in the electronic communications sector, including the transmission of content*".

The technical aspects to consider in the regulatory processes include the relationship between QoS, QoE and network performance. It is essential to have a clear understanding of the relevant quality concepts and approaches from a technical point of view:

- Network and application layers: the two-layer model (a simplified view of layering model) describes how content and applications relate to the underlying IP network (Figure 8.2).
- Distinguishing between Internet access service and specialized services: specialized services intrinsically offer contractual terms ensuring quality of provision.

Figure 8.2: The two layer model: application/content layer and network layer



Source: BEREC

8.2 Network neutrality business aspects

Regarding relevant market developments, growth in fixed Internet traffic is driven more by the increasing volumes of data being used by each subscriber rather than an increase in the number of subscribers. Whereas growth in mobile data traffic is driven by an increase in the number of subscribers, it is not just the increase in connections which has driven higher traffic. Increased take-up is led by a combination of factors – the availability of powerful mobile devices, fast mobile networks and the ever-growing availability of Internet content and applications (many of which are mobile-specific) – providing the means for consumers to download and upload an increasing quantity of data. However, while overall data traffic is increasing, the growth rate of traffic is declining over time for fixed and mobile networks.

On the business side, the revenues of operators are coming under pressure as a result of a range of market developments. Fixed line voice revenues have long been in decline, mainly from substitution by mobile, but also increasingly from VoIP telephony. In addition, SMS revenues are under threat as, thanks to smartphones and applications such as WhatsApp, consumers can send SMS over IP messages without paying their operator a fee. However, users still have to pay the mobile (or fixed) operator the cost of the Internet access (either flat fee or volume-based fee).

Operators have the option to respond to the rising demand for broadband, traffic growth and the call for infrastructure investment by putting in place traffic management tools to address congestion issues. They can also introduce new business models. As noted by BEREC, ISPs can employ a mix of business models:

- Mobile operators may apply data caps to their tariffs as a way to manage traffic growth.
- They can apply price differentiation based on providing some kind of added value. For example, it can be used for providing faster broadband speeds or *gamer tariffs* that provide the required latency levels to ensure a good gaming experience. Another example is the assured QoS needed for continuous HD streaming.

BEREC further explains that within the context of the IP interconnection market, ISPs that purchase their access from wholesale providers are dependent on the networks of others and may have less control of how traffic is managed and on the QoS delivered to their end-users. Content and application providers may try to prioritize their data delivery.

Differentiation of Internet access service offers is also an important issue. Differentiation of applications regarding traffic management can be done in two main ways:

- Application-agnostic traffic management: treats all applications similarly (e.g. IP packets from all applications put in the same forwarding queue).

- Application-specific traffic management: treats individual applications differently (e.g. VoIP is blocked or P2P is throttled while other applications are not).

8.3 Role of the NRA in the regulation of network neutrality

The need for intervention from the NRA will depend on the quality of the Internet access service and its monitoring and evaluation is necessary to detect degradation. Degradation of the IAS as a whole includes the following possible cases:

- ISPs prioritize specialized services at the expense of the IAS as a whole.
- Internet traffic load grows faster than the increase in available capacity.
- IAS of sufficient quality is accessible to only a limited number of users.

The degradation of the Internet access service as a whole is illustrated in Figure 8.3. In this scenario, the IAS-providing ISPs (ISP1) will not be able to directly control the performance beyond its own interconnections to neighbouring networks (ISP2 and ISP3), but ISPs make interconnection agreements after investigating network performance needs and negotiating with peering and transit partners.

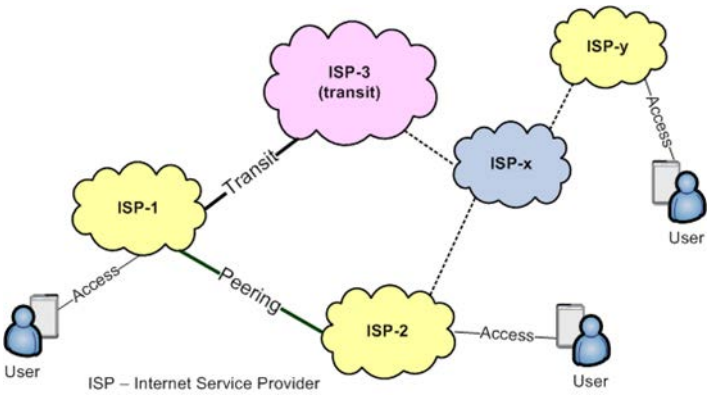
Degradation of IAS with regard to individual applications happens**:**

- VoIP blocking on mobile Internet access services;
- P2P blocking or throttling on mobile or fixed Internet access services;
- differentiation of traffic from content and application providers.

Keeping in mind the possible causes for IAS degradation, the question raised is when is regulatory intervention needed? As noted by BEREC, the market situation should be evaluated to determine whether the problem calls for an intervention taking into consideration:

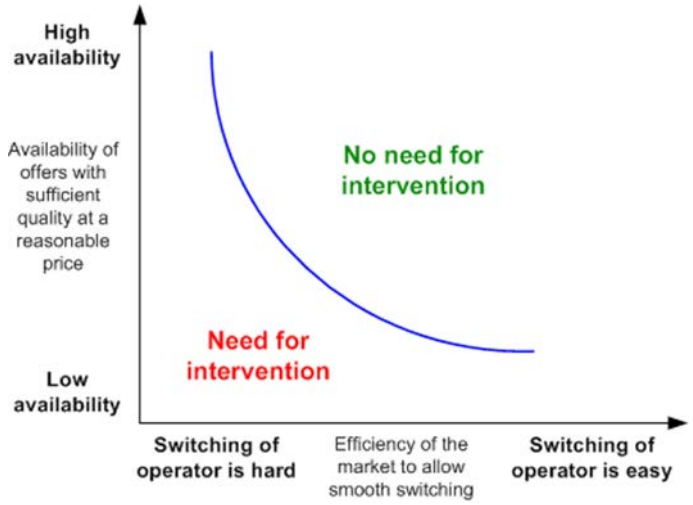
1) the availability of such offers;
2) the ease of switching in a broad sense (switching means the changing of the ISP by the customer), including all burdens faced by customers, such as the price difference between offers.

Figure 8.3: Degradation of the Internet access service as a whole for end-to-end communication between end-users



Source: Based on BEREC guidelines for quality of service in the scope of net neutrality

Figure 8.4: When is regulatory intervention needed?



As stated by BEREC, there is no need for intervention when there is good availability of Internet access service offers with satisfactory quality (i.e. without degradation) at a reasonable price, and the possibility and ease of switching is sufficient.

Regarding the role of the NRA in imposing minimum QoS requirements for IAS, BEREC foresees a regulatory process of up to six steps to determine whether and how to impose minimum QoS requirements:

Step 1: The NRA will typically identify situations that may need further attention.

Step 2: The NRA will perform an evaluation of quality indicators to verify the indications/symptoms and analyse the results in order to determine whether to intervene.

Step 3: If regulatory intervention is needed (based on step 2), the NRA will have to choose which regulatory tool to use.

Step 4: The NRA decides on the type of requirements.

Step 5: he NRA drafts decision and notification.

Step 6: Final decision by the NRA for minimum QoS requirements, and monitoring for compliance.

8.4 Network neutrality regulation case studies

Regulation of network neutrality has been considered within in the context of QoS both in developed and developing countries. This section describes the actual evolution of network neutrality practices, legislation, and regulation in the United States of America and the European Union where the discussion is most advanced.

Countries have taken different approaches to net neutrality regulation[29], including developments in India, where rules against price discrimination were adopted in 2016 (detailed later in this section).

[29] See for example: RATEL (Serbia), *Rulebook on quality parameters for publicly available electronic communication services and monitoring of electronic communication activity*, Official Gazette of RS no. 3/14, 2014, www.ratel.rs/upload/documents/Regulativa/Pravilnici/Telekomunikacije/Rulebook%20on%20quality%20parameters%20for%20publicly%20available%20electronic%20communication%20services.pdf

Another example is Brazil and its Civil Rights Framework for the Internet. Different approaches can include:

- Cautious observation: where countries have currently chosen not to take any specific measures as they may feel no specific action is required; the current regulatory framework may be deemed sufficient;
- Tentative refinement: Where countries have adopted a light-handed approach – e.g. disclosure and transparency, lowering switching barriers, minimum QoS – with some refinements to the existing regulatory regime governing communications services, light-handed net neutrality measures, but not going so far as to prohibit certain behaviours; and
- Active reform: Where countries have taken specific regulatory measures to prohibit specific behaviours by ISPs, often subject to reasonable network management practices.

There is no clear global consensus or one best approach to deal with network neutrality. Several approaches exist, as mentioned above, and the approach taken will depend on each country's respective national circumstances.

8.4.1 Network neutrality regulation in Europe

In the European framework, market power is a key concern. Regulation addresses last mile market power in the fixed network, both for PSTN and for Internet, thus fostering competition. Internet interconnection is generally unregulated to the extent that market power does not seem to be a concern; however, there is no blanket exemption from regulation.

Revisions to the 2003 European regulatory framework were enacted in 2009. The ability of end-users to access content, applications or services of their choice is now an explicit goal of European policy.

Providers of electronic communication services must inform end-users of their practices in regard to traffic management, and provide end-users with the right to change providers without penalty if they are dissatisfied with a change in these practices. The revised framework empowers NRAs to impose, if necessary, minimum QoS obligations on an SMP operator[30]. The approach is based on informed consumer choice rather than explicit prohibitions.

On 11 September 2013, the European Commission proposed a Telecoms Single Market (TSM) Regulation to the European Parliament. Network neutrality was a small but important part of the original legislative proposal; Net neutrality and mobile roaming were the only elements of the TSM proposal that were maintained in the subsequent legislative process.

In November 2015, the European Parliament and the Council enacted Regulation EU 2015/2120, which deals with network neutrality and international mobile roaming. As a regulation, it takes effect in all EU Member States without the need for transposition into national law. Key elements of regulation 2015/2120 include:

- Rights of end-users: "*End users shall have the right to access and distribute information and content, use and provide applications and services, and use terminal equipment of their choice, irrespective of the end user's or provider's location or the location, origin or destination of the information, content, application or service, via their Internet access service*."
- Traffic management**:** Providers of Internet access services *"(are not prevented) from implementing reasonable traffic management measures. In order to be deemed to be reasonable, such measures shall be transparent, non-discriminatory and proportionate, and shall not be based on commercial considerations but on objectively different technical quality of service requirements of specific categories of traffic*."

[30] J. Scott Marcus, *New Network Neutrality Rules in Europe: Comparisons to Those in the U.S.*, May 2016: http://bruegel.org/wp-content/uploads/2016/09/v2.final-Marcus-5.24.16.pdf

- Prohibited practices: Network operators may not "*block, slow down, alter, restrict, interfere with, degrade or discriminate between specific content, applications or services, or specific categories thereof, except as necessary, and only for as long as necessary, …"* in order to comply with legal requirements; preserve the integrity of the network or of end-user equipment; or deal with network congestion "*provided that equivalent categories of traffic are treated equally*".
- Specialized or managed services**:** Network operators, as well as content and application providers, are "*free to offer services other than Internet access services which are optimized for specific content, applications or services, or a combination thereof, where the optimization is necessary in order to meet requirements of the content, applications or services for a specific level of quality*." These services can be offered "*only if the network capacity is sufficient for their provision in addition to any Internet access services provided*."

Regulation EU 2015/2120 goes beyond the changes enacted in 2009, which had ensured that consumers must be informed of network operators' practices, and could switch without penalty if they refused a change. With regard to network neutrality, the regulation further includes the following definitions:

- Overall broadband quality: "*Any significant discrepancy, continuous or regularly recurring, between the actual performance of the Internet access service regarding speed or other quality of service parameters and the performance indicated by the provider of Internet access services … shall, where the relevant facts are established by a monitoring mechanism certified by the national regulatory authority, be deemed to constitute non-conformity of performance for the purposes of triggering the remedies available to the consumer in accordance with national law*."
- Provider of electronic communications to the public**:** Means an "*undertaking providing public communications networks or publicly available electronic communications services*."
- Internet access service: Means "*a publicly available electronic communications service that provides access to the Internet, and thereby connectivity to virtually all end points of the Internet, irrespective of the network technology and terminal equipment used*." This refers to network neutral traffic (not to managed traffic such as QoS-enabled VoIP as PSTN/ISDN replacement or QoS-enabled IPTV).

It further states that "*Providers of Internet access services shall treat all traffic equally, when providing Internet access services, without discrimination, restriction or interference, and irrespective of the sender and receiver, the content accessed or distributed, the applications or services used or provided, or the terminal equipment used*." In that manner, providers of Internet access services shall ensure that any contract which includes Internet access services specifies at least the following:

- "*information on how traffic management measures applied by that provider could impact on the quality of the Internet access services, on the privacy of end users and on the protection of their personal data;*
- *a clear and comprehensible explanation as to how any volume limitation, speed and other quality of service parameters may in practice have an impact on Internet access services, and in particular on the use of content, applications and services;*
- *a clear and comprehensible explanation of the minimum, normally available, maximum and advertised download and upload speed of the Internet access services in the case of fixed networks, or of the estimated maximum and advertised download and upload speed of the internet access services in the case of mobile networks, and how significant deviations from the respective advertised download and upload speeds could impact the exercise of the end-users' rights …*
- *a clear and comprehensible explanation of the remedies available to the consumer in accordance with national law in the event of any continuous or regularly recurring discrepancy between the actual performance of the Internet access service regarding speed or other quality of service parameters…"*

As previously mentioned, QoS is part of consumer protection. Other consumer protection provisions include:

- Supervision and enforcement: "*National regulatory authorities shall closely monitor and ensure compliance with (relevant obligations), and shall promote the continued availability of non-discriminatory Internet access services at levels of quality that reflect advances in technology. For those purposes, national regulatory authorities may impose requirements concerning technical characteristics, minimum quality of service requirements and other appropriate and necessary measures on one or more providers of electronic communications to the public, including providers of Internet access service*s."
- Obligations of providers: This includes that they "*shall make available to that NRA (information relevant to the obligations set out in Articles 3 and 4 in particular information concerning the management of their network capacity and traffic, as well as justifications for any traffic management measures applied*."

Regulation 2015/2120 provides the first EU-wide net neutrality rules being applied in all EU Member States since 30 April 2016. The law sets a common standard for net neutrality throughout Europe.

> Internet providers are required to treat all traffic equally, with no blocking or slowing specific content, applications or services from selected senders or to selected receivers.

Based on its mandate, BEREC published on 30 August 2016, *Guidelines to National Regulatory Authorities (NRAs) on the implementation of the new net neutrality*. The guidelines provide detailed recommendations for the consistent application of net neutrality rules by national regulators across Europe. They do not alter the content of the rules in place that guarantee freedom of Internet by protecting the right of every European citizen to access Internet content, applications and services without unjustified interference or discrimination.

The rules and guidelines have been established to avoid fragmentation in the single market, create legal certainty for businesses, and make it easier for them to work across borders. These guidelines also ensure that the Internet remains an engine for innovation, both for advanced technologies being developed today-- Internet of Things, services like connected vehicles, 5G applications-- and those that will be developed in the future. Recommendations are designed to provide guidance on the implementation of the obligations of NRAs. Specifically, this includes the obligations to closely monitor and ensure compliance with the rules to safeguard equal and non-discriminatory treatment of traffic in the provision of IAS and related end-user rights.

Regarding network neutrality in Europe, as presented by BEREC[31], the role of European NRAs includes the following activities:

- Supervision:
  - monitoring contract information, commercial practices, traffic management practices and specialized services;
  - by means of assessment of practices in the market, technical measurements, information-gathering.
- Enforcement**:**

  For example, as well as imposing fines on ISPs**, r**equiring them:
  - to deal with degradation of IAS;

[31] BEREC, *Net Neutrality Guidelines*: https://www.ietf.org/proceedings/96/slides/slides-96-tsvarea-3.pdf

  - to cease or revise problematic traffic-management practices;
  - to cease providing specialized services in absence of sufficient capacity for IAS.
- Reporting:
  - NRAs to provide annual reports to BEREC and the European Commission;
  - guidelines set out when to provide reports and what to include in them;
  - BEREC planning to summarise main findings of these annual reports.

