Final Report

ITU-D
Study Group 1

Question 2/1

Broadband access technologies, including IMT, for developing countries

6th Study Period
2014-2017

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Question 2/1: Broadband access technologies, including IMT for developing countries

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Preface

ITU Telecommunication Development Sector (ITU-D) study groups provide a neutral contribution-driven platform where experts from governments, industry and academia gather to produce practical tools, useful guidelines and resources to address development issues. Through the work of the ITU-D study groups, ITU-D members study and analyse specific task-oriented telecommunication/ICT questions with an aim to accelerate progress on national development priorities.

Study groups provide an opportunity for all ITU-D members to share experiences, present ideas, exchange views and achieve consensus on appropriate strategies to address telecommunication/ICT priorities. ITU-D study groups are responsible for developing reports, guidelines and recommendations based on inputs or contributions received from the membership. Information, which is gathered through surveys, contributions and case studies, is made available for easy access by the membership using content-management and web-publication tools. Their work is linked to the various ITU-D programmes and initiatives to create synergies that benefit the membership in terms of resources and expertise. Collaboration with other groups and organizations conducting work on related topics is essential.

The topics for study by the ITU-D study groups are decided every four years at the World Telecommunication Development Conferences (WTDCs), which establish work programmes and guidelines for defining telecommunication/ICT development questions and priorities for the next four years.

The scope of work for **ITU-D Study Group 1** is to study "**Enabling environment for the development of telecommunications/ICTs**", and of **ITU-D Study Group 2** to study **"ICT applications, cybersecurity, emergency telecommunications and climate-change adaptation"**.

During the 2014-2017 study period **ITU-D Study Group 1** was led by the Chairman, Roxanne McElvane Webber (United States of America), and Vice-Chairmen representing the six regions: Regina Fleur Assoumou-Bessou (Côte d'Ivoire), Peter Ngwan Mbengie (Cameroon), Claymir Carozza Rodriguez (Venezuela), Victor Martinez (Paraguay), Wesam Al-Ramadeen (Jordan), Ahmed Abdel Aziz Gad (Egypt), Yasuhiko Kawasumi (Japan), Nguyen Quy Quyen (Viet Nam), Vadym Kaptur (Ukraine), Almaz Tilenbaev (Kyrgyz Republic), and Blanca Gonzalez (Spain).

Final report

This final report in response **to Question 2/1: "Broadband access technologies, including IMT, for developing countries"** has been developed under the leadership of its Rapporteur: Luc Missidimbazi (Republic of the Congo); and five appointed Vice-Rapporteurs: Philip Kelley (Alcatel-Lucent International, France), Tharalika Livera (Sri Lanka), Turhan Muluk (Intel Corporation, United States of America), Laboni Patnaik (United States of America) and Yuki Umezawa (Japan). They have also been assisted by ITU-D focal points and the ITU-D Study Groups Secretariat.

ISBN

978-92-61-22591-9 (Paper version)

978-92-61-22601-5 (Electronic version)

978-92-61-22611-4 (EPUB version)

978-92-61-22621-3 (Mobi version)

This report has been prepared by many experts from different administrations and companies. The mention of specific companies or products does not imply any endorsement or recommendation by ITU.

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Executive Summary

Introduction

The World Telecommunication Development Conference (WTDC) in 2014 maintained the two ITU-D study groups to study telecommunication issues of particular interest to developing countries, including the issues referred to in 211 of the ITU Convention. ITU-D study groups should strictly observe Nos. 214, 215, 215A and 215B of the Convention. To facilitate their work, the Study Group has established working groups, rapporteur groups and joint rapporteur groups to study specific Questions or parts of Questions.

ITU-D Study Group 1 (SG1) has been established to provide developing countries with elements of understanding of the different technologies available for broadband access using wireline and terrestrial technologies for terrestrial telecommunications and satellite, including International Mobile Telecommunications (IMT). ITU-D SG1 should continue to address the technical issues involved in the deployment of broadband access technologies, including the integration of these access network solutions into existing and future network infrastructures, Guidelines for the development of broadband access, taking into account the fact that the standardization of broadband access technologies is a priority of the International Telecommunication Union's (ITU) strategic plan and to follow up on the initiatives of all developing countries (as proposed by the six Regional Preparatory Meetings (RPMs) for the World Telecommunication Development Conference).

Question 2/1, which is dedicated to Broadband access technologies, including International Mobile Telecommunications (IMT), for developing countries, was requested to study the following issues:

– Identify the factors influencing the effective deployment of wireline and wireless, including satellite, broadband access technologies and their applications;
– Examine broadband access technologies and their future trends;
– Identify methodologies for migration planning and implementation of broadband technologies, taking into account existing networks, as appropriate;
– Consider trends in the various broadband access technologies, deployments, services offered and regulatory considerations;
– Continue to identify ways and means of implementing IMT, using terrestrial and satellite links;
– Identify key elements to be studied in order to facilitate the possible deployment of systems integrating the satellite and terrestrial components of IMT;
– Provide information on the specific impact of the deployment of all broadband access technologies on underserved populations, including persons with disabilities;
– Provide information on IMT-Advanced systems, based on the advice of Working Party 5D of ITU-R Study Group 5 and working parties of ITU-R Study Group 4.

The Final Report of Question 2/1 includes: (i) an analysis of factors influencing the effective deployment of all broadband access technologies, and (ii) guidelines for deploying broadband access, including training seminars in accordance with the relevant programme of the ITU Telecommunication Development Bureau (BDT). The working methods includes calls for contribution submissions, group meetings, contribution processing, editing of various reports and document management through the electronic platform set up by the BDT.

Sources of input are:

– Results of technical progress in this area within relevant ITU-R and ITU-T study groups, in particular, Working Parties 5D and 5A of ITU-R Study Group 5 and Working Parties 4A, 4B and 4C of ITU-R Study Group 4, ITU-T Study Group 15 (Question 1/15) and ITU-T Study Group 13 (Question 15/13);
– ITU publications, reports and recommendations on broadband access technologies;
– Relevant reports from national or regional organizations of developing countries and developed countries;
– Contributions on the experience gained in the implementation of the networks concerned in developed and developing countries;
– Contributions by Sector Members on the development of wired and wireless broadband access technologies, including access via satellite systems;
– Relevant contributions from service providers and OEMs;
– Contributions and information from BDT focal points on broadband and various broadband access technologies;
– Results and information resulting from the study of Questions related to ICT applications.

Considering the above, this Report summarizes the results of the work on:

– Analysis of factors influencing the effective deployment of all broadband access technologies; and
– Guidelines for the deployment of broadband access, which could be provided through training seminars in accordance with the relevant BDT programme.

This restitution can be summed up in three main points:

– A review of the issue taking into account the previous study results;
– An analysis of the situation, supported by taking into account several contributions of the ITU-D Members and discussed during the ITU-D study group meetings;
– A review of technological developments and deployment modes;
– Review of recommendations conducive to the development of broadband, analyzing documents received, exchanges and debates in committee or working group.

1 CHAPTER 1 – General matters

Definition of Broadband

First of all it is necessary to understand what "Broadband" is, as there are various definitions by ITU-R, ITU-T, the Broadband Commission and other bodies, and there is no consensus on a single definition. However, the lack of a revised common definition has not impeded the work of the ITU up to this point. Some definitions are referred more to the kind of service to be supported than to a specific data rate. See **Annex 3**.

The Global Connect Initiative[1]

- In today's world, access to, and use of, the Internet for the world's citizens and businesses is an essential part of development – similar to roads, ports, electricity, and other infrastructure.
- Sixty percent of the world's population does not have access to the Internet. There are 4.4 billion people living without the economic and social benefits that the Internet has delivered to the 3.2 billion people currently online.
- The Internet is one of the chief economic drivers of the 21st century, and today we are seeing the Internet's economic benefits increasingly shifting to the developing world. Overall, the Internet economy accounts for about 6 per cent of GDP on average in developed markets; while this number is lower in developing markets, the Internet economy is growing at 15 to 25 per cent per year in those economies by some estimates. Further, developing countries are experiencing a 1.4 per cent increase in GDP for every 10 per cent increase in broadband penetration.

With this in mind, e.g. the United States' Department of State launched the Global Connect Initiative to promote and support action from key stakeholders, including governments, industry, civil society, and the technical community, to help bring an additional 1.5 billion people online by 2020. Under this initiative, every partner country or stakeholder contributes what they can to bring us towards these goals, be it infrastructure technology, good regulatory practices, or financial or technical support.[2]

Consideration of the satellite option as a development alternative for universal service and other development-oriented services should be noted.[3]

The obligations that are incumbent upon States with regard to the development of globally-accessible telecommunication services for all in the interests of achieving development objectives – including adoption of the Internet protocol and a policy of broadband deployment through national plans in order to deliver voice, video and data services via the same platform – are taking them towards satellite solutions that will provide access to vast numbers of people on the African continent who have thus far had no more than a hypothetical hope of obtaining telecommunication services.

Despite the efforts deployed by States, the African Telecommunications Union, the International Telecommunication Union and non-governmental organizations, access to those services remains a problem in rural and isolated areas, small developing countries and island communities

In recent years, we have witnessed a clear and dynamic willingness on the part of satellite operators to enter into competition in the telecommunication service provision segment with significant proposals, particularly in the area of telemedicine or e-Learning platforms (Learning Management System (LMS)).

This new trend constitutes a response to the concerns of States whose strategic ambition in terms of telecommunications/ICT is to enable the provision, through the telecommunication network, of high-quality remote education to a significant number of school-leavers; tele-expertise, tele-diagnosis

[1] Document 1/384, "The Global Connect Initiative", United States of America.
[2] Idem.
[3] Document 1/313, "Consideration of the satellite option as a development alternative for the universal service and other development-oriented services", Republic of Senegal.

or teleconsultation services; and mobile financial services for those without access to banking facilities.

Looking at the nature of the offers and proposals being put forward by operators, the satellite solution could be an alternative.

In some countries, the regulatory framework remains an obstacle to the uptake of such offers which encompass all components of the transmission and access network (backhaul, fronthaul and access network). This situation has a braking effect on the exercise of universal service, which is having a hard time taking off in many developing countries.

Telecommunication satellite operators would benefit from offering cost-oriented services in order to capture market shares in a high-speed ecosystem targeting customers in rural and isolated areas that are eligible for the Fund for the Development of Universal Telecommunication Service (FDSUT).

Government authorities and regulators must turn their attention to a review of the legal framework in the interests of further strengthening the principle of technology neutrality and of undertaking an in-depth examination of the services on offer from satellite operators, which could be an alternative solution for the provision of service to territories with accessibility problems and for the provision of such services.

1.1 Factors influencing the effective deployment of wireline and wireless broadband access technologies and applications

There are various factors which can be broadly categorized into two groups[4]:

Physical factors

a) Mobile penetration

Although in many developed countries mobile penetrations is over the 100 per cent penetration levels, most developing countries are yet to achieve such levels. This issue is severe in rural and remote areas in these countries. Mobile penetration acts as a basic platform for Broadband deployment as it provides the necessary basic infrastructure and resource allocation to increase the feasibility of such deployments.

b) Handset ecosystem

The handset ecosystem facilitates the deployment of broadband technologies as the said provides incentives for operators to deploy broadband. Support of different IMT technologies in different bands is a critical factor as this will provide the necessary demand factors to facilitate deployment.

c) Geography

Geographic conditions affect the deployment of wired broadband deployment which creates a challenging terrain and changing conditions for deployment. However, wireless deployment may be affected as results of the requirement to increase in the number of base stations to overcome terrain challenges.

For example[5], Sichuan is a remote south-western Chinese province with more than 40,000 villages and minority regions. In Pugh county, "the last nationwide telephone county" in history, the residents have since 2015 enjoyed 100Mb fiber-optic broadband. This change has been enabled through Sichuan's "Rural Broadband" mode. In Sichuan, the "Rural Broadband" innovative mode, using the planning guide, technological innovation and zoning development, deals with the high costs and

4 Document 1/262, Democratic Socialist Republic of Sri Lanka.

5 Document 1/206, "'Rural Broadband' innovation mode, creating a new era of optical network in rural areas", People's Republic of China.

slow-developed user problems. Government support and business cooperation ease the major challenges related to investment in the rural optical network. IPTV has proven to be a good example to solve some challenges related to urban and rural integration in Sichuan as it provides wise gateways to solve rural application problems.

These innovations partly solve the problem of the broadband, and are creating "a new era of optical network" in rural areas. They get a good harmony of enterprises, users and society. "Rural Broadband" mode is a real example of implementation in rural and remote areas.

d) Spectrum constraints

As there are many users of limited spectrum resources, especially in the wireless domain, spectrum availability for wireless broadband access technologies and applications acts as a constraint in broadband deployment. Existence of strategies for clearance of spectrum in the bands identified for IMT in the ITU Radio Regulations is essential for successful broadband development and deployment.

Sociological and policy factors

The following factors affect broadband deployment from a demand limitation point of view by limiting penetration of internet and/or broadband related products.

a) Content literacy

As much of the content available on the internet is based on languages like English, Spanish, Mandarin Chinese, etc., the lack of knowledge of these languages coupled with lack of local content discourage deployment related to broadband as internet is the main driver of such deployments.

b) ICT literacy

ICT literacy and a cultural attribute of digital savviness attribute in many ways toward the successful penetration of broadband related products. Compared to developed countries, developing countries lack ICT literacy which in turn creates bottlenecks in successful penetration of internet services.

c) Policy directives

Digital road maps related to broadband provide a framework for successful penetration of access technologies and provide a collaborative approach in implementation of different technologies related to satellite, wired and wireless access mechanisms. Therefore, successful implementation of broadband technologies should be carried out considering the factors listed above and by providing the necessary incentives to lessen the bottlenecks arising out of those.

As can be seen from the Sri Lankan experience,[6] several efforts are underway that are examples of social and policy factors. e-Sri Lanka aspires to the ideal of making Sri Lanka the most connected government to its people, and raising the quality of life of all its citizens with access to better public services, learning opportunities, and information. Sri Lanka's over 100,000 hearing and vision impaired, stand to benefit from an "Impaired Aid Project" that has introduced "Digital talking Books" using a new suite of local language accessibility applications. Accessing Government Information Center via a telephone short code from anywhere in Sri Lanka to obtain information is another project implemented under e-Sri Lanka. Both these projects won awards at the 2009 World Summit Awards (WSA), a global initiative for selecting and promoting the world's best e-contents and applications. One of the ideas actioned was to create an e-Society where communities of farmers, students and small entrepreneurs are linked to information, learning and trading facilities. This action was via tele/knowledge centres called Nenaselas (Nena=knowledge+ selas=shops), that spawned across the country bringing within easy reach computer technology, the Internet, and IT skills training to many people who had never even seen a computer.[7]

6 Document SG1RGQ/138, "Broadband in Sri Lanka", Democratic Socialist Republic of Sri Lanka.
7 http://www.icta.lk.

Fixed and mobile operators joined hands with Ministry of Education and the Telecommunications Regulatory Commission of Sri Lanka (TRCSL) to connect ICT labs of leading schools in the capital Colombo and the suburbs with high-speed 4G LTE and the island-wide fiber network. This initiative provides students with seamless access to the Internet for education purposes using the information superhighway. Several educational content portals are also operated under the patronage of telecom operators. One such e-Learning portal, Guru.lk provides educational content under three main categories as School, Professional and Lifestyle. "Guru School" covers about 60 per cent of the school curriculum, "Professional" covers professional education (e.g., curriculum of banking exams) and "Life Style" includes courses such as beauty culture, cookery, yoga, etc.

1.2 Impact of broadband access technologies on underserved populations, including persons with disabilities

As highlighted in **Section 1.1**, both physical and sociological factors affect successful deployment of broadband technologies and following impacts can be visible for such deployments.

a) Equalization of access to knowledge and education

Compared to developed counties, developing countries face a larger disparity in access to resources allocated for education and knowledge sharing. Broadband development provides a platform for the developing countries to close the gap in terms of disparity by providing access to virtual resources over the deployed broadband technologies.

b) Standard of living

Access to knowledge outside its own domain allows people in developing countries to increase the standard of living by deduction or imitation by examples provided by developed countries. Development of broadband allows equal access and opportunity for all layers across a community to participate in the developments and gain benefits thereof.

c) Digital democracy

Platforms operate on top of the broadband layers which allow sharing of content and ideas, allow normal citizens to voice their opinions and views with respect to the development of Government and Non-Government related activities. User based media content development has extended the democracy across the digital domain providing empowerment to the citizens owing to the development of broadband access technologies.

d) Inclusion

Digital inclusion and financial inclusion are many aspects of inclusion which requires attention in a developing countries, which can be achieved by proper development of broadband technologies. As explained above, broadband deployment provides a fundamental layer to build and operates applications which allows to bridge the gap between developed and developing worlds.[8]

eMisr is a national broadband plan that aims at the diffusion of broadband services in Egypt.[9] eMisr is a two staged plan, the first stage ending by 2018, and the second stage ending by 2020. The key strategic objectives of the broadband plan aim to develop ubiquitous top notch telecom infrastructure, creating direct/indirect job opportunities, increasing productivity of governmental entities through up to date ICT platforms, using innovative ICT applications to augment the citizen's life by leveraging the broadband networks. Thus, eMisr is a plan that proposes different strategic directives to meet Egypt's broadband service needs. As such, "eMisr" aims to extend broadband services in all over Egypt including underserved areas.

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8 Document 1/262, Democratic Socialist Republic of Sri Lanka.

9 Document SG1RGQ/63, "The national broadband plan 'eMisr': Transition from planning to execution", Arab Republic of Egypt.

Similarly, access to broadband in Rwanda has been an enabler breaking development barriers and profoundly changing how services are delivered.[10] It also leads to the increase of productivity, access to knowledge, and better prospects for the Rwandan citizens.

As the country is divided into four provinces which are structured in four tiers: 30 districts, 416 sectors, 2,148 cells and 14,837 villages, the government of Rwanda developed the policy aimed to promote the broadband access to reach the low level administrative entities, from districts to sectors, cells and villages, in the spirit of providing equal opportunity to broadband services for all citizens of the entire country.

1.3 Impact of broadband university and development of innovation centers

Congo has experienced a significant development of telecommunications infrastructure to facilitate broadband access to all professional groups, social and citizens[11]. The program has the past two years to carry out projects at the university and training center which has created centers of innovation or technology incubators, which allow many young people to develop projects with broadband access to university or community centers which greatly facilitates the use of ICT and the development of advanced training programs.

We will demonstrate this contribution the impact the deployment of telecommunications infrastructure provides the student conditions and that the development of technological initiatives to provide youth with access to broadband.

Development of broadband in Congo

Congo has initiated an extensive infrastructure deployment plan across the Congolese territory. This deployment has allowed to launch projects at the university, creating incubators. These programs supported by the regulator (Regulatory Agency of Post and Electronic Communications) is to provide young people with professional expressions spaces.

Thus, broadband has allowed and enabled the following:

- Creation of a Technological Innovation Centre and services to the University;
- Creating two incubators Yekolab and BantuHub; and
- Implementation of Tele-education program with universities.

University Innovation in Telecommunications Services Program

The University Innovation in Telecommunications Services Program (PUITS), initiated by the Regulatory Agency of Post and Electronic Communications (ARPCE) and implemented by the CAB (Central African Backbone) project. It is a project funded by the World Bank and the regulator ARPCE. The project has as its objectives to contribute to the improvement of teachers' working environment and the students of the University Marien NGOUABI (UMNG), specifically the Higher National Polytechnic School, as well as to promote exchanges between academia and business.

Outside of academic activities, the platform has housed various other activities, as well as part of the training of awareness, namely:

- January 2015: Initiation of the Master 1 and 2 students to create blogs to prepare for the competition for the best blogger PRATIC organized by the association;
- February 2015: Introduction to the Internet of five team (5) officers of the Education of the University; and

[10] Document 1/165, "Access to Broadband in Rwanda", Republic of Rwanda.
[11] Document 1/266, "Impact of broadband at university and on the development of innovation centres", Republic of the Congo.

– March 2015 workshop of education and training on the DNSSEC (Domain Name System Security Extensions) organized by ARPCE.

Moreover, the program allows researchers and teachers to students to utilize the internet for their work with a free internet connection through broadband.

1.4 ICT in education – broadband access technologies

The role of broadband in education can be broadly defined in order to cover the fundamental areas which should be included in education through broadband.

a) Access to content

Access to proper content is the major bottleneck to be overcome in the physical domain as well as the virtual domain which operates on a deployed broadband technology. The content can vary from text books to content providers such as tutors.

b) Access to resources

Access to resources is a major consideration, which needs to be properly addressed. Although broadband provides a layer to build education and ICT related knowledge sharing portals, there is a need to have proper end terminals such as computers, laptops and notepads which can be used to distribute the content generated.

c) Inclusion

Content generation and resource distribution provide inclusion and reduce the disparity between developed and developing countries. The main consideration of ICT in education is to focus on the requirement and degree of deliverability of the demand generators that can be broadly separated into the following groups:

- Primary and secondary education;
- Professional education; and
- Tertiary education.

For developing countries, the need for localized content is critical for a successful implementation of the education layer on top of deployed broadband technologies. However, unique requirements posed by the education sector need to be carefully analyzed as these factors may be critical for the successful implementation of the education layer. Download bandwidth and latency are certain attributes which require planning assistance for a proper implementation of ICT education in broadband access deployment.

There are various initiatives to raise awareness about the potential of the Information Society through the use of available technologies. Qualcomm Wireless Reach has launched various programs such as the StoveTrace program that demonstrates how mobile phones can aid in advancing the economic, health and environmental objectives of individuals and communities[12]. Low cost devices and free applications bring isolated communities access to information and people worldwide. Another example is the Wireless Heart Health program (2011) to support the prevention and management of CVDs in China's rural communities in collaboration with Life Care Networks[13]. Wireless Heart Health targets rural doctors and patients. This system includes a smartphone with three built-in ECG sensors and an Electronic Health Record (EHR) platform that offers instant access to patient records, including ECG data.

d) Broadband Access Technologies

[12] Document SG1RGQ/374, "India – Stove Trace Case Study", Qualcomm Inc. (United States of America).
[13] Document SG1RGQ/376, "Wireless Heart Health: China Case Study", Qualcomm Inc. (United States of America).

Different broadband access technologies[14] can be used for "ICT in Education" (terrestrial wireless, fibre, cable, satellite etc.). Fixed broadband access technologies are not well developed in developing countries compared to developed countries and therefore wireless technologies play important role. Availability, appropriateness and cost are the key factors in deciding which method to use for Internet access. Alternative terrestrial wireless broadband technologies can be used for the schools if fixed technologies are not available. Satellite broadband is useful for serving remote or sparsely populated areas. If telephone lines already exist in the school, it may be possible to use Digital Subscriber Line (DSL) service, which can be offered without additional investment in infrastructure (other than for a DSL modem). Other fixed broadband options include coaxial cable or fibre-optic connections, although these options may not be available or affordable in many developing countries.

Many countries are connecting schools and other education institutes with broadband access technologies for the usage of ICT in Education. Each country's situation could be distinct but most important step is to develop a national plan for the usage of ICT in Education and a plan for the connection of all schools with broadband. There may be specific measurable targets for the data rates such as to connect all schools at 10 Mbps in 5 years, at 50 Mbps in 10 years etc. For example, United States' "ConnectED Initiative"[15] has a target to connect all schools at speeds no less than 100 Mbps and with a target of 1Gbps. South Africa's National Broadband Policy[16] has a target to connect 50 per cent of schools at 10 Mbps by 2016, 80 per cent at 100 Mbps by 2020 and 100 per cent at 1Gbps by 2030.

Ideally, countries want to connect all schools and other educational institutes with fibre broadband access but the availability at national levels in developing countries will take years. Therefore, a gradual migration plan will be useful. There is also a reality for the remote rural areas we will need satellite technologies. Data rates determines broadband access technologies. Large urban schools with many students will need more bandwidth than small rural schools. The availability of broadband access types in urban and rural areas are also different. At initial phase existing available xDSL, wireless and satellite technologies can be used to connect schools if fibre technology is not available. Insufficient bandwidth will also restrict the use of some educational applications such as distance learning.

m-learning is an important subset of e-Learning (ICT in Education) and mobile broadband access technologies provide opportunity to deliver education at outside of schools all the time. Today, 3G and 4G networks are available and IMT-2020 (5G)[17] may also play an important role for the m-learning. Widespread availability of mobile broadband access networks in developing countries is also an important advantage.

It is also important to prepare a country level broadband access map to evaluate the existing technologies for the all regions and develop a plan accordingly for the provision of broadband connectivity to education systems.

The increasing use of video streaming and interactive online training requires more capacity and high data rates. Additionally, classes can consist of many students and multiple classes can run simultaneously with a result of large number users contending for bandwidth at any time. Therefore, schools need very high speed broadband connectivity.

WLAN Broadband Access technologies are needed for the distribution of broadband to classrooms and each student/teacher internet devices (tablets etc.) everywhere in the school area and university campuses. WLAN technologies and standards are also continuously developing to provide more capacity and high data rates (IEEE 802.11ac, IEEE 802.11ad etc.). IEEE 802.11ac operates in the 5 GHz, IEEE 802.11ad operates in the 60 GHz and both provides data rates up to 7 Gbps. According to "Connect a School, Connect a Community" initiative; not only students but also community living school area

[14] Document 1/176, "ICT in Education – Broadband Access Technologies", Intel Corporation (United States of America).

[15] President Obama's Plan for Connecting All Schools to the Digital Age: https://www.whitehouse.gov/sites/default/files/docs/connected_fact_sheet.pdf.

[16] http://www.dtps.gov.za/documents-publications/broadband.html?download=90:broadband-policy-gg37119.

[17] IMT-2020 refers to the 5G standardization work at ITU.

will able to connect broadband at schools and this will also increase the need for more capacity and distribution with new WLAN Broadband Access technologies. Many universities are also providing free Wi-Fi services to the students and academic personal by using WLAN access technologies.

2 CHAPTER 2 – Broadband access technologies

2.1 Broadband access technologies and their future trends

A high quality broadband connection can be characterized by the following parameters:[18][19]

– High speed – The network must deliver data at a fast rate.

– Low latency – The network must have a minimal amount of delay.

– High capacity – The network must deliver a “quantity” of data that meets customers’ needs.

– High reliability – The network needs to experience few outages.

– Economical and scalable – The network must be cost effective to deploy, maintain, and

– Upgrade as broadband demand increases.

2.1.1 Deployment considerations: wireline vs. wireless

As wireless technology represents an increasing portion of the global communications infrastructure, it is important to understand overall broadband trends and the roles of wireless and wireline technologies. Sometimes wireless and wireline technologies compete with each other, but in most instances, they are complementary. For example, backhaul transport and core infrastructure for wireless networks are usually based on wireline approaches, whether optical or copper. This applies as readily to Wi-Fi networks as it does to cellular networks.[20, 21]

The overwhelming global success of mobile telephony, and now the growing adoption of mobile data, conclusively demonstrate the desire for mobile-oriented communications. GSMA Intelligence, for example, predicts that global mobile data traffic will increase 10-fold from 2014-2019, primarily driven by a projected 66 per cent annual increase in on-demand video.[22] However, the question of using wireless technology, for access is more complex.[23]

GSMA Intelligence Report 2016 also reported that in 2015 mobile growth is increasingly focused on the developing world: more than 90 per cent of the incremental 1 billion new mobile subscribers forecast by 2020 will come from developing markets. The number of smartphone connections globally will increase by 2.6 million by 2020, and again around 90 per cent of that growth will come from developing regions.

Speeds vary widely from under 1 Mbps to over 1 Gbps depending on equipment, configuration, and distance. Many experts believe that 4G LTE performs at close to the theoretical limit of spectral efficiency.

Without additional spectrum or the ability to make that spectrum delivery significantly higher speeds, wireless carriers are building more towers with fiber optic backhaul to meet the broadband needs of their customers.

There are several factors that limit a wireless network’s broadband quality which do not impact wireline broadband networks. Specifically, lack of spectrum limits both speed and capacity. In addition weather and obstacles, such as terrain, attenuate the wireless signal thus limiting availability and

[18] Document 1/188, Qualcomm Inc. (United States of America).
[19] See also Report for Q25/2 ITU-D study period 2010-2014.
[20] The text in Section 2.1.1 is largely taken from the LMH Handbook Vol. 5 on BWA Systems (document RGQ25/2/2, “Liaison Statement to ITU-D Study Group 2 (copy to WP 5A) Revision to Supplement 1 Handbook - Deployment of IMT-2000 Systems - Migration to IMT-Systems”, ITU-R Study Groups - Working Party 5D) with editorial changes.
[21] See also page 22 of Report for Q25/2 ITU-D study period 2010-2014.
[22] “The Mobile Economy”; GSMA Intelligence, 2015 and “The Mobile Economy”; GSMA Intelligence, 2016.
[23] More detailed information may be found in the Report for Q25/2 ITU-D study period 2010-2014.

reducing reliability. Finally, the speed of the network is a function of the number of users and the proximity of those users to the wireless tower. These factors keep wireless technologies from being economically scalable to higher broadband speeds.

Different mobile networks with 2G, 3G, 4G, technologies will continue providing the mobile service in parallel for a long time in the same country.[24] Moreover, each network requires its own frequencies to provide the best service to existing users that gets its service from one network to another depending of its coverage and type of required service (voice or data). Year-after-year, mobile technologies are evolving to provide higher data transmissions, but unfortunately the amount of cell sites has not growth as fast as the data transmission evolves, causing the perception of poor QoS. To solve this problem, more cell sites could be required, but the most important asset to solve the problem is to increase the amount of frequencies that can be used more efficiently for data management with new LTE technologies.

First and second generation wireless networks were focused on voice services, while the focus of 3G and 4G shifted toward data and mobile broadband. While the focus on mobile broadband will continue with IMT-2020, support for a much wider set of diverse usage scenarios expected. IMT-2020 may provide new applications and services both for developed and developed countries. Some of the IMT-2020 applications maybe much more important for the developing countries such as smart transportation systems, eHealth, education, smart grid, agriculture etc.

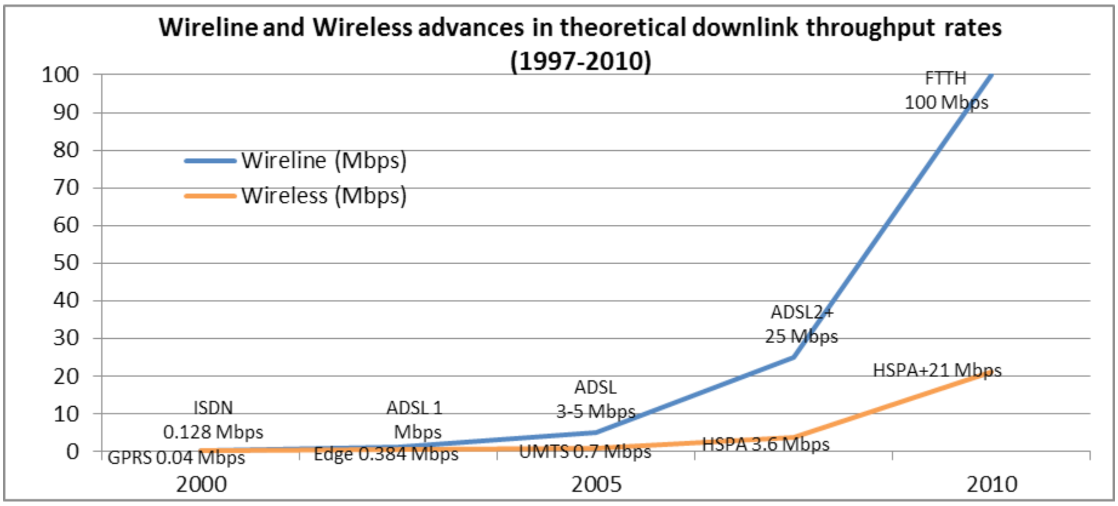
Migration of equipment (access device) at the customer end is always challenging – mainly due to economic reasons and sentimental factors involved in the replacement of customer-owned access device with new one that can support next generation broadband technologies[25]. Migration of existing networks to NGN is viewed as a change from a "TDM-based network" to an "IP-based network". Taking into consideration network possession portions between "access network domain" and "core network domain," migration procedure should be applied to one of such domains first. It is a general understanding that migration of "core network domain" is easier than migration of "access network domain", as the former will have less impact on service provision than the latter. The gradual approach to NGN migration may include the upgrade of the core network including replacement of routers and switches, the second stage of migration is to introduce IP Multimedia core network Subsystem (IMS) or similar for multimedia services, then migrate to IP transport network layer, modernization of the local loop followed by the user level. Many of these changes, however, can also run in tandem with one another.

One must consider the performance and capacity of wireless technologies relative to wireline approaches, what wireline infrastructure may already be available, and ongoing developments with wireline technology. In particular, wireline networks have always had greater capacity, and historically have delivered faster throughput rates. From 2000 to 2010, as shown in **Figure 1**, advances in typical user throughput rates, and a consistent advantage of wireline technologies over wireless technologies.

[24] Document 1/189, "Evolution in mobile broadband networks, for its consideration in the reports", Telefon AB – LM Ericsson (Sweden) and document 1/359, Importance of 5G for Developing Countries", Intel Corporation (United States of America).

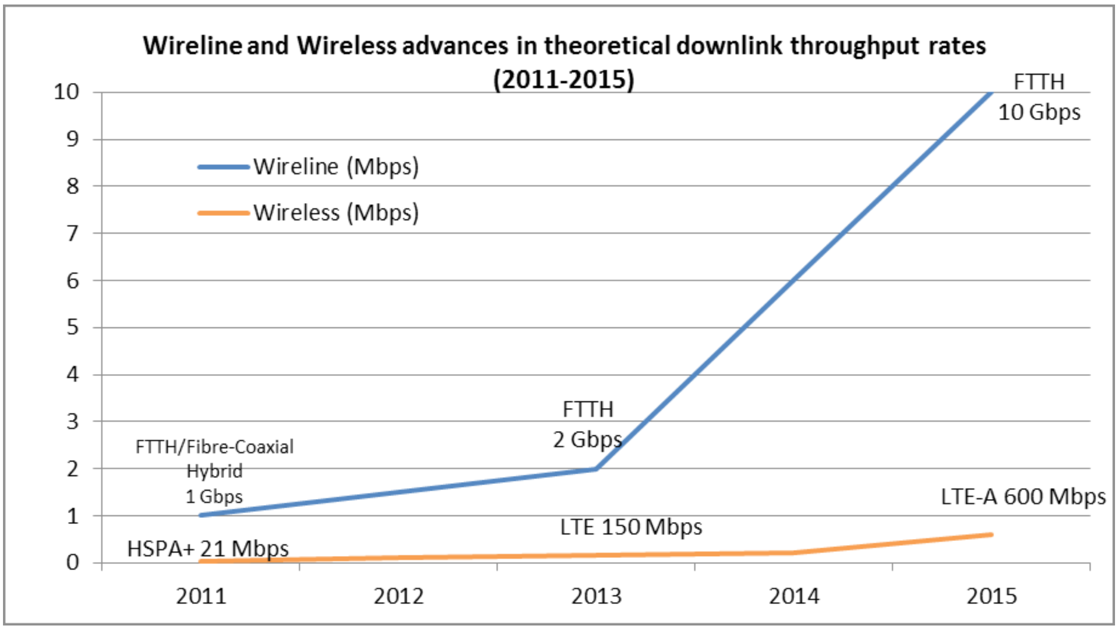
[25] Document SG1RGQ/90, "Developing regulatory framework in the context of Next Generation Networks (NGN) in Nepal", (Nepal Telecommunications Authority (NTA) (Republic of Nepal).

Figure 1: Wireline and Wireless advances in theoretical downlink throughput rates (1997-2010)



Since 2010, wireline technologies have continued their advantage over wireless technologies as shown in **Figure 2**, and gigabit wireline Internet service is being implemented with a provider launching 10 Gbps service in December 2014.[26] LTE-Advanced, now available commercially in over 30 countries, is achieving bandwidths of 600 Mbps, with transmission speeds approaching 1 Gbps in development.[27]

Figure 2: Wireline and Wireless advances in theoretical downlink throughput rates (2011-2015)



In today's world, submarine cables are essential to economic life and the social fabric – they are the international paths that connect the internet. They are critical communications infrastructure carrying more than 98 per cent of international Internet, data, video and telephonic traffic.[28] By comparison,

26 US Internet, Fiber to the Home – Plans and Prices for Residences, available at http://fiber.usinternet.com/plans-and-prices/plans-for-the-home/.

27 Ericsson, Ericsson and Qualcomm Deliver LTE Category 11 Smartphone Experience in Live Demonstration with Telstra, Feb. 26, 2015, available at http://www.ericsson.com/thecompany/press/releases/2015/02/1897731; Frank Rayal, Raising the Stakes in 3.5 GHz: LTE-Advance Achieves 1 Gbps, Jun. 22, 2014, available at http://frankrayal.com/2014/06/22/raising-the-stakes-in-3-5-ghz-lte-advanced-achieves-1-gbps/.

28 Document SG1RGQ/314, "Submarine cables in Africa", Orange (France).

undersea cables dwarf satellites for international communications and are unmatched for their reliability, speed, volume of traffic, and low cost.[29]

Although it is true that most BWA systems are now offering throughputs of up to 5 Mbit/s – which is comparable to what many users experience with a basic DSL or cable-modem service – the overall capacity of wireless systems is generally lower than it is with wireline systems.[30].This is especially true when wireless is compared to optical fiber, which some operators are now deploying to residences. With wireline operators already providing transmission speeds of 200 Mbit/s and even up to 1 Gbit/s to either homes or businesses via next-generation cable-modem services, Very high-speed DSL (VDSL), or fiber – especially for services such as 4K and 8K ultra high definition video – the question becomes, is it possible to match these rates using wireless approaches?[31] While the answer is "yes" from a purely technical perspective, it is "no" from a practical point of view. It is only possible to achieve these rates by using large amounts of spectrum, generally more than is available for current BWA systems, and by using relatively small cell sizes, with limited numbers of users. Otherwise, it simply would not be possible to deliver the hundreds of gigabytes per month that users will soon be consuming – notably due to increased interest in video content – over their broadband connections with wide-area wireless networks. Consider that 4K ultra high definition, defined as 3840 x 2160 pixels, content demands 15 to 25 Mbit/s of continuous connectivity, meaning that one subscriber could essentially consume the entire capacity of a cell sector.[32] Even if mobile users are not streaming feature-length movies in high definition, video is quickly being leveraged for many applications, including education, social networking, education, video conferencing, and telemedicine.[33] However, in recognition of the more limited capacity of wireless networks, many mobile operators employ download limits or other tools in order to prevent network congestion.

A possible wireless approach to address such high-data consumption is with hierarchical cell approaches, such as Femtocells. This presupposes, however, an existing wireline Internet connection (e.g., DSL).[34]

There are new broadband access technologies enabled by wireless devices using the Cognitive Radio System (CRS) techniques through Dynamic Spectrum Access (DSA) for determining available frequencies. There are underway commercial deployments and trials in some countries, utilizing these techniques in the unused TV bands ("TV white spaces") where the local regulations allow it.

This technical solution is being studied at several study groups in ITU-R and their outputs will need to be considered, alongside other relevant research, when evaluating the technical, economical and regulatory aspects of its implementation, especially in developing countries.

Cellular mobile broadband technologies clearly address user needs; hence, their success. The cellular mobile broadband roadmap, which anticipate continual performance and capacity improvements, provide the technical means to deliver on proven business models. As the applications for mobile broadband continue to expand, cellular technologies will continue to provide a competitive platform for tomorrow's new business opportunities".[35]

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[29] See also page 22 of the Report for Q25/2 ITU-D study period 2010-2014.

[30] WiMax Forum FAQ, available at http://www.wimaxforum.org/FAQRetrieve.aspx?ID=62698.

[31] Broadband Commission, State of Broadband 2014: Broadband for All, Figure 3 p. 17 (September 2014), available at http://www.broadbandcommission.org/documents/reports/bb-annualreport2014.pdf.

[32] ITU, Ultra High Definition Television: Threshold of a new age, ITU Recommendations on UHDTV standards agreed, May 24, 2012, available at http://www.itu.int/net/pressoffice/press_releases/2012/31.aspx#.VZwqPM9VhBc; Sony, Do Sony 4K Ultra HD TVs support 4K streaming content?, Feb. 23, 2015, available at https://us.en.kb.sony.com/app/answers/detail/a_id/45145/c/65,66/kw/internet%20speed%20for%204k; Comcast, Ultra High Definition (HD) Sample App FAQs, Mar. 6, 2015, available at http://customer.xfinity.com/help-and-support/cable-tv/uhd-smart-tv; Netflix, Internet Connection Speed Recommendations, available at https://help.netflix.com/en/node/306.