To date, network neutrality incidents in Europe have been rare.

In Europe, competition law functions as an ex post complement to *ex ante* telecommunication regulation; however, it is rarely if ever applied to network neutrality challenges. In the United States, by contrast, competition law is largely pre-empted by sector specific telecommunications regulation as a result of a number of court rulings. This is a difference, but perhaps of limited relevance in practice.

8.4.2 Network neutrality regulation in the United States of America

According to regulation in the United States, telecommunication services are subject to numerous regulatory obligations. Information services are subject to fewer explicit obligations as they were felt not to be subject to market power so long as basic services were available on a non-discriminatory basis.

This distinction historically enabled the Federal Communications Commission (FCC) to avoid regulating the Internet core; however, prior to 2002, Internet access was in effect regulated. During the period 2002-2005, the FCC classified broadband access when bundled with Internet service to be an information service (ignoring any last mile market power concerns). This effectively weakened or lifted pro-competitive remedies, thus reversing the growth of retail competition for DSL lines. It also lifted non-discrimination obligations, thus opening the door to possible network neutrality problems.

In 2005, the FCC issued an Internet Policy Statement[32] *"… to ensure that broadband networks are widely deployed, open, affordable, and accessible to all consumers…:*

- *[C]onsumers are entitled to access the lawful Internet content of their choice.*
- *[C]onsumers are entitled to run applications and use services of their choice, subject to the needs of law enforcement.*
- *[C]onsumers are entitled to connect their choice of legal devices that do not harm the network.*
- *[C]onsumers are entitled to competition among network providers, application and service providers, and content providers."*

The Policy Statement reflected the current views of the Commissioners. No specific rules were adopted and no enforcement mechanisms were identified.

The FCC issued an Open Internet ruling in December 2010, which includes the following rules:

"i. ***Transparency****. Fixed and mobile broadband providers must disclose the network management practices, performance characteristics, and terms and conditions of their broadband services;*

ii. ***No blocking****. Fixed broadband providers may not block lawful content, applications, services, or non-harmful devices; mobile broadband providers may not block lawful websites, or block applications that compete with their voice or video telephony services; and*

iii. ***No unreasonable discrimination****. Fixed broadband providers may not unreasonably discriminate in transmitting lawful network traffic."*[33]

[32] FCC: https://apps.fcc.gov/edocs_public/attachmatch/FCC-05-151A1.pdf
[33] FCC: https://apps.fcc.gov/edocs_public/attachmatch/FCC-10-201A1.pdf

The ruling thus imposes fewer burdens on mobile networks. This ruling, too, was aggressively challenged in the courts (Verizon vs. FCC).[34]

In the United States, specialized services are defined by what they are not, namely broadband Internet access services (BIAS). Following the FCC Open Internet Order of 2015[35], BIAS is defined as: "*A mass-market retail service by wire or radio that provides the capability to transmit data to and receive data from all or substantially all Internet endpoints, including any capabilities that are incidental to and enable the operation of the communications service, but excluding dial-up Internet access service. This term also encompasses any service that the Commission finds to be providing a functional equivalent of the service described in the previous sentence, or that is used to evade the protections set forth in this Part.*"

BIAS also "*does not include enterprise services, virtual private network services, hosting, or data storage services.*"

The FCC Report and Order of March 2015[36] goes somewhat further than the 2010 Order.

- No blocking: ISPs *shall not block lawful content, applications, services, or non-harmful devices, subject to reasonable network management*.
- No throttling**:** ISPs *shall not impair or degrade lawful Internet traffic on the basis of Internet content, application, or service, or use of a non-harmful device, subject to reasonable network management.*
- No paid prioritisation**:** ISPs *shall not engage in paid prioritization*.

Paid prioritization refers to the management of a broadband provider network to directly or indirectly favour some traffic over other traffic.

Regarding enforcement, the Order, in Section 5 article 36, states that the FFC may enforce the rules through "*investigation and the processing of complaints (both formal and informal). In addition, the Commission may provide guidance through the use of enforcement advisories and advisory opinions, and it will appoint an ombudsperson. In order to provide the Commission with additional understanding, particularly of technical issues, the Order delegates to the Enforcement Bureau the authority to request a written opinion from an outside technical organization or otherwise to obtain objective advice from industry standard-setting bodies or similar organizations.*"

The order does not regulate Internet interconnection, but reserves the right to intervene on a case-by-case basis. The 2015 Order fully includes mobile networks, where the 2010 Order was stricter with fixed networks than with mobile.

The prohibition on paid prioritization was not explicit in the 2010 Order. The Open Internet Order of 2015 faces any number of challenges over the coming years. For example, it is subject to various court challenges. The situation may likely change following the published notice of proposed rule-making by the FCC to return to a light-touch framework for broadband Internet access under Title I of the Communications Act.[37]

8.4.3 Network neutrality regulation in India

As network neutrality and pricing regulation are directly dependent upon QoS, and as differentiated pricing is related to traffic management techniques and may be considered as jeopardizing the network neutrality rules, the India regulator, Telecom Regulatory Authority of India (TRAI), issued a

[34] https://www.cadc.uscourts.gov/internet/opinions.nsf/3AF8B4D938CDEEA685257C6000532062/$file/11-1355-1474943.pdf
[35] FCC: https://apps.fcc.gov/edocs_public/attachmatch/FCC-15-24A1.pdf
[36] https://apps.fcc.gov/edocs_public/attachmatch/FCC-15-24A1.pdf
[37] https://www.fcc.gov/document/restoring-internet-freedom-notice-proposed-rulemaking

comprehensive public consultation on *Regulatory framework for over-the-top (OTT) services* in 2015. The public consultation considered:

- whether OTT service providers should be explicitly licensed as are traditional communication services as communication service providers (CSPs) (as are traditional telecommunication services), as application service providers (ASPs), or should be treated as bulk users of telecommunication services;
- possible enactment of explicit network neutrality rules; and
- what level of payments between content providers and network operators might be appropriate.

TRAI issued a second public consultation on differential pricing for data services in December 2015. Based on the results of the December 2015 public consultation, TRAI issued a prohibition of discriminatory tariffs for data services regulations in February 2016. The new regulation forbids all discriminatory tariffs based on content. Any agreement that has the effect of a discriminatory tariff is forbidden. An exception is made for closed electronic communications networks, unless such tariffs are offered or charged by the service provider for the purpose of evading the prohibition in this regulation. A narrow exception is made for emergency services, or at times of grave public emergency. This effectively prohibits the practice of zero rating (where the traffic volume for some specific content would not count toward a network operator data cap).

8.5 Challenges regarding quality of service and network neutrality

From a regulatory perspective, the management of quality of service poses numerous challenges. Differentiated management of QoS potentially offers benefits not only to network operators, but also to content and application providers, and also to consumers and other end-users. However, OTT service providers are not entitled to QoS provision for their services due to network neutrality rules (where they are applied).

Striking a sensible balance in QoS approaches is not easy. For example, from the business side (e.g. telecommunication operators), the QoS enabled services have expected higher investment and operational costs due to QoS functions in the networks.

Measures/rules regarding network neutrality in Europe (*Telecoms Single Market Regulation*), the United States (The Open Internet Order of 2015), and other countries (e.g. India, etc.) have been recently enacted, but it is too soon to say how effective they will be in practice in the long term because OTT services, which are provided on a network neutrality basis, are global, while network neutrality rules are national, or regional in the case of the European Union.

Network neutrality is often considered as the key driver of innovation in the application and service space. It came about the same time as the Internet, and in the beginning Internet was based on network neutrality and a best effort approach for service provisioning. However, with the convergence of telecommunication networks and services towards Internet-based networks and services, there is a need for end-to-end QoS in the new all-IP environment.

In this environment, all services are (or will be) transferred over IP-based networks, but not all IP networks belong to the open (i.e. public) Internet space. Network neutrality refers only to IAS, i.e. open Internet access, not to every IP-based network and service. For example, telephony provided over all-IP networks by a telecommunication operator, with QoS guarantees, as PSTN/ISDN replacement, is not part of the public Internet, and network neutrality does not refer to it. On the other side, OTT voice services such as Skype, Viber, etc., are provided via the IAS which is based on the principle of network neutrality, and are part of the public Internet. Then, having all telecommunication services in a single market (which is better for the business side) gives network neutral services that are in fact OTT i.e. data services (e.g. WWW, e-mail, Skype, Viber, Facebook, BitTorrent, etc.) to be provided together with QoS-enabled services (also called specialized services). These include VoIP with QoS guarantees (e.g. NGN voice service as PSTN/ISDN replacement), IPTV with QoS guarantees, business

services with QoS guarantees (e.g. VPNs), IoT services with QoS guarantees (e.g. smart cities), etc., via the same IP-based fixed or mobile access networks, the same core networks and the same transit networks.

8.6 Network neutrality enforcement

Differentiated QoS can bring significant benefits to consumers, network operators, and content and application providers; however, there is also potential for abuse. Any regulatory approach to network neutrality must therefore take great care in order to strike an appropriate balance, preventing harm without also preventing benefits. With that in mind, we suggest the following checklist on criteria against which to evaluate measures to enforce network neutrality as provided in the European Parliament study on net neutrality[38]:

- Is the legislative or regulatory instrument used sufficiently future proof and technologically neutral?
- Does it appropriately balance costs against benefits in general?
- Does the legislative or regulatory instrument used strike the right balance in preventing harmful divergence, while providing appropriate flexibility?
- Does it strike the right balance in preventing harmful differentiation, while permitting non-harmful differentiation?
- Does it enable prioritization of services that legitimately need it, potentially including real-time voice and videoconferencing over the public Internet, mission critical services (including public protection and disaster relief (PPDR), and transport), and health?
- Does it appropriately balance costs and benefits among the different stakeholders?
- Are all terms defined with adequate clarity?

9 Consumer protection and privacy

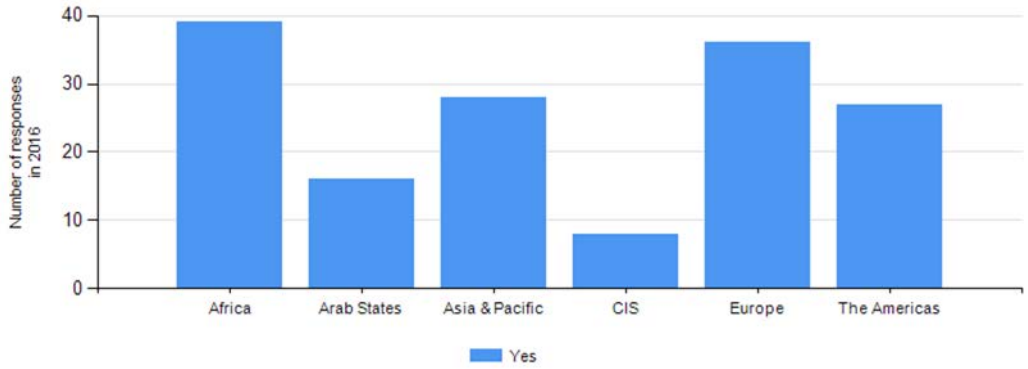
9.1 Consumer protection aspects

Quality of service is important for consumers and is part of consumer protection regulation. The customer/user should have access to QoS information in a clear, transparent, publicly available and appropriate manner. Countries take different approaches to consumer protection with regard to QoS. In 2016, 76 per cent of countries worldwide had a specific telecommunication consumer protection legislation/regulation in place.

A 2013 study by ITU, *Regulation and consumer protection in a converging environment*, found that the most common consumer related provisions addressed by legislation include access to information/transparency, quality of service, equity/right of access to services, protection of personal data, privacy, confidentiality of information, and the right to complain. Less common aspects include a right to end or change a contract, compensation in case of service interruptions, a right to block advertisements, access to emergency numbers, and number portability. Nearly all required network operators to provide consumers with access to pricing/rates information for fixed, mobile, and Internet access and services (for personal computers and smart phones).

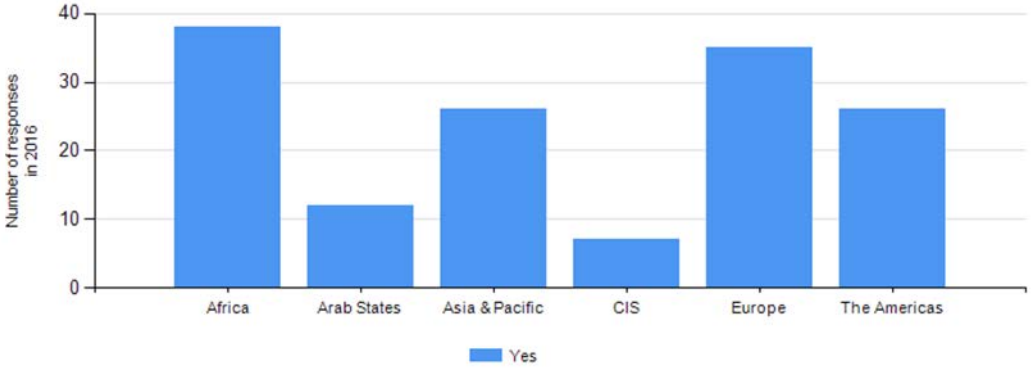
[38] www.europarl.europa.eu/RegData/etudes/STUD/2014/518751/IPOL_STU(2014)518751_EN.pdf

Figure 9.1: Regulator responsible for consumer complaints, 2016



In most countries the national regulatory authority (NRA) is responsible for consumer complaints (Figure 9.1). It is also responsible for consumer education (Figure 9.2). However, regarding the responsibility for tariff information to customers, statistics show that it is mainly the responsibility of regulatory authorities of countries in the Africa region, but in the rest of the world, it can be either the responsibility of the operators or the NRA (Figure 9.3).

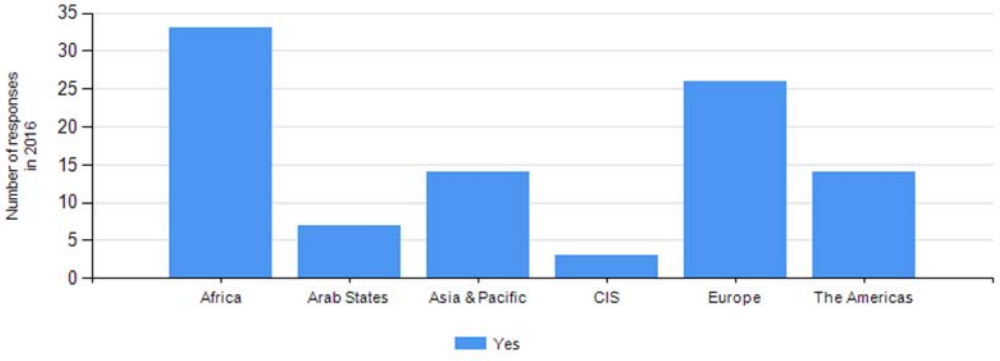
Figure 9.2: Regulator responsibilities for consumer education, 2016



Note: Total country responses: 169 countries.

Source: ITU Telecommunications/ICT Regulatory Database

Figure 9.3: Regulator responsible for tariff information, 2016



Source: ITU Telecommunications/ICT Regulatory Database (Total country responses: 169)

In Serbia for example, according to the rulebook on quality parameters for publicly available electronic communication services and monitoring of electronic communication activity, the operator

is required to publish the offer and the quality parameters for the service provided as per the user contract through various means including in all their retailers, on their website or through information channels such as public media, advertising mail, etc., depending on the type of service. The operator is required to indicate in its general conditions the means by which users can obtain information on quality parameters and data on the minimum level of QoS provision. Among the main concerns (regarding consumer protection) expressed by countries include:

- Out of date legal frameworks**:** Many NRAs are experiencing difficulties in relation to enforcement within the converging environment.
- Challenges within the consumer protection agencies**:** Many respondents were experiencing structural problems within the consumer protection agency or agencies, while others expressed concern about a lack of staff expertise or personnel. Separation of the telecoms regulatory authority from that of broadcasting often led to difficulties.
- Challenges on the consumer side: One-quarter of respondents referred to a lack of consumer education and consumer awareness of their rights.