[33] http://4gamericas.org, Beyond LTE: Enabling the Mobile Broadband Explosion, at 13, Aug. 2014, available at http://www.4gamericas.org/files/7514/1021/4070/Beyond_LTE_Enabling_Mobile_Broadband_Explosion_August_2014x.pdf.

[34] For more information on Femtocells see pages 23-25 of the Report Q25/2 ITU-D study period 2010-2014.

[35] LMH Handbook Vol. 5 on BWA Systems (25/2/4).

The transition to IMT-2020 is expected to provide the higher data rates (1-20 Gbps), lower latency and capacity needed to enable the Internet of Things (IoT), new service models and immersive user experiences.[36]

IMT-2020 is also a faster and more efficient wireless connectivity, but this time, it is also about computing capability. The three major usage scenarios include: (1) enhanced mobile broadband; (2) ultra-reliable and low-latency communications; and (3) massive machine-type communications.

2.1.2 Comparisons, Mobile broadband and Fixed Access networks

For an extensive comparison for Mobile Broadband and Fixed Access networks technologies, from technical and financial considerations point of view, refer to the "Report on Implementation of Evolving Telecommunication/ICT infrastructure for Developing Countries: Technical, Economic and Policy Aspects".[37]

2.1.3 Wireline broadband access technologies

Within the ITU-T, the study and development of Recommendations related to transport in the access networks – in premises networks – is being carried out in a number of different Study Groups e.g. SGs 5, 9, 13, 15, and 16. Also ITU-R and other standards bodies, forums and consortia are also active in this area and Study Group 15 as been appointed as the Lead Study Group on Home Network with coordination purposes.[38]

Main challenge is the existence of a ceiling to network capacity in the predominantly copper "last mile" (between the exchange and the customer premises). Recommendations on VDSL2 vectoring achieves access speeds of 250 Mbit/s, and the next update of DSL (G.fast) will raise the bar to 1 Gbit/s by combining the best aspects of optical networks and DSL.

ITU-T SG15 standardizes shared-access Fibre-To-The-Home (FTTH) technologies known as Passive Optical Networks (PONs) that are a crucial step towards all-optical networks and, by eliminating the dependence on expensive active network elements, PONs enable carriers to make significant savings. 10-Gigabit-capable PON (XG-PON) is ITU-T's latest series of PON standards and achieves access speeds of up to 10 Gbit/s.

Based on the scenario methodologies developed for GII, a series of scenarios have been developed for ANT:

1) Provision of Voice/Data/Video Service over existing infrastructure;
2) Provision of Voice/Data/Video Services over Cable Networks using B-ISDN;
3) The use of ADSL or VDSL to provide video/data bandwidth over copper pairs;
4) Fibre Access Scenario;
5) Wireless Access;
6) Access using satellites;
7) Example of Internet Access;
8) Power Line Transmission (PLT).

36 Document SG1RGQ/359, "Importance of 5G for Developing Countries", Intel Corporation (United States of America).

37 Document SG1RGQ/229, "Updated Report on Implementation of Evolving Telecommunication/ICT Infrastructure for Developing Countries: Technical, Economic and Policy Aspects", BDT Focal Point for Question 1/1, revised in January 2017. Full Report on Implementation of Evolving Telecommunication/ICT infrastructure for Developing Countries: Technical, Economic and Policy Aspects, 2016.

38 Excepted from ITU-T SG15 publication: "Wireline broadband access networks and home networking", 2011, https://www.itu.int/pub/T-TUT-HOME-2011/.

The scenarios are used as references for correlation with the matrix of ANT-related standards for quick retrieval of specific applications (XNI, CATV, etc.). **Table 1** shows the analysis of the scenarios in terms of 1) the services, 2) the core network, 3) the access network, 4) the customer premises network, and 5) the information flow. The underlined characteristics inside the bold boundaries indicate the differentiating attributes from other scenarios.

From this table, it is clearly demonstrated that the main attributes which differentiate scenario 1 through 6 are the transport technologies used in the Access Network, i.e., Cable television (scenarios 1 and 2), ADSL/HDSL, Fibre, Radio, and Satellite, respectively. In scenario 1a) the DSB and terrestrial broadcasting are also included as a means of video distribution.

Scenarios 1 and 2 are different in that, in the former, the core network uses the existing infrastructure, i.e. PSTN/N-ISDN (Narrowband-ISDN), while in the latter the core network is B-ISDN.

Scenario 7 is illustrative of the Internet access, which is somewhat different from the others scenarios which provide voice/data and video.

In its role of Lead Study Group, ITU-T SG15 publishes and maintains regularly the Access Network Transport (ANT), Smart Grid and Home Network Transport (HNT) Standards Overviews and Work Plans documents, including an overview on existing and on ongoing standardization activities that provides an idea on future developments in ITU and in other Standards Developing Organizations (SDOs). More details are shown in **Annex 4.**

The wireline broadband network – ISDN

Integrated Services Digital Network (ISDN) was the first attempt at a completely digital telephone/telecommunications network (as opposed to using modems over switched analogue circuits).

In 1988 Recommendation ITU-T I.121 was published which described an enhanced ISDN service created by multiplexing multiple 64 kb/s channels and managed using Asynchronous Transfer Mode (ATM). A revised version of this Recommendation was published in 1991, describing the basic principles of broadband aspects of integrated services digital network (B-ISDN) and indicating further developments of the ISDN network capabilities. Even though ISDN found several important niche applications such as video conferencing and audio recording, it has never prospered as a consumer broadband access technology, Germany – with 25 million ISDN channels at one point in time – being the notable exception. The deployment of ISDN has continued to fade.[39] Running at a speed of 128 kb/s, ISDN has been replaced by faster technologies that are cheaper to install.[40] Currently, ISDN is mostly used by radio stations and recording studios. In the United States, Verizon announced it would stop taking orders for ISDN service in the Northeastern portion of the country in 2013.[41][42]

The wireline broadband network – DSL

The poor adoption of ISDN as a wireline broadband access technology is attributed to several factors, including delayed standardization, failure to keep pace with advances in applications like video and interactivity, complexity of consumer solutions and limited marketing by the network operators. However the fatal blow to ISDN deployment was the rapid development and commercialization of Digital Subscriber Line (DSL – originally "Digital Subscriber Loop") as a broadband wireline technology.[43] The ITU-T has published DSL standards since the late 1990s. They are summarized in Table 3.3-1

[39] Leslie Stimson, *Expect Verizon ISDN Changes in May*, Radio World (April 2013), http://www.radioworld.com/article/expect-verizon-isdn-changes-in-may/219126.

[40] *The Future of ISDN Voice Over Recording*, Audio Concepts (June 2014), http://hearaudioconcepts.com/the-future-isdn-recording.

[41] Thomas Ray, *Verizon No Longer Taking Orders for ISDN Service in Northeast Starting May 18* (March 2013), http://www.talkers.com/2013/03/28/verizon-no-longer-taking-orders-for-isdn-service-in-northeast-starting-may-18/.

[42] For more information see page 27 of Report for Q25/2 ITU-D study period 2010-2014.

[43] For more information see pages 27-29 of Report for Q25/2 ITU-D study period 2010-2014.

Table 1: Access Network Transport (ANT) scenarios

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Services	a) Voice/Data over telecom network and b) Video over cable, radio & DSB c) Voice/Data/Video over 2way cable	a) Voice/Data over telecom network and Video over cable b) Voice/Data/Video over 2way cable	Voice/Data & Video over ADSL/VDSL	Voice/Data & Video over Fibre Network	a) Wireless Phone Voice/Data over telecom network and Video over cable b) Voice/Data/Video over Radio c) DAB and DVB	B-ISDN, Internet and Mobile Phone via Satellite	a) Data over Internet b) Voice/Video and/or Data over Internet
Core Network	Existing Infrastructure (PSTN/N-ISDN) or NGN (Rec. Y-2012)	B-ISDN or NGN (Rec. Y-2012)	B-ISDN or NGN (Rec. Y-2012)	B-ISDN or NGN (Rec. Y-2012)	N-ISDN or B-ISDN or NGN (Rec. Y-2012)	B-ISDN Or Existing (N-ISDN) or NGN (Rec. Y-2012)	a) POTS/FR/ATM b) ATM Backbone or NGN (Rec. Y-2012)
Access network	a) 1-way Cable Distribution Network b) 2-way Cable Distribution Network c) DSB/terrestrial broadcasting in 1 a)		ADSL/VDSL	Fibre (Fibre to the curb/home)	Radio/Wireless for Voice/Data Cable for a) Video	Satellite	a) ADSL/VDSL b) PSTN/ISDN, HFC, PON c) Fixed wireless Access
CPN	Access Unit TV, PC, Phone		Access Unit TV, PC, Phone	Access Unit TV, PC, Phone	Access Unit TV, PC, Phone, wireless Phone	Access Unit TV, PC, Phone	Access Unit TV, PC, Phone
Information Flow	a) Video Distribution over 1-way cable network, return via PSTN/ISDN				2-way wireless	2-way satellite	

Note: Scenario 8, Power Line Transmission (PLT) has to be added as soon as details are available. Acronyms (e.g., ADSL, VDSL) refer in general to the family of related implementations, not a particular standard.

of Report for Q25/2 (ITU-D study period 2010-2014), along with telephone modem, ISDN standards, and in the newly adopted G.fast standard (G.9701).

G.fast is an ITU-T SG15 Recommendation studied to reply to the continuing customer demand for ever higher bit rate data services, high-speed Internet access and other innovative services.

The wireline broadband network – DOCSIS

The Data Over Cable Service Interface Specification (DOCSIS) was published in 1997. It defines the addition of high-speed data communications to an existing CATV system. Using DOCSIS, MSOs offered competing data communications on their video network, and with the development of Voice Over Internet Protocol (VoIP) offer POTS-like service. The latest version of the standard, DOCSIS 3.1, bonds up to 8 channels from the network to the terminal, and is designed to enable MSOs to offer subscriber access speeds as high as 10 Gbit/s using this technology.[44,45]

The Wireline Broadband Network – FTTx

A fibre optic wireline broadband network can have several configurations, such as Fibre-to-the-Home (FTTH), Fibre-to-the-Building (FTTB), Fibre-to-the-Curb (FTTC) and Fibre-to-the-Node (FTTN) up to Fiber-to-the Desktop (FTTD). In each case the optical network is terminated at an Optical Network Unit (ONU – also known as an Optical Network Terminal, or ONT).

The versions of FTTx are differentiated by the location of the ONU. For FTTH, the ONU is located on the subscriber's premises and serves as the demarcation between the operator's and customer's facilities. For FTTB and FTTC, the ONU serves as a common interface for several subscribers (e.g., the basement of an apartment building or a telephone pole), with the service delivered over the customers' existing TWP drop cables. For FTTN, the ONU is located in an active network node serving dozens to hundreds of subscribers from which service is delivered by existing TWP local loops.

There are two common architectures for FTTx: "Point-to-Point" (PtP) and the Passive optical network (PON). In a PtP configuration, enterprise Local Area Network (LAN) architecture is applied to the telephone access network, with a dedicated optical fibre connection (one or two fibres) from the ONU to the telephone exchange. A PON network is a point-to-multipoint fiber to the premises network architecture in which unpowered optical splitters utilizing Brewster's angle principles are used to enable a single optical fiber to serve multiple premises, typically 32 to 128, several ONU –up to 256, near end users – share a single fibre connection to the network which is typically split at a passive network node.[46]. A PON consists of an Optical Line Terminal (OLT) at the service provider's Central Office (CO) and a number of Optical Network Units (ONUs) near end users. A PON configuration reduces the amount of fiber and CO equipment required compared with point to point architectures.[47]

Gigabit-capable Passive Optical Networks (GPON) and Ethernet Passive Optical Networks (EPON) are two standards that open the door to new opportunities both for vendors and operators. Major vendors have added PON technology to their broadband access portfolios, and operators around the world have shown considerable interest in deploying this technology in combination with VDSL (Fiber-to-the-Cabinet, FTTC) or as residential access (Fiber-to-the-Home, FTTH). The three major PON standards are BPON (broadband PON), GPON, and EPON. BPON and its successor GPON are ITU-T recommendations sponsored by FSAN, a vendor and operator committee. EPON is an IEEE option developed by the IEEE Ethernet in the First Mile (EFM) initiative. Given that operators are driving

[44] Cablelabs, Data-Over-Cable Service Interface Specifications, DOCSIS 3.1, MAC and Upper Layer Protocols Interface Specification, at 49, available at http://www.cablelabs.com/wp-content/uploads/specdocs/CM-SP-MULPIv3.1-I06-150611.pdf and https://community.cablelabs.com/wiki/plugins/servlet/cablelabs/alfresco/download?id=d38ef93a-df24-45ae-bc2c-40ad16e61c8d;1.0.

[45] For more information about DOCSIS see page 29 of the Report for Q25/2 ITU-D study period 2010-2014.

[46] ITU-T, Recommendation ITU-T G.989.1, 40-Gigibbit-capable passive optical networks (NG-PON2): General Requirements, at 12.

[47] ITU-T, Recommendation ITU-T G.989.1, 40-Gigabit-capable passive optical networks (NG-PON2): General Requirements, at 11.

GPON standardization via FSAN, the GPON standard reflects operator needs more directly than does EPON. Although all three systems work on the same principle, there are several differences between them as shown in **Table 2**.

Table 2: Major PON technologies and properties

Characteristics	EPON	BPON	GPON	XG-PON	NG-PON2
Standard	IEEE 802.3ah	ITU-T G.983	ITU-T G.984	ITU-T G.987	ITU-T G989
Protocol	Ethernet	ATM	Ethernet,TDM		
Rate (Mbps)	1250 down / 1250 up, 8b10b-encoded	622 down, 155 up	2488 down, 1244 up	10 Gbps (down)	40 Gbps (down)
Span (Km)	10	20	20		
Split-ratio	16	32	64		

The vast majority of PON systems deployed today are TDM-based PON systems (i.e., B-PON, E-PON, and G-PON). They almost exclusively operate on a single fiber, with WDM used to provide bi-directional transmission. A third wavelength in the downstream is sometimes used for broadcast video services. On the other hand, WDM-PON is very limited deployed. Costs of WDM-PON in delivering mass market dedicated wavelength services are still higher high relative to TDM-PON. WDM and hybrid WDM-PONs are expected to play a greater role in next generation PON systems in the future.

ITU-T has been writing standards for FTTx since the 1990s. They are in the ITU-T G.98x-series of Recommendations, Optical line systems for local and access networks. A summary of key ITU-T FTTx standards is shown in the table on page 30 of the Report for Q25/2 (ITU-D study period 2010-2014) to be complemented with the standard indicated below:[48]

ITU-T G.989.x:	40-Gigabit-capable Passive Optical Networks (NG-PON2)*
*ITU, Transmission systems and media, digital systems and networks, ITU-T G.989.1, ITU-T G.989.2, available at: https://www.itu.int/rec/T-REC-G/en.	

Home networking

As the performance of the broadband wireline network to the home has increased, so has the need for performance of the network within the home. Within the home individual equipment capability has improved enormously.

Unless home networks can use existing physical plant (e.g., the home's electrical, telephone or coaxial cable network), constructing a wireline home network will be expensive in any home, and prohibitive on a societal basis

The ITU-T recently began to address this problem by drafting the ITU-T G.99xx-series of Recommendations. Key ITU-T Recommendations serving as home network standards are summarized in table on page 31 of the Report for Q25/2 (ITU-D study period 2010-2014) to be complemented with the standards indicated below.

ITU-T G.9972:	Coexistence mechanism for wireline home networking transceivers
ITU-T G.9973:	Protocol for identifying home network topology

48 For more information about FTTX see also pages 29-30 of the Report for Q25/2 (ITU-D study period 2010-2014).

ITU-T G.9979:	Implementation of the generic mechanism in the IEEE 1905.1a-2014 Standard to include applicable ITU-T Recommendations
ITU-T G.9980:	Remote management of customer premises equipment over broadband networks

Refer to **Annex 4** for ITU documents that may provide useful references on wireline systems,[49] wireless broadband access technologies, including IMT.

Types of wireless broadband access technologies

"A number of BWA systems and applications, based on different standards, are available and the suitability of each depends on usage (fixed vs. nomadic/mobile), and performance and geographic requirements, among others. In countries where wired infrastructure is not well established, BWA systems can be more easily deployed to deliver services to population bases in dense urban environments as well as those in more remote areas. Some users may only require broadband Internet access for short-ranges whereas others users may require broadband access over longer distances. Moreover, these same users may require that their BWA applications be nomadic, mobile, fixed or a combination of all three. In sum, there are a number of multi-access solutions and the choice of which to implement will depend on the interplay of requirements, the use of various technologies to meet these requirements, the availability of spectrum (licensed vs. unlicensed), and the scale of network required for the delivery of BWA applications and services (local vs. metropolitan area networks)".[50]

Recommendation ITU-R M.1801 contains "Radio interface standards for broadband wireless access systems, including mobile and nomadic applications, in the mobile service operating below 6 GHz". These standards support a wide range of applications in urban, suburban and rural areas for both generic broadband internet data and real-time data, including applications such as voice and video-conferencing. For the standards included in Recommendation ITU-R M.1801 refer to page 32 of the Report for Q25/2 (ITU-D study period 2010-2014).

Additional information specifically related to IMT and IMT-Advanced is presented in **Sections 2.2** and **2.3**. Experience of Kenya on the use of IMT and IMT-Advanced technologies for facilitating the broadband services in Kenya[51] can be found in **Annex 1**. Recommendation ITU-R M.1450 contains "Characteristics of broadband radio local area networks" and includes technical parameters, and information on RLAN standards and operational characteristics. For the standards included in Recommendation ITU-R M.1450 and related annexes refer to page 33 of the Report for Q25/2 (ITU-D study period 2010-2014).

Technical measures for effective use of wireless telecommunication

In the case of wireless telecommunication, unlike wired telecommunication, ensuring adequate capacity is a key issue. Thus, the main concern for wireless telecommunication operators will be acquiring sufficient spectrum to meet the capacity demand. However, the spectrum available for wireless telecommunications is limited. Thus, we have to consider other measures to ensure that the available spectrum is used more effectively.

Applying using smaller cell sizes

Macro cell base stations generally cover wide areas with one station. On the other hand, the number of active users under a Macro cell base station in the covered area is often less than the number of users that would be served in the same area through the use of multiple Micro cells. For more information about the use of different types of cell sizes as well as for other measures to the rapid increase of wireless traffic refer to pages 49 and 50 of the Report Q25/2 (ITU-D Study period 2010-2014).

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49 For more information about home networking see page 31 of the Report for Q25/2 (ITU-D study period 2010-2014).

50 LMH-BWA.

51 Document SG1RGQ/290, "Rural connectivity through subsides and spectrum fees waiver: The Kenyan experience", Republic of Kenya.

2.1.4 Broadband access by fixed-satellite service systems

Satellite telecommunication technology is accelerating the availability of high-speed broadband services including to developing countries, least-developed countries, and land-locked and island countries, and economies in transition.[52] This report includes the technical and operational characteristics of Fixed-Satellite Service (FSS) systems that facilitate the mass-production of simple user terminal equipment at affordable prices for the delivery of high speed broadband as well as examples of their implementation; this includes broadband access at high data-rates via small user terminals, and existing systems having a variety of earth station sizes designed also for other applications and using a variety of frequency bands.

Broadband access over the FSS has been deployed in the 4/6 GHz, 11/14 GHz and 20/30 GHz band allocations. New systems are expected to soon be deployed making use of the 40/50 GHz band allocation as well. While the technology is particularly well suited to reach underserved and unserved areas, the initial development has occurred in major industrialized regions. In the interest of promoting deployments in less developed regions, this Report provides a summary of the enabling regulatory environment and technologies and also provide a repository of case studies to use as reference.

System architectures

Two system topologies are available, and two architectures can be supported by either one. One topology is the star topology, where every terminal is connected to a "base station" through the satellite link. Generally, in this topology, there is far more traffic going from the base stations to each of the terminals (forward link) than from each of the terminals to the base stations (return link). Thus base stations will have larger antennas to accommodate higher gains for the broader bandwidths transmitted. The terminal antenna size is based on the amount of return link bandwidth desired, and may make use of very small or ultra-small aperture antennas, as described in § 6.1. The second topology is known as "mesh", where any terminal communicates with any other terminal directly through the satellite. There are no base stations and thus all earth stations operate on similarly designed uplinks and downlinks.

Within either topology, one architectural option is for every user to have its own Very Small Aperture Terminal (VSAT) or Ultra-Small Aperture Terminal (USAT) (e.g. direct-to-home service). The second option is one that employs "community" earth stations antennas and local terrestrial distribution. Associated with each local "community" earth station would be a terrestrial radio system equipped to serve a number of subscribers within a radius of about 3 km. The number of users that could be supported at any one time would depend upon the bit rates they were using and the activity factors on their connections. This architectural choice may also be implemented without any use of VSATs or USATs, nor the spot beam technology described in § 5.

Regulatory considerations

Advantageous deployment of technological advances is made possible by encouraging transparent and clear regulatory environment. Satellite systems are high risk, costly ventures that can only be afforded when there are policies in place to ease those inherent burdens and provide certainty to operators. Administrations must consider how to provide reasonable means of market entry and set forth clear rules on how this occurs. Through the creation of such a regime, satellite broadband can serve as an important complement to terrestrial broadband services, reaching those in underserved and unserved areas.

An important consideration for satellite broadband entry into a market is the ability to ubiquitously deploy earth stations with minimum regulatory burdens. As seen in the previous section, one architectural option is for every user to have its own VSAT or USAT. An earth station licensing scheme

[52] Report ITU-R S.2361.

must be in place that allows for large quantities of these types of earth stations and its associated equipment to be economically and efficiently authorized for use.

Finally, yet most importantly, FSS spectrum allocation must be protected. Broadband applications require availability of large amount of spectrum in a low interference environment. Much care must be taken when considering spectrum sharing schemes that might impact the ability to operate these applications economically and allow such uses to expand to meet consumer demand.

2.1.5 Future trends

Over the next several years, the key driver of broadband development is expected to be the increasing demand for data. As noted in Section 2.1.1, GSMA Intelligence predicts that global mobile data traffic will increase 10 fold from 2014-2019.[53] Cisco predicts a similar increase, from 2.5 exabytes of mobile data traffic per month at the end of 2014 to an expected 24.3 exabytes per month by the end of 2019.[54] With regard to fixed broadband, technological advances, (e.g., cloud technology, interactive applications, ultra-high definition video, and video-sharing) and increasing demand are also driving next-generation network buildout.[55] Despite the small size of the individual transmissions involved, the huge numbers of devices associated with the Internet of Things (IoT) and machine-to-machine (M2M) communications are expected to increase demands on broadband networks as well. Together, these point to growth in consumption of large amounts of data, such as video and interactive applications, as well as a massive number of relatively small transmissions, as is often the case with M2M communications.

Deployment of broadband is running into difficulties in Madagascar, given the island's remoteness from equipment suppliers, the size of the territory and the time needed to build networks. The existence of the Backbone has not resolved every issue, hence the regulator's decision to facilitate its operation. The most recent texts adopted have been to that effect.[56] Aware of its geographical situation, Madagascar, an island State 1,500 km long and 500 km wide, has made efforts to link up the major towns where the major business sectors (industry, banks and tourism) are located. These towns are separated by distances of tens or hundreds of kilometers and connecting them has always caused problems for operators. The topography of the main island is not conducive to using microwave links, hence the deployment by an operator of 8 000 km of fibre-optic cable in which the State holds a 34 per cent share. Development of broadband in a country depends in part on the means used to "transport" information from one point to another. The existence and use of a major transport network might be one of the keys to its expansion. Future trends in Madagascar can be found in the country experience in **Annex 1**.

Fixed broadband

Next-generation broadband networks

Next-generation broadband networks, which have been in development and deployment for nearly a decade, are expected to be increasingly deployed and leveraged for services currently experiencing significant growth. For example, Singapore is implementing a robust cloud infrastructure with the aim to become a Smart Nation.[57] To do this, Singapore asserts that it needs world-class high speed broadband connectivity within the country as well as very high-speed connections to major cities

53 "The Mobile Economy" 2015; GSMA Intelligence, 2015.
54 Cisco, "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update 2014–2019 White Paper," (February 3, 2015), available at http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white_paper_c11-520862.html.
55 Fibre Systems, The rise of gigabit broadband in Europe, Winter 2015, available at http://www.fibre-systems.com/feature/rise-gigabit-broadband-europe.
56 Document 1/142, "Regulation for the development of broadband", Republic of Madagascar.
57 Infocomm Development Authority (IDA), Cloud Computing in Singapore: Driving Innovation, at 2, 2015, https://dl.dropboxusercontent.com/u/66814130/Cloud%20Computing%20in%20Singapore%20Booklet/2015%20edition/Cloud%20Computing%20in%20Singapore%20(2015%20Edition).pdf.

outside the country.[58] It is therefore implementing the Next Generation Broadband Network (Next Gen NBN), which is expected to support a vibrant cloud computing ecosystem.[59]

Next Gen NBN is an ultra high-speed fibre-optical network that is expected to provide a nationwide broadband access speed of 1 Gbit/s or more.[60] In addition to faster download and upload speeds, Singapore's Infocomm Development Authority (IDA) affirms that the pervasive availability of cost-effective ultra-high speed broadband will pave the way for new services that will help increase companies' operational efficiency, through software-as-a-service and other cloud services, bandwidth-intensive remote back-up, and online collaboration[61]. IDA claims that companies will be able to leverage applications such as high-definition video conferencing and real-time collaboration platforms to interact with employees at home or at remote sites, and with partners and potential customers around the world.[62]

In addition to Singapore, other providers are deploying next-generation networks, including the following:

– Bell Canada is investing more than CAN 1 billion (USD 770 million) to bring 1 Gbit/s Internet service to Toronto, and plans to extend the service to other cities in Ontario, Québec, and the Atlantic Provinces starting in the summer of 2015.[63] The company stated that its fiber rollout will enable Toronto to be "a world-class Smart City," and will allow businesses of all sizes to "do more and make more" and "attract investment and jobs".[64]
– Swisscom, which launched 1 Gbit/s Internet service through its Fibre-to-the-Home (FTTH) network in 2014, has noted that high definition television, cloud services and video conferences are driving private individuals and companies to adopt ultra-fast broadband.[65] The company plans to make its high speed broadband service available to 2.3 million homes and businesses by the end of 2015, and 5 million by 2020.
– Orange France aims to offer 100 percent FTTH coverage in nine cities by the end of 2016. The nine cities, which include Lyon, Montpellier, Nice and Paris, are to become what Orange refers to as "100% Fibre" cities. This initiative is part of the company's broader plan to deploy fiber that will pass 20 million homes by 2022, up from 12 million connectable homes in 2018, and 4 million connectable homes in April 2015.

While most of the current projects to implement Gbit/s Internet services are utilizing fibre, it is important to note that the improved capabilities of DOCSIS 3.1, compared to DOCSIS 3.0, are expected to a provide cost effective way to enable cable operators to make necessary upgrades to their hybrid fibre-coaxial networks in late 2015 to achieve comparable transmission speeds.[66]

Copper network shutdown

With the increasing deployment of IP-based next-generation networks, and due to declining customer demand for legacy voice and data services and their comparatively high maintenance costs, another nascent trend in the wireline world is telecommunications service providers shutting down their copper networks. In January 2015, AT&T announced that it would shut down certain copper

58 Id. at 6.
59 Id.
60 iDA, Next Gen NBN, available at http://www.ida.gov.sg/Tech-Scene-News/Infrastructure/Wired/Next-Gen-NBN.
61 iDA, Next Gen NBN, For Enterprises, available at http://www.ida.gov.sg/Tech-Scene-News/Infrastructure/Wired/Next-Gen-NBN/For-Enterprises.
62 Id.
63 Bell, Gigabit Fibe is coming soon to Toronto, available at http://www.bell.ca/Gigabit-Fibe-Internet#demoToggleJs.
64 CBCnews, Bell promises to bring fastest Internet possible to Toronto, Jun. 25, 2015, available at http://www.cbc.ca/news/canada/toronto/bell-promises-to-bring-fastest-internet-possible-to-toronto-1.3127407.
65 Swisscom, Network Expansion: over a million homes and businesses already connected to ultra-fast broadband, July 30, 2014, available at https://www.swisscom.ch/en/about/medien/press-releases/2014/07/20140730-Netzausbau-Ultrabreitband.html.
66 Fibre Systems, The rise of gigabit broadband in Europe, Winter 2015, available at http://www.fibre-systems.com/feature/rise-gigabit-broadband-europe.

network assets as it moves forward with its IP network transition.[67].While the provider did not specify the markets where it would be abandoning copper assets, it plans to move its network to an all-IP infrastructure by 2020. In 2014, the company began conducting IP transition trials in two locations to provide the FCC with additional information to consider at the outset of the transition process.[68] Operators in other countries, such as Telenor and Telstra, have also announced plans to gradually phase out their copper networks.[69]

Wireless broadband networks

Heterogeneous networks and small cells

As noted in Section 2.1.4, operators may employ differing cell sizes in order to improve capacity and provide optimum wireless coverage. Small cells are ideally suited for higher spectrum bands, such as 3.5 GHz, and there is increasing industry interest and development in small cell technology solutions for this frequency band. However, small cells also bring challenges related to interference protection, requiring all stakeholders to employ the appropriate mitigation techniques.

In addition, multiple technologies – such as IMT-2000, IMT-Advanced, and Wi-Fi – may be used together to deliver the best mobile data experience to users. Operators, vendors, and even governments, are devoting resources to the development of heterogeneous network (or HetNet) designs to meet coverage and capacity needs. For example, Singapore is currently developing an Infocomm Media Masterplan that will include heterogeneous networks among its major features. In Singapore's view, the currently separate mobile and Wi-Fi networks should be more closely integrated, allowing for "anywhere, anytime, any device" connectivity.[70] To that end, Singapore's view of a HetNet is that it should encompass three features:

– Intelligent and seamless access across networks;
– Consistent quality of experience across networks; and
– Innovative and dynamic resource management.

While not an explicit initiative to promote HetNets, the U.S. Federal Communications Commission (FCC) in 2014 revised its rules governing mobile network buildout, in particular with regard to necessary environmental reviews and historic preservation.[71] The goal of the order was to reduce regulatory obstacles and bring efficiency to wireless facility siting. These actions were taken to account for the increasing demand for small cells and distributed antenna systems in order to allow for improved and expanded mobile coverage.

Ericsson has presented a generic approach for the delivery of a high-quality mobile user experience using a three-step approach to development of a HetNet. Carriers can:

– Improve existing macro cells through the employment of additional spectrum, advanced antennae, increased order of diversity on the receiver and/or transmitter, and baseband processing capacity within and between nodes;

[67] SEC, AT&T Form 8-K, Jan. 16, 2015, available at http://www.sec.gov/Archives/edgar/data/732717/000073271715000003/january16_8k.htm.

[68] AT&T Public Policy Blog, Going All-IP in Alabama, Florida, Feb. 28, 2014, available at http://www.attpublicpolicy.com/wireless/going-all-ip-in-alabama-florida/; FCC, IP Transition, available at https://www.fcc.gov/guides/ip-transition.

[69] Telenor, Telenor Group – Citi European & Emerging Telecoms Conference, at 8, 2013 available at http://www.telenor.com/wp-content/uploads/2013/01/Telenor-Citi-TMT-Conference-March-2013.pdf; NBN Co delays copper disconnections in 58 areas, Aug. 21, 2014, available at http://www.itnews.com.au/News/391254,nbn-co-delays-copper-disconnections-in-58-areas.aspx.

[70] Ministry of Communications and Information (Singapore), "Heterogeneous Network," available at https://www.mci.gov.sg/portfolios/infocomm-media/initiatives/infrastructure/hetnet.

[71] Federal Communications Commission, Wireless Infrastructure Report and Order (FCC 14-153) (October 21, 2014), available at https://www.fcc.gov/document/wireless-infrastructure-report-and-order.

– Densify the macro network through the deployment of additional macro cells in an area, such as dividing an area covered by three cells into one covered by six or more cells; and

– Add small cells – either mobile or Wi-Fi – to complement the macro cells[72].

Increased use of unlicensed spectrum

There is increasing industry interest in the use of unlicensed spectrum to provide additional capacity for IMT-Advanced networks. LTE Advanced in unlicensed spectrum, specifically with small cells, can be used to boost the capacity of 4G networks.[73] Using a common LTE core, frequencies in licensed and unlicensed spectrum can be aggregated to provide increased data capacity for end users, such as for streaming media and other rich content. An integrated LTE network provides unified mobility, authentication, security, and management capabilities. This aggregation of licensed and unlicensed spectrum for the deployment of LTE networks has also been called LTE Unlicensed (LTE-U) and Licensed-Assisted Access (LAA), and will be included in the upcoming 3GPP Rel. 13.[74]

The work on unlicensed spectrum use in 3GPP is guided by priorities set in June 2014:

– GHz band;

– Global solution that can work across regions; and

– Licensed-assisted access operation.

3GPP expects to finalize Rel. 13 in 2016, which may provide additional momentum to efforts to leverage unlicensed spectrum for commercial mobile broadband services.

2.2 Ways and means of implementing IMT, using terrestrial and satellite links

Case studies on what measures to take to recover mobile services from the natural disasters using the fixed-satellite have been noted.[75] However, some of the ideas are considered to be applicable to the implementation from nothing (for such as rural communications). In the event of natural disasters, a large number of mobile base stations can be damaged in large areas. Even if the base stations are not damaged, terrestrial lines can be damaged, that leads to service outage of mobile base stations. Mobile communications are commonly and widely used all over the world and play an important role in our daily life. In a disaster relief phase, it is the matter of urgency to recover mobile base stations in order to obtain any information on the safety of missing persons, recover and reconstruct damaged or destroyed roads, public facilities, buildings, etc. In these cases, mobile base stations with satellite backhauls appear as the most appropriate and the only means to quickly set up and provide mobile services, particularly immediately after the disaster.

Some examples of mobile network configuration using both terrestrial and satellite links will be found in this contribution and also in the case study library. In some countries the Internet penetration rate remains very low for a number of reasons which hamper the countries' Internet development even if operators have the technological potential to meet their customers' requirements and are able to follow global trends in terms of the use of innovative ICT solutions. The reasons for such low penetration rate include limited household income to afford connection costs and tariffs, education to technology, broadband quality not-guaranteed.[76]

[72] Ericsson, "Heterogeneous networks," available at http://www.ericsson.com/us/ourportfolio/telecom-operators/heterogeneous-networks.

[73] Qualcomm, "Extending benefits of LTE Advanced to unlicensed spectrum", available at https://www.qualcomm.com/invention/technologies/lte/unlicensed.

[74] See, for example, "Evolution of LTE in Release 13", (February 18, 2015), available at http://www.3gpp.org/news-events/3gpp-news/1628-rel13.

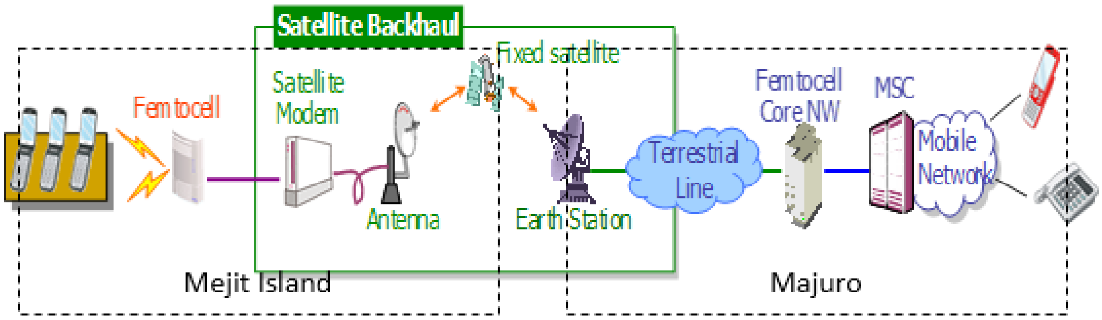
[75] Document SG1RGQ/94, "Example of mobile base stations with satellite backhauls" and document 1/187,KDDI Corporation (Japan).

[76] Document 1/403, "Broadband access technology – Madagascar", Republic of Madagascar.

Other good example of Implementing IMT, using terrestrial and satellite links, is the case study of Marshall Islands. In this case, Mejit Island, remote island, was connected to Majuro, capital of Marshall Islands, with DAMA satellite link using VSAT antenna at Mejit side. In Mejit Island, Femto Base Stations were installed to make it possible to make GSM voice call using ordinary GSM mobile terminals and also to access to Internet. Utilizing of Femtocell Base Station is very much suitable for small scale telecommunication in small islands like Mejit. Because prise for Femtocell is inexpensive and power consumption is remarkably low, though the number of simultaneous calls are limited and the cell size of Femtocell is small.

It was been depicted many time in contributions to ITU-D study groups[77] that combination of satellite communication using VSAT and Femto Base station will be one of very effective measure for rural telecommunications.[78]

Figure 3: Network configuration using Femtocell with satellite backhaul



2.3 IMT-Advanced systems

IMT-Advanced

After the Radiocommunication Assembly (RA-12),[79] in Geneva, 16-20 January 2012, consensus was reached to expand the IMT Radio Interface family by establishing the new IMT-Advanced standard. The Recommendation ITU-R M.2012[80] dealing with IMT was approved by all Member States.

International Mobile Telecommunications-Advanced (IMT-Advanced) systems are mobile systems that include the new capabilities of IMT that go beyond those of IMT-2000. IMT-Advanced systems provide access to a wide range of telecommunication services supporting low to high mobility applications and a wide range of data rates in accordance with user and service demands in multiple user environments. IMT Advanced also has capabilities for high quality multimedia applications within a wide range of services and platforms, providing a significant improvement in performance and quality of service.[81]

The key features of IMT-Advanced address evolving user needs and the capabilities which are being continuously enhanced in line with user trends and technology developments:

– A high degree of commonality of functionality worldwide while retaining the flexibility to support a wide range of services and applications in a cost efficient manner;
– Compatibility of services within IMT and with fixed networks;

[77] Documents from the 2006-2010 study period: RGQ10-2/2/94, 2/177, 2/232.
[78] For details on this case study, see the case study library.
[79] IMT-Advanced webpage: http://itu.int/go/QJ9R. and Report on Implementation of Evolving Telecommunication/ICT infrastructure for Developing Countries: Technical, Economic and Policy Aspects". Document SG1RGQ/229, "Updated Report on Implementation of Evolving Telecommunication/ICT Infrastructure for Developing Countries: Technical, Economic and Policy Aspects", March 2016, amended January 2017.
[80] ITU-R M.2012: Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications Advanced (IMT-Advanced), 2015.
[81] Document 1/203 (Rev.1), Alcatel-Lucent International (France).

- Capability of interworking with other radio access systems;
- High quality mobile services;
- User equipment suitable for worldwide use;
- User-friendly applications, services and equipment;
- Worldwide roaming capability; and,
- Enhanced peak data rates to support advanced services and applications (100 Mbit/s for high and 1 Gbit/s for low mobility were established as targets for research).[82]

The functional network architecture for IMT- Advanced incorporates the following general principles:[83]

- Network based on IP technology

Access networks, which provide a rich set of access mechanisms using various wired and wireless access technologies, terminate layer two link characteristics and provide IP-based connection to core networks. Core networks and application servers connected to them are IP based.

- Modular construction using expandable components:
  - The subsystems themselves, such as access networks, core networks, and application servers; as well as the systems built based on them are hierarchical.
  - Accessibility to each subsystem is separately controlled based on each operator's policy.
- Open interfaces between various systems.

Interoperation with homogeneous networks and with heterogeneous networks is facilitated with open interfaces in various levels of subsystems.

The IMT-Advanced architecture should support multiple access networks, converged services in a converged network, enhanced security and protection, and total service accessibility, based on the services and network capabilities framework of network aspects defined in [ITU-T Q.1703]. The IMT-Advanced architecture is based on the general principles defined in [ITU-T Y.2011].

2.3.1 LTE Advanced

LTE Advanced designates the enhanced versions of LTE introduced in 3GPP Release 10 and subsequent releases. It provides higher bit rates to fulfil the requirements set by the ITU for IMT Advanced and offers improved user experience.

Release 10 offers the following peak rates (actual rates depend on the features deployed):

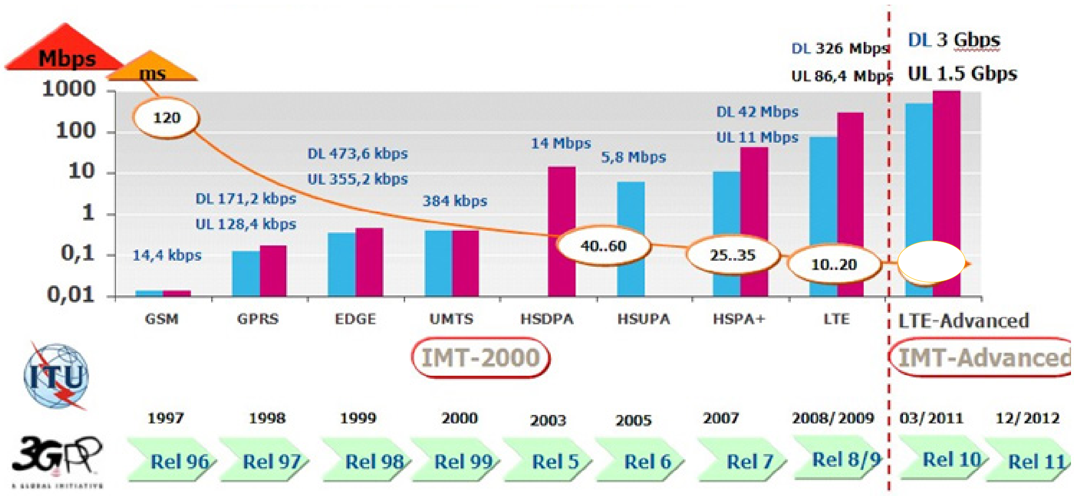
- Peak data rate: Downlink (DL) 3 Gbps, Uplink (UL) 1.5 Gbps;
- Peak spectral efficiency: DL 30 bps/Hz, UL 16.8 bps/Hz).

These peak rates are supported by a new User Equipment (UE) category, category 8; other new UE categories, 6 and 7, support subsets of the enhancements (see details in Appendix 1 to document 1/203 (Rev.1)) .**Figure 4** illustrates the increased peak rate offered by LTE- Advanced compared to previous 3GPP systems.

[82] Data rates sourced from Recommendation ITU-R M.1645 – ´Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000´.

[83] ITU-T Q.1704: Functional network architecture for IMT-Advanced (2008).

Figure 4: Increased peak rate offered by LTE - Advanced compared to previous 3GPP systems



Source: Document 1/203 (Rev.1), Alcatel-Lucent International (France).

Key Radio Access Network (RAN) features introduced in LTE-Advanced Release 10 are:

– Carrier Aggregation (CA);
– Advanced Multiple-Input and Multiple-Output (MIMO) for multi-antenna transmission;
– Heterogeneous Networks and Inter-Cell Interference Coordination (eICIC);
– Enhanced network energy saving and relaying;
– Enhanced Self-Organizing Networks (SON).

LTE-Advanced Release 11 introduces further enhancements including:

– Coordinated Multi-Point (CoMP) operation, enhanced downlink control channels;
– Carrier aggregation enhancements;
– Interference cancellation enhancements.

LTE-Advanced Release 12 has been adopted for IMT-Advanced Release 2, and provides the following improvements:

– Public safety (group communication / Device-to-Device);
– Machine-to-Machine (low cost);
– Small cells (dual connectivity / SON);
– LTE/Wi-Fi Interworking;
– Multimedia Broadcast/Multicast (MBMS) enhancements.

The Release 10 specifications were functionally frozen in March 2011, Release 11 in December 2012, and Release 12 in September 2014.

The benefits of the key features of LTE-Advanced are indicated in **Table 3**.

Table 3: Key features of LTE-Advanced

	Technique	Benefits
Carrier agreggation	Spectrum Aggregation to support wider bandwidth	Peak Data Rate and Spectrum Flexibility, Throughput increase
Advanced mimo techniques	Extension to 8-layer transmission in DL Introduction of SU MIMO up to 4-layer transmission in UL	Peak Data Rate, Capacity and Cell-edge user throughput increase
CoMP	Coordinated Multi Point Transmission in DL and UL	Cell-edge user throughput and Coverage Enhancement, Deployment Flexibility
Heterogenous networks and eICIC	Interference coordination for overlaid cells deployment with different Tx power	Peak Data Rate increase, Better QoE, Spectrum Flexibility
SON Enhancements	Automation, Configuration, Optimization of wireless net-works to adapt to varying radio conditions	Better network performance, Lower cost, Deployment Flexibility
Relaying	Creation of separate cells where wired backhaul is costly or not available	Coverage and flexibility of service area increase, cost effective deployment

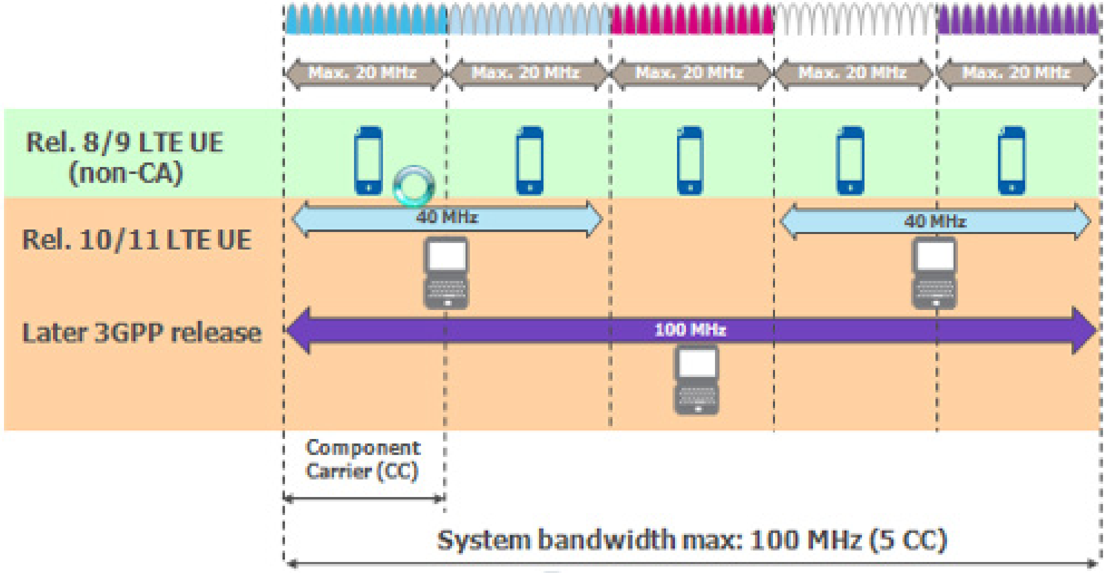
Source: Document 1/203 (Rev.1), Alcatel-Lucent International (France).

Carrier aggregation

LTE-Advanced aims to support peak data rates of 1 Gbps in the downlink and 500 Mbps in the uplink in order to fulfill IMT-Advanced requirements. A transmission bandwidth of up to 100 MHz is required; however, since the maximum size of carriers is 20MHz, it is necessary to aggregate several carriers to achieve the peak rates. LTE-Advanced uses carrier aggregation of multiple Component Carriers (CCs) to achieve high-bandwidth transmission.

These component carriers may be either contiguous or non-contiguous, as illustrated in **Figure 5**. Downlink and uplink Carrier Aggregation can be configured and deployed independently.

Figure 5: LTE-Advanced carrier aggregation of multiple Component Carriers (CCs)



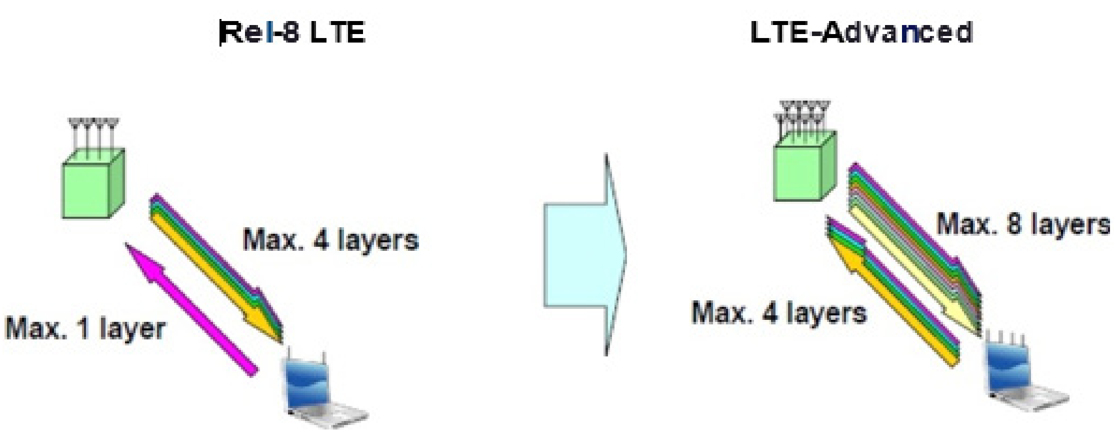
Source: Document 1/203 (Rev.1), Alcatel-Lucent International (France)

Advanced MIMO

Releases 8 and 9 of 3GPP support a maximum of 4 layers for spatial multiplexing, and single- layer beam forming. Release 9 further supports dual layer beam forming, which combines 2- layer spatial multiplexing and beam forming capabilities. With LTE-Advanced in Release 10, support is introduced for up to 8-layer beam forming-based single-user spatial multiplexing.

Figure 6 shows the maximum single-user spatial multiplexing supported provided in LTE-Advanced, compared to Release 8.

Figure 6: Maximum single-user spatial multiplexing supported provided in LTE-Advanced, compared to Release 8

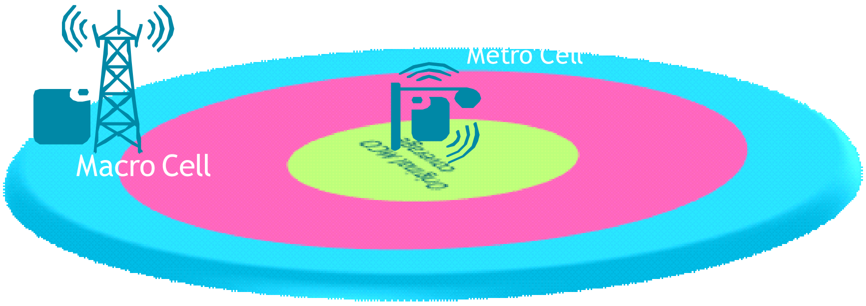


Source: Document 1/203 (Rev.1), Alcatel-Lucent International (France).

Heterogeneous networks and enhanced inter-cell interference coordination

In Heterogeneous Networks deployments, extended metro cells under the coverage of a macro cell result in an excessive interference environment. LTE-Advanced in Release 10 introduces time domain Inter-Cell Interference Coordination (ICIC), otherwise known as "enhanced ICIC" (eICIC) to mitigate interference on the downlink Control Channels. Small metro cells are the single most important technique by which network capacity can be increased to satisfy the exponential explosion in data traffic: the more metro cells are deployed, the greater the capacity, and hence they can deliver orders of magnitude more capacity growth than multiple antenna techniques, for example. Moreover, metro cells can deliver additional capacity even where additional carriers are not available and carrier aggregation cannot be used.

Figure 7: Macro Cell and Metro Cell



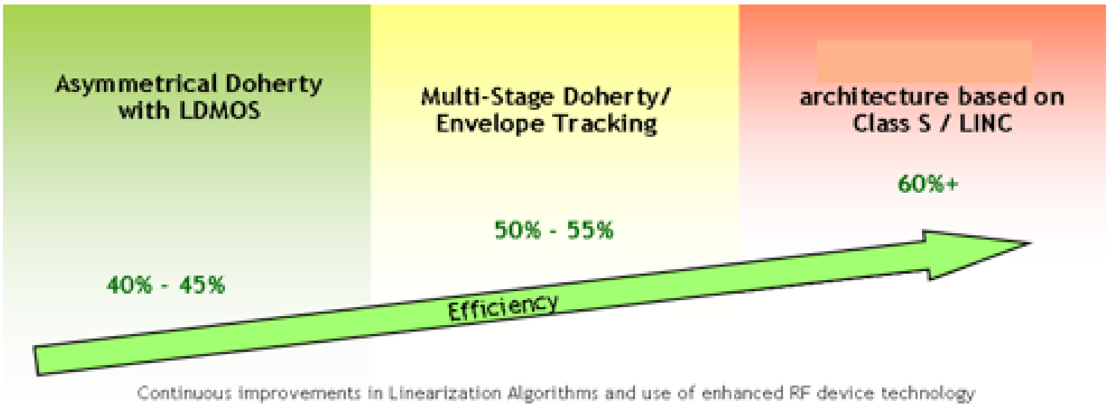
Energy efficiency

Hardware energy-saving features

The industry is dedicating efforts on Power Amplifier (PA) efficiency improvements, working in particular on PA architecture, device technology and linearization algorithms and Peak–to-Average Power Ratio (PAPR) reduction algorithms.

A typical illustration of recent improvements is provided in **Figure 8**:

Figure 8: Power Amplifier (PA) efficiency improvements



Source: Document 1/203 (Rev.1), Alcatel-Lucent International (France).

– **Software energy saving features**

Software techniques are also employed to save energy:

PA power biasing voltage adaptation, to regulate the power supply voltage and control the transmission power of the PA as a function of the traffic load achieve 10-15 per cent power saving.

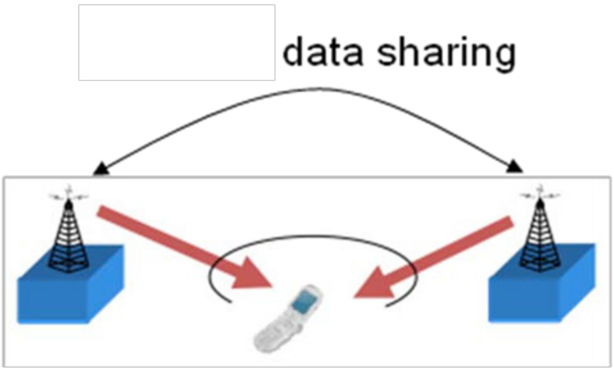
PA dynamic switching: When there is no data/signal to send, the PA is switched off. Typically 7 per cent of power is saved in rural environment.

Cell Switch off: When metro cells are deployed for capacity boosting, autonomous cell switch-off can be performed to reduce energy consumption by putting the cell into a dormant state when its capacity is no longer needed

Coordinated multi-point

A major new feature introduced in Release 11 is Coordinated Multi-Point (CoMP), which is applicable in both DL and UL directions. It is a technique involving the coordination of transmissions from multiple cells or transmission points (see **Figure 11**), or the reception of transmissions from a single UE at multiple reception points. The technique aims mainly at the improvement of cell edge throughput.

Figure 9: Coordinated Multi-Point (CoMP)



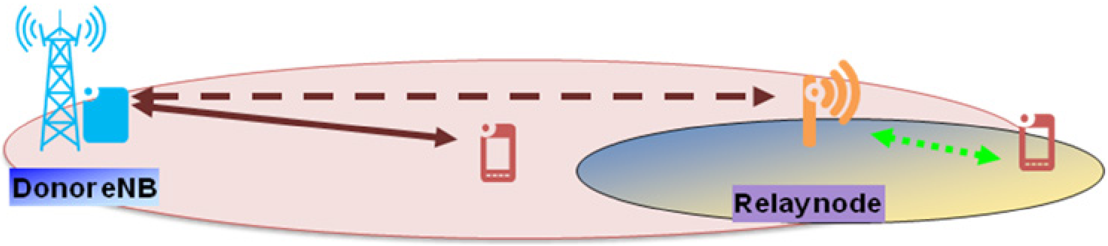
Source: Document 1/203 (Rev.1), Alcatel-Lucent International (France).

Relaying

Relay Nodes (RN) were introduced in Release 10 to enable traffic/signaling forwarding. RNs improve coverage at high data rates and/or extend coverage beyond the cell range.

In addition to fixed RNs, Release 11 supports mobile RNs (i.e. in a train).

Figure 10: Relay nodes (RN)



Source: Document 1/203 (Rev.1), Alcatel-Lucent International (France).

2.3.2 WirelessMAN Advanced

The WirelessMAN-Advanced radio interface specification is developed by IEEE. A complete end to-end system based on WirelessMAN-Advanced is called WiMAX 2, as developed by the WiMAX Forum.

The "WirelessMAN-Advanced System" Global Core Specification is comprised of IEEE 802.16-2009, as amended by IEEE 802.16j-2009, IEEE Std 802.16h-2010, and IEEE Std 802.16m-2011 as further detailed in ITU-R M.2012-1. However, there was no update of WirelessMAN-Advanced for incorporation into the latest detailed specifications of IMT-Advanced (ITU-R M.2012-2).

2.3.3 Satellite component of IMT-Advanced

The terrestrial and satellite components of IMT-Advanced are complementary. ITU-R Report M.2176-1 builds visions of the satellite component of IMT-Advanced in terms of application scenarios, services, system, radio interface and network aspects and the considered specific features. As the terrestrial component alone would not be deployed all over the world, the satellite component of IMT-Advanced systems would be complementary in order to provide a seamless service with global coverage[84]. An integrated satellite and terrestrial network can contribute to the emergence and utility of Next-Generation Networks (NGNs) in providing ubiquitous and universal broadband versatile IP-based services to end users who will require generalized mobility, accessed in a seamless fashion and, ultimately, will dictate its realization through market forces. The ubiquitous coverage of IMT can only therefore be realized using a combination of satellite and terrestrial radio interfaces.[85]

System Aspects:[86] The satellite component of IMT-Advanced is expected to have sufficient power and receiver sensitivity to establish communications with end-user devices that are indistinguishable from the terrestrial component. Large satellite antennas, providing high-gain reconfigurable multi-beam are one of the key attributes of integrated systems. User equipment of an integrated system should have the capability of selecting the relevant component – either the satellite- or terrestrial-based – on the receiving signal level and network availability to keep a given service quality over a wide and continuous service area.

Detailed information is provided in **Annex 5**.

2.3.4 Beyond IMT-Advanced: IMT-2020

In early 2012, ITU-R embarked on a programme to develop "IMT for 2020 and beyond",[87] setting the stage for IMT-2020 research activities that are emerging around the world.

– Through the leading role of Working Party 5D, ITU's Radiocommunication Sector (ITU-R) is finalizing its view of a timeline towards "IMT-2020". The detailed investigation of the key elements of IMT-2020 are underway.

– In 2015, ITU-R finalized its "Vision" of the IMT-2020 mobile broadband connected society. This view of the horizon for the future of mobile technology in support of the growth of IMT is described in Recommendation ITU-R M.2083.

ITU-R Working Party 5D deliverables towards "IMT for 2020 and beyond"

– Vision and Technology Trends:

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[84] For more information on the Satellite Component of IMT-Advance see:
- Recommendation ITU-R M.2047 - Detailed specifications of the satellite radio interfaces of International Mobile Telecommunicatons-Advanced (2013)
- Report ITU-R M.2279 - Outcome of the evaluation, consensus building and decision of the IMT-Advanced satellite process (Steps 4 to 7), including characteristics of IMT-Advanced satellite radio interfaces (2013)
- Report on Implementation of Evolving Telecommunication/ICT infrastructure for Developing Countries: Technical, Economic and Policy Aspects"

[85] For more information on Global Circulation of IMT satellite terminals, see Recommendation ITU-R M.2014-1 (2015).

[86] Report ITU-R M.2176-1- Vision and requirements for the satellite radio interface(s) of IMT-Advanced (2012) and Report on Implementation of Evolving Telecommunication/ICT infrastructure for Developing Countries: Technical, Economic and Policy Aspects" Document SG1RGQ/229 March 2016, amended January 2017.

[87] ITU-R webpage: http://www.itu.int/en/ITU-R/study-groups/rsg5/rwp5d/imt-2020/Pages/default.aspx; Report on Implementation of Evolving Telecommunication/ICT infrastructure for Developing Countries: Technical, Economic and Policy Aspects" and document SG1RGQ/229 + Annex "Updated Report on Implementation of Evolving Telecommunication/ICT Infrastructure for Developing Countries: Technical, Economic and Policy Aspects", BDT Focal Point for Question 1/1, amended January 2017. Full Report on Implementation of Evolving Telecommunication/ICT infrastructure for Developing Countries: Technical, Economic and Policy Aspects, 2016.

- Report ITU-R M.2320: This activity is to address the terrestrial IMT technology aspects and enablers considering the approximate timeframe 2015-2020 and beyond for system deployment, including aspects of terrestrial IMT systems related to WRC-15 studies as part of its scope.
- Recommendation ITU-R M.2083: This activity is to address the longer term vision for 2020 and beyond and will provide a framework and overall objectives of the future developments of IMT.
- Report ITU-R M.2376: The purpose of this report is to provide information on the study of technical feasibility of IMT in the bands above 6 GHz.
- ITU Handbook titled "Handbook on Global Trends in International Mobile Telecommunications" (May 2015) that summarizes the work carried out and the progress towards IMT-2020. This handbook identifies IMT and provides the general information such as service requirements, application trends, system characteristics, and substantive information on spectrum, regulatory issues, guidelines for the evolution and migration, and core network evolution on IMT.
- ITU-R Report on key "5G" performance requirements for IMT-2020. Draft New Report ITU-R M.[IMT-2020.TECH PERF REQ] is expected to be finally approved by ITU-R Study Group 5 at its next meeting in November 2017. http://www.itu.int/en/mediacentre/Pages/2017-PR04.aspx.

Additional reference to the progress of studies on IMT-2020 and all documentation relating to IMT can be found on the ITU-R Working Party 5D website: http://www.itu.int/en/ITU-R/study-groups/rsg5/rwp5d/Pages/default.aspx.

ITU-T Study Group 13 decisions on IMT 2020 and beyond

Focus Group on IMT-2020 (FG IMT-2020) (Established 2015-05; Terminated 2016-12)The Focus Group on network aspects of IMT-2020 was established in May 2015 to analyse how emerging 5G technologies will interact in future networks as a preliminary study into the networking innovations required to support the development of 5G systems. The group took an ecosystem view of 5G research of development and published the analysis in a Report to its parent group, ITU-T Study Group 13.[88]

WORLD TELECOMMUNICATION STANDARDIZATION ASSEMBLY Hammamet, 25 October – 3 November 2016: Resolution 93 – Interconnection of 4G, IMT-2020 networks and beyond[89]

resolves

that ITU-T Recommendations to address network architectures, roaming principles, numbering issues, charging and security mechanisms as well as interoperability and conformance testing for interconnection of 4G, IMT-2020 networks and beyond shall be progressed as quickly as possible,

instructs the Director of the Telecommunication Standardization Bureau

1) to continue to conduct, as necessary, exploratory activities among telecommunication operators in order to identify and prioritize the problems related to achieving interconnection of IP-based networks such as 4G, IMT-2020 and beyond;

2) to submit the results of these activities to the ITU Council for its consideration and required action,

instructs the study groups

1) to identify as soon as possible future ITU-T Recommendations that need to be developed associated with the interconnection of 4G, IMT-2020 networks and beyond;

2) to cooperate, as appropriate, with interested stakeholders and alliances in order to optimize studies on this particular subject,

[88] The Focus Group IMT-2020 concluded its study in December 2016. For more information see http://itu.int/go/B08Y.
[89] WTSA-2016 Res 93.

further instructs Study Group 11

to develop ITU-T Recommendations which specify the framework and signalling architectures to be used for establishing interconnection of 4G, IMT-2020 networks and beyond to achieve interoperability worldwide

further instructs Study Group 2

to develop ITU-T Recommendations which specify the ENUM architecture to be used for interconnection of 4G, IMT-2020 networks and beyond, including administrative control that could relate to the international telecommunication resources (including naming, numbering, addressing and routing).

2.3.5 Conclusions

Through the ongoing developments of IMT-Advanced, IMT remains the foremost state-of-the-art solution for mobile communications capacity. The support provided by IMT-Advanced for spectrum efficiency, advanced multi-antenna transmission, flexible spectrum aggregation, small cells and energy efficiency, ensure the ability of the technology to sustainably and economically meet the growing demands of data traffic for the decades to come. This is of particular interest for developing countries, who can take advantage of the latest advances in spectrum/energy efficiency and "leapfrog" more expensive older technologies.

Support for additional features in the future, including enhanced inter-working with other radio access technologies, and device-to- device communication especially for public safety applications, will further enhance the benefits achieved with deployment of IMT networks.[90]

Figure 11: Device evolution to support greater throughput

	DEFINED IN 3GPP RELEASE 8/9					DEFINED IN 3GPP RELEASE 10/11/12				
	CAT 1	CAT 2	CAT 3	CAT 4	CAT 5	CAT 6	CAT 7	CAT 8	CAT 9	CAT 10
Peakrate DL/UL	10/5 Mbps	50/25 Mbps	100/50 Mbps	150/50 Mbps	300/75 Mbps	300/50 Mbps	300/100 Mbps	3000/150 0 Mbps	450/50 Mbps	450/100 Mbps
RF Bandwidth	20 MHz	20 MHz	20 MHz	20 MHz	20 MHz	40 MHz	40 MHz	100 MHz	60 MHz	60 MHz
Modulation DL	64 QAM	64 QAM	64 QAM	64 QAM	64 QAM	64 QAM	64 QAM	64 QAM	64 QAM	64 QAM
Modulation UL	16 QAM	16 QAM	16 QAM	16 QAM	64 QAM	16 QAM	16 QAM	64 QAM	16 QAM	16 QAM
MIMO DL	Optional	2x2	2x2	2x2	4x4	2x2 or 4x4	2x2 or 4x4	8x8	2x2 or 4x4	2x2 or 4x4
MIMO UL	No	No	No	No	No	No	2x2	4x4	2x2	2x2
Commercial Device Availability				Mid 2013 First CAT 4 CA enabled devices		Mid-2014 First CAT 6 CA enabled devices expected (40MHz)		2015+ First CAT 7 CA enabled devices anticipated		

233 CAT 4 devices (GSA)

Device evolution to support greater throughput

Source: Document 1/203 (Rev.1), Alcatel-Lucent International (France).

[90] "LTE – The UMTS Long-Term Evolution: From Theory to Practice", S. Sesia, I. Toufik, M. Baker, John Wiley & Sons, Second Edition 2011. Appendix 1: LTE-Advanced devices ecosystem

3 CHAPTER 3 – Broadband access deployment

3.1 Methodologies for migration planning and implementation of broadband technologies, taking into account existing networks

There are many factors that need to consider in migrating to broadband technologies and migrating up in the evolutionary paths within broadband technologies.[91]

a) Physical infrastructure

Existing physical Infrastructure acts as a bottleneck not only in the access related infrastructure by including transmission and core related Infrastructure. However, need to note that the degree of difficulty decreases when going from access to core Infrastructure. This constraint is applicable for both wired and wireless development with a varying degree.

b) Spectrum constraints

There are many users to spectrum available for a country among which aviation, military usage dominates creating constraints in using spectrum for broadband technologies. Further, with increase of download/upload speeds for evolutions of IMT technologies, need for spectrum increases. Migration of networks to evolved versions of broadband technologies or to basic versions of broadband technologies, needs to done after considering the spectrum roadmaps and availability of frequency in identified bands.

c) Device ecosystem

Reduction of devices which supports old IMT technologies or, increase of devices which supports newer IMT technologies, provides incentives for operators to look at a network migration on a positive note.

Notwithstanding the above, progressive development by operators or attractive incentives by Regulators would direct or compel a telecommunication market to adopt newer Broadband technologies, migrating from older version.

There are broadly two methods to plan the migration of network from old to new that are listed below:

a) Soft handover

This is where the old network is run for a considerable time in parallel to the new development or plan to continue using the old network for services other than the Broadband needs. In this approach, there will be redundancy in operations, network and wastage of spectrum locked up in older technologies. However, this approach allows operators to migrate to the newer technology with least resistible path considering the factors mentioned above.

b) Hard handover

This is where regulator along with operators provide a closing down date for older equipment, after which older network will not allow planned operations. This approach provides saving of scares resources like spectrum and operations effort but requires a policy level driven framework as their will be a need to replace the existing handsets to accommodate the communications need.

It needs to be noted that paths to be taken to accommodating different broadband technologies may depend of the level of change.

a) Evolutionary changes

[91] Document 1/262, Democratic Socialist Republic of Sri Lanka.

Evolutionary changes happen in a technology where the fundamental network operation changes along with the usage of such technology. The best example is the evolutionary change witness between IMT technologies GSM and UMTS or from 1G technologies to GSM technology.

b) Revolutionary changes

For a migration related to revolutionary changes, the requirement for fundamental change in the network is not significant although the migration allows rich enhancements to the user behavior.

There are specific incentives that need to be drafted by regulators to operators in incentivizing operators to adopt the latest technologies related to Broadband.

a) Spectrum

As the spectrum is the most valuable resource out of the available ones, proper guidance and offering of spectrums in the most appropriate bands allows operators to migrate their network without facing much of constraints in the spectrum domain.

b) Handset subsidies

As highlighted above, handsets play a key role in the migration that increases the feasibility of migrating to newer IMT base technologies.

c) Infrastructure subsidies

There are certain measures that can be taken to incentivize operators to build Broadband related Infrastructure in rural and remote areas by providing them with proper Infrastructure subsidies.

d) IMT and IMT Advanced technologies as facilitators of broadband services in countries

Some countries like Kenya and Congo (Brazzaville) have recognized the role played by IMT technologies to provide mobile services to its populace, and the ICT sector currently made up of three mobile operators continue to roll-out a mix of 2G, 3G and late last year 4G-LTE services. These services are supported by fibre optic infrastructure that have been built the public and private sector as backbone links, and last mile solutions. The ultimate aim is to provide high-speed Internet services in addition to voice services for use by the citizens and to enhance public services delivery in all spheres of life in our country.[92]

In order to facilitate investment and growth in the ICT sector an Open Access and Competitive Provisioning strategy may be part of a legal framework governing ICT Providers' access to basic passive and basic active infrastructure and governs all government policies and actions relating to authorizing existing and future ICT Providers to build, locate, own, and operate physical infrastructure, including international gateways and Internet Exchange Points (IXPs).[93] This approach should ensure transparent, non-discriminatory access to network infrastructure to allow effective competition at the wholesale and retail level, ensuring the provision of competitive and affordable service to end users.

The main objectives of this approach are:

– Encourage provision of broadband services to underserved areas;
– Provide for free and fair competition in the fibre optic and broadband markets;
– Provide Open Access to basic active and basic passive infrastructures in a transparent manner and without discrimination;

[92] Document 1/290, "IMT and IMT Advanced technologies as facilitators of Broadband services in Kenya", Republic of Kenya; Report for Q25/2 ITU-D study period 2010-2014

[93] Document SG1RGQ/300, "Open Access Policy and Competitive Provisioning for Afghanistan's fibre optic and broadband sectors", Afghanistan.

– Enable private companies, public entities, or partnerships between the two to build, own, and operate fibre optic and broadband infrastructure;
– Enable new entrants into the market;
– Open international gateways and Internet Exchange Points (IXPs) to private competition, price negotiation, and operation by private and public sector actors;
– Create an ICT sector free of monopolies and cartels; and
– Provide affordable and reliable broadband access to population.

Ensuring provision of communication services to all citizens in a country is one of the greatest challenges facing regulators and governments in rural areas in development countries[94], experienced to make use of financial support from the Universal Services Fund (USF) and regulatory intervention through a five years spectrum fees waiver. This strategy is expected to reduce the initial cost of rolling out services and also provides operators with a grace period to realize return on investment.

3.2 Policy principles

Some countries are defined, like Sri Lanka, made the National Broadband Policy is based on the following key principles and assumptions:

a) The Policy is more than a policy for the ICT sector of the economy – its reach is the whole economy of Sri Lanka and concerns the production and delivery of goods and services and associated transactions across the whole of the economy;

b) The Policy is concerned with all people in Sri Lanka in terms of their interactions and social engagement with social institutions and each other – its reach is the whole of society;

c) The Policy affects the whole of Government – its reach is the delivery of all services by Government, especially those that can be delivered or supported online;

d) That successful policy outcomes will depend on addressing all components of the broadband eco-system and recognize that plans need to support and strengthen both supply and demand aspects of the eco-system, as well as the absorptive capacity for social and economic change;

e) That successful broadband outcomes will depend on strong leadership from the Government and the ICT sector underpinned by clear policy settings that encourage public and private sector investment;

f) That regulatory and policy settings will facilitate competition and the development of new and innovative services and applications in broadband markets. In particular, it is expected that services and applications will be provided on a sustainable commercial basis to the maximum extent, and that subsidized provision will be limited to high cost, low demand environments and will be once-only or transient interventions in the market; and

g) Those broadband services shall be accessible to all people and communities within Sri Lanka and that all aspects of accessibility (availability, affordability, and capacity to use) need to be addressed.[95]

[94] Document SG1RGQ/290, "Rural connectivity through subsides and spectrum fees waiver: The Kenyan experience", Republic of Kenya.

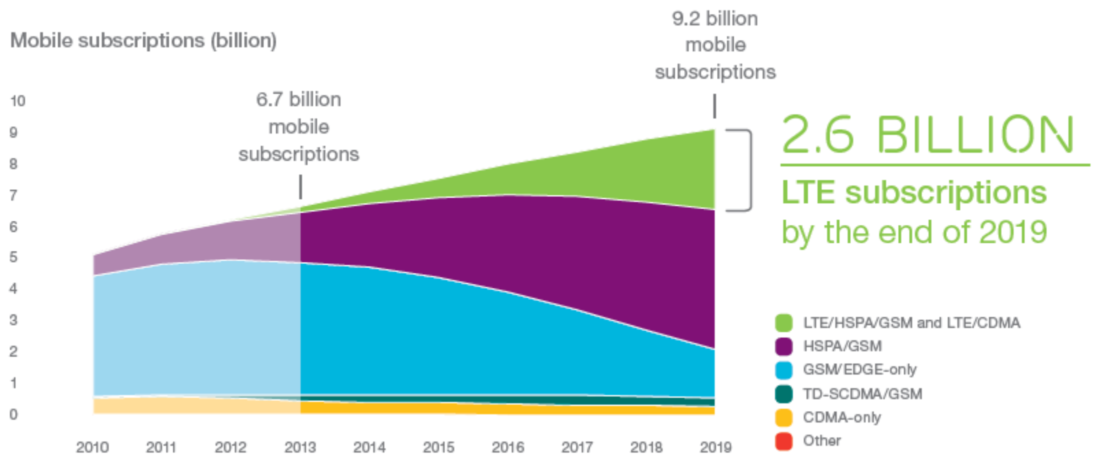
[95] Document SG1RGQ/288, "National Broadband Policy of Sri Lanka", Democratic Socialist Republic of Sri Lanka.

3.3 Trends in the various broadband deployments, services offered and regulatory considerations

3.3.1 Challenges with the deployment of NGA

Figure 12 shows how the migration of mobile services will continue growing from GSM networks into LTE networks, in order to reach the high demand of data, LTE requires more frequencies to provide the highest data transmission demanded and more infrastructures to provide the required Quality of Service (QoS) demanded by users with smart phones, tablets and all new devices connected to the MBB networks to provide the Machine to Machine (M2M) services.[96,97]

Figure 12: Predictions of mobile subscriptions growth by technology



As it is shown in **Figure 12**, the different mobile networks with 2G, 3G and 4G technologies will continue providing the mobile service in parallel for a long time in the same country, each network requires its own frequencies to provide the best service to existing users that gets its service from one network to another depending of its coverage and type of required service (voice or data).

In an effort to roll out NGA, the National Telecom Regulatory in Egypt – NTRA- sets out an ambitious plan for increasing the availability of Internet provision in Egypt under its National broadband plan ("eMisr"), a program described above in **Section 1.2**.[98]

3.3.2 Broadband networks evolution through the Networked Society

The vision of the Networked Society, where everything that benefits from being connected will be connected, places new requirements on connectivity. LTE is a key component in meeting these demands, and LTE release 13 is the next step in the LTE evolution. LTE release 13 will enhance LTE in several aspects, and strengthen its capacity to serve as a platform for the Networked Society. Enhancements in this release include licensed assisted access, which uses the carrier-aggregation framework to exploit unlicensed spectrum as a complement, and multi-antenna enhancements exploiting both the horizontal and vertical domains. These enhancements will improve overall capacity as well as user data rates. Latency reductions in release 13 will also help higher-layer protocols such as TCP to exploit these very high data rates.

At the same time, LTE will expand into new usage scenarios by providing improved support for low-cost and energy-efficient massive machine-type communications through reduced RF bandwidth.

[96] Document SG1RGQ/161, Alcatel-Lucent International (France); Alcatel-Lucent USA (United States of America).
[97] Document 1/189, "Evolution in mobile broadband networks, for its consideration in the reports", Ericsson (Sweden).
[98] Document SG1RGQ/75, "Next generation access for broadband", Arab Republic of Egypt.

Enhancements in direct device-to-device communication will provide improved support for public safety as well as various commercial use cases. LTE is a flexible platform that is continuously evolving to address new requirements and additional scenarios. This LTE evolution can play a vital role in the realization of the Networked Society.

According to the recommendations of Kazakhstan's Interagency Commission on Radio Frequencies (ICRF) of 7 December 2015, cellular communication operators (Kcell, Kar-Tel, MTS and Altel) are able to use frequencies allotted to them under the GSM, DCS-1800 (GSM-1800), and UMTS/WCDMA (3G) standards, for the purpose of organizing LTE (4G) and LTE Advanced cellular communications, that is, applying the principle of technological neutrality.[99]

In addition, the ICRF adopted a decision to distribute 10 MHz of uplink/downlink bandwidth among the current cellular communication operators for a one-off payment and without competition, as a result of the limited number of cellular communication operators.

This principle has been introduced in many countries and is now of particular relevance, given the convergence of services and the increasing interchangeability of various technologies.

High-energy performance targeting reduced network energy consumption is a critical requirement of IMT-2020 networks. It enables to reduce the total cost of ownership, facilitates the extension of network connectivity to remote or rural areas and provides network access in a sustainable and more resource-efficient way.

Energy performance has long played an important role in mobile communication on the device side. High-energy performance in devices has enabled longer battery life, and has been a vital component behind the mobile revolution. However, the need for high-energy performance has also become a key factor for network infrastructure. The challenge here is to reduce total network energy consumption at the same time as managing massive increases in traffic and number of users.

Achieving high-energy performance requires a fundamental change of design principles and implementation practices within the mobile industry. An industry that has focused on providing high traffic capacity and high data rates is now also realizing the importance of high energy performance when there is little, or no, data to transmit or process.

IMT-2020 systems with high energy performance should build on the following design principles: to only be active and transmit when and where needed. This will allow for scalable, manageable and flexible network design that both facilitates truly load-dependent energy consumption and maximizes energy-saving possibilities.

Key technologies to achieve this include ultra-lean design, advanced beam forming techniques, and separation of user-data and system-control planes on the radio interface, as well as virtualized network functionality and cloud technologies.

In summary, the deployment of new mobile broadband networks such as LTE, will help administrations to support the high traffic demand in the near future, it is necessary to have enough new dedicated spectrum for these technologies, considering that existing frequencies are used in the existing mobile networks, some ITU-R studies has shown that the required spectrum for mobile services to handle the expected data traffic by year 2020 is around 1900 MHz.[100]

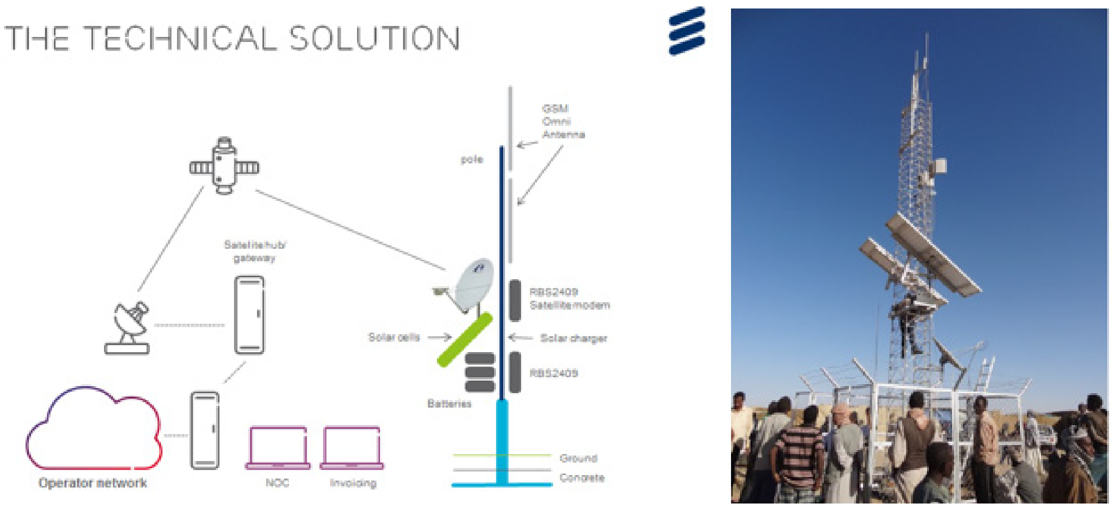
[99] Document SG1RGQ/152, Republic of Kazakhstan.