Adopting best practices for consumer protection: Examples of useful principles identified in the 2013 ITU report *Regulation and consumer protection in a converging environment* to consider in implementing consumer protection and QoS in a world of converged services may be summarized as follows:

Update existing legislation/regulations to make them fit for purpose in a converged regulatory framework:

- *Tackle any potential technical/infrastructure barriers that may deter consumers from subscribing to new products and services.*
- *Make full use of relevant complaints statistics when formulating policy.*
- *Review the framework for content regulation.*
- *Use impact assessments to support evidence-based policy-making.*

Consumer education and information:

- *Promote sufficient competition and choice for consumers.*
- *Ensure consumers have access to timely and accurate information, including about speeds and data traffic management.*
- *Ensure that consumers are informed about potential security and privacy challenges they face and the measures available to limit the risks.*

Build consumer trust in converged services:

- *Promote and safeguard e-commerce and mobile commerce by introducing measures to build trust amongst consumers.*
- *Encourage operators to develop security precautions including built-in security features to prevent unauthorized transactions and data breaches.*

Implementation and enforcement:

- *Provide for a strong, well-resourced consumer protection regulatory team or separate agency with communications expertise.*
- *Agree a clear division of responsibilities among the agencies concerned.*
- *Distinguish between implementation failures versus underlying legislation.*

In 2014, the community of NRAs worldwide adopted the GSR14 *Best Practice Guidelines on Consumer Protection in a Digital World*[39] recognizing that measures can be taken to ensure consumers including people with disabilities have easy and reliable access to ICT services as well as web content, such as developing and regularly reviewing minimum quality of service standards and specifications of new technologies and services; monitoring network service providers; regularly assessing telecommunication/ICT services quality and publishing the results. They further stressed that regulators need to ensure that all service providers make available timely and accurate information about their services and products in a clear, transparent and comparable manner that is conducive to rational decision making. In addition, they noted that consumers should "*be able to understand the nature of the services and the quality of service provided, in addition to their own rights and responsibilities. All regulations related to consumers' right to information should be regularly and consistently updated allowing it to be practical and enforceable.*"

[39] www.itu.int/en/ITU-D/Conferences/GSR/Documents/GSR2014/BestPractices/GSR14_BPG_en.pdf

9.2 Privacy aspects

QoS in IP networks is related to traffic management, where deep packet inspection and other filtering techniques are used by telecommunication operators to see what is carried in IP packets between two and more end-points in the given connection/session (where each IP connection is uniquely identified by the sender and recipient IP addresses, sender and recipient port numbers, and transport protocol such as TCP or UDP). Data used for traffic management (especially data obtained using DPI) may be personally identifiable. This raises privacy issues when regulators specify what can be done for QoS provisioning, for example in terms of traffic management by the operators.

The information that is treated as being personally identifiable can vary from one country to the next. It is not always obvious what data is sensitive; for instance, IP addresses are treated as personally identifiable data in some countries, and they are not, since most of the home networks use private IP addresses which are marked into a single public IP address.

Many countries (e.g. the EU) restrict the uses that can be made of personally identifiable data. Typical restrictions on the use of personally identifiable data may include:

- an obligation to obtain informed consent of the individual;
- a prohibition on uses other than that which the individual specifically approved;
- the duration for which it can be retained.

For example, in the Guidelines on the Implementation by National Regulators of European Net Neutrality Rules[40] issued in August 2016, BEREC explicitly addressed the issue:

"
- *In assessing traffic management measures, NRAs should ensure that such measures do not monitor the specific content (i.e. transport layer protocol payload).*
- *Conversely, traffic management measures that monitor aspects other than the specific content, i.e. the generic content, should be deemed to be allowed. Monitoring techniques used by ISPs which rely on the information contained in the IP packet header, and transport layer protocol header (e.g. TCP, UDP) may be deemed generic content, as opposed to the specific content provided by end users themselves (such as text, pictures and video).*"

10 Quality of service enforcement

QoS is becoming more and more important as networks are being used for delivery of multiple heterogeneous services, each with different requirements on QoS (e.g. bit rates, delays, errors, etc.). More people are using telecommunication services and more people have broadband access, either fixed or mobile or both types, and a multitude of things are becoming connected to Internet (e.g. cars, homes, cities, industry, and other vertical sectors), becoming *smart*.

QoS in the telecommunication world is based on standards (e.g. ITU, ETSI, etc.) and licences (e.g. for spectrum for mobile operators). However, QoS will not exist just by having the mandatory standards or licences included, it has to be *maintained*. To do so, we need to define a set of key performance indicators, which are important to the end-users, and for users (as consumers) to be made aware of them; then, we need to perform measurements of such KPIs.

Finally, QoS is related to the cost of networks and services with defined QoS parameters. QoS impacts end-users, network and service providers, and society in general due to penetration of ICTs/

[40] http://berec.europa.eu/eng/document_register/subject_matter/berec/regulatory_best_practices/guidelines/6160-berec-guidelines-on-the-implementation-by-national-regulators-of-european-net-neutrality-rules

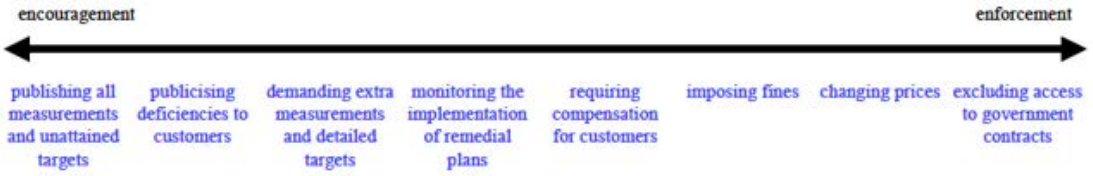
telecommunications into other vertical sectors. Therefore, QoS enforcement is needed (e.g. regulatory notice, publication of KPI measurements, dispute, or penalties).

Enforcement mechanisms of quality of service include the following:

- reports of QoS submitted monthly or quarterly by telecommunication operators to the NRA (may Include technical and non-technical parameters);
- QoS monitoring tools for auditing;
- penalties and disincentives;
- independent customer surveys and their publication.

In general, QoS obligations are only likely to be fulfilled if legitimate concerns are addressed. A requirement for successful QoS monitoring by NRAs, therefore, is to take into account the opinions of operators and consumers fully and openly. This can be achieved through a consultation process, for obligations in licences as well as for obligations in regulations. Typically, at the start and end of a consultation process, the regulator circulates documents that discuss policy options and proposals.

Figure 10.1: Techniques for ensuring compliance



Source: Robert Milne – Antelope Consulting

Figure 10.1 highlights techniques for ensuring that operators fulfil QoS obligations. Serious and persistent failures to fulfil many obligations might be handled by using even more drastic enforcement techniques that are not related directly to QoS, such as withdrawing licences or transferring franchises.

Enforcement techniques are not always practicable – or available under the law in a given country. In particular, one should consider the following aspects regarding QoS enforcement mechanisms:

- Publishing all measurements and unattained targets can be laborious. However, it can help to show that the regulator is fair and open. Publishing at least some measurements is central to helping customers make informed choices: it is often the main technique for encouraging compliance with QoS obligations.
- Publicising deficiencies to customers – by putting remarks in bills, messages or advertisements – needs firm comparisons with other operators or against targets.
- Demanding extra measurements and detailed targets could lead to an emphasis on measurement procedures instead of solutions to problems. Nonetheless, it can be appropriate when the actions needed to improve quality can become effective rapidly.
- Monitoring the implementation of remedial plans may require external agencies skilled in network design and operation to assist regulators. Accompanying this with direct intervention in the activities of the operators could lead to confusion about responsibilities and duties.
- Requiring compensation to customers may not be feasible. It could be useful when customers have better information than regulators about the quality that they receive; can request compensation directly without recourse to regulators or arbitrators; and notice different quality levels very easily (so the compensation can vary with the severity of the deficiency). For example, compensation is more likely to be paid for long fault repair times in fixed wireline networks (or in similar examples) than in other cases of QoS degradation.

- Imposing fines can involve extensive legal processes and may take a long time (as may various other techniques for enforcing compliance with QoS obligations), which is dependent upon the laws in the given country.
- Price changing (by introducing quality factors into price controls, with rewards for good quality as well as penalties for bad quality) needs careful design if it is to act as an incentive to improving quality. The relation between QoS and price controls is not always clear.
- Excluding access to government contracts (e.g. licences) can be difficult to make proportionate to failures by operators, and may not be applicable to several operators at once.

Enforcement mechanisms or techniques require the effort and expertise of various sorts, along with processes that operate efficiently and regularly whenever operators report measurements. In many countries, several techniques are available that provide graduated penalties. Recent examples are presented in the following subsections.

10.1 Quality of service assessment and enforcement: Kenya

In 2011, the QoS report by the Communication Authority (CA) of Kenya found all mobile operators needed to improve QoS, and by 2012, only two operators failed to meet QoS standards. A monitoring report for 2013-2014[41] found all four operators at the time failed to meet service standards as set by the Kenya regulator, leading to fines of KES 500 000.

In 2015, the CA of Kenya introduced a measure that required operators to pay a fine equal to 0.2 per cent of their annual gross revenue if they failed to meet QoS standards. In the 2014/2015 financial year, no mobile operator met QoS standards.

In August 2016, the regulator set rules to improve quality (Figure 10.2). Most of the operators in Kenya indicated they would fall short of scoring 80 per cent on a range of eight indicators, including speech quality, completed calls, call success rate and drop rate. The regulator also called for the public to share their views on the new QoS regulations, which is based on Article 46 of the Constitution of Kenya, which states that consumers have the right to services of reasonable quality. Calls for comments were raised on several issues, including the following:

- Is the range of services under the scope of the proposed QoS assessment framework adequate or inadequate?
- Do you agree with the proposal for the inclusion of the three components namely; Overall Network Performance (NP), End-to-End QoS and Quality of Experience (QoE) in the overall QoS assessment and the ratio of contribution of 20 per cent, 60 per cent, and 20 per cent respectively (see Table 10.1 and Figure 10.2)?
- The given framework did not provide for weighting of samples depending on the area measurements were taken and the authority intends to maintain the status quo. Licensees on the other hand have been advocating for weighting of QoS sampling to reflect larger samples in urban areas and significantly lower weighting of sample volumes measurements taken in rural areas. What should the view on this be?
- Which QoS assessment parameters/KPIs are important?
- Which QoS assessment parameters/KPIs are unimportant and should be excluded in the QoS framework?
- Are the thresholds for parameters (KPIs) well chosen?

These are important questions for any QoS regulation, and particularly enforcement. In fact, establishing the appropriate set of KPIs, their target values, as well as their assessment (by whom, how often,

[41] www.ca.go.ke/images/downloads/RESEARCH/Quality%20of%20Service%20Report%202013-2014.pdf

and how in different areas such as urban areas, rural areas, and highways) provide the basis for QoS enforcement later. Therefore all questions listed above should be well justified and clarified (considering all sides, including customers, operators, regulator, and society in general) in each country. The answers to the above questions may differ from one country to another one.

Regarding data sampling, the number of observations (sample size) is stated to have a minimum absolute statistical accuracy of less or equal to 2 per cent with a confidence level of 95 per cent, while coverage assessment statistical accuracy shall be, as a minimum, less or equal to 0.5 per cent. The QoS assessment framework in Kenya currently covers the following services (end-to-end KPIs and their target values are provided in Table 10.2):

- mobile voice;
- SMS and MMS;
- data/Internet.

According to the proposed QoS rules, the CA of Kenya has been using a QoS assessment tool to verify the level of compliance by operators based on the assessment framework. The compliance assessment methodology is guided by set principles and procedures, which include the submission of returns by the operators on the QoS parameters, where the results of each QoS parameter should be the average of all the measurements recorded for all provinces during the entire reporting period of 12 months, commencing from the effective date of notice. The QoS requirement set by the CA of Kenya is to achieve at least 80 per cent of the listed QoS parameters provided for in the licence calculated from operator data and independent QoS measurements.

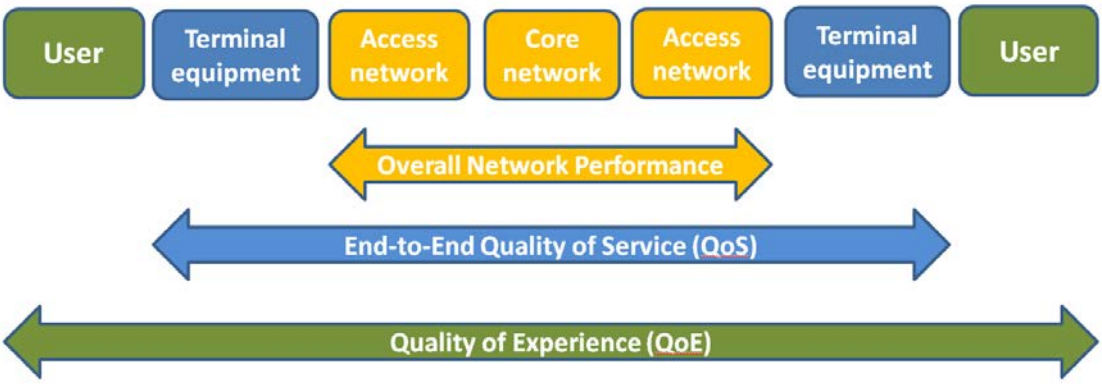
The QoS rules also specify that a failure to achieve at least 80 per cent of the listed QoS parameters upon notification by the authority to the licensee shall be considered as non-compliance with the quality of service condition and may be liable for penalty/sanction as provided in the telecommunication act. In November 2016, the CA fined operators with KES 190 million (USD 18.7 million) for poor quality of service for the 2014/2015 period, which corresponds to 0.1 per cent of their gross annual turnover.

Table 10.1: QoS assessment structure in Kenya

Nature of QoS assessment	Areas of assessment	Source of assessment data	Contribution to the overall assessment
Network performance	The quality of the network infrastructure without terminal devices	Operator network management systems	20%
End-to-end QoS performance	The overall quality of the network including standardized devices	Contracted entities using innovative data capture/analysis	60%
Quality of experience (QoE)	Overall consumer experience	Customer surveys	20%

Source: Communication Authority of Kenya

Figure 10.2: Illustration of QoS functional components (Kenya)



Source: Communication Authority of Kenya

Table 10.2: End-to-end KPIs and target values in Kenya

Service	Key Performance Indicator (KPI)	Target
Voice	Unsuccessful call ratio	< 5%
	Dropped call ratio	< 2%
	Completed call ratio	>= 95%
	Call set up time	Mean value <= 8 s
	Voice quality	>= 3.4 (measured according to ITU-T P.863)
SMS	Successful SMS ratio	>= 95%
	Completion rate for SMS	>= 95%
	End-to-end delivery time for SMS	>= 95% Rate of SMS completed in a delay of less than 30 s. (best practice)
MMS	Successful MMS ratio	>= 95%
	Completion rate for MMS	>= 95%
	End-to-end delivery time for MMS	>= 95% Rate of MMS completed in a delay of less than 180 s. (Best practice)

Service	Key Performance Indicator (KPI)	Target
Data/Internet	Latency	100 ms
	Jitter	50 ms
	Data transfer failure ratio and Throughput of successful data transfer	Data transfer failure ratio (download): =< 10% Data transfer failure ratio (upload): =< 10% (Values proposed for mobile networks) Throughput: highly dependent on access technology Shall be linked to a commercial offer: shall reach 85% of the contractual throughput during the peak period
	Ratio of packet loss	1 / 1,000
	Internet accessibility	>= 98%
	HTTP set-up failure ratio, and HTTP set-up time	HTTP set-up failure ratio: <= 2% HTTP set-up time: 95% within 5 seconds (Values proposed for mobile networks)
	HTTP completion failure ratio, and HTTP completion Time	HTTP Completion failure ratio: <= 90% HTTP Completion Time: 95% within 20 sec. (Values proposed for mobile networks)
	HTTP generic scenario availability	>= 85% (Value proposed for mobile networks)

Source: Communication Authority of Kenya

10.2 Enforcement of quality of service for mobile services: India

In India, the Telecom Regulatory Authority of India (TRAI) formulated standards for mobile Internet under the QoS for Wireless Data Services Regulations 2012, with objectives to:

- understand the current state of QoS for mobile Internet services – policies and practices; and
- provide evidence-based policy recommendations to enhance QoS and promote better enforcement of QoS regulations.