[100] More detailed information can be obtained in the following links: http://www.anatel.org.mx/docs/interes/Ericsson_Mobility_Report.pdf and http://www.ericsson.com/res/docs/2015/ericsson-mobility-report-feb-2015-interim.pdf.

3.3.3 Main considerations for providing Broadband for rural areas

In developing countries it is a challenge to provide broadband services considering the topological and economical situations in rural areas.[101] Mobile networks are the right solution considering its technical characteristics. Nowadays there are technical options to help administrations to provide broadband service in the most remote areas, with cheap and fast technical solutions that consist to install directly a complete cell site in the pole or tower minimizing the installation cost and time, **Figure 13** shows the details for the technical solution for rural areas and a real cell site deployed, with this solution the last uncovered regions in a country can be included into the digital era, if a LTE solution is deployed can be reach peak rates up to 36.7 Mbps.

Figure 13: Technical solution to provide broadband services in rural /remote areas



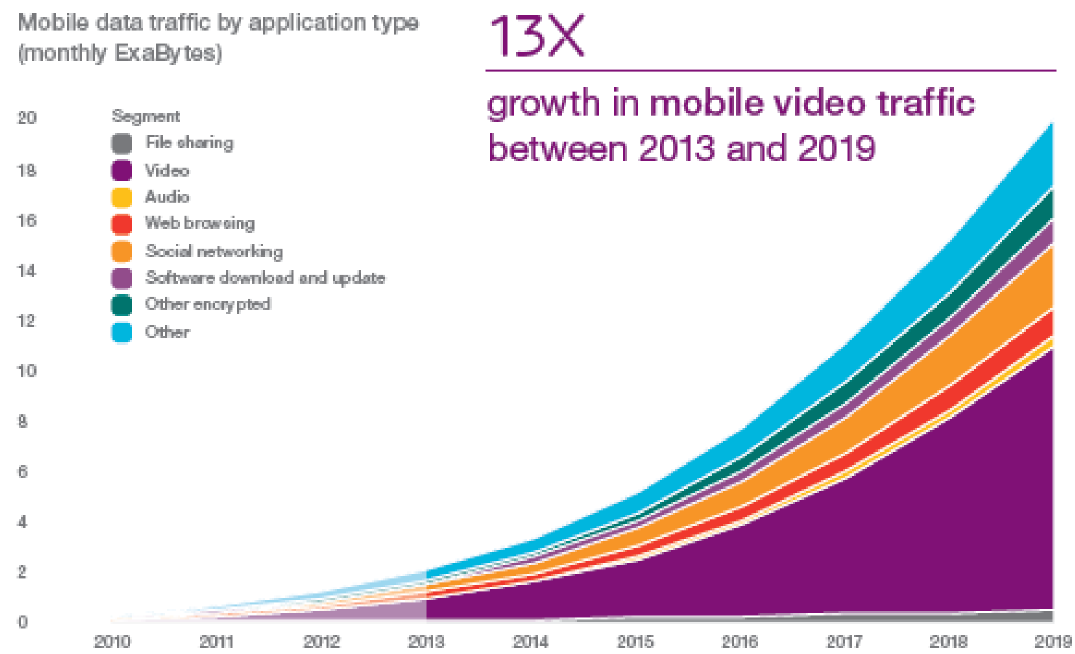
LTE and 3G mobile networks have the capability to serve for applications like have to be Internet of Things (IoT) or Machine to Machine (M2M) application or services, considering that its latency is very low that is one of the technical requirements for these applications and the coverage of these networks cover all required areas for the IoT services.

3.3.4 The regulations for next generation networks

Figure 14 represents how mobile data traffic is growing with the time, video is the application with highest demand and therefore it will be necessary to facilitate the deployment of 4G networks to provide the best quality of service to upload and download videos by the end user.

[101] Document 1/189, "Evolution in mobile broadband networks, for its consideration in the reports", Ericsson (Sweden).

Figure 14: Mobile data traffic by application type



3.3.5 Small cells for broadband deployments in rural areas

It is undeniable that one of the challenges for governments in developing countries, such as those in Latin America, is to provide basic connectivity in rural areas[102], noting that nowadays, basic connectivity is definitely not limited to voice but includes data as an enabler to several other services that should be provided in any broadband development project.[103]

One of the main barriers (for governments and service providers) to cover the population that does not have any communication network, is the cost associated to deploy the fixed infrastructure plus its associated IMT Base Transmission Stations (BTS). Going through traditional solutions such as Macro BTS results in business cases that requires a critical mass in terms of subscribers that exceeds the population of any single rural village – remembering that most of the regulations leave as the last priority for coverage, those areas with less than 500 inhabitants (this number might be higher depending on the country policies). Despite the fact that business cases might be challenging, the crying need of connectivity for those communities in order to enable their growth and contribution to the Gross Domestic Product (GDP), coupled with potential opportunities such as Internet of Things (IoT) in rural areas (related with agriculture and utilities), make the request for different technical solutions a must for governments, service providers and telecom vendors.

Several service providers in Latin America have been testing options scaled down to the size of the populations to be served, in order to achieve costs which are a fraction compared with Macro BTS deployments. These options are based on Small Cells Outdoor which offer a good coverage to the extent of the rural community.

Considering the low power characteristic (5W) of most of the small cells considered for outdoor environment, coverage ranges represent a challenge. In order to address this challenge test scenarios include a combination of Small Cells together with directive antennas, so that coverage reaches nearly 1Km of range when using low frequencies such as 850MHz, and 700m of range when using

[102] Connectivity in rural areas is an issue all over the world. Solutions similar to those described in this section have also been proposed for small villages of Champagne in France.

[103] Document SG1RGQ/161, Alcatel-Lucent International (France), Alcatel-Lucent USA (United States of America).

2100 MHz Band. So depending on the village and coverage required, a design with several small cells and directive antennas can provide the required coverage of the whole objective area or at least address main public centers where most of the population will have open access (schools, hospitals, police departments, recreational parks).

This design allows offering the required coverage, but still two main issues need to be solved. The first one is the backhaul availability, where two options are available:

– Packet Radio microwave links in a daisy chain scheme, connected to the closest IMT Macro Network Base Stations, aiming as a max. 3 to 4 hops between the rural area and the base station. The main benefit of this approach is the low cost associated to microwave radios nowadays and the low latency for IMT connections using such a backhaul scheme.
– Satellite connections. Option 1 works easily in small countries with a macro coverage greater than 90 per cent; but still in large countries where such distances between rural areas and the 1st radio link exceeds the 3 to 4 hops mentioned above, satellite connections are a good option to offer backhaul for those small cells. Latency is still the main challenge associated to this approach, yet some service providers in Latin America performed tests with IMT Small Cells Outdoor with a backhaul satellite connection in the band Ka, with excellent results.[104]

The second issue, equally important, is related to the power required for the whole solution (small cells and microwave equipment) in villages where public electricity is absent. It is critically important to count on a solution with low power consumption (certain service providers request network solutions with power consumption lower than 100W) so that the site can rely on solar panels backed up with batteries (other energy sources could be explored depending on the area, like aeolian energy). Besides the alternative sources being offered, the aim is also to guarantee three days of autonomy considering that those areas are remote and operation could be a real challenge in order to maintain and ensure service continuity.

Once all technical scenarios are tested successfully, the other challenge is operation and maintenance of the infrastructure deployed, considering again the remote condition of the rural areas studied. Currently there are interesting approaches being explored by different service providers, like for example, training communities for first level of support activities, so that any case required first level assistance on site, can be easily supported by community contractors in the village or close by. Or through the franchise scheme of rural areas, where a subcontractor owns the infrastructure together with its operation and maintenance and pays a fee to an existing service provider which grants access to the 3G spectrum usage.

As a conclusion, the technical elements depicted in this section (3G Small cells with directive antennas, packet radio backhaul solution or Satellite links, and lower power consumption to enable alternative energy sources), result in a viable technical solution which at the same time represent a fraction of the total cost of deploying Macro BTS in such areas. Certainly, regulators can also contribute to the accelerated adoption of such solutions, guaranteeing a short-term deadline to providing connectivity to communities of less than 500, as part of the obligations tied to spectrum allocation.

3.4 Key elements in facilitating the possible deployment of systems integrating the satellite and terrestrial components of IMT

There are many factors which needs to be considered in facilitating such deployments which are listed below.[105]

a) Regulatory constraints

[104] Since the IuH Radio Interface over the IpSEC tunnel was perfectly established through the satellite connection, voice calls were also established and a downlink throughput of 18Mbps was experienced in several data applications under a delay of ~680 ms and a jitter of ~15 ms on the transport layer.

[105] Document 1/263, Democratic Socialist Republic of Sri Lanka.

The above will be a major constraint in the deployment as the regulatory frameworks governing Terrestrial IMT and Satellite implementation exist on two different domains and need to have convergence of the above. The above needs to address licensing, spectrum usage and quality of standards attached to operations.

b) Requirements of Hetnet network

Existing Terrestrial IMT implementation is getting adopted to managing Broadband implementation in different technologies (Ex: UMTS, LTE, LTE-A), different spectrum bands etc and the addition of a Satellite system needs to be defined to be compatible with existing Hetnet Network architecture. This will be a key requirement as the convergence will be dependent on the compatibility of systems with each other.

c) Multimode Ddvice adoptability

As elaborated in b), existing network are adopting a Hetnet structure to facilitate devices getting introduced which are compatible with different technologies and different modes of operations. Deployment of such hybrid system of satellite and terrestrial needs to be induced by a considerable penetration of devices which need to work on a Multi Access Mode.

d) Partnership requirement

Similar to constraints posed on regulatory domains, key stakeholders in both IMT and satellite domains exist separately which will require more collaborations. This collaboration should foster to a level where governing bodies, operators need to work together to achieve the end objective of harmonic deployment of satellite and terrestrial broadband coverage.

e) Ecosystem compatibility to complement each other

Broadband deployment can be carried out by IMT technologies providing access and satellite operators providing backhauling requirements. This method of broadband deployment is beneficial, especially with respect to deployments in rural and remote areas where backhauling acts as a major bottleneck.

IMT consists of both terrestrial component and satellite component radio interfaces. The terrestrial and satellite components are complementary.[106] The terrestrial component provides coverage over areas of land mass with population density considered to be large enough for economic provision of terrestrially-based systems. On the other hand, the satellite component provides service elsewhere by a virtually global coverage, especially with strength in providing coverage in the sea, islands, mountainous districts, and sparsely-populated areas. The ubiquitous coverage of IMT can therefore be realized using a combination of satellite and terrestrial radio interfaces.

The satellite component of IMT encompasses IMT-2000, IMT-Advanced and IMT-2020. “Detailed specifications of the radio interfaces for the satellite component of IMT-2000” are identified in Recommendation ITU-R M.1850-1.

For more information on radio interfaces for the satellite component of IMT-Advanced, please refer to Recommendation ITU-R M.2047 “Detailed specifications of the satellite radio interfaces of International Mobile Telecommunications-Advanced (IMT-Advanced)” and Report ITU-R M.2279 “Outcome of the evaluation, consensus building and decision of the IMT-Advanced satellite process (Steps 4 to 7), including characteristics of IMT-Advanced satellite radio interfaces”.

The satellite component will remain integral as networks transition to IMT-2020. The ITU-T Focus Group on IMT-2020 draft “Report on application of network softwarization to IMT-2020” (IMT-O-041) emphasizes in its recommendations to ITU-T Study Group 13 that “IMT-2020 network architecture is required to include multiple RAN technologies including satellite” and recommends studies “of the

[106] Document 1/187, KDDI Corporation (Japan).

integration of satellite technologies into the IMT-2020 network architecture." Experience of Kenya on the use of IMT and IMT-Advanced technologies for facilitating the broadband services in Kenya can be found in **Annex 1**.[107]

3.5 Convention border interconnection in optical fiber

To facilitate the development of Broadband in Africa, an inter-state interconnection program was initiated in Central Africa. The program suffers from a regulatory framework which is a considerable brake on the deployment of infrastructure.[108]

In the implementation of part of the Central African Backbone project in Central Africa, the example of the interconnection between Congo and Gabon inspired the countries of the sub-region have adopted a resolution in 2014 to interconnect countries of the sub-region and to establish the MoU.

Context of the establishment of MoU

The Declaration of Heads of State and Government of the CEMAC to connect eventually optical fiber all the Member States of the sub-region in the third pillar of the Regional Economic Programme (REP) of the CEMAC in 2010-2015, relating to the physical interconnection of its Member States.

Considering the clearly affirmed by the Heads of State and Government of the CEMAC to perfect the EU integration process in order to achieve a harmonious and integrated development of the economies of the sub-region. Taking in this regard the importance of Information Technology and Communication and the recommendations made at the first workshop on Interconnection between fiber optic networks in Congo and Gabon, which was held in Libreville 7 and 8 October 2013 in the presence of the ITU representative for Central Africa.

The two sides agreed to set up an interconnection agreement.

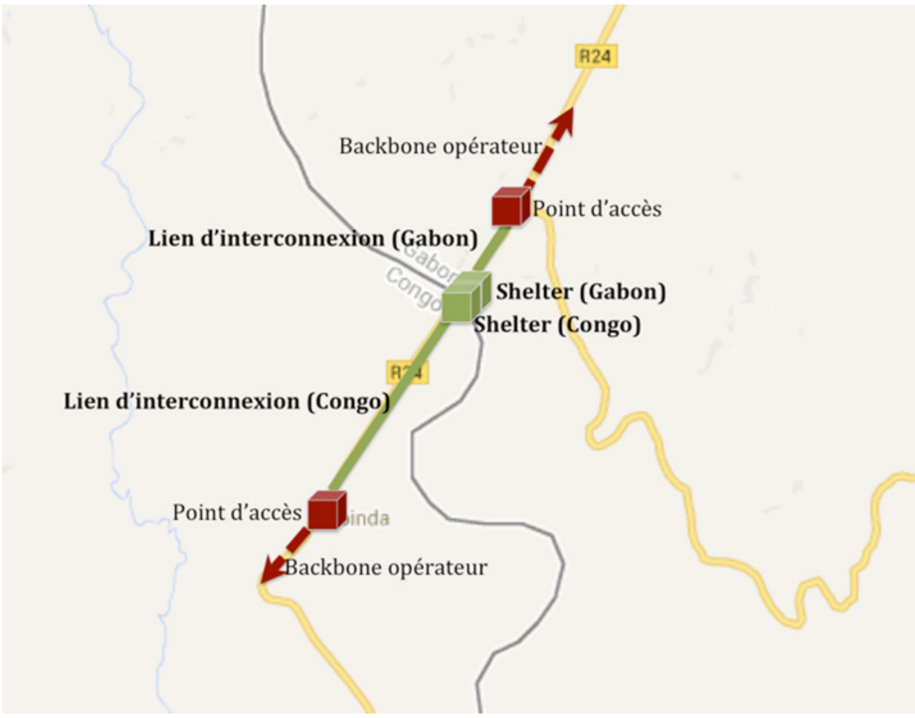
Purpose of the agreement

The two countries had agreed to sign a Memorandum of Understanding which sets the general framework for cooperation between the Republic of Congo and the Republic of Gabon.This signed agreement focuses on the following areas:

- Physical interconnection logic and fiber optic networks of the two countries;
- Coordination of circuits and bandwidth;
- The pooling of resources in the implementation of capacity building programs;
- Mutual offers catering ways to secure communications on both networks.

[107] Document 1/290, "IMT and IMT Advanced technologies as facilitators of Broadband services in Kenya", Republic of Kenya.
[108] Document 1/267, "Impact of broadband at university and on the development of innovation centres", Republic of the Congo.

Figure 15: Interconnection between Republic of Congo and Gabon



Source: Document 1/267, "Impact of broadband at university and on the development of innovation centres", Republic of the Congo.

Structuring the agreement

The MoU content revolves around the points defined by both parties after several preparatory meetings:

- Preamble: purpose, strategic areas of cooperation, the objectives pursued by the two States in the sub-regional integration, role assigned to teams by the project management office;
- Mode of governance of the fiber: ownership, operation, maintenance, wholesale marketing: regimes governing the activity of the property company and the operating company (if different) obligations imposed on the various stakeholders, respect QOS standards, service type marketed;
- Commitment and responsibility of the parties creating a supra national joint committee, composition of the Commission, prerogatives and obligations, articulation with national authorities (regulator, ministry);
- Safety and physical integrity of the network: international standard, existence of redundancy.
- Sustainability of investments: pricing principle ensuring adequate revenues to O&M and renewal investments.

Implementation

The agreement covers two phases of life network its establishment and operation. A joint appointment by the different actors involved in the project is set up for each project phase.

- Network construction

The agreement specifies that each country is responsible for the infrastructure construction of the country and will make available to the other countries the technical elements to ensure the operability of the two networks.

- Network operations

The network operation is carried out by two separate operators, each operating in its territory.

Governance

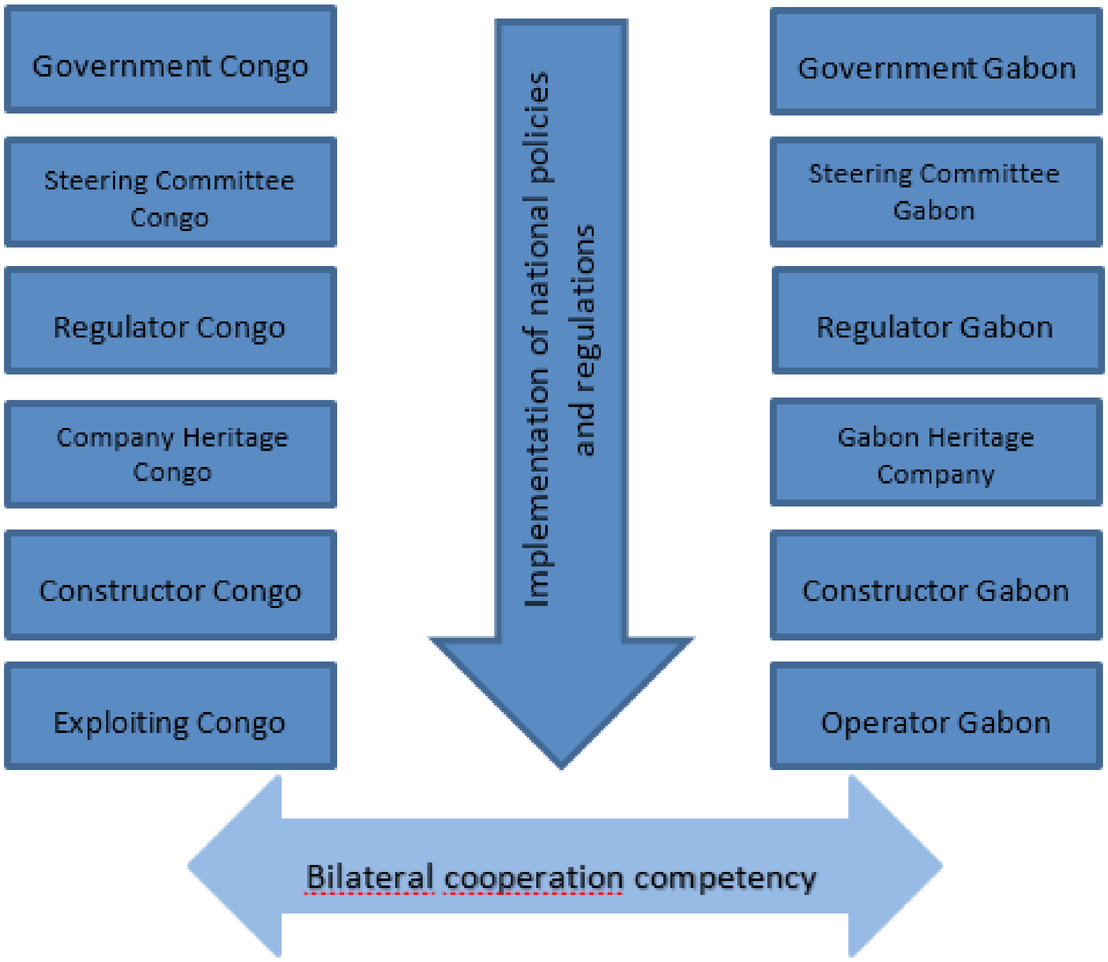
The establishment of a joint committee is responsible for monitoring this protocol. Local government structures are in charge of enforcing existing regulations that must be met by private operators. Public structures have to interface their homologue in the partner country.

Functional scheme

Governance is vertically for bilateral cooperation and competence. The aim is to harmonize the choices made in each country to establish the common framework of management and manage potential conflicts.

It is done horizontally in each country to ensure compliance with regulations in force in each country.

Figure 16: Functional scheme



3.6 How power companies can take part in the construction of fibre-optic FTTH networks

There are largely two business models.[109] Firstly, the power company can participate in the construction of a national fibre-optic network as a joint investor and a contributor of pipelines resources.

[109] Document 1/278, "Discussions on the mode of involvement for power companies to take part in the construction of fibre-optic networks based on their own strengths", People's Republic of China.

Secondly, it can set up a joint venture with a telecom operator to build the fibre-optic network. The first model mainly relies on the national ICT strategies to launch national broadband projects. In this case, in order to save the total investment and encourage the competition among the existing operators, and to promote the further opening of ILECs in particular, the government will take the initiative to invite a national power company to participate in the construction of the national fibre-optic network. The power companies in such countries will participate in the construction of the national fibre-optic network as a co-investor and a contributor of pipelines. Once constructed, the national fibre-optic network will be leased to all telecom operators in a wholesale mode. Globally, we find that, in the construction of the national broadband fibre-optic network in New Zealand, two local power companies North Power fibre and Waikato Networks Ltd have invested some funds and contributed their advantageous pipelines in a certain region to take part in the roll-out of the national fibre-optic network. Afterwards, the fibre-optic facilities in the above-mentioned region were leased to all telecom operators on a fair basis. In Italy, the power company ENEL leveraged its own advantages in fibre-optics, power poles and pipelines to participate in the construction of the national fibre network as joint investor and a contributor of pipeline resources. At the end of the day, the fibre-optic facilities were wholesaled to other operators.

In the second model, the power companies in a number of countries took the initiative to set up a joint venture with telecom operators to build fibre-optic networks. In so doing, both the advantage of power companies (existing pipelines, optical fibres, power poles, operation and maintenance staff, etc.) and that of the telecom operators (telecom operation and maintenance experience, telecom technology advantage) could be brought into play, and this will better solve the technical headaches in the roll-out of fibre-optic networks. However, the crucial issue would be the revenue share model and the initial investment portfolio in the joint venture. Otherwise, when the joint venture grows to a certain size, the dispute between the partners would become increasingly prominent in terms of the specific amount of continued input of cash streams and of the revenue to be shared, leading to all sorts of difficulties endangering the survival of the joint venture. In Ireland, the power company ESB has set up a joint venture SIRO with the local operator VDF in a bid to run wholesale fibre-optic business in 50 regional towns over the next three years. Other operators such as VDF, UPC and Eircom can all lease fibres from SIRO to enable 1Gbps bandwidth services. On the back of the power company (advantages: easily accessible right of way, pipelines and a rich stock of power poles) and the operator VDF (advantages: extensive experience in telecom service operation and trusted technical strength), the joint venture has identified its target region following a thorough market research. Meanwhile, a viable SIRO business plan has been worked out to offer competitive tariffs. From a business model point of view, this approach is more worthy of our reference. In Kenya, the power company has leased out for free its extra poles and existing pipelines. The local operator VDF is responsible for laying optical fibres and building the FTTH network. Fifty per cent of the fibres are provided free of charge to the power company for wholesale lease to other ISPs. In China, in some residential quarters the local power company followed a practice of laying the fibre-optic facilities together with the power lines as early as the homes were under construction. In this case, the telecom operator has to engage in "joint operation" with the power company.

Based on the existing advantages of power companies in fibre-optics and pipeline resources, the construction cost of a decent fibre-optic network will be much less expensive than a stand-alone network created by the telecom operator from scratch. Also, the tough challenge of FTTH will be relatively easy to cope with. Therefore, the wholesale price of optical fibres has been greatly slashed in the above-mentioned countries, and the wholesale lease to other operators has been warmly received in the local markets.

However, there are still some technical hurdles in regard to the roll-out of a fibre-optic network based on the power company's existing fibres, pipelines, power poles and other resources, and these ought to merit our special consideration, e.g., the strong current protection of the active equipment. According to the requirement, passive devices need to be non-metallic, hence no grounding problem will be considered.

4 CHAPTER 4 – Conclusions and general recommendations

The introduction of broadband technologies, community antennas, optical fibre, satellite and fixed and mobile wireless has enabled traditional and new forms of telecommunications to become a reality throughout the world, where social, economic, and technological situation is changing rapidly.

Because physical infrastructure and geography are vastly different from country to country, technology that works well in one geographic area may not work in another. Moreover, high cost for installation and operation of telecommunications infrastructure may have an impact on the deployment of new technologies to allow higher data rate for more demanding applications.

Many challenges need to be overcome in order to deploy broadband access network such as policy, legacy, existing infrastructures, economic and social impact, educational issues, awareness and knowledge, remote and rural areas, spectrum constraints, standards of living, digital democracy, digital and financial inclusions.

From the experience of many countries technologies and strategies of implementing telecommunications broadband access networks are various and diversified. New frontiers of Internet of Things (IoT) and Home Networking need the optimization of physical supports and spectrum usage for optical/copper wirelines, IMT technologies in order to allocate new high-bandwidth demanding services but taking into account legacy and costs.

Public policies and regulatory measures highly contribute to speed up the growth in services in providing access to core network and so to ICT services telecommunications/ICTs, especially in rural and remote areas using. Success stories are described in **Annex 1** dealing with countries experiences.

Advantageous deployment of technological advances is made possible by encouraging transparent and clear regulatory environment. Satellite systems are high risk, costly ventures that can only be afforded when there are policies in place to ease those inherent burdens and provide certainty to operators.

Energy performance has long played an important role in mobile communication on the device side. High-energy performance in devices is a vital component behind the mobile revolution. However, the need for high-energy performance has also become a key factor for network infrastructure. The challenge here is to reduce total network energy consumption at the same time as managing massive increases in traffic and number of users.

Multi-hop, small cells, antennas and microwave links (short distances) or satellite connections (wide areas) may be adopted to reach remote areas from a basic IMT Macro Base Stations.

The following conclusions contain general recommendations which could be useful for developing countries on how to achieve the implementation of broadband access technologies including IMT:

- Overall, a National Plan should be developed and periodically revised by policymakers in order to create a regulatory framework to encourage the deployment of broadband access technology.
- Developing countries are invited to implement incentive policies that stimulate the development of telecommunications networks. Public access points such as telecentres, etc. Infrastructure sharing could be implemented to avoid investment duplication in rural and remote areas in developing countries.
- A primary, secondary and tertiary education plan should be developed and implemented. This will help the rural people and will consequently stop the mobility of population from rural to urban. There may be the need of planning assistance for a proper implementation of ICT education in Broadband Access Deployment. Remote rural communities will benefit of satellite connections where optical fiber is not available.

- The education plan may require partnership cooperation between governments, regulators, operators, and other stakeholders in the implementation of telecommunications/ICTs to all layers of the population in their countries.
- Technical, economic and geographical aspects of the project is essential. Here, technological neutrality should be taken into account. For the access technology, wireless such as 2G, 3G, LTE, Wi-Fi, and WiMax is used most widely, but where very high data rate is demanded wireline solutions should be adopted.
- It is recommended to investigate high-energy performance targeting reduced network energy consumption as a critical requirement especially of IMT-2020 networks. It enables to reduce the total cost of ownership, facilitates the extension of network connectivity to remote or rural areas and provides network access in a sustainable and more resource-efficient way. IMT-2020 systems with high energy performance only be active and transmit when and where needed.
- Due to the low power consumption (5W) of the small cells for outdoor environment, it should be explored the possibility to combine several Small Cells together with directive antennas, so that coverage reaches nearly 1Km of range, suitable to rural areas and small villages and the population will have open access (schools, hospitals, police departments, recreational parks).
- When applicable, Memoranda of Understanding with general framework for cooperation on border interconnection between states are encouraged. International links MoUs are key to achieve a harmonious and integrated development of the economies in the sub-regions by means of agreed design, implementation, operation and maintenance.

Abbreviations and acronyms

Various abbreviations and acronyms are used through the document, they are provided here.

Abbreviation/acronym	Description
ACM	Adaptive Coding and Modulation
ADSL	Asymmetric Digital Subscriber Line
ANT	Access Network Transport
ARPCE	Regulatory Agency of Post and Electronic Communications (Republic of the Congo)
ARPT	Posts and Telecommunications Regulatory Authority (Autorité de Régulation des Postes et Télécommunications) (Republic of Guinea)
ARPU	Average Revenue Per User
ATM	Asynchronous Transfer Mode
ATRA	Afghanistan Telecom Regulatory Authority (Afghanistan)
BDT	Telecommunication Development Bureau
B-ISDN	Broadband ISDN
BSMF	Broadband Speed Measuring Facility
BTS	Base Transmission Stations
BWA	Broadband Wireless Access
CA	Communications Authority
CAB	Central African Backbone
CATV	Cable Television
CC	Component Carrier
CCV	Coordination Committee for Vocabulary
CEMAC	Central African Economic and Monetary Community (Communauté Économique et Monetáire de l'Afrique Centrale)
CGC	Circuit-Group-Congestion signal
CHIPS	Clearing House Interbank Payment System
CLS	Continuous Linked Settlement
CO	Central Office
CoMP	Coordinated Multi-Point
CRS	Cognitive Radio System
CVD	Cardio Vascular Disease
DAB	Digital Audio Broadcasting

Abbreviation/acronym	Description
DCC	Data Communication Centre
DDoS	Distributed Denial of Service
DNSSEC	Domain Name System Security Extensions
DOCSIS	Data Over Cable Service Interface Specification
DPSNTIC	Development of Information and Communication Technologies
DSA	Dynamic Spectrum Access
DSB	Digital Sound Broadcasting
DSL	Digital Subscriber Line
DVB	Digital Video Broadcasting
DWDM	Dense Wavelength Division Multiplexing
ECG	Electrocardiogram
ECOWAS	Economic Community Of West African States
EFM	Ethernet in the First Mile
EHR	Electronic Health Record
eICIC	Enhanced Inter-Cell Interference Coordination
EPON	Ethernet Passive Optical Network
FCC	Federal Communications Commission (United States of America)
FDSUT	Fund for Development of the Universal Telecommunication Service
FOC	Fibre Optic Cable
FR	Frequency Radio
FSAN	Full Service Access Network
FSS	Fixed-Satellite Service
FTTB	Fibre-to-the-Building
FTTC	Fibre-to-the-Curb
FTTC	Fiber-to-the-Cabinet
FTTD	Fiber-to-the Desktop
FTTH	Fibre-to-the-Home
FTTN	Fibre-to-the-Node
GDP	Gross Domestic Product
GHz	Gigahertz
GoR	Government of Rwanda

Abbreviation/acronym	Description
GPON	Gigabit-capable Passive Optical Networks
GSM	Global System for Mobile Communications
GUILAB	Guinéenne de la Large Band
HARQ	Hybrid Automatic Repeat reQuest
HD	High-Definition
HDSL	High-bit-rate Digital Subscriber Line
HNT	Home Network Transport
HSDPA	High-Speed Down-link Packet Access
ICPC	International Cable Protection Committee
ICRF	Interagency Commission on Radio Frequencies (Republic of Kazakhstan)
ICT	Information and Communication Technology
IDA	Infocomm Development Authority (Singapore)
IDI	ICT Development Index
IEEE	Institute of Electrical and Electronic Engineers
IMS	IP Multimedia core network Subsystem
IMT	International Mobile Telecommunications
IMT-2020	Those systems that conform to the corresponding series of ITU Recommendations and Radio Regulations.
IoT	Internet of Things
IP	Internet Protocol
IpSEC	IP Security Protocol
ISDN	Integrated Services Digital Network
ISP	Internet Service Provider
ITU	International Telecomunication Union
ITU-D	ITU Telecommunication Development Sector
ITU-R	ITU Radiocommnication Sector
ITU-T	ITU Telecommunication Standarization Sector
IXP	Internet eXchange Point
KETRACO	Kenya Electricity Transmission Company
KPIs	Key Performance Indicators
LAN	Local Area Network

Abbreviation/acronym	Description
LMH	Land Mobile Handbook
LMS	Learning Management System
LTE	Long Term Evolution
M2M	Machine to Machine
MBMS	Multimedia Broadcast/Multicast
MCIT	Ministry of Communication and Information Technology (Afghanistan)
MHz	Megahertz
MIMO	Multiple-Input and Multiple-Output
MNO	Mobile Network Operator
MoU	Memorandum of Understanding
MPLS	Multi-Protocol Label Switching
MSAN	MultiService Access Node
MSO	Multiple Systems Operator
MUD	Multi-User Detection
NBP	National Broadband Policy (Democratic Socialist Republic of Sri Lanka)
Next Gen NBN	Next Generation Broadband Network
NGA	Next Generation Access
NGN	Next-Generation Networks
NICI	National Information and Communication Infrastructure (Republic of Rwanda)
N-ISDN	Narrowband-ISDN
NIT	Network Integration Test
NOC	Network Operations Centre
NOFBI	National Optical Fibre Infrastructure (Republic ofKenya)
NRA	National Regulatory Authority
NTRA	National Telecom Regulatory (Arab Republic of Egypt)
OFDM	Orthogonal Frequency-Division Multiplexing
OFDMA	Orthogonal Frequency-Division Multiple Access
OLT	Optical Line Terminal
ONU	Optical Network Unit
OPG	Office de la Poste Guinéene (Republic of Guinea)
OTN	Optical Transport Network

Abbreviation/acronym	Description
PA	Power Amplifier
PAPR	Peak–to-Average Power Ratio
PLT	Power Line Transmission
PON	Passive Optical Network
PoP	Point of Presence
POTS	Plain Old Telephony Service
PPP	Point-to-Point Protocol
PSTN	Public Switched Telephone Network
PtP	Public-Private Partnerships
PUITS	University Innovation in Telecommunications Services Program
QoE	Quality of Experience
QoS	Quality of Service
RAN	Radio Access Network
REP	Regional Economic Programme
RN	Relay Nodes
RPM	Regional Preparatory Meeting
RURA	Rwanda Utilities Regulatory Authority (Republic of Rwanda)
SaaS	Software as a Service
SCV	Standardization Committee for Vocabulary
SDH	Synchronous Digital Hierarchy
SDOs	Standards Developing Organizations
SDP	Service Discovery Protocol
SDR	Software Defined Radio
SL	Subscriber Line
SLE	Service Level Agreement
SMEs	Small and Medium Enterprises
SOGEB	Société de Gestion du Backbone National
SON	Self-Organizing Networks
SOTELGUI	Société des Télécommunications de Guinée
SWIFT	Society for World Interbank Financial Telecommunications
TDF	Telecom Development Fund

Abbreviation/acronym	Description
TDM	Time-Division Multiplexing
TMB	Telekom Malaysia Berhad
TRCSL	Telecommunications Regulatory Commission of Sri Lanka (Democratic Socialist Republic of Sri Lanka)
UE	User Equipment
UHF	Ultra-High Frequency
UMNG	University Marien NGOUABI
UMTS	Universal Mobile Telecommunications System
UN	United Nations
USAT	Ultra-Small Aperture Terminal
USB	Universal Serial Bus
USF	Universal Services Fund
VDSL	Very high-speed DSL
VoIP	Voice Over Internet Protocol
VPN	Virtual Private Network
VPS	Virtual Private Server
VSAT	Very Small Aperture Terminal
WARCIP	West African Regional Connectivity Programme
WCDMA	Wideband Code Division Multiple Access
WDM	Wavelength Division Multiplexing
WiMax	Worldwide interoperability for Microwave Access
WLAN	Wireless Local Area Network
WLL	Wireless Local Loop
WRC	World Radiocommunication Conference
WSA	World Summit Awards
WTDC	World Telecommunication Development Conference
xDSL	x-type Digital Subscriber Line
XNI	Any Network Interface

Annexes

Annex 1: Country experiences

Country/ Entity	Source Document	Title	Summary
Afghanistan	SG1RGQ/300	**Open Access Policy and Competitive Provisioning for Afghanistan's fibre optic and broadband sectors**	This document provides information regarding importance, necessity and economic consequences of the Open Access Policy in the country's telecommunication sector, with reference to existing operating companies.
People's Republic of China	1/206	**Rural broadband**	A huge change happened due to the innovation of Sichuan "Rural Broadband" mode. This mode uses the government guide, private capital cooperation, planning guide, technical and management innovation, IPTV as the "Internet +" entry and other innovative approaches. Sichuan is now gradually eliminating the digital gap between urban and rural areas and creating a "new era of rural optical network".
Côte d'Ivoire	1/163	**Guidelines on passive infrastructure sharing**	To ensure effective follow-up of infrastructure sharing by the regulatory authorities, common guidelines need to be elaborated in order to define the key principles that can be adapted in all countries.
Egypt (Arab (Republic of) (1/2)	SG1RGQ/63	**The national broadband plan "eMisr": Transition from planning to execution**	"eMisr" is a plan that proposes different strategic directives to meet Egypt's broadband service needs. "eMisr" aims to extend broadband services in all over Egypt including underserved areas.
Egypt (Arab (Republic of) (2/2)	SG1RGQ/75	**Next generation access for broadband**	The National Telecom Regulatory in Egypt – NTRA- sets out an ambitious plan for increasing the availability of Internet provision in Egypt under its National broadband plan ("eMisr"), a program with ambitious roll-out targets that include improving download speeds is in process so that 80% of Egyptian citizens will have Internet access at (4 Mbps-25 Mbps) by the year 2018, Moreover it is targeted to reach 85% population mobile coverage through 4G, and connecting 50% of Egyptian communities.

Country/ Entity	Source Document	Title	Summary
Guinea (Republic of)	SG1RGQ/62	**National policy and development of ICT infrastructure in Guinea**	Major projects under the policy document's Action Plan have been launched, and implementing them has been a top priority for the department, given their future impact on the life of the Guinean public. Over the period 2011-2014, the posts, telecommunications and NITs sector saw some major developments.
Kazakhstan (Republic of)	SG1RGQ/152	**Broadband access technologies, including IMT, for developing countries**	At present, the communication sector is undergoing considerable changes: standards and technologies are changing, new services are emerging ever more frequently, and the need to meet growing demand for new services is stimulating more rapid development by operators. The technologies most in demand include passive optical network technologies (FTTx, GPON), xDSL-technologies (VDSL2, ADSL+) and Ethernet technologies (local cable networks).
Kenya (Republic of)	SG1RGQ/290	**IMT and IMT Advanced technologies as facilitators of broadband services in Kenya**	Kenya has recognized the role played by IMT technologies to provide mobile services to its populace, and the ICT sector currently made up of three mobile operators continue to roll-out a mix of 2G, 3G and late last year 4G-LTE services. These services are supported by fibre optic infrastructure that have been built the public and private sector as backbone links, and last mile solutions. The ultimate aim is to provide high-speed Internet services in addition to voice services for use by the citizens and to enhance public services delivery in all spheres of life in our country.

Country/ Entity	Source Document	Title	Summary
Madagascar (Republic of) (1/2)	1/142	**Regulation for the development of broadband**	Deployment of broadband is running into difficulties in Madagascar, given the island's remoteness from equipment suppliers, the size of the territory and the time needed to build networks. These towns are separated by distances of tens or hundreds of kilometers and connecting them has always caused problems for operators. The topography of the main island is not conducive to using microwave links, hence the deployment by an operator of 8 000 km of fibre-optic cable in which the State holds a 34 per cent share. The existence and use of a major transport network might be one of the keys to its expansion.
Madagascar (Republic of) (2/2)	SG1RGQ/29	**Trends in Broadband in Madagascar**	This contribution briefly reviews the various uses of broadband in Madagascar, the different technologies used by the operators, and the difficulties encountered in deployment, as well as measures taken by the Government to promote broadband development.
Madagascar (Republic of)	1/403	**Broadband access technology in Madagascar**	Madagascar is ranked among the top 20 African countries in terms of broadband access. The Internet penetration rate (around five per cent) remains very low in Madagascar, for a number of reasons which hamper the country's Internet development.
Orange (France)	SG1RGQ/314	**Submarine cables in Africa**	Details on ACE, Africa Coast to Europe, submarine cable, in Annex 1-L related to 'country experiences'.
Rwanda (Republic of)	SG1RGQ/165	**Access to Broadband in Rwanda**	This paper describes broadband access technologies currently deployed in Rwanda to provide broadband Internet access and deliver other content and applications at much faster speeds. To boost this accessibility and ensure affordable broadband for all citizens in Rwanda, a national broadband policy was developed.

Country/ Entity	Source Document	Title	Summary
Sri Lanka (Democratic Socialist Republic of)	SG1RGQ/138	**Broadband in Sri Lanka**	Developing Sri Lanka as a knowledge hub in Asia, is a key development strategy of the Government. In Sri Lanka broadband is defined as "Technology neutral high speed data communication service with a broader bandwidth capacity not less than 1Mbps down link, which enables the operation of wide array of applications and services online.
Sri Lanka (Democratic Socialist Republic of)	SG1RGQ/288	**National Broadband Policy of Sri Lanka**	A National Broadband Policy is intended to provide an overarching framework to harmonize and align the Government's efforts to drive the introduction of broadband infrastructure and to identify new initiatives that will help improve the availability, affordability and relevance of broadband services. The Policy reflects the Government's ambition to build sound policy foundations for the long-term development of the broadband sector as a key part of the infrastructural support for Sri Lanka's economy and society.
Viet Nam (Socialist Republic of)	SG1RGQ/257	**Broadband strategy of Viet Nam**	The creation of information society on the basis of broadband infrastructure is a key to success and helps developing countries (including Vietnam) access to the knowledge economy soon. From the above objectives, the Government of Vietnam has carried out the national broadband strategy with specific targets and action plans.
Zimbabwe	SG1RGQ/230	**Infrastructure sharing**	An inclusive consultative process has resulted in cooperation which has seen the country come up with a well-accepted regulatory framework for sharing infrastructure to reduce costly duplication of facilities, thereby reducing the cost of services and increasing access to Telecommunication/ICT services.
Orange (France)	SG1RGQ/314	**Submarine cables in Africa**	Details on ACE, Africa Coast to Europe, submarine cable, in Annex 1-L related to 'country experiences'.

Afghanistan – Open Access Policy and Competitive Provisioning for Afghanistan's fibre optic and broadband sectors Afghanistan's fibre optic and broadband sectors

1. Overview

Modern telecommunications have connected Afghans to a degree never before seen in the country's history, creating unity and economic prosperity. Since their respective formations, the Ministry of Communication and Information Technology (MCIT) and Afghanistan Telecom Regulatory Authority (ATRA) have faithfully administered the telecommunications sector through well-crafted free market policies, laws, regulations and procedures to the great benefit of the Afghan population. Support from the Government of Afghanistan for robust private sector competition in the telecommunications industry serves as a key driver for nearly universal access to mobile communications. However, a new threshold has been reached.[110]

To ensure future growth in the Information and Communications Technology (ICT) sector a new policy is needed to facilitate sustainable development through a private-sector-led fibre optic and broadband market. In accordance with Articles 10, 11, and 37 of the Constitution of Afghanistan and with the direction of the High Economic Council, MCIT formulated this policy of Open Access and Competitive Provisioning for Afghanistan's Fibre Optic and Broadband Sectors, to attract private investment and, in turn, promote a robust communications marketplace, free of monopolies, which provides affordability, ubiquity, and growth in other economic sectors. Through this policy, MCIT and ATRA seek to formulate further policies, statutes, regulations and procedures promoting these goals and build upon the impressive achievements in this sector of the last decade.

This policy of Open Access and Competitive Provisioning is the guiding principal for the legal framework governing ICT Providers' access to basic passive and basic active infrastructure and governs all government policies and actions relating to authorizing existing and future ICT Providers to build, locate, own, and operate physical infrastructure, including international gateways and Internet Exchange Points (IXPs). This policy ensures transparent, non-discriminatory access to network infrastructure to allow effective competition at the wholesale and retail level, ensuring the provision of competitive and affordable service to end users. This policy is to be animated by government actions that treat all parties under consistent and equal terms, that are executed according to established timeframes and that afford due process.

The policy of Open Access and Competitive Provisioning is the legal framework for operators/service providers to access fiber optic and broadband infrastructure for a fair price, as well as providing the right for private businesses to build, own, and operate active and passive infrastructure. This policy further authorizes the Afghan government, in particular MCIT, or its successor as the ministry responsible for telecommunications, and ATRA, or its successor as the telecommunications regulator, to establish and implement necessary regulations for attainment of goals of this policy.

2. The need for Open Access and competitive provisioning

Despite robust growth for more than a decade, the information and communication technology sector has plateaued, in terms of revenues, connectivity, and technological advancement. Current infrastructure is not able to handle the increased data traffic requirements of wireless 3G, 4G, and fixed broadband technology users, which has grown to nearly 10 per cent penetration and make up approximately 15 per cent of industry revenue. As a result, the international trend of transition from voice to data has been slow in Afghanistan and broadband access is still not widespread. To meet the growing needs of the population, facilitate the Government of Afghanistan's commitment to connect 15 million Afghans to the internet by 2020, and to facilitate Afghanistan's long-term goal of serving as a major data transit route from South to Central Asia and beyond, significant private investment is needed to develop a world class fiber optic backbone.

[110] Document SG1RGQ/300, "Open Access Policy and Competitive Provisioning for Afghanistan's fibre optic and broadband sectors", Afghanistan.

In addition to investment, the sector needs capable and accountable services providers. International experience has shown that, when properly regulated, private sector owned and operated networks provide better secure service, to larger segments of the population, at a better price than state enterprises. Further, with appropriate oversight, private operators provide industry leading Cybersecurity and protection of national network security. The Open Access and Competitive Provisioning Policy provides clear guidance and government approval for private sector investment and participation in the fibre optic and broadband internet sectors.

3. Objectives of the Open Access and competitive provisioning policy

It is an obligation of the ministry responsible for telecommunications and the telecommunications regulator to create and maintain a level playing field for all investors, providers of ICT services, and other operators and a market free of cartels and monopolies. The objectives of this policy are:

- Facilitate investment and growth in the ICT sector;
- Encourage provision of broadband services to underserved areas;
- Provide for free and fair competition in the fibre optic and broadband markets;
- Provide Open Access to basic active and basic passive infrastructures in a transparent manner and without discrimination;
- Enable private companies, public entities, or partnerships between the two to build, own, and operate fibre optic and broadband infrastructure;
- Enable new entrants into the market;
- Open international gateways and Internet Exchange Points (IXPs) to private competition, price negotiation, and operation by private and public sector actors;
- Create an ICT sector free of monopolies and cartels; and
- Provide affordable and reliable broadband access to the entire Afghan population.

4. Principles of Open Access and competitive provisioning

This policy establishes the guiding principles for the legal framework relating to authorizing existing and future ICT Providers to build, locate and operate physical infrastructure. For purposes of this policy, ICT Providers are defined as private, public, or partnered entities that are primarily engaged in producing information and communications goods or services, or supplying technologies used to process, transmit or receive information and communications services and that require access to passive and active infrastructure. For further purposes of this policy, retail markets are defined as markets where sales are being made to end users, and wholesale markets are defined as markets where customers are businesses who source inputs that will be used to sell to other businesses or, ultimately, to end users.

This policy shall govern all government actions related to passive and active communications infrastructure. This policy is animated by government actions that (i) treat all parties under consistent and equal terms, (ii) are executed according to established time frames, and (iii) afford due process to all ICT Providers, users, and stakeholders.

In view of established best practices internationally, the following constitute the fundamental principles of this policy document:

- Treat all ICT Providers and would be ICT Providers of retail communications (telephone and Internet) services on an equal and fair basis through access to basic passive and active infrastructure;
- Encourage sharing of basic infrastructure, but not obligate telecommunication companies to share their own basic infrastructures unless their existing capacities exceed their requirements as reported by the providers;

– Expedite decisions pertaining to licensing, authorizing, reviews and redress by establishing open, clearly defined processes and decision making mechanisms and affording due process at every stage, including redress;

– Afford non-discriminatory access to basic infrastructure to all ICT Providers regardless of ownership status;

– Ensure all carriers must be offered the same effective rate and same effective date (non-discrimination);

– Encourage market-based, commercial arrangements between Afghan and foreign carriers for the exchange of traffic;

– Create regulations and processes only through procedures that provide preliminary and adequate notice of adoption timeframe, actual draft language and an opportunity for public comment prior to adoption in an open hearing forum;

– Implement cost-oriented pricing for access to passive infrastructure and facilitate market-based pricing for access to active infrastructure;

– Permit current and future licensed ICT Providers, including the Mobile Network Operators (MNOs) – whether individually or as part of a consortium – to build their own fibre optic infrastructure which, for the avoidance of doubt, shall be subject to the same Open Access and Competitive Provisioning terms set forth herein;

– Facilitate the construction or installation of ICT infrastructure, such as fibre optic networks, by ICT Providers; such ICT Providers shall be eligible to enter into contracts and obtain any and all authorizations from any other private sector entities such as, but not limited to, landowners, builders, engineers and consultants and to obtain such government permits relating to land use or environmental impact without obtaining additional authorization from the ministry responsible for telecommunications, the telecommunications regulator, or any other government authorities; provided however, such ICT providers shall be obligated to report to the telecom regulator their initial plans (and thereafter upon material alternation) regarding location, capacity and basic operation information;

– Consideration will be given to appropriate separation of wholesale and retail offerings and offering of dark fibre capacity whether through accounting, operational or management arrangements in order to facilitate policing of potential cross-subsidization and other anti-competitive practices.

– The Afghan government, including the ministry responsible for telecommunications and the telecommunications regulator, shall assist ICT Providers seeking to construct communications infrastructure with obtaining Rights of Way to facilitate deployment of such infrastructure (including fibre optic) build-out in the same manner that it facilitates such Rights of Way for Afghan Telecom. The telecommunications regulator will issue details of Service License Agreements and cost information to departments engaged in Right of Way approval with due consideration of information obtained during the course of public consultations;

– To improve network redundancies by facilitating aforementioned Open Access rights to dark fibre provided in the communications networks that support electricity transmission and distribution infrastructure, including but not limited to, that owned by Da Afghanistan Breshna Shurkot;

– The Telecom Development Fund (TDF), or a similar universal services fund, shall be utilized in order to encourage infrastructure development across the country, including, but not limited to, rural and underserved areas.

– Given the increasing need for radio frequency spectrum for advanced services to support broadband access, the telecommunications regulator will ensure proper spectrum availability for operators to meet capacity requirements, with due consideration of information obtained during the course of public negotiations.

5. Implementation rules and method

This Policy on Open Access and Competitive Provisioning took effect on August 28th, 2016 when it was approved by the High Economic Council and the President of Afghanistan. This approved Policy encourages the owners of communications infrastructures to share their resources in order to ensure large and small communications operators/service providers have an equal access to these infrastructures, operate in a free and fair competitive market, and provide better and affordable services to the users with minimum capital.

This Policy enables private companies, public companies, and public private partnerships to be certified or licensed by the telecommunications regulator to build, own, and operate fibre optic and broadband internet infrastructure, as well as international gateways and IXPs. As well, this Policy encourages due consideration for liberalization of "next generation technologies" as they become available to the market. Finally, this policy necessitates that the fibre optic and broadband sectors be free of any monopolies, either private or public. To ensure that the aforementioned objectives and principles of this policy are followed, the following rules and methods further govern Open Access and Competitive Provisioning:

– **Non-discrimination**

Owners of communications infrastructures, whether government or privately owned and whether occupying a dominant market position or otherwise, shall not prefer one operator to another in distributing or providing access to these resources in the market.

Specifically, provision of access to infrastructure and services shall not be denied on the basis of factors such as ownership of the applicant of the infrastructure or services, volume or quantity of the services in question, technology used by the services applicant and/or actual or potential market power of the applicant. Variation that would result in increased cost for the service provider shall be addressed consistent with pricing policy determined by the telecommunications regulator. Such variations shall not be the cause for the rejection of a fair request for access services.

MNOs, as fibre-optic operators, shall be required to provide access to any requesting communications operator and shall be subject to relevant interconnection obligations (e.g. on a fair, cost-oriented and non-discriminatory basis, making access charges and terms and conditions publicly available). Finally, no capable and properly vetted service provider will be prevented from investing in, owning, or operating fibre optic infrastructure in Afghanistan, provided that each company can demonstrate their ability to provide the services proposed and has obtained appropriate authorization or license as may be required by the telecommunications regulator.

– **Transparency**

This refers to the principle that the owners of communications infrastructure (government-owned or private) shall operate by providing full, consistent and open disclosure to the services applicants and strive to employ usable and easily understood information. If not publicly available, sufficient information about the terms of any open access arrangement must be made available to any interested parties, so that any access seeker may be aware of access terms and conditions. Transparency may be implemented by means of a reference offer or by another mechanism that provides enough information to requesting parties as determined by the telecommunications regulator.

– **Pricing**

Prices for the provision of the communications infrastructures shall be fixed by the owners of such infrastructures as may be prescribed or directed by the telecommunications regulator, consistent with internationally accepted principles, with due consideration of information obtained during the course of public consultations. Pricing for access to passive infrastructure should be cost-oriented and pricing for access to active infrastructure should be market-based.

In view of the ICT market in Afghanistan, application of the principle of market-based pricing shall be consistent with international best practices to the largest extent possible given the operating environment in Afghanistan.

Pursuant to the Policy on Open Access and Competitive Provisioning, the price charged for services offered by the government organizations, owners of communications infrastructures, and/or the operator or operators determined to have significant or dominant power in the market shall be determined on the basis of costs the services provider incurred in rendering such access services, not in proportion to the prevailing market prices. To this end, the telecommunications regulator shall specify how to price services, but not prescribe prices, and shall prevent uneconomic, anti-competitive pricing of the services by communications providers in the market as determined appropriate through introducing relevant procedures and regulations.

– **Exchange traffic and international gateways**

The exchange of traffic between different networks is fundamental for ensuring communication between users of different networks. Where such traffic is classified as being provided over Internet Protocol (IP), Internet Exchange Points (IXPs) (where ISPs exchange Internet traffic among their networks) can play a critical role in providing more efficient and cost-effective exchange of traffic within a national market as opposed to transiting such traffic through third-party facilities located in foreign jurisdictions where such traffic is to be delivered back to the national market. This policy allows private companies, government entities, and non-profit entities to operate IXPs in order to minimize local IP traffic being exchanged outside Afghanistan and returned, thereby reducing costs to consumers and improving network performance.

ICT Providers shall be eligible to enter into contracts with international private or government entities to interconnect facilities, exchange traffic, or any other commercial agreement relating to terrestrial fibre, microwave, or satellite facilities. Such exchange and transit agreements will allow Afghanistan to leverage its geographic location to serve as a transit point to connect backhaul and backbone networks to undersea and wholesale networks located in other national jurisdictions. Such exchanges and transit facilities shall be permitted and appropriately certified or licensed, with access subject to reasonable tariff structures to be determined by the telecommunications regulator, with due consideration given to information obtained during the course of public consultations

– **Reasonableness and right of refusal**

As the provision of infrastructures under private sector or government control cannot be unlimited, this policy shall not require ICT Providers to develop communications infrastructures but will permit such operators to obtain use of communications infrastructure through access services. However, access must be fair and reasonable in that fair and reasonable requests for access should be granted without discrimination and in due course. Available infrastructure shall be shared with the market subscribers/applicants on a first-come-first-serve basis. Rejection of an application for access shall only be possible under the following circumstances:

- The applicant requests services with technical specifications beyond the technical capability of the service provider and negotiations to resolve this problem do not produce the desired results; or
- If the requested communication infrastructures have already been distributed and the service provider does not have additional capacity.

Access that would result in increased cost for the underlying infrastructure provider shall be addressed in the pricing terms and conditions approved by the telecommunications regulator.

If ICT infrastructure operators reject an application for access under terms and conditions established by regulation, the applicant may appeal to the telecommunications regulator for review and shall be entitled to an open hearing by the telecommunications regulator; resolution of the dispute shall be communicated via a written and publicly available decision. Further, redress of disputes over Open Access, including status of available capacity, shall be resolved through public hearings and written, publicly available decisions.

People's Republic of China – Rural broadband

1) Overview

Sichuan is a remote south-western Chinese province with more than 40,000 villages and minority regions. In Pugh county, "the last nationwide telephone county" in history, the residents have since 2015 enjoyed 100Mb fiber-optic broadband. This change has been enabled through Sichuan's "Rural Broadband" mode.[111]

This mode uses the government guide, private capital cooperation, planning guide, technical and management innovation, IPTV as the "Internet +"entry and other innovative approaches. It has realized the revolutionary changes in rural broadband network. Sichuan is now gradually eliminating the digital gap between urban and rural areas and creating a "new era of rural optical network":

"20M started, 100Mb popularized, 1000M leaded" becomes the fact. More than 3,100 townships and 25,000 villages are realized all-optical access, and optical users are over 7 million. Sichuan is expected to become the first Chinese "all-optical province".

What are the typical significance of the mode and the promotion value?

2) Rural broadband faces many challenges

– Rural all-optical access is a great construction

From a global look, the optical network strategy of Sichuan is in the right trend of technological innovation. But both in Sichuan and the country, all-optical access is a large social progress, involving wide range and difficulty.

– Rural broadband faces larger investment and lower income, a company is weak

Rural telecommunication is generally poor, and the investment cost is much higher than in the city. According to the statistics, rural user's cost is four times of the city, but the user's ARPU value is far below the city. The costs can be recovered in 2 years in urban areas, but more than 10 years in villages. Totally, the rural broadband in Sichuan will cost about 30 billion yuan. Such a large investment is an impossible task fora company.

– Rural broadband is lack of sustainable business applications

Rural broadband network can't only be built. The business applications become a major problem, otherwise it will result in irrecoverable investment and social waste of resources.

3) "Rural Broadband" mode's exploration and practice

– Planning guide, zoning, in batches for construction

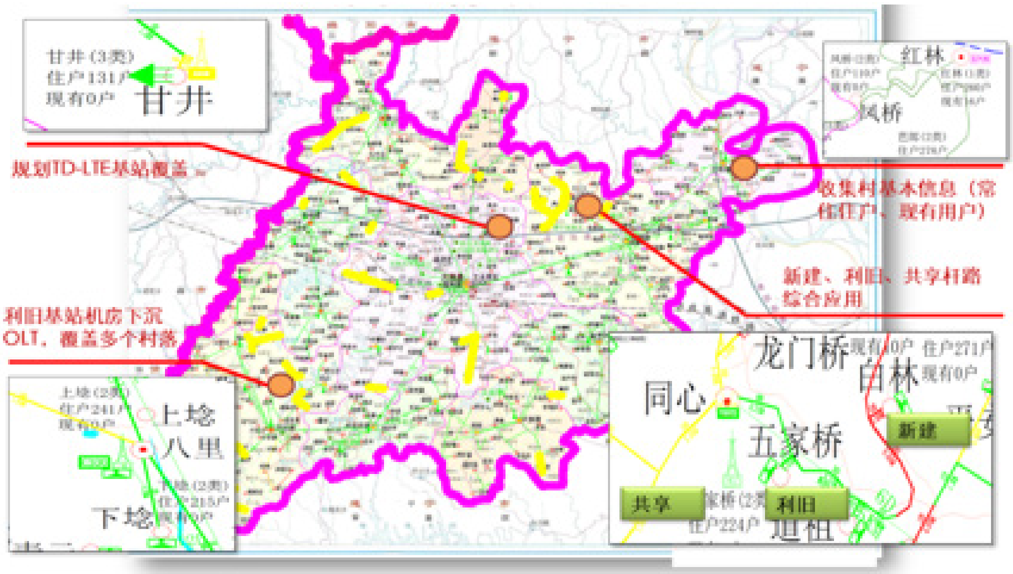
Sichuan bold decided to build the all-optical rural broadband and break through the bandwidth bottleneck fundamentally. In order to avoid blind construction and reduce investment pressure, Sichuan Telecom and Sichuan Design have the idea of planning guide, zoning and in batches for construction. They found the "rural broadband county-wide full view of planning" method.

The method uses a full view of the plan. First, a comprehensive graph is made to show the network resources and market information of the whole county in rural areas. The graph includes pole resources, shared resources, base station resources, existed broadband access, households, market demand etc. Second, it combines FTTH and LTE technology, wired and wireless resources, uses the whole network thinking, and takes the initiative to cross regional network. Third, it innovatively divides the whole county villages into class 1, class 2 and class 3, according to the market demand and

[111] Document 1/206, "'Rural Broadband' innovation mode, creating a new era of optical network in rural areas", People's Republic of China.

investment returns. Each class is individually identified in the graph, and is taken a different strategy of investment and construction. Thus, the plan has a good targeted.

Figure 1A: County-wide full view of planning example



By planning guide, the "Rural Broadband" is more purposeful, targeted and controllable. Through meticulous management, they partially avoid the risk of rural development and improve the scale and sustainability of construction.

– Improve the accuracy of construction, reduce investment risk, and achieve investment returns

Communication is a typical scale industry. Enlarging the network coverage and user scale, increasing revenue and reducing the marginal costs are the core of the rural broadband.

Sichuan Telecom set up a rural broadband investment and income calculation method. They establish the model of the optical port, port cost, port usage and revenue; calculate the balance between different scenarios and business revenue. The model is publicized to the frontline staff, so that the needs of rural construction can be accurately analyzed. Meanwhile, based on the principle of first marketing, locking prospective users can achieve relevance and accuracy of construction, improve investment returns and reduce investment risk.

– Government guide & private capital cooperation achieve a win-win situation

Faced 40,000 villages, capital is the biggest problem. Sichuan Telecom seizes the opportunity to become the Chinese pilot provinces, and get hundreds of million yuan of funds. They also get the local governments support. At the same time, with the national private capital opening policy, Sichuan Telecom actively attracts social capital investment. One year, they have gotten hundreds of million yuan on public funding, and thousands of villages on the investment. Through cooperation with Sichuan Changhong and Jinzhou Company, they had promoted the development of local industry chain.

– Technological innovation and management innovation

First, "Rural Broadband" has adopted a series of building strategy, technology materials and design innovation.

Second, they optimized engineering organization and management innovation. Joint work and a whole undertake service, achieved the efficiency of the project. Sichuan Telecom, Sichuan Comservice, Sichuan Design and Sichuan Supervision set up the “Rural Broadband Promotion Office” to form a unified work of the Quartet. The special office can instantly find and solve various problems in engineering, and enhance the overall management efficiency.

– Take the IPTV as the Internet+ entrance

Sichuan Telecom, broadcasting, Internet companies and intelligent industries build development alliance. Based on fiber-optic network and IPTV, they integrate a variety of information technology applications and create a multi-party cooperation and benefit mode. The 4K television has covered the remote areas to enrich the cultural life of farmers and herdsmen.

Figure 2A: Rural broadband countryside application field

在扎西泽仁民居体验IPTV　　登巴客栈100M光网IPTV

Meanwhile, IPTV has achieved Internet + livelihood, + education, + tourism, + industry (special agricultural products), etc. IPTV is now using some most familiar and acceptable methods, combining application, quietly promoting development of information technology in rural areas. IPTV has been an efficient entry close to the user for "Internet +”.

4) “Rural Broadband” mode as reference

– Urban-Rural, all-optical networks can bridge the digital gap

Face historic choice, building all-optical networks in Sichuan rural areas, will break the bandwidth bottleneck fundamentally. Sichuan, located in the southwest of China, is a representative province. For the Chinese broadband strategy, experiences and achievements in Sichuan have considerable reference value.

Broadband is a social progress. Both in the east and west, in the urban and rural areas, there is a huge difference in the broadband market and development, but technical direction should be consistent. The sample of Sichuan is very prospective and meaningful.

– With planning guide and technical innovation, scale benefit can be achieved

Rural construction could ensure max investment returns in correct ways. In Sichuan “Rural Broadband”, the pre-marketing experience, earnings estimates, the county-wide view of planning, technical and management innovation, are all good ways.

- Governments and enterprises are both essential.
- Combine government’s support and private capital cooperation, we can develop and promote rural areas in common.
- Promoting “Rural Broadband” universal service needs the fund.

In fact, it is true that eliminating digital gap eventually need to establish a standard, state-supported universal service fund. For many countries, the popularity of broadband development needs the country's fund.

– Rural "Internet +", IPTV is the entry

IPTV in Sichuan has been provided a good example of the urban and rural integration "Internet +". IPTV is the intelligent entrance to "Internet +".It can both give people benefits and promote sustainable innovation and development of information industry chain.

5) Issue summaries

"Rural Broadband" innovative mode, using the planning guide, technological innovation and zoning development, deal with the high costs and slow-developed user problems; using government support and business cooperation, ease the major problem in rural optical network investment; using IPTV as a wise gateways solve rural application problems. These innovations partly solve the problem of the broadband and create "a new era of optical network" in rural areas. They get a good harmony of enterprises, users and society. "Rural Broadband" mode is a real example in rural and remote areas worthy of promotion.

Côte d'Ivoire – Guidelines on passive infrastructure sharing

In order to promote the deployment of telecommunication networks, regulatory authorities are generally required to encourage sharing of passive and active infrastructure among operators of public telecommunication/ICT networks. To ensure effective follow-up of infrastructure sharing by the regulatory authorities, common guidelines need to be elaborated in order to define the key principles that can be adapted in all countries.[112]

The guidelines in question should focus on the following key areas:

– Regulation of passive and active infrastructure sharing;

– Infrastructure sharing regimes to be applied in the case of operators with significant market power and those without significant market power;

– Criteria for identifying the passive and active infrastructure subject to sharing, depending on the market;

– Definition of a tariff framework methodology for each type of passive and active infrastructure;

– Introduction of a requirement to declare passive and active infrastructure assets of each type;

– Definition of Quality of Service requirements for the different types of infrastructure;

– Definition of the general principles that need to be included in infrastructure sharing agreements.

Egypt (1/2) – The national broadband plan "eMisr": Transition from planning to execution

1) Introduction

"eMisr" is a national Broadband plan that aims at the diffusion of Broadband services in Egypt. "eMisr" is a two staged plan, the first stage ending by 2018, and the second stage ending by 2020, The key strategic objectives of the Broadband plan aim to develop ubiquitous top notch telecom infrastructure, creating direct/indirect job opportunities, increasing productivity of governmental entities through up to date ICT platforms, using innovative ICT applications to augment the citizen's life by leveraging the broadband networks.[113]

[112] Document 1/163, "Elaboration of guidelines on passive infrastructure sharing", Republic of Côte d'Ivoire.

[113] Document SG1RGQ/63, "The national broadband plan "eMisr": Transition from planning to execution", Arab Republic of Egypt.

"eMisr" is a plan that proposes different strategic directives to meet Egypt's broadband service needs. "eMisr" aims to extend broadband services in all over Egypt including underserved areas.

By 2018 it is envisaged to increase households fixed broadband coverage to 80 per cent and increase fixed broadband penetration to ~40 per cent of the households. Moreover it is targeted to reach 85% population mobile coverage through 4G and a population penetration of 25 per cent for mobile broadband services, last but not least connecting 50 per cent of Egyptian communities (Governmental entities like schools, hospitals, youth clubs, etc.) to high speed (50 Mbps) broadband connections. Broadband diffusion will be accomplished through fostering supply (Networks) and demand sides (Services) through a mixture of regulatory and investment packages.

2) Adoption of an appropriate regulatory framework

To achieve these objectives, the national broadband initiative will focus on fostering both supply and demand sides. Supply side shall be encouraged through the focus on the rollout of up-to-date broadband networks; Regulatory intervention will be the catalyst for speeding up the networks rollout. This regulatory intervention will be in the form of implementing a unified license regime allowing the four incumbent operators to provide all telecommunications services to users (Fixed/mobile/data), the issuance of a second infrastructure operator license allowing the licensee to build and operate infrastructure in Egypt, and awarding 4G spectrum and licenses.

Another catalyst for both supply and demand is direct governmental contribution by implementing a series of government funded projects to connect governmental sectors like education, health, justice, etc. with high speed broadband access and taking the necessary measures to ensure service usage and sustainability.

The final pillar is a demand stimulation through promoting e-content, e-commerce and the use of ICT to develop a digital economy and society, transparent government and efficient public administration

3) Programs and projects

a) Developing the required infrastructure

- Introducing the unified licensing regime which entails allowing the four incumbent operators to provide all telecommunications services to users (fixed/mobile/data).
- The issuance of a second license allowing the licensee to build and operate infrastructure in Egypt including optical fiber cables and the right to lease it to other licensees.
- Planning to allow 4G spectrum and awarding the relevant licenses by end of 2016.

b) Governmental

- Implementing a series of government funded projects to connect communities like (Schools, hospitals, universities, other governmental entities) with high speed broadband access and taking the necessary measures to ensure service usage and sustainability.
- The first project was launched in February 2014. The project addresses the social targets and aim to enhance the development of infrastructure in Egypt. Project aims also to provide broadband connections to governmental entities across Egypt in order to achieve high quality of services provided to the Egyptian citizen.
- The project leverages infrastructure for 1604 institutions affiliated to nine ministries and government bodies with download speed 20 Mbps, including ministries of education, health, youth, scientific research, etc.

c) Demand stimulation

- Opening channels with beneficiary sectors to explore their ICT plans for digital inclusion, relevant applications like (e-Gov, e-Education, e-Health, etc.) will run over the broadband

and hence stimulating demand on the government side and improving efficiency of public services.

Egypt (2/2) – Next generation access for broadband

1. Introduction

Today, the use of the Internet has become global trend, and access to the Internet at increasingly higher connection speeds which is widely known as Next Generation Access (NGA) which will be a key for smart, sustainable and inclusive development.[114]

Therefore, the National Telecom Regulatory in Egypt (NTRA) sets out an ambitious plan for increasing the availability of Internet provision in Egypt under its National broadband plan ("eMisr"), a program with ambitious roll-out targets that include improving download speeds is in process so that 80 per cent of Egyptian citizens will have Internet access at (4 Mbps-25 Mbps) by the year 2018, Moreover it is targeted to reach 85 per cent of the population mobile coverage through 4G , and connecting 50 per cent of Egyptian communities (Governmental entities like Schools, hospitals, youth clubs, etc.) to high speed Broadband connections (50 Mbps) or more.

2. Challenges with the deployment of NGA

Meeting the NGA targets will be very challenging. The availability of fiber based connections for the Internet have been significantly lower in developing countries in general compared to the developed countries. Most of developing countries remains dependent on current DSL ("digital subscriber line") broadband connections based on the existing copper network infrastructure. In order to achieve the very high access speeds that are envisaged under national broadband plan, it will be necessary to develop high-speed networks and achieving this requires overcoming the following challenges:

- **The need for next generation regulations**

The NGA objectives inserted in the national broadband plan are ambitious ones. In the past, attempts to stimulate greater provision through changes in regulation, for example local loop unbundling in conjunction with introduction of mobile data services, have been only partly successful in extending broadband access nationwide.

Despite a number of wide ranging successful initiatives, Egypt is experiencing increasing disparities of access to the Internet and has consistently lagged behind leaders in connectivity compared with different countries in term of speed.

On the other hand, whenever public sector funds such as universal service funds are used to subsidize private firms to invest in underdeveloped areas, there is the possibility that this infringes on existing regulations. Governmental aid is generally undesirable since it creates market distortions.

However, there are may be particular situations where subsidies may be considered acceptable. In particular, providing public grants can be considered acceptable if it will enable rapid development in underserved regions.

- **Competition between different access technologies**

Changes in the underlying telecommunication technologies present both opportunities as well as further challenges. The explosion in mobile data over the past decade years is opening up a range of new options using 4G technologies such LTE ("Long Term Evolution"). These have the potential to deliver speeds up to 100 mbits/s and sometimes even more. They could in principle be used in combination to deliver the most cost effective solution, avoiding the prohibitive costs associated with universal FTTH/FTTP fixed access technology. This also compares favorably with xDSL technology which is limited to line speeds. Nevertheless, these advanced technologies also require substantial investments simply to make them available in the densely populated urban areas.

[114] Document SG1RGQ/75, "Next generation access for broadband", Arab Republic of Egypt.

This creates the risk that the resources that will be required may not be distributed fairly between different citizens.

- **Investment model**

Meeting the NGA objective will require private investment combined with public support, appropriate investment models should be used to ensure that public funds are distributed as fairly as possible and only used where the private sector is unable to provide a solution, In addition, to delivering effective governance to ensure that national objectives are met.

There are a range of investment models for NGA networks, all of which are available to the public sector for funding network deployment to meet the objectives (DPO, PPP, etc.). These models represent a range of options for combining public and private investment, and offer differing levels of involvement, commitment and retained risk by the public sector. Each model is applicable in different circumstances, depending on the scope of the required infrastructure, the specific aims of the public sector, and the investment/risk desire of potential private sector partners.

3. Main considerations

For choosing the right invest model to build a NGA network, it is recommended to take the following issues into consideration:

– **Scalability**

It is becoming more and more apparent that it is not financially viable to implement fiber to the premises ("FTTP") solutions across all areas. It is unrealistic to implement FTTP across the whole target area as its costs are economically excessive. Instead there is a focus on providing a significantly faster service than is currently available. While this is not ideal, it will still provide benefit within the constraints of the economic situation.

New technological alternatives offered by 4G may overcome some of the current financial obstacles. As the demand for access to data services continues to increase exponentially, any step increase in download speeds in rural and remote regions could be accommodated, even where it still compares poorly with what is available in urban areas.

– **Sustainability**

From a sustainability perspective, it is positive to see that some licensed national operators are participating in the implementation. This is particularly the case if they are involved in providing wholesale services that are an extension of the services they offer in other areas of the country. This helps to ensure that customers have access to a wide range of products and services fairly, and gives them access to the best deals in the national level.

– **Open access**

The NGA network must be open and flexible to enable innovation by service providers at price levels that are competitive and fair, and that will encourage potential competing providers to become wholesale customers of the NGA network rather than setting up a separate network. NGA provider can be a pure wholesale access provider to ensure that conflicts of interest are avoided.

The threat from the copper network can be mitigated by incorporating the existing copper infrastructure as part of the scope. There are complications, the need to ensure that regulatory conditions supporting existing services are met, and it requires the participation of the incumbent network operator.

– **A long term view**

NGA network can be particularly attractive to those investors looking for a cautious but relatively secure annual return over a long period from a business with a steady cash flow.

In order to attract the level of investment required to meet objectives, it will be necessary to supplement public investment with significant private sector investment.

In order to attract investment from organizations looking for such return profiles, it is vital to minimize the risk by carefully designing the terms of the partnership agreement.

4. Conclusions

- Less populated and remoter areas of the country, where the investment is unviable, should not have to face a digital divide.
- Partnership between the public and private sectors is necessary, given the costs involved in implementing future prove NGA network for broadband.
- Innovative regulatory models will be a necessity if the ambitious NGA targets are to be realized.
- It is positive to see that some licensed national operators are participating in the implementation plan.

Guinea – National policy and development of ICT infrastructure in Guinea

After a period of transition which ended in December 2010, the new authorities in Guinea inherited a telecommunication/ICT sector which presented special challenges.[115]

The prevailing situation at that time was characterized by:

- A juridical and regulatory framework favourable to competition but not sufficiently geared to the actual conditions in the sector.
- A Posts and Telecommunications Regulatory Authority (ARPT) in the process of being developed.
- A Pan-African Online Services Network (eHealth, e-Education, e-Diplomacy) under development.
- A telecommunication company, the Société des Télécommunications de Guinée (SOTELGUI), in difficulties.
- A postal authority, the Office de la Poste Guinéene (OPG), with largely run-down facilities unable to provide an effective postal service.
- A National Policy and Strategy Document for the Development of Information and Communication Technologies (DPSNTIC), including a plan of action which envisages major structural projects requiring funding of almost USD 500 million.
- Poor national telephone and Internet coverage: 4.26 million GSM users for a total population of 11 million, a penetration rate of 40.44 per cent, which was markedly lower than the regional average.
- Optical fibre, and therefore broadband, still at the theoretical stage.

Thanks to the new authorities, and with the assistance of bilateral and multilateral partners, major projects under the policy document's Action Plan have been launched, and implementing them has been a top priority for the department, given their future impact on the life of the Guinean public.

Over the period 2011-2014, the posts, telecommunications and NITs sector saw some major developments, described below.

[115] Document SG1RGQ/62, "National policy and development of ICT infrastructure in Guinea", Republic of Guinea.

Formalization and adoption of the WARCIP-Guinea/World Bank Programme

WARCIP (West African Regional Connectivity Programme) is a programme funded by the World Bank for the purpose of implementing the following projects:

– ACE submarine cable landing and construction of the terminal station;

– Capacity building for ministry and ARPT staff;

– Participation in restructuring of SOTELGUI.

The construction of the landing station was completed on schedule. Other WARCIP projects concern: (i) capacity building for ministry staff; (ii) capacity building for ARPT staff; and (iii) support for restructuring SOTELGUI.

Submarine cable landing project in Guinea

Some background information

The first submarine cable to cross the Guinean coast was laid in 1975. After Dakar, the cable laying survey had envisaged a landing at Conakry, then at Abidjan. Given the conflictual relations between Guinea and its neighbours (Senegal and Côte d'Ivoire), the cable landing at Conakry was seen more as a means of destabilizing Guinea's revolutionary regime than as a much needed means of communication and of tackling the isolation country.

The second submarine cable on the Guinean coast was the one laid in 1987. Before then, in 1986, Guinea was supposed to confirm its commitment to this investment. During the same year, the country's new authorities launched a broad programme of economic and social reforms which have affected every area of national life. With other priorities to consider, and because of a failure to perceive the importance of such a submarine cable project, Guinea missed this second opportunity.

The third submarine cable, SAT-3/WASC/SAFE, with a length of 28 000 km, connects Portugal, Spain (Canary Islands), Senegal, Côte d'Ivoire, Benin, Nigeria, Cameroon, Gabon, Angola, South Africa, France (Réunion Island), Mauritius, India and Malaysia.

As with the previous submarine cables, Guinea was included in SAT-3 which had registered its terminal landing in Malaysia. As Telekom Malaysia Berhad (TMB) was the strategic partner, expectations were high. At the launch of the project in 1997, a down payment of USD 500 000 had been paid as an advance on the subscription required by the project initiators.

Unfortunately, at the end of 1998, as a result of financial difficulties in SOTELGUI, which had paid the subscription, the latter was withdrawn and Guinea's commitment to SAT-3 was cancelled. The SAT-3/WASC/SAFE submarine cable was inaugurated in 2002, without a landing in Guinea.

ACE submarine cable landing at Conakry (Guinea)

The ACE submarine cable landing was established at Kipé (Conakry) in January 2011. Once the construction of the submarine cable landing station at Kipé (Conakry) had been completed, the cable was commissioned during the first quarter of 2013 and subsequently brought into operational use under licenses issued by the telecommunication/ICT ministry.

Since that date, the operators and IAPs have reaped clear benefits as a result of significant quality of service improvements and, for consumers, significant reductions in connection and communication costs.

The terminal station GUILAB was officially opened on 2 June 2014, by the President of the Republic, Professor Alpha Condé.

On 11 September 2014 at 07h.38, all Guinean circuits through Banjul suffered an outage. Initial investigations revealed an electrical fault in the ACE submarine cable in the Banjul segment. Traffic was restored at 01h50 on 12 September. This was the second recorded outage.

These repeated circuit outages cause prejudice and major losses to the local operators and IAPs, and to Guinean users too. This highlights the need to consider a second (redundant) submarine cable project to provide back-up in the event of an ACE cable circuit outage.

Creation and deployment of the Guinéenne de la Large Band (GUILAB)

Within the framework of the public/private partnership recommended by the World Bank, which is funding the project, the **Guinéenne de la Large Band (GUILAB)** was established to manage ACE submarine cable capacity.

GUILAB was set up under a presidential decree with the mandate to ensure operation and maintenance of the submarine cable landing station at Kipé (Conakry).

To date, the major concern has been efficiency of tariffs applied in billing submarine cable capacity to users, both current operators and new arrivals. The Ministry takes an interest in this key issue because it determines the revenue generated by monthly and annual license fees paid into the public treasury by operators.