In 2015, TRAI published a consumer handbook on telecommunications providing consumers with a QoS guideline[42]:

The TRAI Act provides that the authority shall lay-down the standards of quality of service to be provided by the service providers and conduct periodical survey of such services so as to protect the interest of the consumers of telecommunication service.

Regarding QoS, the consumer handbook says (Figure 10.3):

TRAI has laid down the Quality of Service standards for various services through QoS regulations issued, from time to time. TRAI has separate QoS regulations governing the standards of quality of service for wireline (Basic), cellular mobile telephone services (2G & 3G), broadband services and recently

[42] www.trai.gov.in/sites/default/files/TRAI-Handbook-2015-ENG-30092015.pdf

for wireline data services. The important parameters on quality of service and the benchmarks for meeting the parameters by the service providers are given at Annex-I and II.

In 2016, a report was published on the QoS of mobile operators in India. Through network measurements, which involved direct evaluation of mobile Internet services at various rural and urban locations, mobile Internet services were evaluated on technical parameters such as throughput, latency, availability, etc. The network measurement study highlighted that the QoS experienced by users differs considerably from the advertised values provided by the various telecommunication providers, and to a certain extent also from the values reported by them to TRAI. It also seemed that in many cases, simply taking better care of the configurations of the cellular networks could lead to better performance.

Figure 10.3: Important QoS parameters, for basic and cellular mobile services

Sl. No.	QoS parameter	Benchmark
1.	Provision of landline telephone after registration of demand	within 7 days (subject to technical feasibility)
2.	Shifting of landline telephone connection	95% of requests to be attended within 3 days
3.	Fault repair in urban areas (landline)	At least 85% by next working day and 100% within 5 days
4.	Fault repair in rural and hilly areas (landline)	At least 75% by next working day and 100% within 7 days
5.	Resolution of billing/charging complaints	At least 98% within 4 weeks and 100% within 6 weeks
6.	Period of applying credit/ waiver/ adjustment to customer's account on resolution of complaints	Within one week of resolution of the complaint
7.	Termination/closure of service	Within 7 days
8.	Refund of security deposit after closure	100% within 60 days

Sl. No.	QoS parameter	Benchmark
1.	Service provisioning/activation time	100% cases in < 15 working days (subject to technical feasibility)
2.	Fault repair/restoration time	99% within 3 days. **Rebate** :Faults pending for > 3 days and < 7 days : rebate equivalent to 7 days of minimum monthly charge or usage allowance. Faults pending for > 7 and <15 days : rebate equivalent to 15 days of minimum monthly charge or usage allowance. Faults pending for > 15: one month rebate equivalent to 1 month of minimum monthly charge or usage allowance.
3.	Resolution of billing complaints	100% within 4 weeks
4.	Refund of deposits after closure	100% within 60 days.
5.	Broadband connection speed (download)	Subscribed broadband connection speed to be met > 80% from ISP Node to user.

Source: TRAI

Figure 10.4: India QoS for mobile services: Consumer satisfaction

Summary of Key Findings			
Parameter	**West Bengal**	**Rajasthan**	**New Delhi & NCR**
Respondents	300	300	130
QoS is the rationale for selecting service provider	42%	52%	64%
Level of Satisfaction with QoS is good	45%	24%	52%
Level of Satisfaction with tariff is good	28%	15%	26%
Awareness levels in respondents is good (regarding data plan)	63%	62%	82%
Service providers should regularly alert customers on data usage	83%	62%	58%
Service providers should mention the exact amount of data that is consumed per month by users	58%	73%	60%
Respondents do not know about bandwidth but want to know the same	92%	56%	92%
Respondents know about TRAI	40%	46%	85%
Respondents do not know about QoS parameters but want to know	65%	93%	81%
Penalties should be put in place for breach of QoS parameters	95%	99%	97%
Service providers should be ranked (quarterly) on the basis of their performance	91%	98%	97%

Source: TRAI

The consumer survey (Figure 10.4) revealed that the respondents across the three states chose their service provider (for mobile Internet) on the basis of QoS but were largely unsatisfied with the service and the high charges. The table provides a snapshot of the data obtained from the respondents. Most consumers (over 95 per cent) requested penalties for breach of the QoS parameters.

The report included recommendations for TRAI to:

- Mandate more rigorous QoS measurement and reporting methodologies by the ISPs, and make the data reflective of actual end-user observed performance. Steps should be taken to make this data available in user-friendly ways to improve consumer awareness. Steps should also be taken to enable auditing of this data by non-state actors.
- Adopt a *nutrition label* for QoS to provide key information such as speed variations, service limits and conditions, pricing and other relevant information to empower consumers with information to compare broadband services in India and make an informed decision.
- Provide complete information to consumers on mobile Internet services, at the time of sales as well as on the service provider websites. Strict rules should be imposed against misleading advertisements by ISPs, and reported performance should be compared with the performance that was originally advertised to understand the differences arising between promised and achieved performance.
- Introduce a system of ranking on QoS performance for mobile Internet service providers to instil competition and enhance QoS efficiency and innovation.
- Set penalties in case of breach of QoS parameter benchmarks by service providers.

The report also called for consumers to be made aware of their entitlements/actual terms of service; and empowered to get necessary information through a speed test, for instance, which would allow them to test their services and compare them with the regulatory benchmarks. In addition to drafting regulations, TRIA was called on to focus on educating consumers of their rights and provisioning of a complete set of information on the product, i.e. mobile Internet.

TRAI was also called on to make its presence felt across India by establishing regional centres and through awareness workshops to inform consumers regarding the relevance of QoS parameters for mobile Internet services.

In 2016, TRAI published a consultation paper on the review of network related quality of service standards for cellular mobile telephone service in India[43]. According to the paper, TRAI monitors network related QoS parameters in a cellular mobile telephone service network, as shown in Table 10.3.

In order to improve the QoS provided by service providers, TRAI has prescribed financial disincentives through *Standards of Quality of Service of Basic Telephone Service (wireline) and Cellular Mobile Telephone Service (Second Amendment) Regulations, 2012 (24 of 2012)*, dated 8 November 2012. Based on this, TRAI has been monitoring compliance to these regulations through monthly/quarterly performance reports submitted by service providers. Wherever non-compliance with the benchmark is observed, the service provider is given an opportunity to explain the matter, and after considering the reply submitted by the service provider, if found unsatisfactory, financial disincentives are imposed on the defaulting service providers. However, TRAI had analysed the compliance reports of cellular mobile telephone service providers for several quarters and concluded that in many cases, the amount of financial disincentives had not been sufficient to provide QoS according to the given benchmarks (i.e. targets for the selected QoS parameters as performance indicators). This situation was considered by TRAI as an indication of the lack of commitment (or initiative) on the part of service providers to improve QoS. Therefore, after undertaking public consultations to review the amount of financial disincentives, TRAI prescribed increasing financial disincentives for consecutive repeat instances of non-compliance with the benchmark through the *Standards of Quality of Service of Basic Telephone Service (wireline) and Cellular Mobile Telephone Service (Fourth Amendment) Regulations, 2015.* The revised amount of financial disincentives are:

- *Not exceeding Rupees one lakh per parameter for first non-compliance with the benchmark in a quarter;*
- *Non-compliance with the benchmark of the same parameter consecutively in two or more subsequent quarters, not exceeding Rupees one and a half lakhs for a second consecutive contravention and not exceeding Rupees two lakhs for each consecutive contravention thereof;*
- *Non-compliance with the benchmark for the same parameter in any subsequent quarter, which is not a consecutive non-compliance, Rupees one lakh per parameter.*

The structure of financial disincentives is based on whether the QoS parameter is met or not, and no consideration is given to the extent of how bad the performance is. The financial disincentive is the same whether the benchmark is not met by 1 per cent or 5 per cent. One option towards streamlining QoS parameters will be to explore the possibility of a scheme of graded financial disincentive so that in the case of very poor performance the financial disincentive could be very stringent. At the same time, there could be reduced financial disincentives in case there is an improvement in performance. TRAI has publicly asked for views on introducing graded financial disincentives based on performance and what the amount/quantum should be for financial disincentives for various parameters. One may note that such an approach could be considered as a good practice for QoS enforcement in a country that is struggling with provision of satisfactory QoS by service providers (telecommunication operators).

[43] www.trai.gov.in/consultation-paper-review-network-related-quality-service-standards-cellular-mobile-telephone

Table 10.3: Network service quality parameters 2G and 3G services in India

Name of parameter	Benchmark	Averaged over a period
Network availability		
(a) BTSs accumulated downtime (not available for service) (2G) Node-B accumulated downtime (not available for service) (%age) (3G)	≤ 2%	One Month
(b) Worst affected BTSs due to downtime (2G) Worst affected Node-B due to downtime (%age) (3G)	≤ 2%	One Month
Connection establishment (Accessibility)		
(a) Call set-up success rate (within licensee own network) (2G) (3G)	≥ 95%	One Month
(b) SDCCH/ paging channel congestion (2G) SDCCH/paging channel and RRC congestion (%age) (3G)	≤ 1%	One Month
(c) TCH congestion (2G) TCH and circuit switched RAB congestion (%age) (3G)	≤ 2%	One Month
Connection Maintenance (Retainability)		
(a) Call drop rate (2G) Call drop and circuit switched voice drop rate: (%age) (3G)	≤ 2%	One Month
(b) Worst affected cells having more than 3% TCH	≤ 5% up to	One
drop (call drop) rate (2G)	31.03.2011	Month
Worst affected cells having more than 3% TCH drop	≤ 3% From	
(call drop) and circuit switched voice drop Rate:-	01.04.2011	
CBBH (3G)		
(c) Connections with good voice quality (2G) Connections with good voice quality and circuit switch voice quality (CSV quality) (3G)	≥ 95%	One Month

Source: Telecom Regulatory Authority of India (TRAI), Consultation Paper on Review of network related Quality of Service standards for Cellular Mobile Telephone Service, 2016.

10.2.1 Suggested penalties in India for breach of quality of service

In October 2016, TRAI recommended INR 3 050 crore penalties (approximately USD 45 million) for violating quality of service rules. This amount refers to a combined penalty on Bharti Airtel, Vodafone India, and Idea Cellular, for not giving interconnection to Reliance Jio Infocomm in breach of the licence terms.

TRAI recommended that the Department of Telecommunications (DoT) initiate action against each of the top three carriers in the country, saying that violating licence terms warranted revocation of the licence. Since it would have caused significant inconvenience to consumers, penalties were recommended instead.

10.2.2 Prohibition of discriminatory tariffs for data services

TRAI issued a consultation paper on *Differential Pricing for Data Services* in December 2015, and enacted prohibition of discriminatory tariffs for data services in February 2016. The consultation primarily sought the views of stakeholders on whether the service providers should be allowed to charge differential tariffs based on the websites/applications/platforms being accessed on the Internet.

Based on the responses received and internal deliberations, TRAI has issued regulations aimed at ensuring that consumers get unhindered and non-discriminatory access to Internet. Such regulations intend to make data tariffs for access to the Internet non-discriminatory on the basis of the content.

TRAI has also published the following regulations[44]:

a) No service provider shall offer or charge discriminatory tariffs for data services on the basis of content.

b) No service provider shall enter into any arrangement, agreement or contract, by whatever name called, with any person, natural or legal, that has the effect of discriminatory tariffs for data services being offered or charged by the service provider for the purpose of evading the prohibition in this regulation.

c) Reduced tariff for accessing or providing emergency services at times of public emergency has been permitted.

d) Financial disincentives for contravention of the regulation have also been specified.

TRAI also specified penalties, or consequences for contravention of these regulations on tariffs for data services. If a service provider is in contravention of these regulations, the authority may, without prejudice to the terms and conditions of the licence, or the Act or rules or regulations or orders made, or directions issued, thereunder, direct the service provider to withdraw such tariff(s) and also order such service provider to pay, by way of financial disincentive, approximately USD 730 for each day of contravention, subject to a maximum amount: provided that no order for payment of any amount by way of financial disincentive shall be made by the authority unless the service provider has been given a reasonable opportunity of representing against the contravention of the regulation. The amount payable by way of financial disincentive under these regulations shall be remitted to such head of account as may be specified by the authority.

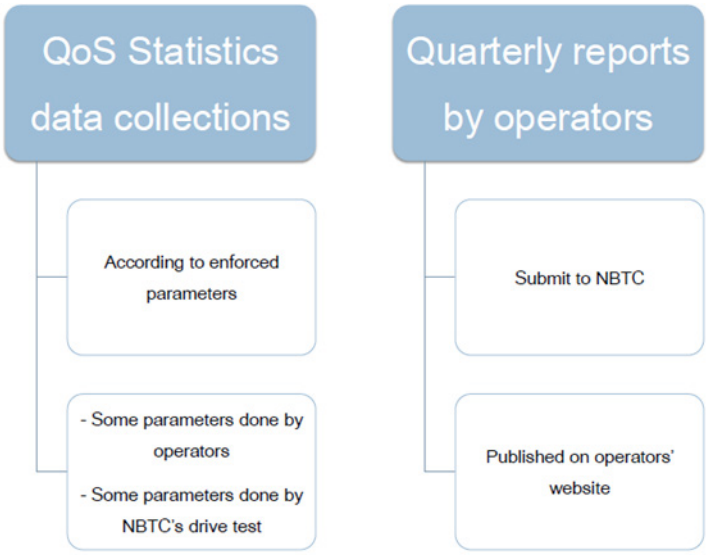
By jeopardizing the network neutrality approach for the Internet access service (e.g. giving toll-free access to a given service, such as Skype, Facebook, Youtube, or any other OTT service), the demand for such services is expected to rise and produce possible additional congestion in some time periods or at some locations (e.g. in a mobile network) that will influence the overall QoS (e.g. available bit rates in a mobile network, which uses shared data channel for all users in a given cell) for Internet access service, i.e. for data services.

10.3 Enforcement of broadband quality of service: Thailand

The approach by the Thailand regulator, the National Broadcasting and Telecommunications Commission (NBTC), to enforce broadband QoS is presented in Figure 10.5. It consists of QoS statistics data collection and quarterly reports by operators.

[44] www.trai.gov.in/sites/default/files/Regulation_Data_Service.pdf

Figure 10.5: Enforcement of broadband QoS



Source: NBTC: Broadband quality of service: Role of the Thai Telecom Regulator, 2015

However, some enforcement concerns have been identified by the NBTC:

- authenticity of the QoS reports, because statistical data is collected by operators, and there are no means to double check authenticity of the data;
- low consumer awareness of the QoS reports;
- QoS reports are not easily accessible on operator websites;
- report publishing is delayed and outdated;
- the penalty procedure and time-frame prescribed by the law is cumbersome.

The policy framework is targeted at introducing modifications to the regulations to address some of these problems/obstacles. Some of the modifications include: QoS reports to be published (linked) from operator homepages with specific banner required by regulator; specifying time limit of the quarterly report submission and website publishing; and conducting parallel QoS testing and measurements by the regulator. The regulator aims to promote consumer awareness and accessibility of QoS data, which could include a QoS survey as well as data from the complaint mitigation centre in order to promote and strengthen healthy competition.

10.4 Internet access service regulation: Europe

In the BEREC guidelines for the Internet access service, NRAs can decide to:

- require an ISP to take measures to eliminate or remove the factor that is causing the degradation;
- set requirements for technical characteristics to address regulation infringements, for example, to mandate the removal or revision of certain traffic management practices;
- impose minimum QoS requirements;
- impose other appropriate and necessary measures, for example, regarding the ISP obligation to ensure sufficient network capacity for the provision of high quality non-discriminatory Internet access service (IAS);
- issue cease and desist orders in case of infringements, possibly combined with periodical (daily/weekly) penalties, in accordance with national law;

- impose cease orders for specific specialized services unless sufficient capacity is made available for IAS within a reasonable and effective time-frame set by the NRA, possibly combined with periodical (daily/weekly) penalties, in accordance with national law;
- impose fines for infringements, in accordance with national law;
- prohibit the blocking and/or throttling of specific applications;
- prohibit congestion management practice that is specific to individual applications;
- require access performance, such as minimum or normally available speeds, to be comparable to advertised/maximum speeds;
- place qualitative requirements on the performance of application-specific traffic;
- requirements and measures could be imposed on one or more ISPs, and it may also, in exceptional cases, be reasonable to impose such requirements in general to all ISPs in the market; and
- the imposition of any of these requirements and measures should be assessed based on their effectiveness, necessity and proportionality.