In order to enhance government representation in GUILAB, two administrators (one from the Ministry of Finance and one from the Ministry of Posts, Telecommunications and NITs) have been appointed to its board.

Implementation of the Pan-African Online Services Network project

This comprises three tiers: **e-Education, eHealth and e-Diplomacy,** in training centres, universities, community health centres and hospitals in the capital and in the country's interior:

- **EHealth:** the eHealth site was inaugurated on 30 December 2012. Although routine on-line training is followed on the site by some doctors, it is still not used for consultations, which could lead to gradual deterioration of medical facilities. To solve this problem, partnership with other public, private and foreign medical centres is envisaged.
- **E-Education:** the launch of the e-education component on 21 June 2013 has resulted in very encouraging results for this site, which after only 17 months is now on its third distance training promotion for 120 students. Gamal University in Conakry, which has been a beneficiary of this pilot project, is in partnership with seven Indian universities which offer 27 distance learning programmes (certificate, bachelor's degree, master's degree). To date some 49 students are enrolled in ten programmes offered in Indian universities: AMITY, BIRLA PILANI, DELHI, MDRAS and IGNOU.
- **E-Diplomacy:** this component, which was initially established within the Department of Telecommunications with conclusive results, has been transferred to the Ministry of Foreign Affairs in Conakry.

Transposition of ECOWAS Acts into national legislation and preparation of a draft new law on telecommunications/ICTs

With this objective in view, a national technical transposition committee was set up at the beginning of 2011. It has operated in accordance with the ECOWAS Acts/Directives and has prepared a draft "New law on general telecommunication regulation in the Republic of Guinea".

This law takes account of current conditions in the sector, technological changes and sub-regional integration needs. The draft law clarifies the roles and responsibilities of each stakeholder (ministry, regulator, operators and consumers) in an environment subject to constant technological changes.

Following validation by ECOWAS of this procedure, the draft law was referred to the National Assembly in April 2014 for ratification.

The delay in applying this Law will obviously have a negative impact on the promotion of certain market segments and certain new products.

Modernizing equipment of mobile operators and ISPs

This involves switching from second to third generation by the end of the first decade of the 21st century and from third to fourth generation at the start of the second decade.

Outage in the SOTELGUI GSM network

This occurred on 12 September 2012, the network serving inter alia as interconnection and transmission support for local operators.

Changing the national numbering plan

In the light of the growing demand for numbering resources by mobile phone operators, the numbering plan based on eight digits had reached its capacity limits and was no longer keeping up with the rapid development of networks and services. In 2013, the ARPT launched a new nine-digit plan, which will easily meet the growing needs of operators and ISPs.

National coverage in a state of constant change

Between 2011 and 2015, the 333 main sub-prefecture centres and the Conakry special zone achieved full GSM telephony coverage. Coverage in the administrative regions and in the Conakry special zone has greatly improved over the past three years. For the prefecture and sub-prefecture centres, coverage is 100 per cent, which means that the entire population in these main towns in Guinea now enjoys the same benefits of mobile telephony.

Mobile telephony

The number of telephone users grew from 4 261 000 in 2010 to 9 201 000 in December 2014, equivalent to an average annual increase of 1 235 000 users. The penetration rate was 88.45 per cent in 2014, compared to 40.44 per cent in 2010.

Table 1A: Annual growth in number of GSM users

Annual growth in number of GSM users		
Year	**Number of users**	**Penetration rate**
2010	4 261 000	40.44%
2011	5 364 000	49.38%
2012	5 587 000	49.88%
2013	7 536 000	65.33%
2014	9 401 000	88.45%

Source: ARPT

Figure 3A: Growth in number of users

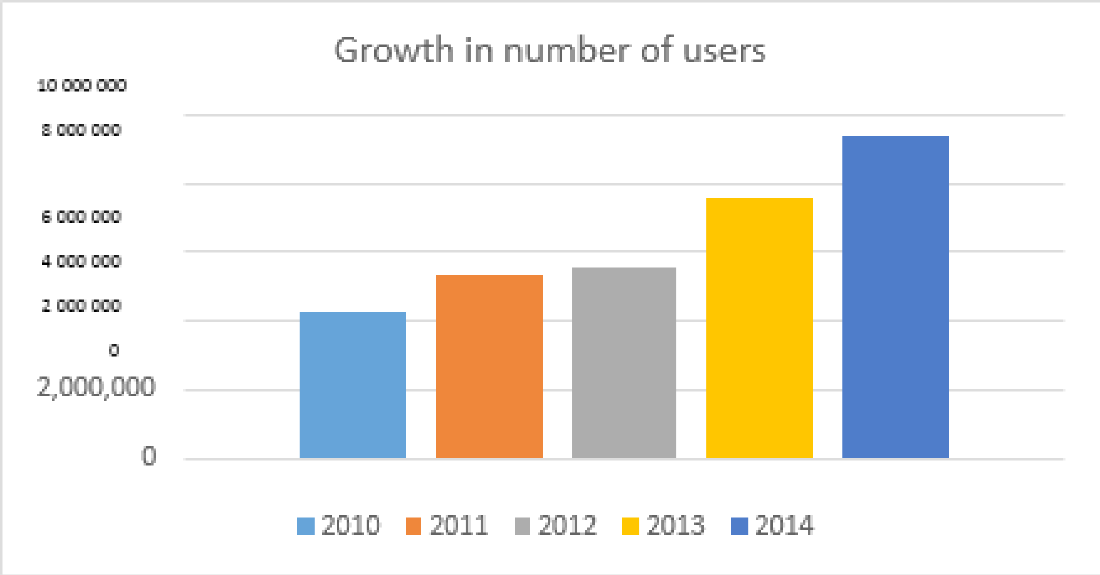
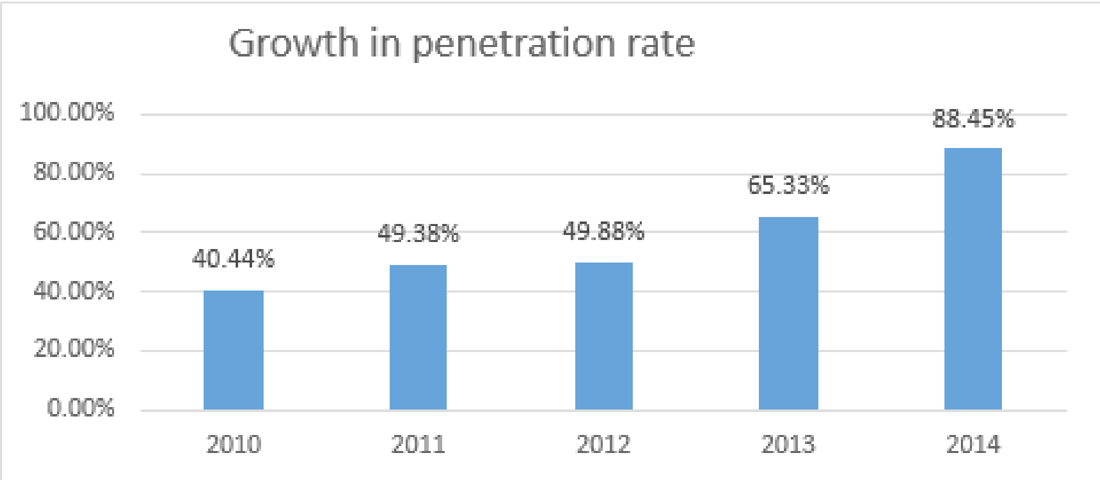


Figure 4A: Growth in penetration rate



Prepaid: 99.77 per cent; post-paid: 0.23 per cent.

Annual average growth between 2010 and 2014: 21.88 per cent.

Inauguration of work on the national fibre-optic backbone project

Funding for the 4 000 km national fibre optic backbone is to be underwritten by a loan provided by China's EXIMBANK. Following an international bidding process, a contract to construct the national backbone was concluded by Huawei Technology and the Government of Guinea for **USD 238 million**.

As the various preliminary administrative, institutional and legal arrangements were such that it was possible to implement the loan agreement and release the necessary funds, the Government on December 2014 announced its decision to go ahead with the backbone project.

Establishment of the Société de Gestion du Backbone National (SOGEB)

Decree D/2014/199/PRG/SGG of 15 September 2014 established the management company Société de Géstion du Backbone National (SOGEB), a public company owned by the State and all the other eligible shareholders.

SOGEB has financial and managerial autonomy and is placed under the overall authority of the telecommunications/ICT ministry.

Kazakhstan – Broadband access technologies, including IMT, for developing countries

At present, the communication sector is undergoing considerable changes: standards and technologies are changing, new services are emerging ever more frequently, and the need to meet growing demand for new services is stimulating more rapid development by operators.[116]

The technologies most in demand include passive optical network technologies (FTTx, GPON), xDSL-technologies (VDSL2, ADSL+) and Ethernet technologies (local cable networks).

Passive optical networks

At the present time, there is little difference, in terms of capital expenditure and labour, between the construction of copper wire and fibre-optic infrastructure. That is why it is now economically attractive for alternative operators to build new optical networks "to the subscriber", competing successfully with operators that use copper wire distribution networks.

In the light of the experience of network architecture planning, it makes sense to deploy PON networks in areas that are moderately built-up. The main advantage of a passive optical network by comparison with other access technologies is its broad coverage area combined with the highest possible transmission speeds.

GPON passive optical networks make use of potentially faster transmission protocols compared to EPON, BPON, xDSL, and the latest technologies. This enables us to build access networks with speeds of up to 2.5 Gb/s downstream and 1.25 Gb/s upstream, with guaranteed quality of service. The economic efficiency of GPON technology has been confirmed in practice through estimates based on a GPON branch allowing connectivity of one or more subscribers (depending on their requirements and the type of services required).

xDSL technologies

The main criterion for operators in modernizing networks is that there should be sufficient resources available to provide services requiring broadband subscriber access networks. For that reason, some operators are already using FTTN (Fibre-to-the-Node) technologies, reducing the length of the copper Subscriber Line (SL) by installing street cabinets or outlets within the customer's building, with subsequent use of xDSL technology. For subscribers in such cases, it makes sense to use VDSL (VDSL2) technology, cutting the SL length down to 400 or 500 meters. This makes it possible to boost the speed of the stream for the subscriber to 30-50 Mb/s.

Ethernet technology

Ethernet technology is used as an alternative to passive optical networks. However, compared to PON networks, it is not possible using this technology to transmit an analogue TV signal on a separate wavelength, and there is no centralized management of subscriber ports and devices. A fundamental drawback of this technology is the need to attribute a separate fibre to each subscriber.

Wireless broadband access technologies (LTE)

LTE technology is mobile data transmission technology which facilitates broadband access services for mobile subscribers. LTE is standardized by the 3GPP organization and is the general standard for the development of CDMA and UMTS technologies to satisfy future demand as regards data transmission speeds. The LTE-Advanced standard, comprising Release 10 and subsequent LTE releases, has been approved by ITU as the wireless network standard that meets all requirements for 4G wireless

[116] Document SG1RGQ/152, Republic of Kazakhstan.

communications and is included in the IMT-Advanced list. All current deployments of LTE networks are based on Releases 8 and 9.

LTE technology, according to 3GPP Release 8, allows:

– Up to 200 active users per cell using 5 MHz of bandwidth;
– A base station range of up to 5 km (30-100 km with sufficient antenna elevation);
– Handover support with GSM, UMTS and CDMA access subsystems.

The LTE standard uses OFDMA technology in terms of physical hardware for data transmission, and at the network level uses the IP Protocol. Introducing LTE makes it possible to develop high-speed cellular communication networks optimized for data packet switching at speeds of up to 326 Mb/s. in the downstream channel (base station to user) and up to 72 Mb/s in the upstream channel. The LTE base station range can vary. In the best cases, it will be about 5 km, although it can if necessary be 30-100 km (given sufficient antenna elevation). LTE can be used with a range of bandwidths, from 1.4 to 20 MHz, and different channel division technologies for the downstream and upstream: FDD (frequency division duplex) and TDD (time division duplex).

According to the recommendations of Kazakhstan's Interagency Commission on Radio Frequencies (ICRF) of 7 December 2015, cellular communication operators (Kcell, Kar-Tel, MTS and Altel) are able to use frequencies allotted to them under the GSM, DCS-1800 (GSM-1800), and UMTS/WCDMA (3G) standards, for the purpose of organizing LTE (4G) and LTE Advanced cellular communications, that is, applying the principle of technological neutrality.

In addition, the ICRF adopted a decision to distribute 10 MHz of uplink/downlink bandwidth among the current cellular communication operators for a one-off payment and without competition, as a result of the limited number of cellular communication operators.

This principle has been introduced in many countries and is now of particular relevance, given the convergence of services and the increasing interchangeability of various technologies.

People in all regions will gain access to modern communication services, and the technological backwardness of rural population centres will be considerably reduced.

Access to cloud computing: challenges and opportunities for developing countries

The cloud computing model is intended to ensure convenient network access on demand to a shared set of configurable ICT resources (networks, servers, storage, applications and services) that can be made available rapidly, with minimal administrative effort and minimal interaction with the service provider.

Every year cloud computing is more widely used in developing countries but this sometimes leads to problems:

1) The inadequate extent of trunk lines and broadband access networks, which are supposed to facilitate the spread of cloud services. Access to cloud computing requires a constant and stable network connection.
2) The failure to use, or limited use of, cloud computing in the small and medium-sized business sector. Small and medium-sized businesses play a major role in the economic development of rapidly developing countries, but small businesses often lack the financial resources required to take advantage of cloud computing or IT services in general.
3) Software: limitations as regards the software than can be deployed in the cloud and offered to users. Software users are restricted in the software used and do not always have the possibility of adapting it to their own particular purposes.
4) At the present time the issue of resolving disputes within a legal framework is being discussed.

For all the complications and problems that have arisen, use of the cloud in our market has every prospect of success.

This is largely linked to the advantages of cloud computing, which include:

1) Low cost:

   - Reduced expenditure on servicing virtual infrastructure resulting from the development of virtualization technologies, which means using fewer staff to service a company's entire IT infrastructure;
   - Using the cloud on a leasing basis enables users to reduce the costs of purchasing expensive hardware and to focus more on financial investment in improving the company's business processes, which in turn makes start-up easier.

2) Flexibility: the unlimited nature of the computing resources (memory, processors, disks, etc.): thanks to the use of virtualization systems, the process of scaling and administering the cloud is made easier, as the "cloud" can autonomously provide users with resources which they need, and user pays only for actual use.

3) Reliability of cloud systems especially those sited in specially equipped Data Communication Centres (DCCs), is very high, as such centres have reserve sources of power and storage, trained staff, regular data backups, high Internet channel capacity, and resilience to DDoS attacks.

Drivers of growth in the cloud computing market include the following:

1) SaaS (Software as a Service) model – the highest-level variant of "cloud" products.

2) The State: e-Government and government services, and inter-agency document exchange, are all centres of growth for cloud service providers.

Basic services provided by communication operators in the field of cloud computing are:

- Basic DCC services: co-location, rent-a-rack, DCC / IP VPN transport;
- Cloud services: VDC, SAN, dynamic cloud server, VPS, Hyper V, cloud video-conferencing, Webinar, Microsoft Exchange, SharePoint, Lync, Happy Drive virtual hosting;
- IN services: freephone, premium rate calls, televoting, reduced rate services, contact centre services;
- IT outsourcing: IN technical support and assistance (software and hardware), structured cable systems, infrastructure leasing for government events, adjustment and installation of IN components);
- SDP: video online, video call, virtual contact centre;
- M2M: emergency calls in the event of major accidents and disasters, cash registry systems;
- Software leasing: antivirus programs, utilities, text processing, audio, video and photographic processing, finance and book keeping.

Kenya – IMT and IMT Advanced technologies as facilitators of broadband services in Kenya

1. Overview of broadband services in Kenya

The mobile service sub-sector in Kenya has shown positive growth with 38.3 million subscriptions recorded from 1st January to 31st March 2016 up from 37.7 million subscriptions registered during the previous period. This marked an increase of 3.5 million subscriptions compared to the same quarter of the previous financial year. Subsequently, mobile penetration grew by 1.5 percentage points during the period under review to stand at 89.2 per cent up from 87.7 per cent recorded last quarter.[117]

2. Coverage of various IMT technologies in Kenya

Figure 5A shows a Geo-Portal incorporated latest coverage maps of all three mobile operators in Kenya, namely Safaricom Ltd, Airtel and Orange Network, creating a combined signal coverage map for -90dBm service quality as shown in the figure. The spatial analysis including the LandScan population distribution shows that only 5.6 per cent of the Kenyan population has no access to voice communications services. Whereas geographical coverage is only 45 per cent of Kenya's land area, 94.4 per cent of the population is already covered by 2G mobile services.

Figure 5A: Coverage pattern in Kenya's mobile networks services.

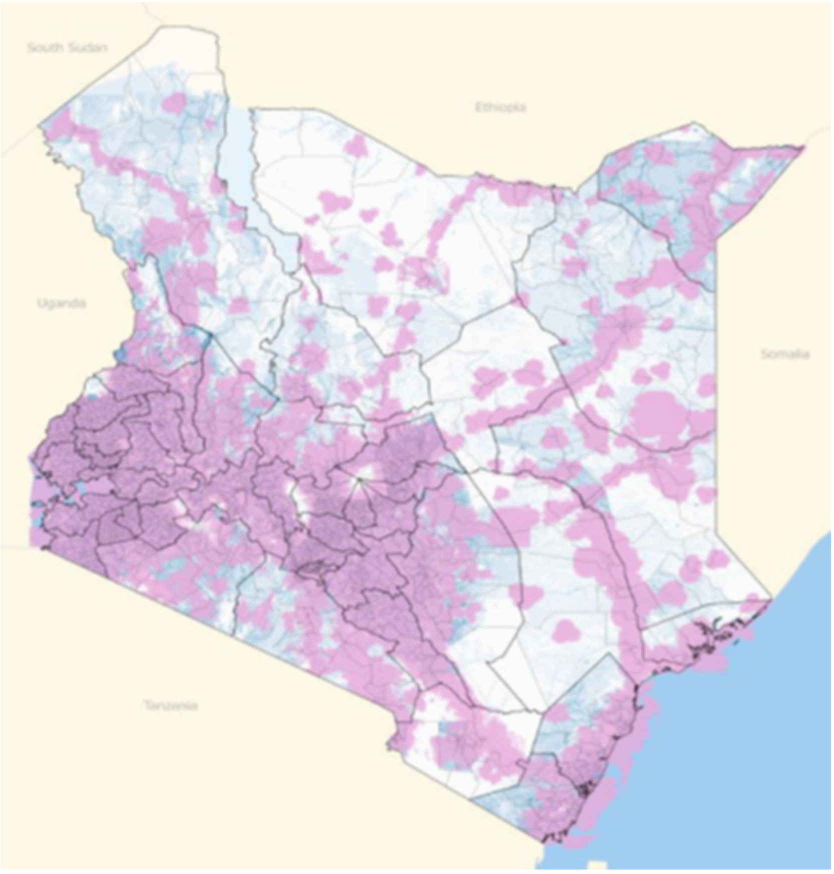


Table 2A: Key to Figure 5A

Type of coverage	Key
Combined 2G coverage	National reach at -90 dBm signal strength
3G Operator coverage	3 Safaricom, Airtel and Orange Networks

The uncovered sub-locations

Only 164 out of a total of 7,149 sub-locations remain totally uncovered, while a further 418 have less than 50 per cent of their populations covered. **Table 3A** below summarizes the GIS coverage analysis.

117 Document 1/290, "IMT and IMT Advanced technologies as facilitators of Broadband services in Kenya", Republic of Kenya.

Table 3A: Sub-location population 2G coverage

Table 6: Sub-location population 2G coverage					
Coverage	**100%**	**>90%**	**50% – 90%**	**< 50%**	**0%**
Sub-location	**5,657**	**485**	**425**	**418**	**164**

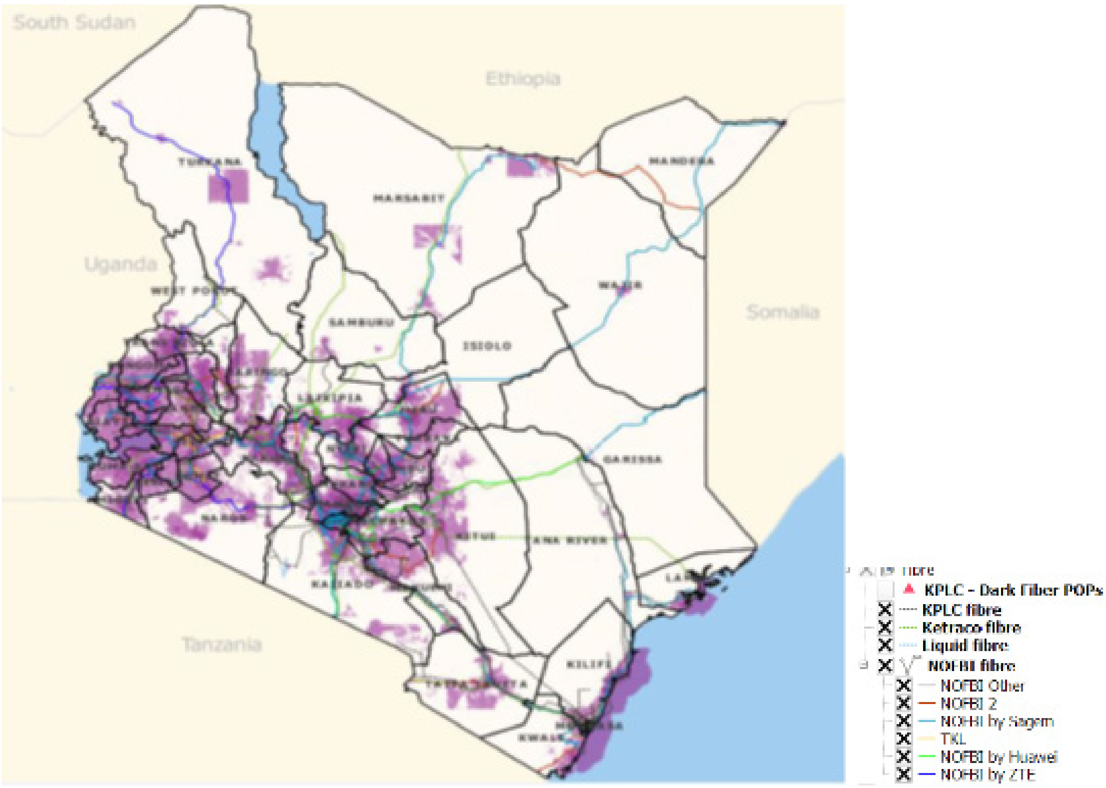
As indicated in **Figure 5A**, virtually all of the major unserved areas are in the North and East regions of the country, as well as in the Southwest border counties of Kajiado and Narok.

3. Third Generation (3G) Mobile – Broadband coverage

Coverage of 3G coverage and Fibre Optic Cable (FOC) Services in Kenya

Figure 6A illustrates the broadband coverage but includes also the National Optical Fibre Infrastructure (NOFBI) owned and operated by the Kenya government and private fibre routes as well as Kenya Electricity Transmission Company (KETRACO) and Kenya Power and Lighting Company (KPLC) line routes which either have or could be equipped with optical fibre.

Figure 6A: 3G coverage and Fibre Routes



Whilst 3G service geographical coverage is only 17 per cent of the geographical land area, 78 per cent of the population is covered; thus the access gap for 3G broadband service is 22 per cent of the population. The regional disparity for 3G is more pronounced than for 2G, even though the population coverage has improved significantly in recent years and will continue to expand through market forces, especially as 3G devices become more affordable and popular.

Every County in Kenya has at least one population centre with 3G coverage, except Isiolo County which today has zero percent 3G coverage. Analysis by sub-location indicates that 1,244 sub-locations country-wide have zero 3G coverage and a further 977 have less than 50 per cent coverage as shown in **Table 4A**.

Table 4A: Sub-location population 3G coverage

Sub-location population 3G coverage					
Coverage	100%	>90%	50% – 90%	< 50%	0%
Sub-location	2,454	1,324	1,146	977	1,244

As indicated, while every county headquarter has been reached by NOFBI at least, the extension of broadband transmission into the large geographical gap areas would still be a costly undertaking. However, many thousands of potential broadband users who are not yet connected, such as primary and secondary schools, health centres and Government offices, are located within less than 1 Km of a fibre route. Thus, there is very good potential for an early USF broadband outreach program to reach key sectors with demand, especially considering the needs of schools and tertiary educational institutions below university level. These could greatly benefit from connectivity in the short term. General users of 3G will continue to adopt the services and grow in accordance with the increase in general demand for data communications and the commercial expansion of the networks.

Management of the Digital Dividend

Digital dividend is the UHF spectrum available after the global analogue TV broadcasting switch off in June 2015. The first dividend in the 790-862 MHz band for wireless mobile broadband services was identified during the World Radiocommunication Conference (WRC) in 2007. The ITU then embarked on a study to determine the actual channelization plan. Subsequently, WRC-2012 resolved to expand the band to include 694-790 MHz also known as Digital Dividend II. In view of the WRC-12 decision, the NRA completed the process of migrating digital TV broadcasting channels earlier assigned within the 694-862 MHz band to channels in 470-694 MHz band, which provides upper limit of terrestrial television broadcasting to channel 48.

The two Broadcast Signal Distributors (BSD) in Kenya have rolled out DTT signals countrywide and the analogue switch off was completed. In this regard, a portion of the 790-862 MHz band has been assigned for the roll out of LTE Mobile broadband network on trial basis. Currently the National Regulatory Authority (NRA) is in the process of carrying out the necessary planning for the assignment of Digital Dividend II (within the 694-790 MHz band) after the recent World Radiocommunication Conference held in 2015 (WRC-15).

The World Bank's investment arm the International Finance Corporation has proposed a Public Private Partnership (PPP) approach towards the allocation of spectrum in the telecom industry.

Through the report, unlocking growth potential in Kenya, the IFC states that the country's lack of a market-oriented process for assignment could become a challenge in the distribution of available free spectrum. Safaricom, for instance, signed a Sh15 billion security deal with the government in exchange for the fourth generation radio spectrum in the 800MHz band as part of the agreement. It pointed out that Public-Private Partnerships (PPP) have the potential to affect competition by strengthening the private partner's position in the market and this should be considered when designing an agreement.

Sharing 800MHz band

Late last year the National Regulatory Authority (NRA), Communications Authority of Kenya (CA) proposed the sharing of the 800MHz band spectrum among the three operators saying that the alternative spectrum which comprised thee third dividend as already stated above was not ready for distribution as it awaited the decision of WRC-15. The NRA stated that it would issue Safaricom with a license allowing it to operate in the 800MHz frequency band and begin earning from the high speed Internet. However as part of the arrangement Safaricom Ltd. would enter into individual sharing agreement with interested mobile operators.

4. 4G Mobile Broadband coverage

In December, 2014, the NRA allocated part of the 800MHz band to one of the mobile operators in Kenya, Safaricom to launch 4G LTE network beginning with the urban areas. The rollout of 4G-LTE high-speed data offering and is the first high-speed Internet service of its kind in the Kenya. This service is available at the moment in two of the largest cities in Kenya, namely Nairobi, and the coastal city of Mombasa.

5. Conclusion

The mobile network services sector continues to demonstrate tangible increase despite the fact that we have penetrations at more than 80 per cent after sixteen years of services in our country. The coverage of the population by 2G services is over 90 per cent, but it is important to note that whilst the geographical coverage of 3G service is currently 17 per cent of the physical landscape, 78 per cent of the population is covered reflecting an access gap of 22 per cent of the population for 3G broadband service; a figure that is impressive and demonstrates the use of this IMT technology. The recently launched 4G services in Kenya has covered the two major cities, and as more spectrum is made available after the World Radio Conference 2015, we expect more uptake of this high-speed service by the population. It is also important to note that progress on the provision of back-haul infrastructure is being carried out on a public-private partnership to augment the footprint of high-speed Internet services to the national and devolved government system in Kenya.

Madagascar (1/2) – Regulation for the development of broadband

1. Introduction

Deployment of broadband is running into difficulties in Madagascar, given the island's remoteness from equipment suppliers, the size of the territory and the time needed to build networks.[118] The existence of the Backbone has not resolved every issue, hence the regulator's decision to facilitate its operation. The most recent texts adopted have been to that effect. Aware of its geographical situation, Madagascar, an island State 1 500 km long and 500 km wide, has made efforts to link up the major towns where the major business sectors (industry, banks and tourism) are located. These towns are separated by distances of tens or hundreds of kilometres and connecting them has always caused problems for operators. The topography of the main island is not conducive to using microwave links, hence the deployment by an operator of 8 000 km of fibre-optic cable in which the State holds a 34 per cent share. Development of broadband in a country depends in part on the means used to "transport" information from one point to another. The existence and use of a major transport network might be one of the keys to its expansion.

The overview that follows provides an outline of current and future networks in Madagascar.

2. Overview

We have two international interfaces: EASSY 25.73Gbis, operated at 25 per cent, and Lion (1 and 2) 2.015Gbists, operated at 40 per cent.

– National: 8 000 km of optical fibre with 4 lambda and 10 Gbit/s.
– Operators: three mobile operators and two data transmission operators.
– Customers:
  - Mobile: 47 per cent of the population
  - Fixed: 1 per cent
  - Overall ARPU: USD 2 per month.

[118] Document 1/142, "Regulation for the development of broadband", Republic of Madagascar.

Despite the efforts of the operators, broadband is not yet an everyday thing for the people of Madagascar. Other major difficulties that still have to be overcome to achieve this are:

– The financial resources available to users;
– Setting up distribution networks;
– Electricity production;
– Regulation of markets.

The first point concerns the purchase of equipment: smartphones, tablets or other devices, in order to benefit from all possible means of broadband access. The minimum price of a portable phone to connect to the Internet is USD 50, which is not affordable for all citizens, whose average daily wage is USD 2. Duty on imported goods plays a part. The question now is whether the experience of other countries, and especially under-developed countries, can help us to rectify this situation.

Operators in developing countries are almost without exception faced with the other two points indicated above. At the same time the regulator in Madagascar considers that market regulation is a priority area for developing broadband.

The following paragraphs detail recent decisions adopted by the regulators to promote the broadband market.

3. Most recent decisions by the regulator

– Liberalization

This means allowing all operators to deploy the technologies they deem to be necessary to their development. The fixed operator can deploy mobile networks, mobile operators can deploy fixed networks. All operators are allowed to offer all services when licenses are renewed. A list of cities to be covered over the next few years has been proposed to all the operators. The list includes the target cities that will benefit from 3G or 4G technology.

– Sharing arrangements

These apply above all to passive infrastructure such as masts, premises and optical fibre pairs. The aim is to enable all operators to exchange capacity by volume or by direct sale. The aim of such arrangements is to ensure that the operator does not have to worry about onerous investments in transport media but can instead focus on sales to end customers.

– Setting a maximum price for capacity

Given that a single operator deployed the national backbone, the regulator is aware that the operator in question has a dominant position in relation to the others, which has prompted the imposition of a limit on the maximum price for capacity. Any other operator wishing to conclude a contract for a certain capacity is protected by an order which “imposes” a maximum monthly charge for an STM segment by km and the cost of the annual SLA.

4. Conclusion

Broadband has a place in Madagascar’s economic and human development. Although the penetration rate is still relatively low, the authorities hope, with the recent measures, to see a real increase in the next few years. At any event, the current commercial launch of 4G is bound to contribute to a further increase.

Madagascar (2/2) – Trends in Broadband in Madagascar

1. Introduction

Broadband technology, one of the most recent innovations in the field of telecommunications, began to be used in Madagascar some years ago.[119] Despite an interpretation of the precise definition of broadband that is somewhat confusing for users (service technology, speed or volume), the country's three mobile operators and fixed service operator manage with some difficulty to provide broadband for their customers. This technology is increasingly becoming an integral part of the country's social and economic life, and the relevant ministry has therefore decided to monitor broadband trends and market penetration very closely.

This contribution briefly reviews the various uses of broadband in Madagascar, the different technologies used by the operators, and the difficulties encountered in deployment, as well as measures taken by the Government to promote broadband development.

2. Madagascar in brief

- Surface area and population: 587,041 km2/22,000,000 inhabitants
- Internet coverage (mobile): 65 per cent
- Internet penetration rate: 11 per cent
- High-speed Internet access cost (from 512 kbit/s): USD 125, or 250 per cent of average monthly income
- Average cost of a portable device allowing access to Internet: from USD 15

3. Broadband in Madagascar

Since the introduction of broadband among professional groups, the services on offer have constantly grown. Broadband is becoming a powerful and positive tool for the country, and one which cuts times and distances. Important uses include the following:

- **Remote working:** ten years ago the first data processing centre was opened in Madagascar's capital. Since then, various teleworking centres have been established and offer telemarketing and sales, IT teledevelopment (IT services companies), and so on.
- **Telemedicine:** Since 2010, telemedicine has become a reality in Madagascar with the establishment of a medical imaging centre with broadband links to India, providing real-time assistance during difficult surgical procedures.
- **E-Governance:** The Government of Madagascar uses a private intra-ministerial broadband communications network.
- **E-Learning:** Universities in particular are able to provide remote teaching and access to virtual libraries thanks to broadband. About 20 universities have benefited from this technology over the last 20 years.
- **Cyber centre:** the general public, especially in urban areas, can enjoy universal services based on broadband through access centres.

In addition, the smart phone and tablet invasion of the market has also given groups of various customer groups access to broadband. A range of services are offered by operators through terminal devices of this kind.

4. The different broadband access networks

The fixed operator offers two types of broadband access:

- xDSL or ISDN, available to businesses and private individuals: speeds on offer can be up to 8 Mbit/s.
- FTTH: services offered since 2010.

[119] Document SG1RGQ/29, "Trends in broadband in Madagascar and proactive measures by the regulatory agency", Republic of Madagascar.

The mobile operators, on the other hand, offer their customers access using USB keys with 3G connectivity. In the light of demand from certain customers, however, especially from businesses, they also provide local radio loop access networks.

"Backhauling" makes use of optical fibre (8 000 km) and microwave links. Given the size of the territory concerned, deployment in remote areas presents the problems described below.

5. Difficulties of deployment

– Difficulties of deploying broadband access networks

As regards wired networks, deployment of broadband access networks is very costly, starting with the hardware (IPDSLAM, MSAN, GPON), but there are also problems of access in some areas as well as inadequate coverage by the electrical power grid. Only the large and medium-sized cities are better served, with around 30 sites installed in 2014. As regards copper or fibre-optic distribution networks, these require major capital expenditure for civil engineering work, and this rarely encourages the operator to become involved.

With regard to the mobile operators, development of 3G networks is less difficult given that appropriate infrastructure for older generation stations is already operational. The operators are upgrading 2G stations to 3G and will soon upgrade to 4G. The 1 000 base stations on the island include 511 3G stations (30 per cent of the total), half of which are in or around the capital.

– Difficulties of "backhaul" deployment

Aware that the growth in the number of users requires a transport (backhaul) network with sufficient capacity for data communications, the operators encounter many problems with the deployment of a suitable transport network. In the case of optical fibre, the cost of the work required makes coverage of certain locations impossible, especially areas remote from main roads. Most of these sites are covered by microwave links from an optical fibre Point of Presence (PoP). Some operators are thus obliged to negotiate for capacity with other operators in order to be able to bring their traffic to their Network Operations Centres (NOCs). In order to facilitate implementation of these principles, the regulatory authority has put forward the measures set out in paragraph 6 below.

6. Proactive measures

Cognizant of the difficulties referred to in paragraph 5 above, the regulatory authority has adopted a number of incentive measures, as follows:

– Liberalization

This means allowing all operators to deploy the technologies they deem to be necessary to their development. The fixed operator can deploy mobile networks, mobile operators can deploy fixed networks. All operators are allowed to offer additional services when licences are renewed subject to transparent regulatory conditions.

– Sharing arrangements

These apply above all to passive infrastructure such as masts, premises and optical fibre pairs ("dark fibre"). The aim is to enable all operators to exchange capacity by volume or by direct sale.

7. Conclusion

Broadband has a place in Madagascar's economic and human development. Although the penetration rate is still low, the authorities hope, with the recent regulatory measures, to see a real increase in the next few years. At any event, the current commercial launch of 4G is bound to contribute to a further increase in the penetration rate.

Madagascar (Republic of) – Broadband access technology in Madagascar

1. Introduction

– Global statistics show that the Internet market is booming and evolving very rapidly, particularly in developed and emerging countries. This phenomenon is due to the deployment of broadband, above all mobile, using a variety of access technologies.[120]

Despite its low Internet penetration rate, Madagascar is ranked among the top 20 African countries having high-speed Internet, based in particular on the use of 4G/LTE technology. This contribution presents in the first place the technological potential of the operators providing Internet services in Madagascar, taking the case of Gulfsat Madagascar as an example. Then we will look at the main obstacles to Internet development in Madagascar.

2. Presentation of the operator Gulfsat Madagascar[121]

– A provider: Internet, private network, international links for companies and individuals;

– Over 20 years of experience in the Malagasy and international markets;

– Three international interfaces – optical fibre (cables EASSY and LION) and satellite O3b;

– Over 20 towns and cities covered by its national network, and 100 per cent satellite coverage;

– Over 2000 professional customers;

– Over 40 000 private customers.

3. Technological potential of Gulfsat Madagascar

To meet its customers' requirements, Gulfsat has, over the years, developed a whole range of services. In addition to Wireless Local Loop (WLL), Very Small Aperture Terminal (VSAT), Wireless Local Area Network (WLAN) and WiFi technologies, several generations of mobile networks have already been deployed by the company, the most recent was 4G/LTE.

It is the second operator using 4G/LTE in Madagascar, the other being the incumbent operator TELMA. Thanks to these innovative technologies, Gulfsat is able to provide high-speed voice and data communications to its private and professional customers. With such a technological potential, Gulfsat is in a position to develop the Internet market and compete with the other major operators present in the country's telecommunication sector.

4. Main obstacles to Internet development in Madagascar

It can be seen that Madagascar is following the global environment in terms of its use of the new broadband network technologies. However, its Internet penetration rate (less than five per cent) remains very low by comparison with the global trend (over 40 per cent), progressing enormously from year to year at a rate that is well below satisfactory and thus calling for considerable improvement in the coming years.

The reasons for this low penetration rate are numerous, and include the following:

– Limited household budgets: very few households can afford an Internet connection in Madagascar (not only because of its very high cost, but also on account of low income levels);

– Unaffordable access to the Internet tariffs;

– Lack of familiarity with the tools in question;

– Non-guaranteed nature of the broadband provided by operators;

– Insufficient 3G/4G signal in the national territory.

[120] Document 1/403, "Broadband access technology – Madagascar", Republic of Madagascar.
[121] http://www.blueline.mg/corporate/presentation-de-blueline.

Orange (France) – Submarine cables in Africa

Submarine cables – At the heart of the global internet

In today's world, submarine cables are essential to economic life and the social fabric – they are the international paths that connect the Internet.[122] They are critical communications infrastructure carrying more than 98 per cent of international internet, data, video and telephonic traffic. By comparison, undersea cables dwarf satellites for international communications and are unmatched for their reliability, speed, volume of traffic, and low cost. For example, The Society for World Interbank Financial Telecommunications (SWIFT), The Continuous Linked Settlement (CLS) Bank, and the United States' Clearing House Interbank Payment System (CHIPS) all depend exclusively on submarine cables for daily transactions values at several trillion US$.[123] The "cloud" of computer servers distributed in data centres worldwide is based on seamless connection via international submarine fiber-optic cables. With the laying of submarine cables along the west coast of Africa in 2009-2012, in particular the Orange-led ACE project, only about 20 of the world's nations and territories remain isolated from fiber-optic cables.

West Africa – Submarine cables

In 2008, France Telecom (now Orange) first conceived the creation of a major submarine cable system between Penmarch, in Brittany on France's Atlantic coast, and South Africa, a distance of 17,000 kilometers, using state-of-the-art fiber optic transmission technology.

To implement this exceptional project – representing a cost of $700 million – the Orange Group teamed up with selected partners. It formed a consortium – the prevalent business model for construction of submarine cables – initially comprising 15 major players, all with a direct stake in the arrival of broadband in their respective countries:

- Orange subsidiaries: Côte d'Ivoire, Cameroon, Mali, Niger and Senegal.
- Governments: Republic of Gabon and the Republic of Equatorial Guinea.
- Operators: Dolphin Telecom, MTN and others.
- In-country consortia grouping other partners: Cable Consortium of Liberia, Guilab (Guinea).
- International Mauritania Telecom and others.

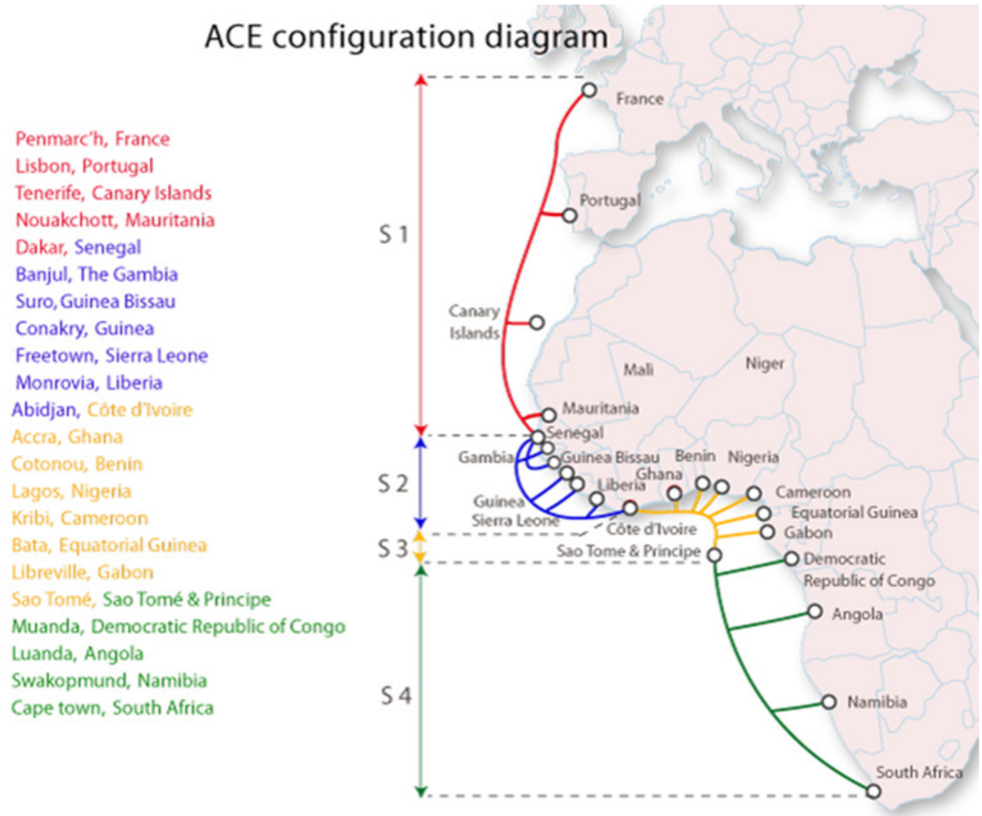
The 19 current ACE consortium members

- ACE Gabon
- Benin ACE GIE
- Cable Consortium of Liberia Inc.
- Canalink
- Dolphin Telecom
- Gambia Submarine Cable Co. Ltd.
- Guinéenne de la Large Bande S.A.
- International Mauritania Telecom Ltd.
- MEO
- MTN

[122] Document SG1RGQ/314 , "Submarine cables in Africa", Orange (France).
[123] White Paper commissioned by the International Cable Protection Committee (ICPC) and submitted to the UN General Assembly, *"Submarine Cables and Biological Diversity beyond Areas of National Jurisdiction"*, September, 2016, available at https://iscpc.org/news.

- Orange S.A.
- Orange Cameroon
- Orange Côte d'Ivoire
- Orange Mali
- Orange Niger
- République de Guinée Équatoriale
- Sierra Leone Cable Ltd.
- Sonatel
- STP Cabo

Figure 7A: ACE configuration diagram



Since the system opened for service in 2012, it has been contributing to the development of a high-quality, secure, global network. ACE is the first ever cable designed from the outset for seamless upgrade to 100 Gbps technology per one wavelength. The total rate of the ACE cable reaches up to 12.8 Tbps by using Dense Wavelength Multiplexing (DWDM) technology. This technology supports tomorrow's ultra-high-speed broadband networks. Boosting cable capacity is simply a matter of plugging in new transmission equipment housed in the "dry" landing stations.

This vital international project and others like it are democratizing broadband internet in Africa, empowering inhabitants to improve their farming and fishing by applying new techniques and accessing regional markets, to extend access to classrooms and teachers, and to improve medical care through telemedicine.

By 2018 the ACE cable will serve 19 countries, including France, Portugal, Spain (Canary Islands), Mauritania, Senegal, Gambia, Guinea, Sierra Leone, Liberia, Ivory Coast, Ghana, Benin, Nigeria, Equatorial Guinea, Gabon and São Tomé and Principe, and South Africa, all coastal countries. Two landlocked countries, Mali and Niger, are joined to it via a terrestrial connection. By the end of the second phase, the cable will cover 17,000 km under the Atlantic Ocean.

Submarine cables offer new possibilities for growth in the countries they serve. The World Bank estimates that a 10 per cent increase in broadband internet access contributes to an increase of 1.38 per cent in Gross Domestic Product. Submarine cables enable this sustainable growth, with each successive cable connection to a country boosting economic prosperity for its people.

Box 1: Case study

Case study

Africa remains the world's most digitally isolated continent. The fixed broadband penetration rate is less than 1 per cent due to the low number of copper lines – limiting access to ADSL – and to the high cost of satellite connections. However, the deployment of fiber-optic submarine cables since the early 2000s has significantly improved this situation.

Even in Senegal, one of Africa's most economically advanced countries; in 2012 fixed internet penetration remained very low: 1.5 per cent. The arrival of submarine cable ACE is changing the digital experience of broadband customers in the country.

Since the cable came on line, citizens have expanded their digital horizons: more reliable Internet connections, fast downloads of large files, voice over IP and – for businesses – cheaper access to sophisticated services such as videoconferencing, e-learning and eHealth. By cutting the cost of international bandwidth, the ACE cable system is making broadband affordable to far more people.

In seven of the ACE countries, this new international information highway has brought the first ever direct connection to the global optical fiber broadband system, dramatically improving communication with the rest of the world: Gambia, Guinea, Equatorial Guinea, Liberia, Mauritania, Sao Tomé & Principe and Sierra Leone. These countries' participation in the project was made possible by substantial financing from the World Bank, which is also at present supporting the Republic of Guinea-Bissau in its plans to connect to the ACE system. ACE remains open to including additional countries and contributing in this way to the continent's social and economic development by spreading digital services to the wider population.

Submarine cables are also important for marine and climate research: dozens of cable-enabled projects are now active in the oceans with many more planned, for ocean climate monitoring, tsunami warning, and fundamental research.

Rwanda – Access to broadband in Rwanda

1. Background

Under the National Information and Communication Infrastructure (NICI) framework, the Government of Rwanda deployed a national high-speed fibre-optic backbone that spans all thirty districts and connects eleven border posts. This allows the telecom operators to connect to the international submarine fibre-optic cables that landed on the African east coast. These cables have given the entire region fibre-based international bandwidth.[124]

[124] Document 1/165, "Access to Broadband in Rwanda", Republic of Rwanda.

In addition to progress registered in broadband rollout by operators in Rwanda, in November 2014, a new infrastructure-sharing regime by way of a wholesale-only, open-access 4G LTE network was launched, which will allow access to retail providers, including current ISP players, as well as Mobile Virtual Network Operators, on fair, transparent and non-discriminatory basis.

2. Broadband access technologies currently deployed in Rwanda

Broadband access network enable delivery of information, goods and services that stimulate economic growth and help domestic businesses compete. Without such access, remote communities risk becoming increasingly marginalized and lacking in essential educational, medical, government, e-commerce and social services. On this basis, the Government of Rwanda has invested in developing broadband infrastructure all over the country.

Table 5A describes the registered technologies in broadband rollout by operators and the Government of Rwanda.

Table 5A: Registered technologies in broadband rollout by operators and the Government of Rwanda

Fixed Access Technologies	Mobile Access Technologies	
	3rd Generation	4th Generation
– **Kigali Metropolitan Network (KMN):** It is a high-speed fiber-optic network that spans across Kigali. KMN interconnects all government institutions including schools, health-care centres and local government administrative entities in the Kigali metropolitan area to broadband Internet access. – **National Fiber Optic Backbone:** The country's national backbone project covers all districts of Rwanda with a total length of about 3,000 km. – **Gigabit Passive Optical Network (GPON):** This is known as Fiber-to-the Home (FTTH). It is the installation and use of optical fiber from a central point directly to individual buildings such as residences, apartment buildings and businesses to provide unprecedented high-speed Internet access. Currently, MTN Rwanda Ltd and Liquid Telecom Ltd are deploying this technology in different villages of Rwanda. By connecting a small village like apartment, the end point after splitting is via ADSL. – **Point-to-Point through WiMAX:** MTN Rwanda Ltd deployed this technology in all of its towers to connect the citizens living in remote areas on broadband Internet access via radio antennas.	– As of March 2015, **3G and 3.5G mobile technologies** were deployed geographically in Rwanda by: • MTN Rwanda Ltd at the level of 64.49% with 85.07% of population, • Tigo Rwanda Ltd at the level of 12.03% with 47.89 of population, • Airtel Rwanda Ltd at the level of 15.36% with 22.19% of Population. – **High-Speed Down-link Packet Access (HSDPA):** This access technology was deployed geographically in all major cities of the country with 7.05 Mbps practically at the highest ever measured. – **Evolved High Speed Packet Access (HSPA+):** Airtel Rwanda Ltd has deployed the Release 9 of this technology in all major cities of Rwanda.	– **Long Term Evolution (LTE):** In November 2014, Rwanda launched a high-speed broadband network 4G LTE. The network was established through an agreement between the Government of Rwanda and KT Corporation, South Korea's largest telecommunications provider. The Network is expected to cover the entire country and 95 per cent of the population by 2017. By now 5 cities among 30 of the country are connected to 4G LTE Internet since the launch of this technology. There has been a big increase in subscribers from day to day as the three telecommunication firms (MTN Rwanda Ltd, TIGO Rwanda Ltd and AIRTEL Rwanda Ltd) signed contracts with 4G service provider

The infrastructure laid for access to broadband in Rwanda has become a driver of economic growth, social cohesion, productivity and innovation across all sectors, notably governance, health, education and agriculture.

3. Internet penetration in Rwanda

The country targets to become a regional centre for training of high quality ICT professionals and researchers. With a population of 11.7 million people, Rwanda's mobile penetration stands at 71.8 per cent with internet penetration at 28.1 per cent as of March 2015.

Figure 8A: Rwanda trend in total internet Subscribers as of March 2015

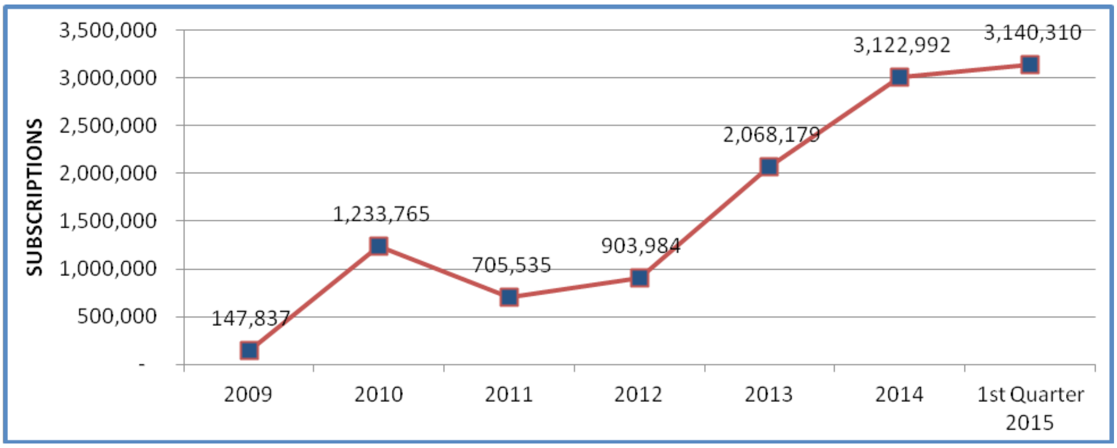
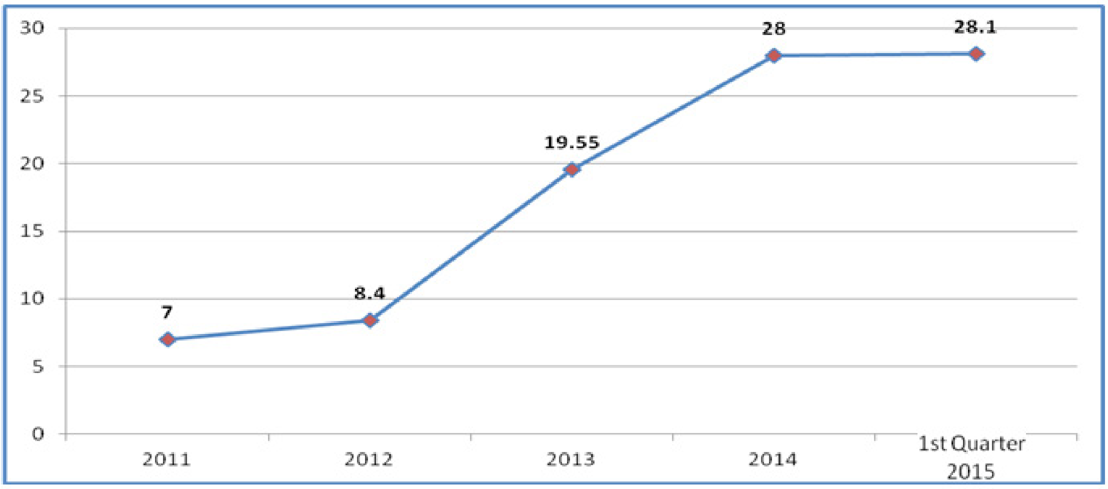


Figure 9A: Internet penetration rate trend as of March 2015



Source: RURA operators' returns

4. Approach to accelerate broadband in Rwanda

In 2013, Government of Rwanda (GoR) developed its national broadband policy with the vision of ensuring the transformation of Rwanda into an Information society driven by universal access to high speed, reliable, affordable and secure Broadband infrastructure and services by 2020. This policy has major benefits that will come as result of improved connectivity:

– Improved quality and access of healthcare services will reinforce the use of advanced medical applications like telemedicine, the management and exchange of patients' electronic records information, across Rwanda.

– Improved government service delivery will greatly enhance the government's capability to communicate within government institutions, and with its citizens. Provide online service for informational and transactional purposes, which will drive down the cost to government, of service delivery.

– Improved quality of education by enabling delivery of digital contents for instruction, irrespective their location; it will also facilitate the relationship between institutions.

– Arts, culture and entertainment: citizens will experience an evolution in the entertainment scene: this will play a role in improving and expanding channels of knowledge dissemination.

– Reduced cost of communications and improved marketability for investment creates an environment that stimulates economic growth due to the lower cost of communications that attracts businesses to all parts of the country, and the streamlined distribution of products and services to all corners of the nation. With the improved access to the rest of the country and the world through Broadband, all areas of the country will be able to increase their marketability, and therefore attract more investment.

– Increased employment and growth of SMEs (Small and Medium Enterprises). Broadband connectivity unlocks creativity and creates economic activities that create jobs, more especially to the youth.

This policy positioned broadband as a driver of economic growth, social cohesion, productivity and innovation across all sectors of the economy and promote guide initiatives to drive down the cost of end-user equipment; stimulate the development and uptake of relevant content; and driving aggressive digital awareness campaigns.

5. Conclusion

Access to broadband in Rwanda has been an enabler breaking development barriers and profoundly changing how services are delivered. It also leads to the increase of productivity, access to knowledge, and better prospects for the Rwandan citizens.

As the country is divided into four provinces which are structured in four tiers: 30 districts, 416 sectors, 2,148 cells and 14,837 villages, the government of Rwanda developed the policy aimed to promote the broadband access to reach the low level administrative entities, from districts to sectors, cells and villages, in the spirit of providing equal opportunity to broadband services for all citizens of the entire country.

Sri Lanka – Broadband in Sri Lanka

1. Overview

Developing Sri Lanka as a knowledge hub in Asia, is a key development strategy of the Government. Broadband plays a critical role in the workings of this strategy. The term "broadband" has come to be synonymous with high speed internet use in general.[125] In Sri Lanka broadband is defined as "Technology neutral high speed data communication service with a broader bandwidth capacity not less than 1Mbps down link, which enables the operation of wide array of applications and services online".

2. Broadband policy

National Broadband Policy is widely acknowledged as the key enabler to facilitate uptake of broadband for socio-economic transformation of a country. Having identified the necessity of a policy towards the rapid development of broadband services in Sri Lanka, a five year policy has been drafted by Telecommunications Regulatory Commission of Sri Lanka (TRCSL) and the said policy will be

[125] Document SG1RGQ/138, "Broadband in Sri Lanka", Democratic Socialist Republic of Sri Lanka.

implemented after obtaining the views of all stakeholders and with the approval of the relevant authorities of the Government in the near future.

The main objectives of the national broadband policy are to identify the impediments that hamper the rapid development of high speed broadband in Sri Lanka, propose a pragmatic strategy to overcome such and to provide guidance to stakeholders to build country wide network with state of the art technology that flourishes the living standards of the public whilst taking the country towards a sustainable economic growth by the year 2019 with the aid of data communication technology.

One of the key targets of the policy is to encourage the utilization of High Speed Broadband Internet Services in Sri Lanka through a strategic process, transforming broadband to a status of leading technology, enabling it to drive the socio-economic development in the country. Furthermore, to make broadband affordable with an access speed equal or greater than 25Mbps, where all citizens could equally access the internet irrespective of their locality by the year 2019 is another target of this policy.

After consultation with all stakeholders, a national broadband standard was developed by TRCSL in 2013 as an important initial step towards improving broadband services. In this standard, Fixed Broadband is defined as a technology neutral broadband service with speeds equal or greater than 1Mbps which limits its operations to a fixed location whereas mobile Broadband is defined as the technology neutral broadband service with speeds equal or greater than 1Mbps which provides the mobility functions to the user (broadband subscriber). The broadband subscriber is defined as an internet customer who consumes greater than 100MB within a period of 30 consecutive days and using an access service with the speed equal or greater than 1Mbps to access the internet. The said standard will be revised in 2016 after implementing the national Broadband Policy.

3. Broadband technologies/infrastructure

Access network

– Fixed broadband

ADSL, ADSL2 and ADSL2+ are the common form of DSL used in Sri Lanka. ADSL2+ is now replacing with VDSL2, delivering high speed internet up to 100Mbps to subscribers. It can deliver amazing broadband performance while delivering triple-play services of Telephone, Broadband and Peo TV. Existing broadband users will get immense freedom to get connect to any “carrier grade” public Wi-Fi Hotspots by using the same broadband username and password which they use at home or office to connect to the internet. With the development of fibre network in the country, most of the copper lines have been replaced with fibre up to the Multi-Service Access Nodes, which connects subscribers to the Core Network to provide multiple services from a single platform. FTTC and FTTB technologies are now available to all users in a neighborhood or building, which supports download speeds of up to 100Mbps. Fixed 4G LTE was introduced in 2014 with download speed up to 50Mbps for the provision of broadband services across the country. Metro Ethernet delivers high-bandwidth connectivity for high-rises, large corporate officers and important commercial locations in metropolitan areas, including cities outside the Capital of Sri Lanka. This is based on the Metro Ethernet Forum Standard and offers capacity and reliability in the demanding arena of data communications for enterprises. Access to world class broadband technologies such as VDSL2, 4G LTE, Carrier-Grade Wi-Fi & Fibre technologies will support the enterprises, growing SME segment and also the public sector to become more resilient in achieving a SMART Sri Lanka.

– Mobile broadband

Sri Lanka’s Mobile operators have deployed several industry leading technologies for the provision of Mobile Broadband services. Being a regional pioneer in launching the 3G technology, Sri Lanka also witnessed the first 4G deployment in South Asia by launching 4G LTE network in April 2013. All five mobile operators have deployed 3G networks and two operators have deployed commercial mobile 4G LTE networks. 3G and 4G technologies cover in excess of 75 per cent of the country’s population which is expected to grow further with the healthy competition prevalent among operators. Wider availability of faster Mobile Broadband services has propelled Sri Lanka's internet penetration providing equal access to information and e-services resulting in inclusive development. Particularly, the recent introduction of low cost smart devices is observed as breaking the affordability barrier which acted as a hindrance for expedited adoption of mobile broadband services.

Transport network

– **National connectivity**

Sri Lanka launched the country's first ultra-speed national fibre optic backbone transmission network in 2014 with a new generation OTN based 100G Dense Wavelength Division Multiplexing (DWDM) solution, which transmits eight terabits per second. Within less than half a century, the optical transport industry has migrated from PDH, through Synchronous Digital Hierarchy (SDH), Wave-length Division Multiplexing (WDM), to Optical Transport Network (OTN) based 100G DWDM boosting network speeds from mega bit level to terabit level performance and progressing from pure manual network configuration and management to modest levels of automation.

Some of the mobile operators are transforming their transport network to a more flexible, future proof and agile network architecture to cater ever increasing bandwidth demand due to the rapid growth of the broadband and enterprise services. This has developed number of fiber routes connecting the cell sites directly into the fiber and restricting the remaining sites just one microwave hop away from the fiber. Instead of maintaining separate backhaul networks for IP, TDM and business traffic it also converged into a single IP transport network based on OTN, IP/Multi-Protocol Label Switching (MPLS) and packet based synchronization distribution technologies improving efficiency significantly. This system will eliminates the mobile backhaul nightmare most of the operators face around the world.

– **International connectivity**

Sri Lanka's global connectivity strengthened via multiple submarine cable systems: SEA-ME-WE-3 (39,000km), SEA-ME-WE-4 (20,000km), Bharath-Lanka (Tuticorin-Colombo 320km), Dhiraagu-SLT(Male-Colombo 850km), FLAG (Japan-India-SL-UK-USA 28,000 km), BBG (Singapore-Oman/UAE 8,000 km). Sri Lanka's geographical location makes it a natural nexus for communications in the Indian Ocean and helps ensure that the country plays a key role in the process of unfolding new technologies across the region. Sri Lanka has partnered with 17 other countries to build SEA-ME-WE-5, spanning approximately 20,000km from Asia Pacific to Europe via Sri Lanka.

4. Regulatory initiatives

Web browsing, Over-the-top Video Streaming, File transfer and VoIP are the most popular services used by internet users of many countries around the world. The users expect high quality videos when streaming YouTube and other online TV shows and movies. On the other hand, advertised or promised broadband speed figures offered by service providers have a mismatch with user experiences. Setting up a regulatory frame work for QOS monitoring of real time and non-real time applications is a challenge for the regulator. QOS measurement methodology has to be carefully designed considering two aspects; how measurements are made and who makes the measurements.

TRCSL introduced Broadband Speed Measuring Facility (BSMF) in 2011 as an industry bench-marking tool. Internet users in Sri Lanka can check their internet speed by downloading different sizes of files from three dedicated servers (Tier 1-IP backbone with 1Gbps dedicated uplink port) hosted in the United States of America, the Netherlands and Singapore data centers via TRCSL web metering facility.[126]

[126] Speed measuring facility can be found in the following link: http://www.trc.gov.lk/2014-05-12-13-25-54/internet-speed-test.html.

In addition, TRCSL has installed a fully-automated system for speed monitoring of broadband service providers in a common platform. These test results are published on the TRCSL website on a monthly basis.[127]

However, implementation of an appropriate regulatory framework for QoS for mobile and fixed broadband services is a key task identified for 2016 by the Regulator. Identification of a minimum number of Key Performance Indicators (KPIs), development of a mechanism to monitor the identified KPIs and establishment of a set of obligations by internet services providers will be implemented through a public consultation process in the first six months of 2016.

5. Applications

E-Sri Lanka aspires to the ideal of making Sri Lanka the most connected government to its people, and raising the quality of life of all its citizens with access to better public services, learning opportunities, and information. Sri Lanka's over 100,000 hearing and vision impaired, stand to benefit from an "Impaired Aid Project" that has introduced "Digital Talking Books" using a new suite of local language accessibility applications. Accessing Government Information Center via a telephone short code from anywhere in Sri Lanka to obtain information is another project implemented under e-Sri Lanka. Both these projects won awards at the 2009 World Summit Awards (WSA), a global initiative for selecting and promoting the world's best e-contents and applications. One of the ideas actioned was to create an e-society where communities of farmers, students and small entrepreneurs are linked to information, learning and trading facilities. This action was via tele/knowledge centres called Nenaselas (Nena=knowledge+ selas=shops), that spawned across the country bringing within easy reach computer technology, the Internet, and IT skills training to many people who had never even seen a computer.[128]

Fixed and Mobile Operators joined hands with Ministry of Education and TRCSL to connect ICT labs of leading schools in the Capital, Colombo and the suburbs with high-speed 4G LTE and the island-wide fiber network. This initiative will provide students with seamless access to the Internet for education purposes using the information superhighway. Several educational content portals are also operated under the patronage of telecom operators. One such e-learning portal, Guru.lk provides educational content under 3 main categories as School, Professional and Lifestyle. "Guru School" covers about 60 per cent of the school curriculum, "Professional" covers professional education (e.g.: curriculum of banking exams) and "Life Style" includes courses such as beauty culture, cookery, yoga etc.

6. Challenges

Despite licensed Operators expanding their broadband network footprint, several challenges exist in faster adoption of broadband services. Lower IT literacy curtails the relevance of ICT services for a large population. However the improvement of IT literacy will help change this situation significantly in the near future. On the other hand, the cost of smart devices acts as a deterrent for data service adoption among lower income population. However, the introduction of low cost devices breaking the affordability barrier is a welcome change which has taken place as a result of deliberate efforts of Operators and the evolution of the eco system in general, is seen to help alleviate this challenge.

Sri Lanka (Democratic Socialist Republic of) – National Broadband Policy of Sri Lanka

1. Introduction

Developing Sri Lanka as a knowledge hub in Asia is a key development strategy of the Government. Broadband plays a critical role in the workings of this strategy.[129] The term "broadband" has come to be synonymous with high-speed internet use in general. Broadband provides enhanced communication, improved access to markets and services, improved access to education and health services, and

[127] Comparison of Speed Test Results of service providers can be found in the following link: http://www.trc.gov.lk/2014-05-12-13-25-54/speed-test-results.html.

[128] http://www.icta.lk.

[129] Document SG1RGQ/288, "National Broadband Policy of Sri Lanka", Democratic Socialist Republic of Sri Lanka.

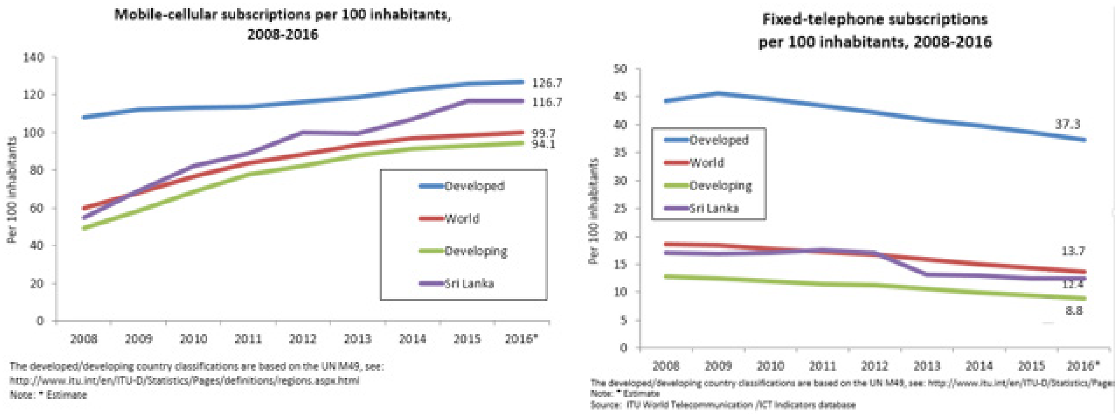
better access to information, news and entertainment. Broadband enables new solutions to national development challenges and will enable new ways of showcasing and advancing national culture and of engagement with and between all people in Sri Lanka. As experience to date shows, both in Sri Lanka and overseas, broadband has the potential to transform completely the way government, business and consumers communicate and interact with one another, and the possibilities have only now begun to be explored.

Sri Lanka has five mobile operators, three fixed operators and many ISP's. With the introduction of 3G/HSPA in 2006/7 the internet growth accelerated. Out of five mobile operators, two are with 4G LTE capability while other three are equipped with latest 3G technologies in their portfolios. All three fixed operators are equipped with CDMA 2000 1x, WiMax and 4G LTE technology while incumbent use the ADSL, ADSL2 and ADSL2+ (ADSL2+ is now replacing with VDSL2) in addition to wireless technologies. Further, two operators have been licensed to provide FTTx.

As per the Measuring the Information Society Report 2016, Sri Lanka ranked as 116th in the IDI Ranking List with the IDI Value of 3.57 with a slight increase compared to 2015.

The present status of the fixed/mobile telephone subscriptions and fixed/mobile broadband subscription can be seen in **Figure 10A**.

Figure 10A: Status of the fixed/mobile telephone subscriptions and fixed/mobile broadband subscription



2. Objectives of NBP

National Broadband Policy (NBP) is widely acknowledged as the key enabler to facilitate uptake of broadband for socio-economic transformation of a country. The overall objectives of the National Broadband Policy are to facilitate the earliest and widest level of adoption of broadband within Sri Lanka, the development of services and applications and ensuring widespread and affordable access by all sectors of the economy and society.

3. Broadband policy initiatives

A policy for broadband reflects the Government's ambition to build up a foundation for the long-term development of the broadband sector as a key part of the infrastructural support for Sri Lanka's economy and society. Having identified the necessity of a policy towards the rapid development of broadband services in Sri Lanka, TRCSL has obtained assistance from ITU to formulate a NBP for Sri Lanka.

4. Draft NBP

Draft NBP was formulated after completing the following activities:

– Analyze current broadband infrastructure developments (including a gap analysis to identify the parts of the broadband supply chain were infrastructure development needs to be prioritized), the market situation (market players, subscribers, revenue, growth etc.), policies and regulatory initiatives undertaken to promote broadband;

- Compare international best practices including Broadband Commission reports, identify the current barriers and opportunities to stimulate broadband in Sri Lanka;
- Assess the current ICT status of Sri Lanka using ICT Development Index (IDI), which includes, among others, indicators on fixed telephone lines, mobile subscriptions, Internet users, broadband penetration, international Internet bandwidth, and percentage of households with a PC;
- Examine the opportunity for Sri Lanka to leapfrog into the broadband era by leveraging modern technological options and infrastructure, government support, investment incentives, competition etc., and highlight the potential for policy makers, regulators and other stakeholders to foster the development and adoption of broadband in Sri Lanka;
- Obtained inputs from stakeholders in Sri Lanka (through a questionnaire) on the requisites for a national broadband policy, especially regarding the current and future regulatory framework and the policy initiatives related to broadband;
- A national workshop was conducted to inform, educate, and gather information from the stakeholders and sharing proposals of NBP.

5. Policy principles

This National Broadband Policy is based on the following key principles and assumptions:

- The Policy is more than a policy for the ICT sector of the economy – its reach is the whole economy of Sri Lanka and concerns the production and delivery of goods and services and associated transactions across the whole of the economy;
- The Policy is concerned with all people in Sri Lanka in terms of their interactions and social engagement with social institutions and each other – its reach is the whole of society;
- The Policy affects the whole of Government – its reach is the delivery of all services by Government, especially those that can be delivered or supported online;
- That successful policy outcomes will depend on addressing all components of the broadband eco-system and recognize that plans need to support and strengthen both supply and demand aspects of the eco-system, as well as the absorptive capacity for social and economic change;
- That successful broadband outcomes will depend on strong leadership from the Government and the ICT sector underpinned by clear policy settings that encourage public and private sector investment;
- That regulatory and policy settings will facilitate competition and the development of new and innovative services and applications in broadband markets. In particular, it is expected that services and applications will be provided on a sustainable commercial basis to the maximum extent, and that subsidised provision will be limited to high cost, low demand environments and will be once-only or transient interventions in the market; and
- Those broadband services shall be accessible to all people and communities within Sri Lanka and that all aspects of accessibility (availability, affordability, and capacity to use) need to be addressed.

6. Short to Medium Term Policy Goals

The short to medium term horizon for the purposes of this Policy is five years. Within that five-year horizon, and through the achievement of the Strategic Implementation Plan, the following goals will be achieved during the period to 2021:

– Effective organizational arrangements will be in place to coordinate the planning of broadband infrastructure investment and rollout, and the provision of additional capacity in anticipation of demand;
– Subject to (a), clear competition policy settings will be in place for the provision of broadband services at wholesale and retail levels;
– Fixed and mobile services will be available to 100 per cent of the population of Sri Lanka – which means that all people will be within the service coverage areas of at least one fixed broadband network and of at least one mobile broadband network;
– 95 per cent of active mobile services will be connected to broadband-enabled devices designed for data operation at 3G or later generations of mobile capability;
– 2G mobile networks will have been decommissioned;
– 75 per cent of Sri Lankans will have access to fixed broadband services in their homes, at school, in community facilities, or at work;
– 95 per cent of Sri Lankan households will be have broadband access, whether mobile or fixed or both;
– Fixed broadband services will be routinely provided with planned download data rates of 100 Mbps, and mobile broadband download rates will be routinely provided with planned download data rates of 40 Mbps, by the end of the first five year period;
– Substantial local content in Sinhala and Tamil will be available online, particularly on Government portals providing for access to Government, education content, health content and agriculture services;
– 100 per cent of all primary, secondary, and tertiary education facilities will have broadband services so that teachers and students may access online educational resources; and
– 100 per cent of hospitals and health centres will be connected to broadband for remote diagnostic and supervisory support and for other e-Health applications.

7. Implementation of NBP

This initial version of the Plan covers the five calendar years from 2017 to 2021, along with a Strategic Action Plan. The Draft NBP will be published as a consultation document to obtain views from the public including the stakeholders and thereafter final NBP will be prepared. The final version of the NBP will be implemented after obtaining necessary approval from the government in 1Q17.

Viet Nam (Socialist Republic of) – Broadband strategy of Viet Nam

1. Principles of strategy implementation[130]

– Building up and developing modern, safe, high-capacity, high-speed and national wide service coverage broadband telecommunication infrastructure.
– Providing diversified broadband telecommunications services with good quality and reasonable rates according to the market mechanism.
– Modern technology: Applying the telecommunications technology which is modern, energy saving, environmentally friendly, appropriate with the general development trend in the world;

[130] Document SG1RGQ/257, "Broadband strategy of Viet Nam", Socialist Republic of Vietnam.

ensures the efficiency of network investment; meets the market demand, the interests of society; and the level of perfection of such technology is appropriate with the conditions in Vietnam.

– Efficiency of using telecommunication resources: Using effectively the telecommunication resources, frequency resources, domain names, IP internet addresses, satellite orbit resources to serve modern broadband telecommunications infrastructure and providing diversified broadband-based services with high quality and reasonable cost.

– Synchronous technology and networks: Carrying out the synchronization of technology and network (between broadband telecommunications network infrastructure and existing telecommunications networks) to increase the data download speed from 15 per cent to 50 per cent of the downstream data download speeds.

2. Specific objectives toward 2020

Broadband for community

– **Broadband for family**

At least 40 per cent of households (or individual subscribers) across the country can access to and use the fixed broadband services, in which at least 60 per cent of the subscribers are connected to the minimum downlink speed at 25Mb/s.

– **Broadband for the public telecommunications access points**

100 per cent of public telecommunications access points across the country can use the fixed broadband services in which at least 50 per cent of the points applying fixed broadband access with minimum speed downlink at 50Mb/s.

– **Broadband for public library location**

Over 99 per cent of public library points across the country can use the fixed broadband services in which at least 50 per cent of the points apply the fixed broadband access with minimum speed downlink at 50Mb/s.

– **Mobile Broadband**

Ensuring at least 95 per cent of residential areas are covered with 3G / 4G with average downlink speed at greater than 4Mb/s in urban and 2Mb/s in rural areas.

Broadband for office

– **Broadband for educational institutions**

More than 99 per cent of educational institutions have broadband connections in which at least 60 per cent of higher education institutions such as colleges, universities and institutes use broadband services with minimum downlink speeds at 1Gb/s; at least 60 per cent of general educational establishments, vocational schools, vocational training centers can access to broadband with minimum speed downlink at 50Mb/s.

– **Broadband for clinics and treatment**

More than 99 per cent of health care facilities across the country have broadband connections in which at least 20 per cent of facilities with broadband access applying minimum speed downlink at 100Mb/s; from 40 per cent to 60 per cent of connections to minimum downlink speed at 25MB/s.

– **Broadband for administrative authorities and enterprises**

- 100 per cent of agencies and units of the Party, the Government, political organizations – social and enterprises have broadband connections in which at least 30 per cent minimum downlink speed connection at 100Mb/s; from 40 per cent to 60 per cent minimum downlink speed connection at 25MB/s.

- 100 per cent of websites of the agencies and units of the Party, the Government, political organizations – social; the public administrative services portal, public professional services supports IPv4 and IPv6 Internet protocols at the same time.

3. Implementation resolution

– **Solutions on policy mechanisms and telecommunications legislation:** Keep improving the system of mechanisms, policies and regulations on licensing, tariffs, service quality, interconnections, resources, infrastructure telecommunications technology, network security, and information security in line with the development trend of broadband, technology convergence, services, intelligent applications and matching the development of Vietnam.

– **Solutions on market and services:** Creating favorable conditions for all economic sectors to participate in the telecommunications market; carrying out management under market mechanism, fair competition, transparency of policy mechanism, non-discrimination among enterprises; granting the licenses for implementing 4G mobile networks and other generations.

– **Solutions on infrastructure:** encouraging and enhancing maximum interconnection and sharing telecommunications infrastructure between telecommunication operators, using shared public infrastructure interdisciplinary; supporting telecommunication enterprises having investment capacity to build up optical fiber transmission system of international sea, land with modern technology, ensuring high capacity to meet the international connection capacity and reserve capacity towards international connection.

– **Solutions on telecommunication resources:** researching and building up mechanisms and policies to allow the re-use part or the entire band (850MHz / 900MHz/1800MHz) available to deploy mobile communication system IMT satisfying user needs of quality of mobile broadband services; Implementing digital transmission, terrestrial television broadcasting to release band 694-806 MHz; accelerating deployment of radio access technology effectively and use high frequency spectrum; Enhancing the implementation of the National Action Plan on IPv6, development and application of advanced technology, modern, efficient use of telecommunication resources on the platform next generation core networks, broadband access networks, IPv6 Internet.

– **Solutions on science and technology:** Developing investment priorities to transmission technology of wireline broadband networks, radio; organizing research and development applications serving the broadband program; promoting the development and application of technical regulations and standards, deploying high-tech applications in establishing networks and service supply; Strengthening the application of information technology in the management and exploitation of telecommunications infrastructure of broadband networks, providing a variety of services to reduce costs, improve cost and investment efficiency of the telecommunications business.

– **Solutions of organizational machine and training on human resources:** To implement the programs and projects of communication, training human resources of high quality telecommunications and ICT skills for people in rural areas lying, remote, border, and island areas.

– **Solutions on safety telecommunications infrastructure:** Construction and promulgate safety regulations on telecommunications infrastructure, particularly infrastructure next generation core network, mobile core network, backbone transmission networks, fiber-optic network the sea and the exclusive-use information systems to serve the Party and the State; Ensure national network DNS server, system traffic transit country safe operation and reliability with IPv6 addresses;

– **Resources solution:** Apply the incentives for business research and manufacture of terminal wireless broadband and wireline; use of public telecommunications services Vietnam to build broadband telecommunications infrastructure and support universal broadband telecommunications services; mobilizing development assistance funds to foreign investment in the development of broadband telecommunications infrastructure priority in rural areas, remote areas, remote areas and islands.

– **Solutions on international cooperation:** Promoting international integration in the field of telecommunications; coordinate the exchange of experience on policy development, legislation, research and development and application of broadband communications technology, management training professionals, telecommunications engineering; Facilitate the mechanisms and policies for corporations and enterprises of Vietnam telecommunications investment abroad.

4. Conclusion

Program of development of broadband telecommunications infrastructure by 2020 plays an important role in narrowing the gap in comparison with developed countries and in meeting the requirements of economic and social development in period of international economic integration and bringing many benefits of tariff and service quality to users.