Penalties are not included in the BEREC guidelines as these will depend on the national legislation of the European countries. However, Article 6 of the guidelines published in September 2016 states: *Member States shall lay down the rules on penalties applicable to infringements of Articles 3, 4 and 5 and shall take all measures necessary to ensure that they are implemented. The penalties provided for must be effective, proportionate and dissuasive.*

The practice so far shows that imposing penalties is not the first enforcement measure taken in European countries. The market is competitive and QoS enforcement in Europe is currently based on a soft touch approach, which is targeted mainly to audit measurements on QoS and their publication for consumers to make informed decisions on services, less on applying penalties.

10.5 Quality of service regulation and sanctions: Ghana

In pursuance of the mandate of the National Communications Authority (NCA) of Ghana to ensure fair competition and protect consumers in Ghana, QoS obligations have been outlined in Annex D1 and D2 of the cellular mobile licence[45]. These obligations are monitored and enforced through consumer oriented methodologies:

- Monthly operator reports: Daily busy hour conditions for the radio network and each interconnect route among all operators are reported through a common template with definitions for each parameter. This enables the authority to assess the network level performance of each operator. This is useful for trend analysis and guides directives on remedies for congestion and network instability.
- Billing verification: The tariffs of each operator to all national and selected popular international destinations are verified quarterly or when new tariffs are implemented by any operator. This is to ensure billing accuracy.
- Consumer satisfaction survey: A total of 5 000 mobile users are sampled in the 168 districts to achieve the 95 per cent confidence level at an error margin of + 1.39 per cent. The stratified sample allocation to each of the five operators is per respective market share and network availability in the districts of Ghana. These capture the consumer ratings of service attributes and expectations. This has been useful in focusing on consumer concerns and the formulation of regulatory policies.

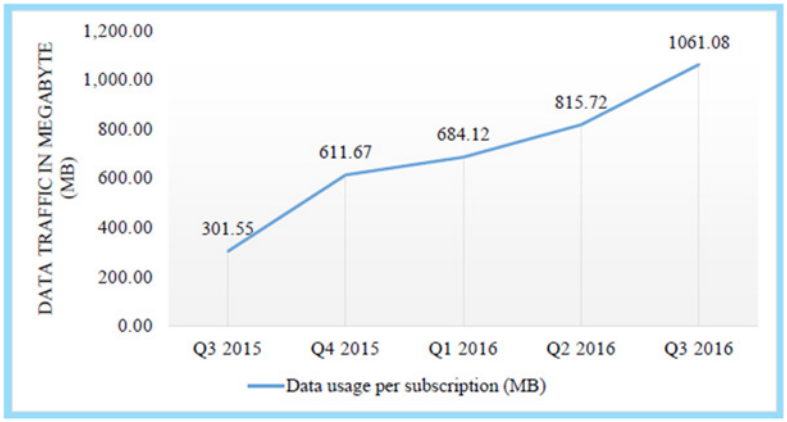
[45] https://nca.org.gh/industry-data-2/reports-2/monitoring-reports-2/?url=/industry-data-2/reports-2/monitoring-reports-2/

- Assessment of radio network parameters: Automated drive testing of all operators is done simultaneously in localities during busy hours to ascertain the quality of experience to mobile phone users. These measure and analyse parameters such as: coverage strength, call set-up time, call set-up failure rate, call congestion rate, call drop rate, call completion rate and call audio quality.

Ghana has high mobile cellular penetration (129.7 subscriptions per 100 inhabitants) and high mobile broadband penetration (66.8 subscriptions per 100 inhabitants) among the membership of the West Africa Telecommunication Regulators Assembly (WATRA), according to ITU ICT-Eye data from 2015. The penetration of fixed telephony (one subscription per 100 inhabitants) and fixed broadband (0.3 subscriptions per 100 inhabitants) in 2015 was negligible compared to the number of mobile subscribers. Hence, similar to other countries in West Africa, QoS regulation is mainly targeted at the mobile sector.

Tables 10.4 to 10.10 show the QoS parameters (KPIs) for different services and target values, set by NCA and include: interconnection, cellular mobile service, basic telephone service, Internet service, and broadband wireless access. Statistical bulletins are published every quarter, and according to 2016 third-quarter data, there is constant growth in mobile telephony minutes, number of SMS, and mobile Internet traffic (in gigabytes). This shows a high penetration of mobile customers, including traditional mobile telephony and SMSs, and mobile broadband. Figure 10.6 illustrates the almost exponential increase of mobile data usage per subscription.

Figure 10.6: Mobile data usage per subscription in Ghana



Source: National Communications Authority of Ghana; Mobile Network Operators, 2016.

Figure 10.6 shows that Internet traffic per mobile user has tripled in a period of one year, from 2015 Q3 to 2016 Q3; this is remarkable considering that mobile broadband subscriptions had reached 69.2 per cent of the population by 2016 Q3. However, Ghana has also faced QoS problems in the mobile networks. NCA started to work with mobile operators on improving QoS around 2010. To boost QoS in the country, NCA also applied QoS enforcement measures with penalties in the period 2011-2015, as outlined in the boxes with news articles from that period. QoS enforcements in the given examples refer to mobile voice services, for unavailability of the services, or high call blocking and/or call dropping probabilities for voice services as KPIs for voice were not met. Since mobile voice in the given period was circuit switched, blocking appears to be due to the unavailability of a free voice channel because of congestion, while dropping probability happened due to unavailable free channels for handover of an established voice connection from one cell (old cell) to another cell (new cell) due to congestion in the new cell or cells (meaning the call cannot be handed over and is dropped). This is mainly due to network planning and optimization. Capacity is not enough in these cases for the served number of customers in the peak time/busy hour of the day (peak time/busy hour is the hour in a given day on average that has higher traffic volume for a given service, such as voice in this analysis).

Overall, this example highlights that enforcement led to improvements in 2016 and the sanctions on default of QoS compliance remained in the latest version of QoS regulations in Ghana as provided in Table 10.11. The sanctions NCA can apply as per 2016 QoS regulation include a directive to expand capacity, financial compensation, and fines depending on the parameters. These are listed in Table 10.4.

Table 10.4: QoS parameters for interconnection in Ghana

No	Parameter Name	Target	Measurement Formula
1	Interconnection route utilization	Not more than 70% of capacity	Amount of carried traffic to another network x100
			Total capacity of route to another network
2	Time to repair (TTR) interconnection route	Not more than One Hour	Time of total service restoration-Time of notification of fault

Source: NCA, *The National Communications (Quality of Service) Regulations 2016*

Table 10.5: QoS parameters for cellular mobile service in Ghana

No	Parameter Name	Target	Measurement Formula
1	Service coverage	>-75dBm (for indoors) >-85dBm (for in-vehicles) >-95dBm (for outdoors in city)	Field strength measurements
2	Call connection success rate	> 99%	Number of successfully connected call attempts x100 Total number of attempts
3	Call drop rate	< 2%	Number of calls dropped x100 Total number of attempts
4	Voice service access delay	< 10 seconds	Maximum time taken for voice service connection in all cases
5	Voice quality (Mean Opinion Score {MOS})	> 3.5	ITU Recommendation on Voice Quality Testing
6	Downtime for cell (site)	< 4 hours	Time restored- Time of fault
7	Downtime for interconnect route	< 1 hour	Time restored- Time of fault
8	Minimum data speed rate	> 2 Mbit/s	Throughput
9	Data service availability	≥ 99.9%	As measured in data networks
10	Data service utilization	≤ 80%	As measured in data networks
11	Data service access time	< 5 seconds	Maximum time taken for data service connection in all cases
12	Data access success rate	≥ 99%	Number of service connections made x100
			Total number of connections requested

No	Parameter Name	Target	Measurement Formula
13	Data service drop rate	≤ 1%	Number of service connections lost x100
			Total number of service connections made
14	SMS/MMS delivery success	> 99%	Number of SMS/MMS to recipients delivered x 100
			Total No. of SMS/MMS received at service centre
15	SMS/MMS delivery time	< 5 seconds	Time of service delivered to destination number – Time of service sent from originating number
Billing, customer service & satisfaction measures			
16	Voice calls	Accurate charging	Per second charging
17	Messaging	Accurate charging	Message length of 160 characters
18	Internet services	Accurate charging	QoS charging; volume charging; time charging
19	Interactive voice response (IVR)	< 15 seconds	Duration of announcement of the entire IVR options before a customer can make a choice
20	Call centre operator response	< 30 seconds	Duration of waiting after the option to a customer care assistant has been chosen by the customer
21	Customer satisfaction on overall quality of service	> 95%	Number of answers as good quality Number of customers interviewed

Source: NCA, *The National Communications (Quality of Service) Regulations 2016*

Table 10.6: QoS parameters for basic telephony service in Ghana

No	Parameter Name	Target	Measurement Formula
1	Time to repair (TTR)	≤ 8 hours	Sum of duration of each repair time in hours for all the fault incidences in a day
2	Call connection success rate	> 99%	Number of successfully connected call attempts x100 total number of attempts
3	Call drop rate	< 2%	Number of calls dropped x100 total number of attempts
4	Voice service access delay	<10 seconds	Maximum time taken for voice service connection in all cases
5	Voice quality MOS	> 3.5	ITU Recommendation on Voice Quality Testing
Billing, customer service and satisfaction measures			
6	Voice calls	Accurate charging	Per second charging
7	Provision and installation of telephone on premise after payment	≤ 5 days	Number of days from service request to service operations

No	Parameter Name	Target	Measurement Formula
8	Interactive voice response(IVR)	< 15 seconds	Duration of announcement of the entire IVR options before a customer can make a choice
9	Call centre operator response	< 30 seconds	Duration of waiting after the option to a customer care assistant has been chosen by the Customer
10	Customer satisfaction on overall quality of service	> 95%	Number of answers as good quality Number of customers interviewed

Source: NCA, *The National Communications (Quality of Service) Regulations 2016*

Table 10.7: QoS parameters for Internet service in Ghana

No	Parameter Name	Target	Measurement Formula
1	Call connection success rate	< 99%	Number of successfully connected calls x100 total number of attempts
2	Call drop rate	< 2%	Number of calls dropped x100 total number of connected calls
3	Voice service access delay	< 10 seconds	Maximum time taken for voice service connection
4	Voice quality MOS	> 3.5	ITU Recommendation on Voice Quality Testing
5	Downtime for cell (site)	< 4 hours	Time restored- time of fault
6	Downtime for interconnect route	< 1 hour	Time restored- time of fault
7	Minimum data speed	≥ 2Mb/s	Throughput
8	Data service availability	≥ 99.9%	As measured in data networks
9	Data service utilization	≤ 80%	As measured in data networks
10	Date service access time	< 5 seconds	In all cases
11	Data access success rate	≥ 99%	Number of successful connections made x100 Total number of connections requested
12	Data service drop rate	≤ 1%	Number of connections lost x100 Total number of connections made

Source: NCA, *The National Communications (Quality of Service) Regulations 2016*

Table 10.8: Billing, customer service and satisfaction measures for Internet service in Ghana

No	Parameter Name	Target	Measurement Formula
13	Provision and installation of Internet equipment (modem and related accessories) on premise after payment	≤ 5 days	Number of days from service request to service operations

No	Parameter Name	Target	Measurement Formula
14	Interactive voice response (IVR)	< 15 seconds	Duration of announcement of the entire IVR options before a customer can make a choice.
15	Call centre operator response	< 30 seconds	Duration of waiting after the option to a customer care assistant has been chosen by the customer.
16	Customer satisfaction on overall quality of service	> 95%	Number of answers as good quality
			Number of customers interviewed

Source: NCA, *The National Communications (Quality of Service) Regulations 2016*

Table 10.9: QoS parameters for broadband wireless access in Ghana

No	Parameter	Target	Remarks
1	Service delivery Waiting time for service activation	< 2 days	This depends on availability of service coverage within the customer's area of interest.
2	Service coverage	>-75dBm (for Indoors) >-85dBm (for In-vehicles) >-95dBm (for outdoor in city)	Field strength measurements
3	Point of interconnection utilisation	≤ 70%	
4	Peak hour traffic utilization	≤ 80%	Ratio of utilized capacity in resource bocks (RBs) to configured RBs on the radio interface
5	Latency	≤80 milliseconds	
6	Data service availability	≥ 96%	
7	Data service access time	< 5 seconds	In 100% of cases
8	Data service access failure rate	≤ 1%	
9	Data service drop rate	≤ 1%	
10	Minimum download data speed minimum upload data speed	≥ 10 Mbit/s ≥ 2.5 Mbit/s	Upload – download ratio 1:4 for each subscriber at all times
11	Downtime for interconnect route	< 1 hour	Within 24 hours
12	Downtime for radio access/ mean time to repair (MTTR)	< 1 hour	Within 24 hours
13	Voice call set-up time	< 10 seconds	In 100% of cases
14	Call connect failure rate	≤ 1%	

No	Parameter	Target	Remarks
15	Voice and /or video MOS	> 3.5	International Telecommunications Union (ITU- T Recommendation POLQA Rating 1 to 5)
16	SMS / MMS delivery success	> 99%	Number of SMS/MMS to recipients delivered x 100
			Total number of SMS/MMS received at service centre
17	SMS/MMS delivery time	<5 seconds	Time of service delivered to destination number- time of service sent from originating number
18	Voice calls	Accurate charging	Per-second charging
19	Messaging	Accurate charging	Message length of 160 characters
20	Internet services	Accurate charging	QoS charging; volume charging; time charging
21	Interactive voice response (IVR)	< 15 seconds	Duration of announcement of the entire IVR options before a customer can make a choice
22	Call centre operator response	< 30 seconds	Duration of waiting after the option to a customer care assistant has been chosen by the customer
23	Calls to customer service call centre	> 95% of the calls should be successful.	

Source: NCA, *The National Communications (Quality of Service) Regulations 2016*

Table 10.10: Customer satisfaction attributes for all service types in Ghana

Functional Attribute	Benchmark
Customer satisfaction on overall quality of service	> 90%
Percentage of customers satisfied with the provision of service	> 90%
Percentage of customers satisfied with the network availability	> 90%
Percentage of customers satisfied with reliability	> 90%
Percentage of customers satisfied with billing performance	> 90%
Percentage of customers satisfied with help/enquiry services	> 90%

Source: NCA, *The National Communications (Quality of Service) Regulations 2016*

Table 10.11: Sanctions on default on QoS compliance in Ghana

No	Parameter Name	Sanction	Amount (Ghana Cedis)
1	Interconnection route utilization	Directive to expand capacity within 3 months	GHS 50 000 per day after 3 months on default of operator(s) responsible for delay
2	Time to repair (TTR) interconnection route	Compensation	GHS 50 000 per hour to be paid by defaulting operator to the other interconnect party
3	SDCCH Congestion	Fine	GHS 50 000 per hour per locality to be paid by defaulting operator to authority
4	Call connection success rate	Fine	GHS 50 000 per hour per locality to be paid by defaulting operator to authority
5	Call drop rate	Fine	GHS 50 000 per hour per locality to be paid by defaulting operator to authority
6	Voice service access delay	Fine	GHS 50 000 per hour per locality to be paid by defaulting operator to authority
7	Downtime for cell (site)	Announcements to affected locality after first hour	GHS 50 000 per hour after 4 hours to be paid
8	Data service availability	Fine	GHS 50 000 per hour per locality to be paid by defaulting operator to authority
9	Data service utilization	Directive to expand capacity within 3 months	GHS 50 000 per day after 3 months on default of operator(s) responsible for delay
10	Data service access time	Fine	GHS 50 000 per hour per locality to be paid by defaulting operator to authority
11	Data access success rate	Fine	GHS 50 000 per hour per locality to be paid by defaulting operator to authority
12	Data service drop rate	Fine	GHS 50 000 per hour per locality to be paid by defaulting operator to authority
13	% of SMS / MMS delivery success	Fine	GHS 50 000 per hour per locality to be paid by defaulting operator to authority
14	Time to repair (TTR) a fixed telephone service	Compensation	GHS 500 per hour after 8 hours per customer
15	Provision and installation of telephone on premise after payment	Compensation	GHS 3 000 per day after 5 days per customer
16	Provision and installation of Internet equipment (modem and related accessories) on premise after payment	Compensation	GHS 3 000 per day after 5 days per customer

No	Parameter Name	Sanction	Amount (Ghana Cedis)
17	Accurate charging of services	Fine after notification by authority to correct in four (4) hours	GHS 50 000 per hour per locality to be paid by defaulting operator to authority

Source: NCA, *The National Communications (Quality of Service) Regulations 2016*

10.6 Quality of service regulation: Bangladesh

In Bangladesh, organizational responsibility for enforcement of licensing conditions, and monitoring and enforcement of QoS lies with the NRA, the Bangladesh Telecommunication Regulatory Commission (BTRC), endowed under the Telecom Act. The Telecom Policy and the Telecom Act of Bangladesh emphasize the quality of service to be rendered by the licensees, and the licences issued by the Commission, and specify the QoS parameters, standards and the benchmarks that must be complied with. The provisions made therein:

- to direct operators to submit reports along with necessary information on any of their activities (Art.31 (i));
- to ensure auditing of operators' procedure and systems in order to measure compliance with the directions issued by the Commission, to examine the propriety of the reporting system of the operators, and to give directions on these matters (Art.31 (j));
- to provide necessary directions to operators to ensure that the Commission has sufficient opportunity to inspect the books and records of the operators and to monitor their activities (Art. 31 (k));

Duties and functions with regard to QoS, standards, monitoring and enforcement also empower BTRC to issue enforcement orders to ensure compliance with the provisions of the Act and, in appropriate cases, to impose and realize administrative fines (Art. 31 (n)).