Zimbabwe – Infrastructure sharing

1. Introduction

Zimbabwe has recognized the role played by infrastructure in the deployment of Telecommunication/ICT technologies and how sharing infrastructure can be a major factor in effective deployment of these technologies.[131] An inclusive consultative process has resulted in cooperation which has seen the country come up with a well-accepted regulatory framework for sharing infrastructure to reduce costly duplication of facilities, thereby reducing the cost of services and increasing access to Telecommunication/ICT services.

In carrying out their operations, these network operators have been laying or constructing their own infrastructure in a manner which has resulted in duplication if not triplication along the country's high ways linking major cities and towns. Telecommunication towers on the country's hills and other sites are often seen in threes as each of the country's mobile telecommunication operators built its own towers, while all three dug trenches alongside the country's major highways to lay their fibre optic networks.

This has meant that some of the infrastructure is underutilized while a significant part of the country does not have relevant infrastructure especially fibre optic infrastructure. In order to coordinate joint use of Infrastructure and avoid unnecessary duplication across all utility sectors, the Government through the Regulator has come up with a policy position that encourages Infrastructure Sharing. The policy is also designed to reduce the cost of service to consumers.

In pursuance of the policy, widespread consultations were embarked on, which involved telecommunication/ICT companies, electricity power companies, municipal authorities and other stakeholders as well as consumer watch groups to map the way forward.

Challenges faced during the consultations were many but resistance from some of the telecommunications operators was one of them. Resistance was based mainly on the following grounds:

– That the operators who had sunk millions of dollars into their infrastructure did not want to participate because they feared that they would not be that be able to recoup their sunk costs;

– That some operators were failing to pay interconnection fees timely and were always in arrears and would not be able to pay their counterparts the rentals for sharing infrastructure; and,

– That some operators had more infrastructure than others and sharing would benefit more those who had not spent any money on infrastructure and disadvantaged.

[131] Document SG1RGQ/230, "Infrastructure sharing as a factor influencing the effective development of wireline and wireless services, including broadband access technologies and their applications", Republic of Zimbabwe.

The consultations helped in ironing out most of these challenges resulting in a legislative drafting team made up of Legal and Technical staff from both the Regulator and the Private Sector being set up to draft relevant Regulations. The regulations were seen as a way of entrenching the agreement reached by all those who participated during the consultations so that no party would renege from the agreed position.

The regulations which cover the powers of the Telecommunications Regulatory Authority of Zimbabwe, in relation to infrastructure sharing, the procedures for requesting sharing, negotiations, agreements, infrastructure sharing charges, the rights of the parties sharing infrastructure and resolution of infrastructure sharing disputes were drafted.

The Regulations are now undergoing scrutiny by the Ministry of ICT, Postal and Courier Services for onward transmission to the Attorney General will scrutinize them further before they can be examined by Parliament and gazetted.

The process has shown that where members of a nation decide to work together for common good, even insurmountable challenges can be resolved.

Although the regulations are not operational yet Operators are already sharing some infrastructure on a willing lessor and lessee basis.

2. Conclusion

Zimbabwe's experience has shown that where there is objection to infrastructure sharing or other measures to aid effective deployment of telecommunication/ICT technologies, widespread consultation and the involvement can provide a solution which may turn out to be acceptable to all stakeholders.

It is recommended that infrastructure sharing be treated as a major strategy to achieve efficient provision of infrastructure leading to effective deployment of both wire line and wireless broadband technologies.

It is also recommended that the recommendation section of the final report takes into account the role played by infrastructure sharing in the effective deployment of broadband technologies.

Annex 2: Impact of broadband on universities and the development of innovation centers

1. Incubators

– YEKOLAB

YEKOLAB is a nonprofit organization that was established in January 2014 under the leadership of the Regulatory Agency of Post and Electronic Communication (ARPCE) and JCertif International, anxious to boost the ICT sector and promote the growth of most innovative companies.

More than an incubator Startup, YEKOLAB is a center of excellence and training in new technologies and emerging business on:

- The free certified training and Congolese experts in new technologies and emerging business;
- Incubation of the young project leaders to encourage entrepreneurship and accelerate the establishment of enterprises;
- The Laboratory dedicated to research and development through the implementation of innovative projects and open source.

Achievements – Incubation (2015-2016)

The aim is to encourage entrepreneurship through incubation and accelerating five to ten companies innovative companies, from design to marketing by way of investment research on a period of 6 to 8 months. Among other topics covered: business creation techniques, marketing, leadership, partnership and funding, coaching and growing competence of the teams.

- 200 young people trained on entrepreneurship;
- 18 events and training sessions;
- companies admitted to Yekolab Acceleration Program (example BEVOLUS Consulting, Rbtech and Elednot);
- 2 Innovative Startup during growth;
- 1 project award in the United States of America by Oracle: A Drone that obeys voice Lingala to help farmers: https://www.youtube.com/watch?v=U5WG6EyBO9Y.

Achievements – Training (2015-2016)

- 400 people trained for free in Web and Mobile applications creation techniques;
- 58 people admitted for certified training;
- 52 events and presentations organized to support application developers and young entrepreneurs;
- 7,000 people freely accessed the co-working space equipped with high-speed Internet connection via Wi-Fi for Internet searches.

YEKOLAB free offers users a modern working environment with over 875m^2 of space and all the equipment necessary for the development of major projects that includes:

- Equipped training rooms;
- A broadband Internet connection via fiber optics (4 Mbit/s);
- A power generator in case of power failure.

The slogan sums up the vision YEKOLAB "Train each participant as a potential employee or an entrepreneur".

– **BANTUHUB**

The BantuHub is a Technology Hub in Brazzaville (Republic of the Congo) that integrates the concept of co-working; it is also a Startups incubator where all the conditions are met to turn ideas into companies.

It is an initiative of the Association Bantutech to meet the problems of the self-employed in the information technology sector and communication (ICT) in Congo. Indeed, the BantuHub wants that the contractor or project owner can have access to resources to carry out its projects as a work room, a broadband Internet connection, or a library. It is also a meeting place with other freelancers and bloggers.

You should know that at present, some companies favor this form of work for the economy and flexibility but also to boost the creativity of their employees. In this case, the BantuHub conducts regular activities training/brainstorming and conferences on the theme of ICT.

Achievements – Training (2015-2016)

The following topics were discussed:

– Fight against digital illiteracy

Mainly dedicated to women. This event, held in the form of training sessions, formed opportunities for exchange between initiators and participants on Web professions, including that of Community Manager and also of web designer.

– Startup talks

The objective of this event named "Startup Talks" was to help youth create their startups by showing them the different methods to move from passion to business.

Note that their book space named "Bantuthèque" has 2,000 digital books on ICT, entrepreneurship, available to students, teachers and other self-employed.

Space African co-working BantuHub proposes an innovative ecosystem for startups to transform ideas into businesses and visionary entrepreneurs.

2. Conclusions

The impact of broadband is to look beyond the standard use of digital services by citizens, businesses and public structures.

Entrepreneurial initiatives are born in a juvenile and student community, through access to broadband, the underdeveloped countries are interested in digital innovation and entrepreneurship in the sector, which is very important in the creation of wealth by the digital and especially job creation in standard areas of development.

Annex 3: Definition of broadband

Liaison Statement from ITU-R WP4A to ITU-D SG1 Question 2/1 on definition of Broadband[132]

"Working Party 4A (WP 4A) thanks ITU-D Study Group 1, Question 2/1 for its liaison statement (Document 4A/194) on broadband access technologies, including IMT, for developing countries, and the question on the definition of the term "Broadband".

WP 4A would like to inform ITU-D Study Group 1, Question 2/1, that Report ITU-R S.2361 "Broadband access by fixed-satellite service systems" contains relevant information on the above issue, including a reference to the understanding of the term "Broadband" in the context of the Report (see the footnote on the bottom of page 1)."

Liaison Statement from ITU-R WP5D to ITU-D SG1 Question 2/1 on the definition of Broadband[133]

"WP 5D considered Doc. 5D/364, which asks to share any updates on the definition of the term 'Broadband'. Since 1985 WP 5D and its predecessor WPs have been developing IMT, which from the beginning have supported mobile broadband. In addition to the definitions[134] from Recs. ITU-T I.113, ITU-R F.1399, and ITU-R M.1801 quoted in the liaison statement, there is also Recommendation ITU-R M.1224-1 "Vocabulary of terms for International Mobile Telecommunications (IMT)", first published in 1997 and revised in 2012, which recommends these definitions for use in Recommendations and Reports related to IMT:

– "**Broadband wireless access (BWA)**: Wireless access in which the connection(s) capabilities are broadband.

– **Broadband:** Having instantaneous bandwidths greater than around 1 MHz and supporting data rates greater than about 1.5 Mb/s."

WP 5D also recognizes the Report developed by ITU-D Question 25/2, which is Access technology for broadband telecommunications including IMT, for developing countries; particularly the paragraph in its summary as follows:

"It should be noted that there are many different definitions of the term, 'broadband'. Different countries, technologies, and international agencies use different definitions of the term. In 1990, the ITU defined Broadband Wireless Access (BWA) as "Wireless access in which the connection(s) capabilities are higher than the primary rate."[2] Within ITU-D Study Group 2 Question 25/2, there were several alternative proposals for a definition of broadband. However, there was no consensus on a single proposed definition, nor was it considered within the purview of the group to undertake a new definition on the part of the ITU."

It appears that some degree of acceptance of a variety of definitions of broadband has not impeded the work of the ITU up to this point.

WP 5D appreciates ITU-D SG 1 keeping us informed on this matter and looks forward to cooperating further with ITU-D Study Group 1 Question 2/1. The next meeting of WP 5D (Meeting No. 26) will be held from 14-22 February 2017."

[132] Document SG1RGQ/259, "Liaison Statement from ITU-R WP4A to ITU-D SG1 Question 2/1 on definition of Broadband", ITU-R Study Groups – Working Party 4A.

[133] Document SG1RGQ/268, "Liaison Statement from ITU-R WP5D to ITU-D SG1 Question 2/1 on the definition of Broadband", ITU-R Study Groups – Working Party 5D.

[134] These definitions make reference to the "primary rate", which is defined in Rec. ITU-R F.1399 as "The transmission bit rate of 1 544 kbit/s (T1) or 2 048 kbit/s (E1)".

Liaison Statement from ITU-R WP5A and ITU-R WP5C to ITU-D SG1 Question 2/1 on definition of Broadband[135]

"WP 5A and WP 5C thank ITU-D Study Group 1, Question 2/1, for the question posed in Doc. 5A/175=Doc. 5C/105. Question 2/1 specifically requested that WP 5A and WP 5C provide any updates on the definition of the term 'broadband'. WP 5A and WP 5C note that Doc. 5A/175=Doc. 5C/105 already cites Recommendation ITU-R M.1801, which was developed by WP 5A. Recommendation ITU-R M.1801 was last updated in 2013 and refers to the definitions in Recommendation ITU-R F.1399, which is also the responsibility of WP 5A. It includes the following text in footnote 2:

"2 *Broadband wireless access* is defined as wireless access in which the connection(s) capabilities are higher than the *primary rate*, which is defined as the transmission bit rate of 1.544 Mbit/s (T1) or 2.048 Mbit/s (E1). *Wireless access* is defined as end-user radio connection(s) to core networks."

WP 5A and WP 5C were also copied on the reply liaison statement from WP 5D in Doc. 5A/182=Doc. 5C/109, which usefully points out that the Report developed in the previous study cycle by ITU-D Question 25/2 (Access technology for broadband telecommunications including IMT, for developing countries), included the following paragraph on this topic in its summary:

"It should be noted that there are many different definitions of the term, 'broadband'. Different countries, technologies, and international agencies use different definitions of the term.

In 1990, the ITU defined Broadband Wireless Access (BWA) as "Wireless access in which the connection(s) capabilities are higher than the primary rate." [136]Within ITU-D Study Group 2 Question 25/2, there were several alternative proposals for a definition of broadband. However, there was no consensus on a single proposed definition, nor was it considered within the purview of the group to undertake a new definition on the part of the ITU.

As WP 5D noted, it appears that there has been some degree of acceptance of a variety of definitions of the term 'broadband'; and, this lack of a revised common definition has not impeded the work of the ITU up to this point.

WP 5A and WP 5C appreciate ITU-D SG 1 keeping us informed on this matter and look forward to cooperating further with ITU-D Study Group 1 Question 2/1. The next meetings of WP 5A and WP 5C will be held from 22 May–1 June 2017."

Liaison Statement from ITU-R Coordination Committee for Vocabulary (CCV) and Standardization Committee for Vocabulary (SCV)[137]

"At the joint CCV/SCV November 2016 and January 2017 meetings, the CCV and SCV considered Documents CCV/12, 13, 15 and 18 on the definition of the term "broadband".

It was mentioned that further work is required on this issue in order to provide a more general/broad definition that encompasses not only the views of ITU-R but also those of ITU-T in order to have a single ITU definition. It was also mentioned that the term "broadband" is too general and therefore it would not be appropriate to provide a specific definition that could create some limitations on the use of the term. In that regard, it was suggested as a way forward to consider the term "broadband access" which is more specific and thus more appropriate for a definition.

The meeting further noted that it appears that there has been some degree of acceptance of a variety of definitions of the term 'broadband'; and, this lack of a revised common definition has not impeded the work of the ITU up to this point.

[135] Document SG1RGQ/283, "Liaison Statement from ITU-R WP5A and ITU-R WP5C to ITU-D SG1 Question 2/1 on definition of Broadband", ITU-R Study Groups – Working Party 5A.

[136] Recommendation ITU-R F.1399, "Vocabulary of terms for wireless access" (2001).

[137] Document 1/405, "Liaison Statement from ITU-R CCV and SCV to ITU-D SG1 Question 2/1 on the definition of broadband", ITU-R Study Groups – Coordination Committee for Vocabulary (CCV) and Standardization Committee for Vocabulary (SCV)

Given the existing similarities between the various provided definitions and/or understandings in Documents CCV/13, 15 and 18, it was finally suggested to try to combine them in a single definition for the term "broadband access".

Considering the above, one possible definition for the term "broadband access" would be:

Access in which the connection(s) capabilities support data rates greater than 2 Mbit/s.

Therefore, by this liaison statement, the CCV and SCV would like to provide the above comments and suggestions for consideration by ITU-D Study Group 1 Question 2/1 (as well as for information to ITU-R Working Parties 4A, 4B, 4C, 5A, 5B, 5C, 5D and 6A)."

Liaison Statement from ITU-R WP5D (IMT Systems) to ITU-D SG1 Question 2/1 on broadband definition[138]

"At the 26th meeting of Working Party 5D (WP 5D), Documents 5D/386, 5D/395, 5D/426 were received on the definition of the term "broadband".

WP 5D would like to thank the CCV and SCV for its information on the definition of "broadband access". As it was noted before, there has been some degree of acceptance of a variety of definitions of the term "broadband", which has not impeded the work of the ITU.

WP 5D notes that 2 Mbps is relatively low data rate relative to the speeds which can be provided with current technologies. However, as the proposed definition is a minimum value, WP 5D is in accordance with the merged single definition for the term "broadband access".

WP 5D appreciates CCV/SCV keeping us informed on this matter".

– **Broadband Commission – The State of Broadband: Broadband for all. A report by the Broadband Commission. Report 2010 and Report 2014.**

Definition of Broadband – Broadband Commission: "The Commission did not explicitly define the term "broadband" in terms of specific minimum transmission speeds because countries differ in their definitions. Recognizing that broadband is sometimes also defined in terms of a specific set of technologies, many members of the Commission found it appropriate to refer to broadband "as a network infrastructure capable of reliably delivering diverse convergent services through high-capacity access over a mix of technologies". The Commission's report therefore focuses on broadband as a cluster of concepts, such as an always-on service (not needing the user to make a new connection to a server each time), and high-capacity: able to carry lots of data per second, rather than at a particular speed".)

[138] Document 1/435, "Liaison Statement from ITU-R WP 5D to ITU-D SG1 Question 2/1 on broadband definition", ITU-R Study Groups – Working Party 5D.

Annex 4: Other ITU Sector Relevant Recommendations and Reports

Based on the request from the Question 2/1 Rapporteur Group meeting which was held on 14 April 2016, this Annex provides an overview of other ITU Sector Relevant Recommendations and Reports.[139] The references included in this Annex are taken from the Report on Implementation of Evolving Telecommunication/ICT infrastructure for Developing Countries: Technical, Economic and Policy Aspects"[140] presented by the BDT Focal Point for Q1/1.[141]

1. Mobile broadband access networks

1.1. International Mobile Telecommunication (IMT)

ITU-R Recommendation	M.1034	Requirements for the radio interface(s) for International Mobile Telecommunications-2000 (IMT-2000)	1997
ITU-R Recommendation	M.1035	Framework for the radio interface(s) and radio sub-system functionality for International Mobile Telecommunications-2000 (IMT-2000)	1994
ITU-R Recommendation	M.1036	Frequency arrangements for implementation of the terrestrial component of International Mobile Telecommunications-2000 (IMT 2000) in the bands 806-960 MHz, 1 710-2 025 MHz, 2 110-2 200 MHz and 2 500-2 690 MHz	2012
ITU-R Recommendation	M.1078	Security principles for International Mobile Telecommunications-2000 (IMT-2000)	1994
ITU-R Recommendation	M.1079	Performance and quality of service requirements for International Mobile Telecommunications-2000 (IMT-2000) access networks	2003
ITU-R Recommendation	M.1168	Framework of International Mobile Telecommunications-2000 (IMT-2000)	1995
ITU-R Recommendation	M.1225	Guidelines for evaluation of radio transmission technologies for IMT-2000	1997
ITU-R Recommendation	M.1457	Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications-2000	2013
ITU-R Recommendation	M.1579	Global circulation of IMT-2000 terrestrial terminals	2015
ITU-R Recommendation	M.1580	Generic unwanted emission characteristics of base stations using the terrestrial radio interfaces of IMT-2000	2014
ITU-R Recommendation	M.1581	Generic unwanted emission characteristics of mobile stations using the terrestrial radio interfaces of IMT-2000	2014

[139] Document 1/365, "Contribution to Annex II on 'Other ITU Sector Relevant Recommendations and Reports'", BDT Focal Point for Q1/1.

[140] Document SG1RGQ/229 + Annex "Updated Report on Implementation of Evolving Telecommunication/ICT Infrastructure for Developing Countries: Technical, Economic and Policy Aspects", BDT Focal Point for Q1/1. Document submitted in March 2016 and amended in January 2017.

[141] The complete list of ITU publications, including Recommendations and Resolutions, can be accessed through this link: http://www.itu.int/en/ITU-D/Technology/Documents/NGN/List_Chapters_ITU_Recommendations_Reports.pdf.

ITU-R Recommendation	M.1645	Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000	2013
ITU-R Recommendation	M.2012	Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications Advanced (IMT-Advanced)	2014
ITU-R Report	M.2134	Requirements related to technical performance for IMT-Advanced radio interface(s)	2008
ITU-R Recommendation	M.687	International Mobile Telecommunications-2000 (IMT-2000)	1997
ITU-R Recommendation	M.816	Framework for services supported on International Mobile Telecommunications-2000 (IMT-2000)	1997
ITU-R Recommendation	M.817	International Mobile Telecommunications-2000 (IMT-2000). Network architectures	1992
ITU-R Recommendation	M.819	International Mobile Telecommunications-2000 (IMT-2000) for developing countries	1997
ITU-T Supplement	Q.1740-Supplement	Supplement on scenarios and requirements in terms of services and deployments for IMT and IMS in developing countries	2014
ITU-T Recommendation	Q.3909	The framework and overview of NGN conformance and interoperability testing	2011
ITU-T Recommendation	Y.2011	General principles and general reference model for Next Generation Networks	2004
ITU-T Recommendation	Y.2012	Functional requirements and architecture of next generation networks	2006

1.2. Satellite component of IMT

ITU-R Recommendation	M.1850	Detailed specifications of the radio interfaces for the satellite component of International Mobile Telecommunications-2000 (IMT-2000)	2014
ITU-R Recommendation	M.2014	Global circulation of IMT-2000 satellite terminals	2012
ITU-T Recommendation	M.2014-1	Global circulation of IMT satellite terminals	2015
ITU-R Recommendation	M.2047	Detailed specifications of the satellite radio interfaces of International Mobile Telecommunications-Advanced (IMT-Advanced)	2013
ITU-R Report	M.2176	Vision and requirements for the satellite radio interface(s) of IMT-Advanced	2012
ITU-R Report	M.2279	Outcome of the evaluation, consensus building and decision of the IMT-Advanced satellite process (Steps 4 to 7), including characteristics of IMT-Advanced satellite radio interfaces	2013

1.3. IMT for 2020 and beyond

ITU-R Recommendation	M.2083	IMT Vision – “Framework and overall objectives of the future development of IMT for 2020 and beyond”	2015

ITU-R Report	M.2376	https://www.itu.int/pub/R-REP-M.2376	2015

1.4. Consideration for developing countries

ITU-R Handbook	ITU Handbook	Migration to IMT-2000 Systems- Supplement 1 (Revision 1) of the Handbook on Deployment of IMT-2000 Systems	2011
ITU-R Recommendation	M.1645	Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000	2013
ITU-R Recommendation	M.1822	Framework for services supported by IMT	2007
ITU-D SG Final Report	Q 26/2	Migration from existing networks to next-generation networks for developing countries: technical, regula-tory and policy aspect	2014
ITU-T Supplement	Q.1740-Supplement	Supplement on scenarios and requirements in terms of services and deployments for IMT and IMS in developing countries	2014

1.5. Transition to IMT

ITU-T Technical Paper	Icrease- QoE / QoS	How to increase QoS/QoE of IP-based platform(s) to regionally agreed standards	2013
ITU-D SG Final Report	ITU-D Question 18/2	ITU-D Question 18/2- Strategy for migration of mobile networks to IMT-2000 and beyond Mid-Term Guidelines (MTG) on the smooth transition of exist-ing mobile networks to IMT 2000 for developing countries	2002
ITU-T Handbook	ITU-T – Handbook – Converging networks	Converging networks	2010
ITU-T Handbook	ITU-T Handbook – Future Networks	Future Networks	2012
ITU-T Technical Paper	ITU-T Technical Paper M2M	Impacts of M2M communications and non-M2M mobile data applications on mobile networks	2012
ITU-D SG Final Report	Q 18-1/2	Implementation aspects of IMT 2000 and infor-mation-sharing on systems beyond IMT 2000 for developing countries: Supplement to GST	2010
ITU-D SG Final Report	Q 26/2	Migration from existing networks to next-generation networks for developing countries: technical, regula-tory and policy aspect	2014
ITU-T Technical Paper	Tech paper-Multiple Radio Access	Multiple radio access technologies	2012
ITU-T Technical Paper	Tech paper Sensors	Applications of Wireless Sensor Networks in Next Generation Networks	2014

ITU-D Guidelines	Transition IMT (GST)	Guidelines on the smooth transition of existing mobile networks to IMT-2000 for developing countries (GST)	2006
ITU-D Guidelines	Transition IMT (MTG)	ITU-D Question 18/2- Strategy for migration of mobile networks to IMT-2000 and beyond Mid-Term Guidelines (MTG) on the smooth transition of existing mobile networks to IMT 2000 for developing countries	2002

2. Fixed broadband access networks

2.1. Overview

ITU-T Supplement	G Suppl. 50	Overview of digital subscriber line Recommendations	2011

2.3 Hybrid fiber/copper networks

ITU-T Recommendation	J.295	Functional requirements for a hybrid cable set top box	2012
ITU-T Recommendation	L.47	Access Facilities using hybrid fibre/copper networks	2000

2.4 Fixed-Mobile convergence general requirements

ITU-T Recommendation	H.323 v7	Packet-based multimedia communications systems	2009
ITU-T Recommendation	Q.1741.1	IMT-2000 references to release 1999 of GSM evolved UMTS core network with UTRAN access network	2002
ITU-T Recommendation	Q.1741.2	IMT-2000 references to release 4 of GSM evolved UMTS core network with UTRAN access network	2002
ITU-T Recommendation	Q.1741.3	IMT-2000 references to release 5 of GSM evolved UMTS core network	2003
ITU-T Recommendation	Q.1741.4	IMT-2000 references to release 6 of GSM evolved UMTS core network	2005
ITU-T Recommendation	Q.1741.5	IMT-2000 references to Release 7 of GSM-evolved UMTS core network	2008
ITU-T Recommendation	Q.1741.6	IMT-2000 references to Release 8 of GSM-evolved UMTS core network	2009
ITU-T Recommendation	Q.1741.7	IMT-2000 references to Release 9 of GSM-evolved UMTS core network	2011
ITU-T Recommendation	Q.1741.8	IMT-2000 references to Release 10 of GSM-evolved UMTS core network	2013
ITU-T Recommendation	Q.1742.1	IMT-2000 references to ANSI-41 evolved core network with cdma2000 access network	2002
ITU-T Recommendation	Q.1742.10	IMT-2000 references (approved as of 31 December 2011) to ANSI-41 evolved core network with cdma2000 access network	2013
ITU-T Recommendation	Q.1742.11	IMT 2000 references (approved as of 31 December 2012) to ANSI-41 evolved core network with cdma2000 access network	2014

ITU-T Recommendation	Q.1742.2	IMT-2000 references (approved as of 11 July 2002) to ANSI-41 evolved core network with cdma2000 access network	2003
ITU-T Recommendation	Q.1742.3	IMT-2000 references (approved as of 30 June 2003) to ANSI-41 evolved core network with cdma2000 access network	2004
ITU-T Recommendation	Q.1742.4	IMT-2000 references (approved as of 30 June 2004) to ANSI-41 evolved core network with cdma2000 access network	2005
ITU-T Recommendation	Q.1742.5	IMT-2000 references (approved as of 31 December 2005) to ANSI-41 evolved core network with cdma2000 access network	2006
ITU-T Recommendation	Q.1742.6	IMT-2000 references (approved as of 31 December 2006) to ANSI-41 evolved core network with cdma2000 access network	2007
ITU-T Recommendation	Q.1742.7	IMT 2000 References (approved as of 30 June 2008) to ANSI-41 evolved Core Network with cdma2000 Access Network	2007
ITU-T Recommendation	Q.1742.8	IMT-2000 references (approved as of 31 January 2010) to ANSI-41 evolved core network with cdma2000 access network	2008
ITU-T Recommendation	Q.1742.9	IMT-2000 references (approved as of 31 December 2010) to ANSI-41 evolved core network with cdma2000 access network	2011
ITU-T Recommendation	Q.1762/Y. 2802	Fixed-mobile convergence general requirements	2007
ITU-T Recommendation	Y.2001	General Overview of NGN	2004

2.5 Required capabilities for broadband access for Fixed Mobile Convergence

ITU-T Recommendation	Q.1762/Y. 2802	Fixed-mobile convergence general requirements	2007
ITU-T Recommendation	Q.1763/Y. 2803	FMC service using legacy PSTN or ISDN as the fixed access network for mobile network users	2007
ITU-T Recommendation	Y.2808	Fixed mobile convergence with a common IMS session control domain	2009

2.6 Considerations for using legacy PSTN and ISDN

ITU-T Recommendation	Q.1763/Y. 2803	FMC service using legacy PSTN or ISDN as the fixed access network for mobile network users	2007
ITU-T Recommendation - Series	Y.2600-Series	ITU-T Recommendation Series Y. 2600Packet-based Networks	2006

3. Broadband access for rural applications

3.1. Challenges for telecommunications/ICT/broadband development in rural and remote areas

ITU-D Recommendation	D.20	Policy and regulatory initiatives for developing telecommunications/ICTs/broadband in rural and remote areas https://www.itu.int/rec/D-REC-D.20/	2014
ITU-D Recommendation	D.19	Telecommunication for rural and remote areas https://www.itu.int/rec/D-REC-D.19/	2010
ITU-D SG Final Report	Focus Group 7	New Technologies for Rural Applications, Final Report of ITU-D Focus Group 7	2000
ITU-D SG Final Report	Q10-2/2	Telecommunications for rural and remote areas Final Report http://www.itu.int/pub/D STG-SG02.10.2-2010	2010
ITU-D SG Final Report	Q10-3/2	Telecommunications/ICTs for rural and remote areas http://www.itu.int/pub/D- STG-SG02.10.3-2014	2014
ITU-D SG Terms of Reference	Q5/1	Terms of Reference http://www.itu.int/net4/ITU-D/CDS/sg/rgqlist.asp?lg=1&sp=2014&rgq=D14-SG01-RGQ05.1&stg=1	2014

3.2. ITU-D Study Group Case Study Library

ITU-D Study Group Case Library	Study Group Case Study Library	ITU-D Study Group Case Study Library http://www.itu.int/en/ITU-D/Study-Groups/Pages/case-study-library.aspx	2015 – on-going

4. Core networks

4.1. Overview

ITU-D SG Final Report	Q 26/2	Migration from existing networks to next-generation networks for developing countries: technical, regulatory and policy aspect	2014
ITU-T Recommendation	Q.1740 Series	IMT-2000 references of core and access networks	2002-
ITU-T Recommendation	Y.2012	Functional requirements and architecture of next generation networks	2006

4.2. Required capabilities for core networks

ITU-D SG Final Report	Q 26/2	Migration from existing networks to next-generation networks for developing countries: technical, regulatory and policy aspect	2014
ITU-T Recommendation	Y.2001	General Overview of NGN	2004
ITU-T Recommendation	Y.2007	NGN capability set 2	2010

4.3. Technology and deployment of core networks

ITU-R Recommendation	M.1645	Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000	2013

ITU-R Report	M.2114	Key technical and operational characteristics for access technologies to support IP applications over land mobile systems	2007
ITU-D SG Final Report	Q 26/2	Migration from existing networks to next-generation networks for developing countries: technical, regulatory and policy aspect	2014
ITU-T Recommendation	Q.1703	Service and network capabilities framework of network aspects for systems beyond IMT-2000	2004
ITU-T Recommendation	Q.1706/Y. 2801	Mobility management requirements for NGN	2006
ITU-T Recommendation	Y.1001	IP framework- A framework for convergence of telecommunication networks and IP network technologies	2000
ITU-T Recommendation	Y.2001	General Overview of NGN	2004
ITU-T Recommendation	Y.2012	Functional requirements and architecture of next generation networks	2006
ITU-T Recommendation	Y.2021	IMS for Next Generation Networks	2010
ITU-T Series	Y.2050	Series on IPv6-Based Next-generation Networks	2008-
ITU-T Recommendation	Y.2051	General overview of IPv6-based NGN.	2008

4.4. NGN interoperability testing

ITU-D SG Final Report	Q 26/2	Migration from existing networks to next-generation networks for developing countries: technical, regulatory and policy aspect	2014

5. Home networks

5.1. Overview

ITU-T Recommendation	G.9971	Requirements of transport functions in IP home networks	2010

5.2. Required capabilities for core networks (Y.2001)

ITU-T Recommendation	Y.2064	Energy saving using smart objects in home networks	2014
ITU-T Recommendation	Y.2070	Requirements and architecture of the home energy management system and home network services	2015
ITU-T Recommendation	Y.2291	Architectural overview of next generation home networks	2011

5.3. Architectural overview of next generation home networks

ITU-T Recommendation	Y.2291	Architectural overview of next generation home networks	2011

6. Network operation and management

6.1. Overview

ITU-T Recommendation	M.3400	TMN management functions	2000

6.2. Required capabilities for next generation home networks

ITU-T Recommendation	M.3060/Y. 2401	Principles for the Management of Next Generation Networks	2006

6.3. Management, architectures and technology

ITU-T Recommendation	M.3060/Y. 2401	Principles for the Management of Next Generation Networks	2006

6.4. Accounting, charging and billing

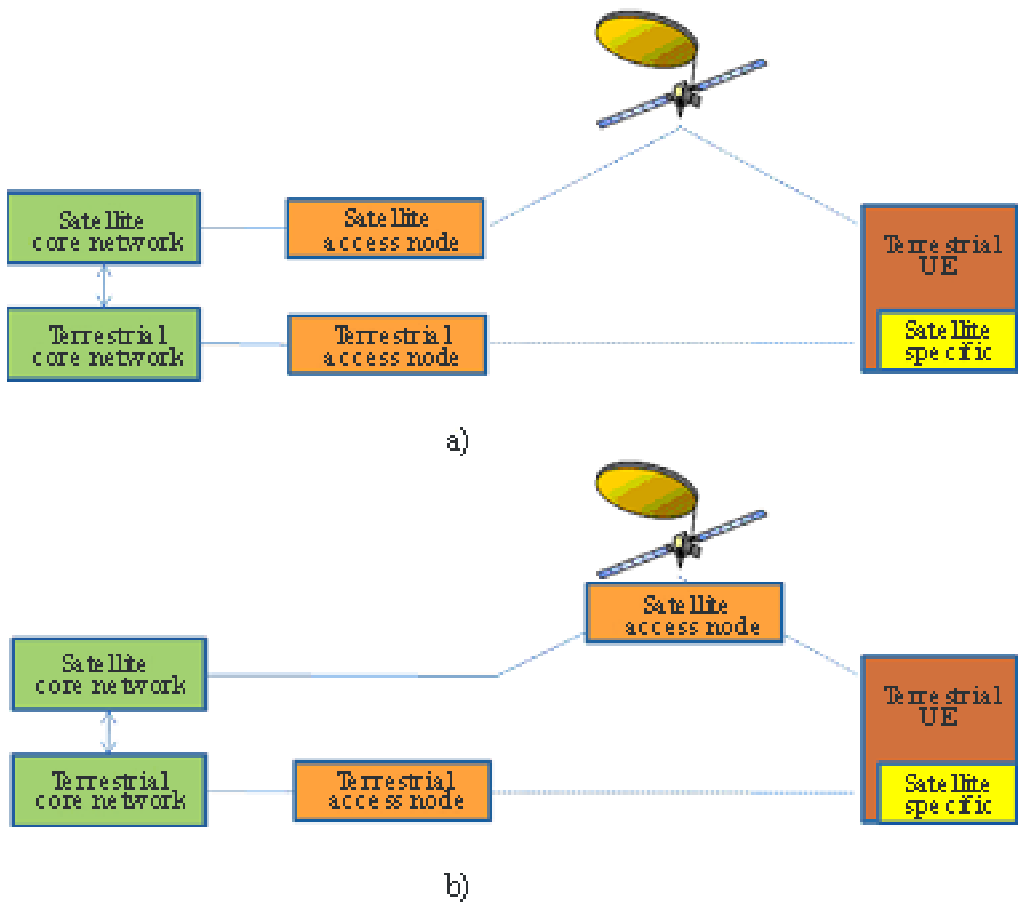
ITU-T Recommendation	Y.2012	Functional requirements and architecture of next generation networks	2006

7. Additional documentation from ITU-T Study Group 15

Additional documentation on activities and Recommendations of ITU-T Study Group 15 as Lead Study Group on Access Networks concerning the latest version of the Access Network Transport (ANT), Smart Grid and Home Network Transport (HNT) Standards Overviews and Work Plans can be found in the Liaison Statement SG1RGQ/260.

Annex 5: Information on satellite component of IMT-Advanced

Figure 11A: Concept for integrated system



Radio interface aspects

The objective of the integrated IMT-Advanced system is to use, as far as possible, the same equipment and protocols, i.e. the same hardware, software and facilities for both satellite and terrestrial components of IMT-Advanced to minimize costs.

In particular, the satellite radio interface of IMT-Advanced should be compatible, and may have a high degree of commonality with, a terrestrial radio interface.

As the candidate terrestrial radio interfaces of IMT-Advanced, 3GPP LTE-Advanced and IEEE WirelessMAN-Advanced (IEEE Std 802.16m) radio interfaces have been chosen. The technology of both radio interfaces is the Orthogonal Frequency-Division Multiplexing (OFDM) and Multiple-Input and Multiple-Output (MIMO). In general, the combined use of OFDM and MIMO will improve the spectral efficiency and capacity of the wireless network.

In addition, some advanced technologies considered in the terrestrial component can be applied to the satellite component as follows:

– Multi-hop relay which is introduced to enable traffic/signaling forwarding between a satellite and user equipment;

– Spectrum aggregation where two or more component carriers are aggregated in order to support higher data rates via wider bandwidth;

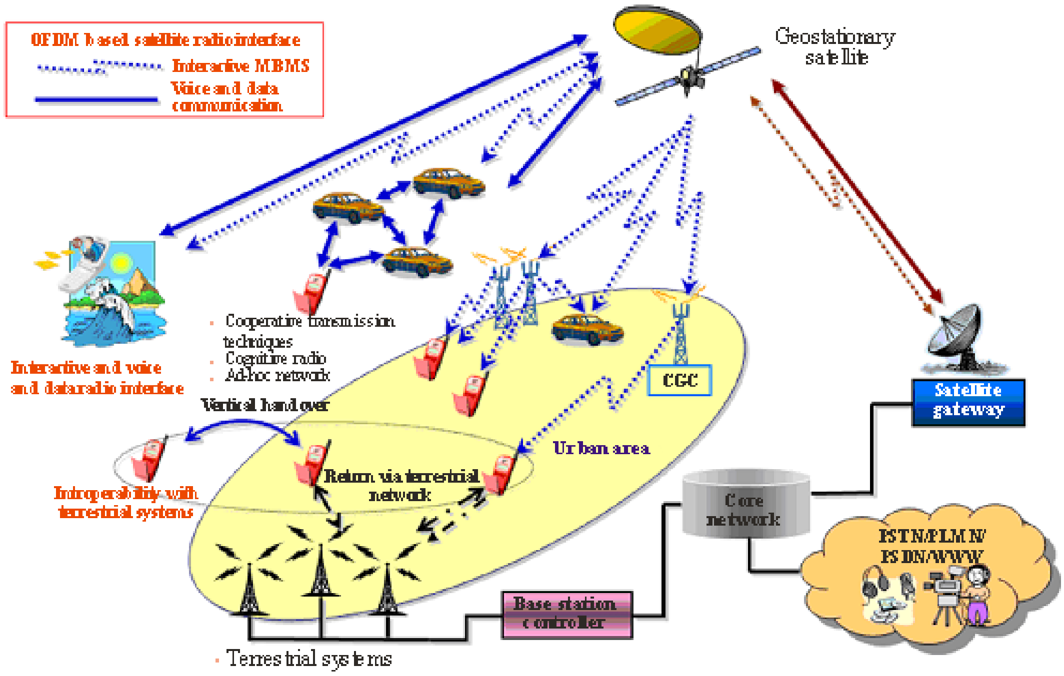
– Support of scalable bandwidth wherein a satellite can support a plurality of maximum bandwidths and flexibly allocate bandwidths to user equipment from the maximum bandwidths;
– MIMO techniques in forward and return links from multi-satellites, and use of dual polarization;
– Network MIMO in which antennas from neighbouring beams can be combined to transmit multiple streams to beam-edge users in order to minimize inter-beam interference;
– Inter-beam interference management including inter-beam interference cancellation, interference avoidance and interference coordination techniques in order to increase beam-edge throughput;
– Self-organizing/optimizing network which can automatically extend, change, configure and optimize the network coverage, capacity, beam size, topology, and frequency allocation and bandwidth.

Possible system architectures for the satellite component of IMT-Advanced

Figure 5 describes an overall system architecture for the system concept under consideration. The following factors can be considered:

– Satellite component: It will provide services and applications similar to those of the terrestrial component beyond terrestrial and CGC coverage.
– CGCs: In order to provide mobile satellite broadcasting/multicasting services, they can be deployed in areas where satellite reception is difficult, especially in urban areas.
– Terrestrial component: The satellite component can cover regions beyond terrestrial coverage. The areas not adequately covered by the terrestrial component include physically isolated regions, gaps in the terrestrial network coverage and areas where the terrestrial infrastructure is permanently, or temporarily, destroyed in the event of a disaster. In order to provide the terrestrial fill-in service, vertical handover of the satellite component with terrestrial component is considered one of the most important techniques.
– Advanced technologies: the following "IMT-Advanced enabling technologies" can be considered in enhancing the cost-effectiveness and competitiveness of the satellite component.
    - Horizontal integration of services and networks on personal mobile devices via Software Defined Radio (SDR) technology.
    - Optimized communication techniques (MIMO, MUD, turbo detection, HARQ, ACM, pre-equalization, IPv6).
    - Introduction of new concepts and techniques for increased coverage, data speeds and spectral efficiencies, such as ad-hoc networking, cooperative MIMO and relaying, cognitive radio techniques for dynamic spectral sharing.

Figure 12A: System architecture for the satellite component of IMT-Advanced (Rep M2176-02)



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ISBN 978-92-61-22601-5

9 789261 226015

Printed in Switzerland
Geneva, 2017

07/2017