10.7 Southern African Development Community countries: Quality of service regulation and enforcement

This section highlights the experience of selected countries from the Southern African Development Community (SADC) on QoS regulation and enforcement, targeted mostly at mobile services, as contained in the workshop report from the 2017 ITU and SADC training on quality of service, and quality of experience for SADC.

10.7.1 Botswana

The mandate of the Botswana Communications Regulatory Authority (BOCRA) covers QoS regulation and enforcement as specified in the national Communications Act. BOCRA has published QoS guidelines that cover mobile voice, fixed voice, SMS, fixed and mobile Internet parameters, which include targets, measurements methods, reporting formats and periods, as well as management parameters, such as service down times and call centre response times. There are also many published guidelines such as procedures for reporting infringement, enforcement, revocation and cancellation, however, there are no provisions for compensation to be paid to consumers. The development of these guidelines was guided by ITU standards, extensive industry consultation, country benchmarking, and country experience.

The measurement methods in the guidelines include operator submissions on mobile voice and fixed Internet parameters, independent monitoring tools using site test probes, consumer feedback campaigns, scheduled operator meetings, site visits geared towards corroborating information received from operators, as well as ad-hoc investigations where licensees were visited without notice.

Fixed and mobile voice, SMS, and Internet services are monitored independently with probes located at strategic areas and with scheduled calls to each other. BOCRA used two mobile probes for drive tests carried out on identified problem areas. The results were compared with submissions from operators for verification.

BOCRA has recently launched a customer feedback campaign, in both paper and online formats (*My Network, My Quality),* to identify problem areas being faced by customers, investigating three main QoS parameters, call set up success, call drop rate, and call quality. In addition, BOCRA holds biannual customer satisfaction surveys and provides a consumer on-line complaints procedure.

10.7.2 Malawi

The Malawi Communications Regulatory Authority (MACRA) has the mandate to protect the interests of consumers, purchasers and other users of communication services in respect of prices, quality of the services provided and terminal equipment supplied, and has the responsibility of monitoring the activities of licensees to ensure compliance with the terms and conditions of their licence and applicable regulations. Currently, QoS parameters and targets are specified in operator licences and include provisioning, customer care, network infrastructure, short messaging (SMS), billing, mobile and fixed voice/data services. The parameters and targets were arrived at through benchmarking exercises with other regulators; international best practices; consultation with operators and other stakeholders; and country experience.

Currently, the measurement of the parameters is done through customer surveys, drive tests, quarterly reports from operators and technical audits. The Consolidated ICT Regulatory Management System (CIRMS) is being implemented to allow MACRA to obtain measurements in real-time. The results would be published in the public media. The objectives of the measurements include to assist customers to make informed choices, to independently verify compliance to terms and conditions of licensees, as well as to help operators maintain and improve QoS delivery. The failure by an operator to meet a QoS target amounts to a breach of licence. The sanctions for breach of licence are as follows:

- Issue a warning.
- Issue a compliance order directing licence to take appropriate remedial steps.
- Impose a penalty – maximum penalty is USD 40 000; minimum penalty USD 2 500.
- Revocation of licence for substantial breaches, if a QoS target is missed for the first time, a first warning is issued. If it is missed for a second time, a second warning is issued. The third time sees the revocation of the licence.
- The licence may not be renewed for failure to adhere to licence terms and conditions, including QoS targets.

Generally, licensees can defend themselves before any regulatory sanction is taken against them. There are no provisions for compensation to the user.

10.7.3 Mauritius

The Information and Communication Technologies Authority (ICTA) of Mauritius is responsible for QoS regulation and deals with monitoring and enforcement as provided under the ICT Act 2001 as amended (https://www.icta.mu/acts.html) below:

"The ICTA under section 18(1) (b) of the ICT Act 2001 is to provide economic and technical monitoring of the information and communication industry in accordance with recognized international standard practices, protocols and having regard to the convergence of technology. Also, under section 18(1) (f) of the ICT Act 2001 ICTA is to establish, for public operators, performance standards and linkage standards in relation to the provision of international and local telephone services, and monitor compliance with both of those standards" and

"to report, in such manner as may be required, to the Minister or to any other person on any matter that lies within its purview, such as the performance of public operators, the quality of consumer service and consumer satisfaction, measured against the best available international standards of practice. In furtherance to section 18(1) (n) of the ICT Act 2001, ICTA is to ensure the safety and quality of every information and communication services including telecommunication services, and for that purpose, determine technical standards for telecommunication network, the connection of customer equipment to telecommunication networks."

QoS regulation was released in April 2014 empowering ICTA to enforce QoS measures (https://www.icta.mu/docs/laws/qos.pdf). The next step is to update the QoS monitoring and enforcement framework in order to deploy the appropriate mechanisms to monitor QoS.

10.7.4 Mozambique

The *Instituto Nacional das Comunicações de Moçambique* (INCM) has the mandate to define the parameters, indicators, and methodology for measuring QoS. The QoS indicators are defined in Annex I in the QoS Regulation approved by Decree No. 6/ of May 2011. In 2015, Annex I was revised to amend the parameters, indicators and targets, and introduced Annex II which defines the methodology, including network performance monitoring and drive testing.

In 2015, INCM engaged consultants to conduct a pilot drive testing in the Maputo region to assess the new indicators and targets. INCM was responsible for measuring network related indicators in the revised Annex I, while operators were responsible for measuring non-network related parameters. In 2017, a contractual process to acquire a network performance monitoring system based on the raw data from operators was started.

10.7.5 Namibia

The objectives of the Communication Act of 2009 include promotion of the availability of high quality, reliable and efficient telecommunication services to all users in Namibia, and ensures consumer protection. Section 129 empowers the Communications Regulatory Authority of Namibia (CRAN) to make regulations prescribing QoS.

Regulations on licence conditions for telecommunication service licensees (2012) stated that telecommunication licensees shall comply with QoS standards as prescribed by the authority in terms of the regulations regarding network quality, infrastructure, billing, and service quality.

Following regulations that set out licence conditions for spectrum use licences (2013), licensees are obliged to provide information to enable the authority to monitor and enforce consumer protection and quality of service. Regulations prescribing QoS standards applicable to service licensees (2015) specify QoS parameters and targets, as well as enforcement measures and process. The services covered by the regulations include fixed telephony, network coverage, cellular mobile telephony, cellular mobile data services, SMS, customer care services, call centre services, interconnection and network infrastructure.

The parameters and targets specified in the regulations are guided by ITU Recommendations, ETSI documents, industry consultation, as well as benchmarking with other countries. The measurement of parameters is currently carried out through operator documents and reports. In 2016, independent field tests were outsourced to assess applicable QoS parameters and targets.

On enforcement, any licensee who fails to maintain the minimum QoS standards or fails to submit the required reports is guilty of contravening the regulations. In these cases, the authority can issue a warning and final date for submission, require the licensee to implement a remedial plan, or order

the licensee to compensate subscribers or consumers for poor quality of service. The associated penalties are:

1. NAD 500 000 (approximately USD 37 000: For failure to perform measurements for reporting, submitting false or misleading information and contravening quality of service standard set out in Section 2 of Annexure A (billing and customer service);
2. NAD 1 000 000 (approximately USD 74 000): For contravening quality of service standard as set out in Sections 1 and 3 of Annexure A (service quality and network quality) and for repeat offenders; and
3. NAD 5 000 000 (approximately USD 368 000): For failure to implement a remedial plan agreed with the authority.

Before imposing the fine, the authority gives the licensee the opportunity to be heard before the authority decides whether to impose a penalty.

10.7.6 South Africa

The Electronic Communications Act No. 36 of 2005 mandates the Independent Communications Authority of South Africa (ICASA), established by ICASA Act No. 13 of 2000, to set out the minimum standards for the end-user and subscriber Service Charter. The provisions on QoS and its enforcement are contained in the end-user and subscriber Service Charter 2016. SANS (South African National Standards) 1725 defines the QoS parameters and measurement methods. The license terms and conditions commits to the Service Charter and SANS 1725.

The services covered by SANS 1725 include fixed telephony, network coverage, cellular mobile telephony, and SMS. The measurement of cellular mobile voice and data parameters are currently monitored by quarterly drive tests conducted in all provinces. Enforcement of the Service Charter is carried out through mediation and rebate as per Regulations 13 of the end-user and subscriber Service Charter. Sanctions include monetary fines of up to five million Rand, or non-monetary fines, such as publishing the breach in national media channels.

10.7.7 Swaziland

The Swaziland Communications Commission (SCCOM) QoS regulations, enacted in 2016, have yet to be implemented and will include activities such as monitoring and enforcement. The QoS regulations include both penalties and compensation to the user as part of the sanctions.

10.7.8 Zimbabwe

The 2001 Postal and Telecommunication Act (Chapter 12:05) gave the Postal and Telecommunications Regulatory Authority of Zimbabwe (POTRAZ) the mandate to monitor QoS in Zimbabwe. The Postal and Telecommunications (Quality of Service) Regulations Statutory Instrument 42 of 2016 (SI 2016-042) is the legal instrument that specifies QoS standards and enforcement measures. Regarding ICTs, the Statutory Instrument covers cellular telecommunication services, public fixed voice telephony services, data and Internet services, interconnection services, and customer care parameters.

The main objectives of QoS regulations include:

a. Promoting the interests of the consumer by setting minimum QoS standards.
b. Enabling the authority to monitor operators and enforce minimum QoS standards.
c. Promoting effective competition in the sector.
d. Improving performance of public operators.

The obligations of the licensee in terms of QoS regulations should be:

a. Meet or exceed the minimum QoS standards as set by the authority.

b. Provide consumers with enough information to enable them to make informed decisions.

c. Submit network performance data as required by the authority.

d. Retain QoS raw data for the minimum of time specified by the authority.

POTRAZ currently operates two different but complementary approaches to QoS monitoring based on:

- network element counters, whereby QoS audit reports are generated by processing and analysing probe measurement files; and
- active testing (stationary/walk/drive testing) whereby QoS audit reports are generated by processing and analysing log files from active tests.

Zimbabwe experienced a significant drop in penalty calls, going from 1 104 penalty cells in August 2016, to 295 in March 2017. Currently, the penalty schedule is being reviewed to bring it into line with the QoS regulations published in 2016.

10.7.9 Southern African Development Community countries recommendations on quality of service regulation

Overall, the Communications Regulators' Association of Southern Africa (CRASA) focuses on harmonization of the ICT regulatory environment in the SADC region. Considering the current state of QoS regulation and enforcement in the SADC countries, the following recommendations to CRASA can be considered as some of the most recent:

- CRASA should come together and move towards a common position on net neutrality as a regional group that consequently determines QoS policies and regulations on Internet services.
- CRASA may consider adopting the EU programme on mapping broadband in southern Africa with the main target of support planning of broadband investments, as well as reduction of investment costs.
- CRASA may consider developing a common broadband measurement platform[46], similar to the one being developed in the EU[47]
- Strengthened participation of CRASA members is recommended in ITU activities on QoS regulation, as well as capacity building via the ITU QoS Training Programme (QoSTP).

10.8 Short guidelines on quality of service enforcement

As a guideline on QoS enforcement, the regulatory authority may start with recommendations and move towards obligations in cases where the recommendations are important and practical, and the operator is not willing to comply. As already stated in Chapter 3 on QoS regulatory frameworks, the regulator can start by *naming and shaming* strategies to tighter regulation, before using financial penalties and finally moving to more drastic legal enforcement. Encouragement and enforcement should be graduated and proportional for the benefit of end-users. However, there is currently a noticeable difference in QoS enforcement between countries with developed (i.e. mature) telecommunication markets and countries with developing (i.e. less mature) markets. In mature (or competitive) telecommunication markets, QoS enforcement should be targeted to regulatory notice and publication of QoS measurements (on different KPIs for different services) on a website or in an official gazette,

[46] https://ec.europa.eu/digital-single-market/en/news/mapping-broadband-services-towards-integrated-platform-european-level

[47] https://ec.europa.eu/digital-single-market/en/news/mapping-broadband-services-towards-integrated-platform-european-level

with the aim of informing consumers. In less mature markets, regulatory authorities should consider applying financial penalties as a tool for QoS enforcement (for example in Kenya and India) after having given prior notice to telecommunication operators to improve QoS in a given time period (e.g. several months).

Furthermore, in less mature telecommunication markets and as part of QoS enforcement, the following measures may be considered as good practice:

- Requirement for operators to submit and/or publish additional information about the quality of the relevant services, including but not limited to its implementation of a remedial plan within a time-frame determined by the authority.
- Implementation of cost effective measurement systems that could independently assess the quality of service delivered by operators and perceived by consumers.
- Constructive dialogue on findings and possible remedies.
- Directives including but not limited to directing operators to compensate subscribers/consumers for poor QoS.
- Directive to meet KPI target values within a given realistic time period (e.g. three months) and impose fines after the given period if the directive is not fulfilled.
- Fines/penalties for poor QoS on selected technical KPIs for voice, SMS/MMS, and Internet/data services, which are of importance (e.g. voice call success rate, voice call drop rate, data service availability, data access success rate, data traffic congestion, guaranteed minimum bit rates in downlink and uplink, etc.).
- Fines/penalties for poor performance on the non-technical KPIs (e.g. accurate charging/billing of services, etc.).
- Compensation to customers (e.g. for longer time periods to repair a non-working service, provision and installation of Internet equipment such as modem, etc.).
- Fines/penalties for failures by an operator to perform measurement, reporting and record keeping as set out in national QoS regulations.
- Fines/penalties for submission or publication of false or misleading information about the QoS.
- Fines/penalties for obstructing or preventing an investigation by the regulator in respect of the QoS measurement, reporting, data collection and record-keeping procedures.
- Stating specific QoS conditions (KPIs, target values, and enforcement measures for cases of non-compliance) in the spectrum licences of mobile operators (because they are the dominant way to access telecommunication services in less mature telecommunication markets).

Overall, there is no global rule on applying penalties for QoS enforcement, therefore it should be done on a per country basis, by considering all relevant factors that could influence QoS degradation, and considering the benefits for end-users and society in general, as well as the telecommunication market and business aspects.

QoS must be encouraged and can be enforced.

11 Summary and concluding remarks

Regulation and management of QoS and QoE today are becoming increasingly important and complex with a profusion of ever evolving technologies, networks and services with different QoS capabilities in a highly competitive, challenging and globalized digital environment.

ITU-T Regulation Guidelines (published as Supplement 9 to E.800-series) provide the fundamentals of quality of service regulation, including QoS parameters and activities, recommended approaches, including information gathering, penalties and dialogue, specifying parameters, levels and measurement methods. This manual extends ITU-T Supplement 9 to ITU-T E.800 series Recommendations, *Guidelines on regulatory aspects of QoS* by introducing more hands-on information about QoS and QoE, as well as practical approaches in QoS regulation for telecommunication/ICT services.

Overall, the aim of QoS regulation remains to ensure fairness and high quality user experience. Nowadays, QoS regulation can be targeted to two types of services:

1. Individual services, session or connection, with QoS guarantees, such as QoS-enabled VoIP, QoS-enabled IPTV, or mission-critical services (specialized services over IP networks) are provided with QoS guarantees by the operator (e.g. IoT, machine-to-machine (M2M) services), etc.

   Individual services have different sets of KPIs (per service). When these services are provided over IP-based networks, which is a typical scenario today, then the common KPIs for IP-based services can also be applied to these individual services. The QoS of TV and IPTV services are rarely regulated (of course, this statement is valid if one does not include here the spectrum management for terrestrial TV broadcast systems).

2. Internet access service, by enforcing KPIs for Internet access services (e.g. bit rates in uplink and downlink, delay, jitter, loss ratio), the regulatory authority may ensure that end-users will have satisfactory quality when using OTT services (e.g. web services, e-mail, Skype, Viber, Youtube, Google, Google docs, Facebook, Twitter, BitTorrent, etc.), provided in a best effort manner based on principles of network neutrality. However, consumer education is also an important part of QoS regulation as home network (e.g. WiFi) or user equipment (e.g. low end CPU and memory) can result in lower QoE, and vice versa.

QoS regulation is directly related to QoS monitoring. Different regulatory approaches can be used to implement a quality monitoring system, including:

- Traditional regulation: The quality monitoring system may be implemented and run by the regulatory authority, either by the authority itself or by using an independent measurement provider. With a sufficient legal basis, the regulatory authority may also impose the establishment of a quality monitoring system on the operators. This option allows full control over the methodology for implementation, as well as the generated measurement data.
- Co-regulation: The regulatory authority in some cases may find it appropriate to establish joint regulator-stakeholder systems, rather than imposing implementation merely on the operator. Under such a scheme, cooperation with stakeholders may be useful to meet specific needs and/or regulatory objectives, such as:
  - system development by independent research institutions;
  - performing measurement campaigns with the help of consumer organizations;
  - publishing results on third party comparison websites.

  In this case, the regulatory authority can choose to involve different stakeholder categories and set up a cooperative monitoring system to share responsibilities and costs with independent research organizations and other third parties. Such cooperative systems using different governance solutions are already in place in some national markets. These may include public-private partnerships based on inter-institutional agreements; advisory bodies such as steering committees and technical round tables; and international cooperative

forums. Co-regulation should be guided by the same principles as formal regulation, i.e. it should be objective, justified, proportional, non-discriminatory, and transparent.

- Self-regulation: The regulatory authority may decide to leave measurement systems to be deployed by the market, and to promote self-regulatory initiatives, as well as publishing monitoring results[48]. For example, NRAs may launch education and information campaigns to increase consumer awareness of the availability and use of measurement tools, while inviting operators to make available user friendly tools to their customers. With this method, the regulatory authority may have some influence, but does not control the methodology of the QoS monitoring system, its implementation or generated data from measurements.

To enable consumers to test their broadband connection and monitor the broadband quality, regulatory authorities are increasingly providing broadband speed test tools free to all via their websites.

Defining appropriate and transparent QoS requirements can assist operators to provide quality services at affordable costs to consumers and regulatory authorities have a key role to play. Consultation and collaboration between regulatory authorities and regional and international organizations, including ITU, is very important in developing QoS regulation, and in particular monitoring and measurement tools.

With the publication of QoS commitments, and hence enforcement via "truth in advertising", the division of responsibilities between all parties could vary (e.g. the regulator, the operators, third-party service providers, vendors of monitoring tools and equipment, experts engaged in the process of QoS monitoring that will result in QoS enforcement, law and policy-makers, government, etc.), but primary responsibility is a matter of consumer protection. However, when the QoS monitoring indicates QoS levels significantly below advertised values (e.g. below 80 per cent of advertised values, as an example), then the regulatory authority should consider applying financial penalties to *quality* non-conformant operators. Such penalties should be gradual and proportional, trying to achieve a balance between having high quality telecommunication/ICT services on one side, while maintaining/ensuring sustainability of telecommunication operators and service providers in a single competitive market on the other.

Based on country experiences and good practices identified in previous ITU Trends in Telecommunication Reform reports (2003-2016), the following recommendations for QoS regulation can be made:

- The human capacities and technical resources of the telecommunication operators and customer opinions through widespread consultations, working groups, and open meetings helps to make monitoring effective.
- The performed measurements should be important for customers, practical for operators and comparable between operators. They should concentrate on only a few aspects of QoS.
- The measurements published should be accessible and helpful to customers, and fair to operators. They should be made available in ways appropriate to the intended users.
- Any targets set should be useful for customers and realistic for operators.
- Monitoring tasks should be regularly updated regarding measurement tools and applied tests (for example, to test higher bit rates, larger files are needed for upload and download).
- Defining appropriate and transparent QoS requirements can assist operators in developing countries to provide quality services at affordable costs.
- The NRA needs to define appropriate parameters, KPIs, and methodologies for QoS measurements, which are applicable to networks run by telecommunication operators, supporting both IPv4 and IPv6.

[48] BEREC, *Monitoring quality of Internet access services in the context of net neutrality*

- When defining appropriate quality of service standards, it is also important to maintain an environment where consumers have the ability to choose services according to their needs.

NRAs should have the appropriate skill set to carry out QoS regulation; therefore continuous capacity building is key to adapting to market and regulatory changes. NRAs can benefit greatly by learning from each other. The arguments for cooperation between regulators are very strong and can bring substantive benefits through the sharing of good practices and mutual learning.

Annex 1: Quality measurement tools

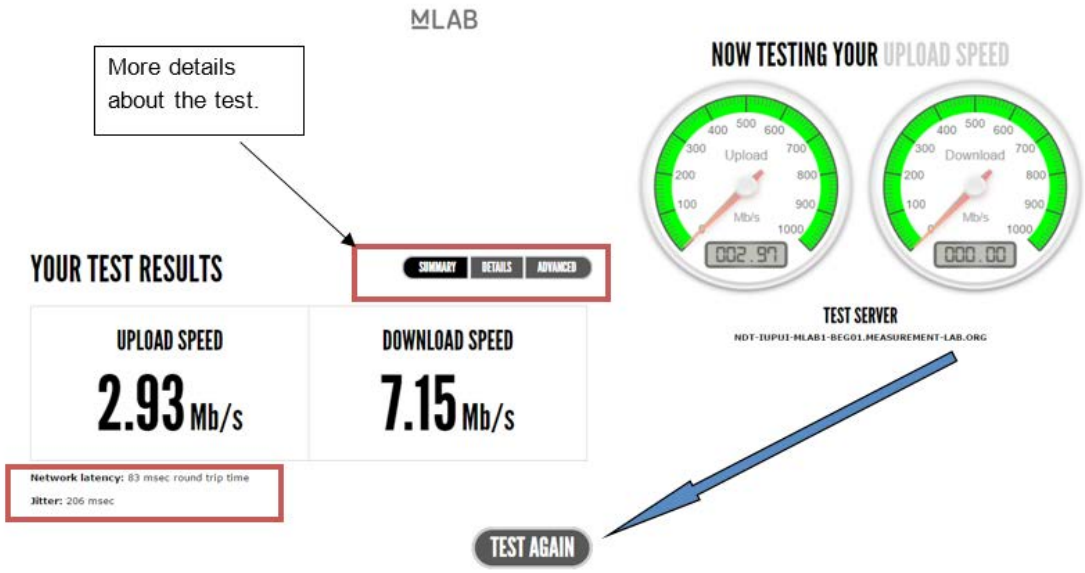
There are many tools available to perform broadband QoS measurements, some of them are available for free, and some of them are commercially offered to ISPs. This section describes several quality measurement tools. It is not intended as an exhaustive list of tools available, but rather to serve as a starting point.

A.1.1 Network diagnostic tool

A network diagnostic tool (NDT) is a client/server program that provides network configuration and performance testing for a user desktop or laptop computer. The system is composed of a client program (command line or java applet) and a pair of server programs (a web server and a testing/ analysis engine). Both command line and web-based clients communicate with a Web100-enhanced server to perform diagnostic functions. Multi-level results allow novice and expert users to view and understand the test results.

Both client and server processes are used to perform a specific set of tests. The server processes include a basic web browser to handle incoming web-based client requests. The server also runs a second process that performs the specific tests needed to determine what problems, if any, exist. That process then analyses the test results and returns these results to the client. NDT tests can be run via a web page (Figure A.1.1) or via a Unix command line tool.

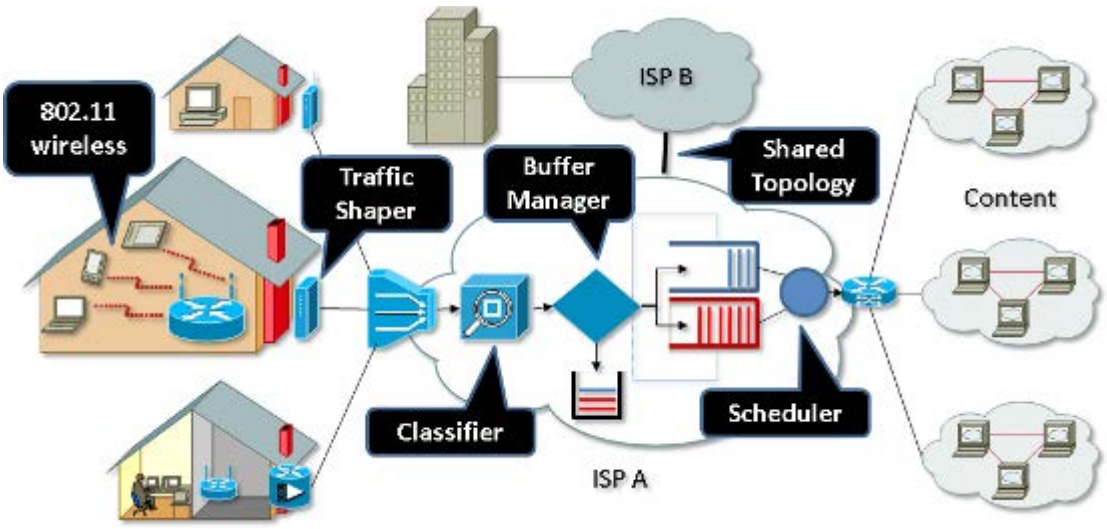
Figure A.1.1: Example measurements with the NDT tool



Source: M-Lab[49]

[49] Network diagnostic testing by M-Lab is available via: https://www.measurementlab.net/tests/ndt/

Figure A.1.2: NetInfer tool illustration of end-to-end Internet path



Source: NetInfer

Figure A.1.2: NetInfer tool illustration of end-to-end Internet path

A.1.2 NetInfer: End-to-end inference of Internet performance problems

NetInfer (http://netinfer.net/) provides a suite of tools for inference and diagnosis of Internet performance problems. NetInfer offers:

- **DiffProbe, Detecting ISP Traffic Discrimination.** The goal of DiffProbe is to detect if an ISP is classifying certain kinds of traffic as low priority, providing different levels of service for them. DiffProbe actively (and non-intrusively) probes the network path and tries to diagnose the nature and extent of traffic discrimination.
- **ShaperProbe Detecting ISP Traffic Shaping**. The DiffProbe ShaperProbe makes use of the Measurement Lab (M-Lab) research platform. (http://netinfer.net/diffprobe/shaperprobe.html)
- Illustration of the implementation of NetInfer is provided in Figure A.1.2.

A.1.3 Measurement tool for investigating network neutrality: Neubot

Neubot (network neutrality bot: www.neubot.org/**)** is a free software Internet bot, developed and maintained by the Nexa Center for Internet and Society at Politecnico di Torino, Italy, that gathers network performance data useful to investigate network neutrality. Once installed, it runs in the background and periodically performs active transmission tests with M-Lab servers (https://www.measurementlab.net/tools/neubot/). Three tests are currently implemented: a speed test that emulates HTTP; bit-torrent, which emulates Bit-Torrent; and raw, which performs a raw TCP test. All tests measure the application-level throughput and round-trip time, both in upload, and download directions.

A.1.4 Measurement tool SpeedTest by OOKLA

The SpeedTest by OOKLA is available at www.speedtest.net/ (Figure A.1.3). It measures ping round-trip time, upload and download speed. OOKLA claims that this is used by 80 per cent of ISPs globally. The OOKLA website also claims that approximately 10 billion speed tests have been carried out as of January 2017.

Figure A.1.3: SpeedTest by OOKLA



Source: OOKLA

OOKLA (https://www.ookla.com/) also offers commercial solutions called NetGauge to ISPs (based on SpeedTest technology) through a claimed set of customizable broadband performance testing and monitoring tools.

Annex 2: Quality measurement platforms

The basic idea of a controlled measurement platform is to provide infrastructure and architecture that allow for active measurements (client/server architecture). Such platforms may provide a pre-defined set of measurement tools or even offer an open infrastructure where any measurement tool may be implemented. The tools used can be either hardware or software based. Hardware-based probes are used as these measurement platforms are designed to allow for precise measurements under controlled conditions, following detailed measurement scenarios.

A.2.1 Measurement Lab (M-Lab)

Measurement Lab (M-Lab https://www.measurementlab.net/**)** is an open, distributed server platform provided to researchers to deploy Internet measurement tools developed by different parties. M-Lab is not a complete measurement platform by itself; it does however provide the infrastructure to set-up a measurement platform by deploying respective measurement tools on top of it. Data collected by those tools is released into the public domain (open data principle).

An important aspect of M-Lab software is that it is licensed as open-source. Users and organizations have the possibility to verify the security of the platform from their perspective, can modify the existing software for their special needs, and can develop new software with the option of it becoming an M-Lab tool.

Another important point is that all the collected and stored measurement results in M-Lab servers are publicly available to the community (open data principle). The advantage of this solution is that everyone can use the data; in addition, historical data can be easily collected and processed. It is then up to the NRA or third parties to process and present the data in a coordinated way.

At present some NRAs in Europe are cooperating on the basis of a Memorandum of Understanding with M-Lab. The Hellenic Telecommunications & Post Commission (EETT) in Greece uses the NDT and Glasnost tools for its HYPERION tool. The Office of the Commissioner of Electronic Communications and Postal Regulation (OCECPR) in Cyprus has also adopted M-Lab tools, using the same interface

as EETT. In Austria, the Regulatory Authority for Broadcasting and Telecommunications (RTR) has integrated the NDT into its RTR-NetTest.

A.2.2 RIPE Atlas

RIPE Atlas (https://atlas.ripe.net/) is the main RIPE Network Coordination Centre (NNC) Internet data collection system. It is a global network of hardware devices – called probes and anchors – that actively measures Internet connectivity (Figure A.2.1). Anyone can access this data via Internet traffic maps, streaming data visualisations, and an API (application programming interface). RIPE Atlas users can also perform customized measurements to gain valuable data about their own networks.

Figure A.2.1: All RIPE Atlas probes are shown on a map on the website



Source: RIPE

RIPE Atlas probes and anchors conduct built-in measurements including ping, traceroute, DNS, SSL/TLS (Secure Sockets Layer/Transport Layer Security) and HTTP. User-defined measurements can also be defined. RIPE Atlas Probes are small, USB-powered hardware devices that hosts connect to an Ethernet port on their router. RIPE Atlas Anchors (Figure A.2.2) are both enhanced RIPE Atlas probes with more measurement capacity, as well as regional measurement targets within the greater RIPE Atlas network. As such, RIPE Atlas anchors provide valuable information about local and regional connectivity and reachability of the Internet. There are currently over 9 000 active probes in the RIPE Atlas network, spread across all regions in the world. The network is constantly growing.

Figure A.2.2: All RIPE anchors locations



Source: RIPE

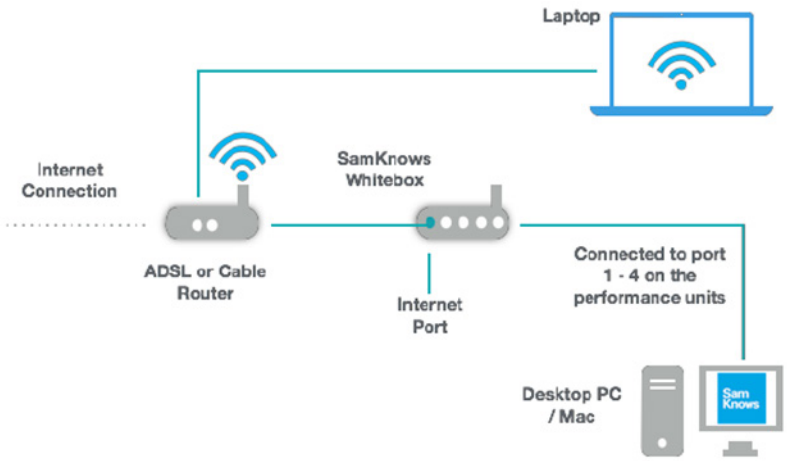
A.2.3 The global platform for Internet measurement: SamKnows

The SamKnows performance monitoring framework (https://www.samknows.com/) is a distributed network of Whiteboxes in actual consumer homes used to accurately measure the performance of fixed line broadband connections based on real-world usage. These are controlled by a cluster of servers, which host the test scheduler and the reporting database. The data is collated on the reporting platform and accessed via a reporting interface and secure FTP. The framework also includes a series of speed-test servers, which the nodes call upon according to the test schedule.

SamKnows uses hardware probes (Whiteboxes) for the purpose of accurately measuring end-user broadband performance (Figure A.2.3). The Whiteboxes execute a series of software tests over the broadband connection they are connected to. The results of these tests are reported securely on to hosted backend infrastructure.

The majority of tests run against a network of test nodes. These are dedicated servers either "on-net" (on the local ISP's network) or off-net (on the public Internet). Some tests will execute against real applications hosted on the Internet, mimicking their behaviour and measuring key performance variables. When a testing cycle has been completed, the results are encrypted and transmitted over SSL to the hosted backend infrastructure for processing and presentation through a web interface to each panellist and other interested parties. Panellists are, as part of the terms of service, required to leave their Whitebox and other networking equipment permanently powered on and connected to ensure consistent testing.

Figure A.2.3: SamKnows probe location



All SamKnows Whiteboxes run a custom distribution of Linux, derived from OpenWrt. Many standard OpenWrt features have been removed to save space on the device, and some additional features have been added to support the measurements. The custom firmware is flashed at the factory and is not directly upgradeable by the user hosting the Whitebox. The firmware is remotely upgradeable by SamKnows. This cut-down operating system provides network connectivity and the measurement applications alone – there is no web interface and the Whitebox provides no routing functionality. Panellists have no ability to disable, reconfigure or influence the SamKnows software in any way through normal usage.

SamKnows firmware makes use of General Public License (GPL) v2.0 licensed code. The source code for SamKnows' firmware build is available at: https://files.samknows.com/~gpl.

All communications between the Whitebox and the Data Collection Service on the backend hosted infrastructure are initiated by the Whitebox, encrypted over SSL and subject to authentication. The Whitebox communicates with the target test nodes over a variety of TCP and UDP ports. The Whitebox will also communicate with some unmanaged services over both TCP and UDP. The SamKnows software

suite has the ability to auto-update itself, download updated binaries and testing schedules from the Data Collection Service, and store locally in RAM or flash

Determining the best measurement server

Upon start up, the application runs a brief latency measurement to all measurement servers hosted by SamKnows. This process determines the nearest measurement server (in terms of latency). The measurement server with the lowest round-trip latency is selected as the target for all subsequent measurements (throughput, latency and packet loss). Additionally, if the ISP has installed 'on-net' measurement servers within their network, then the application will also select the nearest one of these servers. Measurements are run against both the on-net and off-net servers.

Cross-traffic, in-home network issues and configuration differences

One of the key advantages of the hardware-based Whitebox is its ability to detect cross-traffic and defer tests. Furthermore, its position within the home network (connected directly to the modem or gateway) means that it is unaffected by in-home network issues (such as those caused by wireless networks).

A purely software-based approach is not able to account for such issues. However, a number of mechanisms can be applied in an attempt to reduce or detect their impact. Cross-traffic within the local client (e.g. PC) is measured and tests will not be executed if the client is transferring more than 64 kbit/s.

Additionally, the web-based test will poll the user's gateway via UPnP (Universal Plug and Play) for traffic counters. This allows for cross-traffic within the home to be fully accounted for, and measurements will not be executed if the gateway is transferring more than 64 kbit/s. However, this UPnP-based approach is far from universally supported. A study from February 2012 showed that approximately 22 per cent of gateways in Europe supported traffic counter reporting by UPnP, but this figure is expected to rise[50].

In-home network issues (such as poor wireless) cannot be excluded by the web-based test. However, we can attempt to identify them. In particular, the web- based test records the connection media used by the client and its connected speed (e.g. Ethernet at 100 Mbit/s, or wireless at 54 Mbit/s). Additionally, the web-based test will also run a brief ICMP (Internet Control Message Protocol) latency and packet loss measurement to the user's gateway. If this reports more than 2 ms latency and 0% packet loss, then the measurements are aborted with a message stating that the user's in-home network appears to be operating poorly.

Client configuration issues (such as insufficient TCP settings, firewall products, RAM or CPU) are checked for before measurements begin. If these fall outside of accepted bounds, then the tests are aborted and the user is informed. In all of the error conditions above, the user will be informed of the reason why the measurements were not executed. The user may override the failure and run the measurements anyway, but the results will be recorded on the server side with a *tainted* flag, indicating that they were not run under optimal conditions.

The SamKnows methodology and platform have been designed to be flexible enough to allow for whatever future modifications or enhancements are required, but at the same time the out-of-the-box solution provides a fully inclusive package of every available performance measurement test. Table A.1 shows details about possible measurements.

[50] https://ec.europa.eu/digital-single-market/en/news/quality-broadband-services-eu-march-2012

Table A.1: Primary measures with SamKnows

Metric	Primary measure(s)
Web browsing	The total time taken to retrieve a page and all of its resources from a popular website
Voice over IP	Upstream packet loss, downstream packet loss, upstream jitter, downstream jitter, round-trip latency
Download speed	Throughput in Mbit/s utilising three concurrent TCP connections
Upload speed	Throughput in Mbit/s utilising three concurrent TCP connections
UDP (User Datagram Protocol) latency	Average RTT of a series of randomly transmitted UDP packets
UDP packet loss	Percentage of UDP packets lost from latency test
DNS resolution	The time taken for the ISP recursive DNS resolvers to return an A record for a popular website domain name

Source: SamKnows (https://www.samknows.com/)

Table A.2: Example test schedule with SamKnows (Europe)

Test Name	Test Target(s)	Test Frequency	Test Duration	Est. Daily Volume
Web browsing	3 popular websites	Hourly, 24x7	Est. 3 seconds	8.4MB
Voice over IP	1 off-net test node	Every other hour, 24x7	Fixed 10 seconds at 64 k	1.92MB
Download speed	1 off-net test node	Once 12am-6am Once 6am-12pm Once 12pm-6pm Every hour 6pm-12am	<30M bit/s = 6MB 30-50 Mbit/s = 12MB file size >50 Mbit/s = 10 seconds duration	54MB 108MB >~540MB
Upload speed	1 off-net test node	Once 12am-6pm Once 6am-12pm Once 12pm-6pm Once 6pm-12pm	<10 Mbit/s = 3MB fixed size 10-20 Mbit/s = 6MB >20 Mbit/s = 10 seconds duration	18MB 36MB >~216MB
UDP latency	1 off-net test node	Hourly, 24x7	Permanent	1MB
UDP packet loss	1 off-net test node	Hourly, 24x7	Permanent	N/A (uses above)
DNS resolution	3 popular websites	Hourly, 24x7	Est. 1 second	0.1MB

Source: SamKnows

A sample test schedule of the SamKnows platform is shown in Table A.2. The SamKnows Internet measurement platform actively performs testing in more than 40 countries on behalf of telecoms regulators and ISPs (https://samknows.com/global-platform) including CRTC in Canada, the Federal Communications Commission (FCC) in the United States, the Office of Communications (Ofcom) in the

United Kingdom, the InfoComm Media Development Authority (IMDA) in Singapore, OFCA in Hong Kong, China, Anatel in Brazil, ACCC (Australian Competition and Consumer Commission) in Australia, the European Commission, and others.

Acronyms

ACCC	Australian Competition and Consumer Commission
ADSL	Asymmetric digital subscriber line
AGCOM	Autorità per le Garanzie nelle Comunicazioni
AMR	Adaptive multi-rate
API	Application programming interface
ARCEP	Autorité de Régulation des Communications électroniques et des Postes
AS	Autonomous system
ASP	Application and service provider
ATM	Asynchronous transfer mode
BEREC	Body of European Regulators for Electronic Communications
BI	Business interface
BIAS	Broadband Internet access service
BOCRA	Botswana Communications Regulatory Authority
BTRC	Bangladesh Telecommunication Regulatory Commission
BTS	Base transceiver downtime
BUTS	Bulk users of telecommunication services
CA	Communication Authority (Kenya)
CAP	Content and application provider
CBBH	Cell bouncing busy hour
CCI	Call clarity index
CDNs	Content delivery networks
CDR	Call data record
CE	customer edge
CIRMS	Consolidated ICT Regulatory Management System
CIS	Commonwealth of Independent States
CM	complaint management
CPI	Comparable performance indicators
CPU	Central processing unit
CRAN	Communications Regulatory Authority of Namibia
CRASA	Communications Regulators' Association of Southern Africa
CRTC	Canadian Radio-television and Telecommunications Commission
CSCF	Call session control function
CSP	Communication service provider
CSV	Circuit switch voice

dBm	Decibel-milliwatts
DHCP	Dynamic Host Configuration Protocol
DL	Download
DNS	Domain name system
DoT	Department of Telecom
DPI	Deep packet inspection
DSCP	Differentiated Services Code Point
DSL	Digital subscriber line
DSLAM	Digital subscriber line access multiplexer
DTMF	Dual tone multi frequency
EAM	End-user application measurement
EDM	End-user device measurement
EDGE	Enhanced Data rates for Global Evolution
EETT	Hellenic Telecommunications & Post Commission
EPS	Evolved packet system
ETSI	European Telecommunications Standards Institute
FCC	Federal Communications Commission (US)
FRT	Fault repair time
FTP	File transfer protocol
FTTH	Fibre-to-the-home
FTTN	Fibre-to-the-node
FTTP	Fibre-to-the-premises
FTTX	Fibre-to-the-x
GPL	General Public License
GPON	Gigabit-capable passive optical networks
GPRS	General Packet Radio Service
GSM	Global system for mobile communications
HD	High-definition
HFC	Hybrid fibre-coaxial
HSPA	High speed packet access
HTML	HyperText Markup Language
HTTP	Hypertext transfer protocol
IANA	Internet Assigned Numbers Authority
IAS	Internet access service
ICANN	Internet Corporation for Assigned Names and Numbers

ICASA	Independent Communications Authority of South Africa
ICMP	Internet Control Message Protocol
ICT	Information and communication technology
ICTA	Information and Communication Technologies Authority (Mauritius)
IETF	Internet Engineering Task Force
IMDA	InfoComm Media Development Authority (Singapore)
IMS	IP multimedia subsystem
IoT	Internet of Things
INCM	Instituto Nacional das Comunicações de Moçambique
INMD	In-service non-intrusive measurement device
IP	Internet Protocol
IPDV	IP packet delay variation
IPER	IP packet error ratio
IPLR	IP packet loss ratio
IPRR	IP packet reordering ratio
IPTV	Internet Protocol Television
IPTD	IP packet transfer delay
IPXs	IP eXchanges
IVR	Interactive voice response
IXP	Internet eXchange Points
IRA	ineffective registration attempt
ISDN	Integrated services digital network
ISP	Internet service provider
ITU	International Telecommunication Union
IVR	Interactive voice response
KPI	Key performance indicators
LTE	Long-Term Evolution
M2M	Machine-to-machine
MACRA	Malawi Communications Regulation Authority
MDT	Mean down time
MMS	Multimedia Messaging Service
MOS	Mean opinion score
Ms	Millisecond
MTBF	Mean time between failures
MTTF	Mean time to failure

MTTR	Mean time to repair
NAP	Network access point
NB	Narrowband
NBTC	National Broadcasting and Telecommunications Commission (Thailand)
NCA	National Communications Authority (Ghana)
NDT	Network diagnostic tool
NER	Network error rate
NGN	Next generation network
NNC	Network Coordination Centre
NP	Network performance
NRA	National Regulatory Agency
NS	Network section
OCECPR	Office of the Commissioner of Electronic Communications and Postal Regulations (Cyprus)
OECD	Organisation for Economic Co-operation and Development
OFCA	Office of the Communications Authority (Hong Kong)
Ofcom	Office of Communications (UK)
OLT	Optical line terminal
ONT	Optical network terminal
OS	Operating system
OSI	Open Systems Interconnection
OSP	Online service provider
OTT	Over-the-top
P2P	Peer-to-peer
PC	Personal computer
P-CSCF	Proxy call session control function
PoC	Push-to-talk over cellular
PDP	Packet data protocol
PPDR	Public protection and disaster relief
PE	Provider edge
PESQ	Perceptual evaluation of speech quality
PLMN	Public land mobile network
POI	Point of interconnection
POLQA	Perceptual objective listening quality assessment
POTRAZ	Postal and Telecommunications Regulatory Authority of Zimbabwe
POTS	Plain old telephone service

PS	Packet switched
PSM	Project self-management
PSTN	Public switched telephone network
QCI	Quality classification identification
QoE	Quality of Experience
QoS	Quality of Service
QoSD	QoS delivered by service provider
QoSE	QoS experienced/perceived by customer/user
QoSO	QoS offer/planned be service provider
QoSR	QoS requirements of user/customer
QoSTP	Quality of Service Training Programme
QSDG	Quality of Service Development Group
RAB	Radio access bearer
RAM	Random-access memory
RB	Resource blocks
RIO	Reference Interconnect Offer
RRC	Radio resource control
RTCP	Real-time transport control protocol
RTP	Real-time transport protocol
RTR	Austrian Regulatory Authority for Broadcasting and Telecommunications
RTT	Round-trip time
SA	Service availability
SADC	Southern African Development Community
SCCOM	Swaziland Communications Commission
SCR	Session completion ratio
SDCCH	Stand-alone Dedicated Control Channel
SDH	Synchronous digital hierarchy
SDO	Standards Developing Organization
SDS	Short Data Service
SEER	Session establishment effectiveness ratio
SG12	Study Group 12
SG12RG-AFR	Regional Group on QoS for the Africa Region
SIP	Session initiation protocol
SLA	Service Level Agreement
SMP	Significant market power

SMS	Short Message Service
SON	Self-organizing networks
SP	Service provider
SQA	Service quality agreement
SQEG	Speech Quality Experts Group
SRD	Session request delay
SRVCC	Single radio voice call continuity
SSL	Secure Sockets Layer
SWB	Super-wideband
TCH	Traffic channel
TCP	Transmission control protocol
TDM	Time division multiplexing
TE	Terminal equipment
TI	Technical interface
TLS	Transport Layer Security
TRAI	Telecom Regulatory Authority of India
TSM	Telecoms Single Market
TTR	Time to repair
UDP	User datagram protocol
UL	Upload
UMTS	Universal Mobile Telecommunications System
UNI	user-network interface
UPnP	Universal Plug and Play
USB	Universal Serial Bus
VDSL	Very high bit rate digital subscriber line
VoIP	Voice-over-IP
VoLTE	Voice over LTE
VPN	Virtual private network
VQEG	Voice Quality Experts Group
WAP	Wireless application protocol
WATRA	West Africa Telecommunication Regulators Assembly
WB	Wideband
WCIT	World Conference on International Telecommunications
WLAN	Wireless local area network
WPs	Working Parties

WTP	Willingness to pay
WTSA	World Telecommunication Standardization Assembly

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