最后报告

ITU–D
第1研究组

第2/1号课题
发展中国家的宽带接入技术（包括国际移动通信（IMT））

第6研究期
2014-2017年

联系我们

网站： www.itu.int/ITU-D/study-groups
国际电联电子书店： www.itu.int/pub/D-STG/
电子邮件： devsg@itu.int
电话： +41 22 730 5999

第2/1号课题： 发展中国家的宽带接入技术（包括国际移动通信（IMT））

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前言

国际电联电信发展部门（ITU-D）研究组提供一种文稿驱动工作的中立平台，政府、行业和学术界的专家在此聚集，制定实用的工具和导则并开发资源来解决发展问题。ITU-D成员通过ITU-D研究组的工作，研究和分析以任务为导向的具体电信/ICT课题，从而加快各国发展优先工作的进展。

研究组为所有ITU-D成员提供机会来交流经验、提出想法、交换意见，并就研究处理电信/ICT优先工作的适当战略达成共识。ITU-D研究组负责根据成员提交的输入意见或文稿来制定报告、导则和建议书。国际电联通过调查、文稿和案例研究收集的信息利用内容管理和网络发布工具公开提供，以方便成员的轻松访问。研究组的工作与ITU-D不同计划和举措相关联，以发挥协同作用，使成员在资源和专业知识上受益。与在相关议题领域开展工作的其他群体和组织进行协作至关重要。

ITU-D研究组的研究课题由四年一届的世界电信发展大会（WTDC）决定，每届WTDC为界定下一个四年的电信/ICT发展问题和优先工作制定工作计划和导则。

ITU-D第1研究组的工作范围是研究**“发展电信/ICT的有利环境”**，ITU-D第2研究组则是研究**“ICT应用、网络安全、应急通信和适应气候变化”**。

在2014-2017年研究期，由以下人员指导**ITU-D第1研究组**的工作：主席McElvane Webber（美利坚合众国）和代表六个区域的副主席：Regina Fleur Assoumou-Bessou（科特迪瓦）、Peter Ngwan Mbengie（喀麦隆）、Claymir Carozza Rodriguez（委内瑞拉）、Victor Martinez（巴拉圭）、Wesam Al-Ramadeen（约旦）、Ahmed Abdel Aziz Gad（埃及）、Yasuhiko Kawasumi（日本）、Nguyen Quy Quyen（越南）、Vadym Kaptur（乌克兰）、Almaz Tilenbaev（吉尔吉斯共和国）和Blanca Gonzalez（西班牙）。

最后报告

针对**第2/1号课题：“发展中国家的宽带接入技术（包括国际移动通信（IMT））”**的最终报告在报告人Luc Missidimbazi（刚果共和国）的领导下制定，参与工作的还有5位副报告人：Philip Kelley（阿尔卡特-朗讯国际，法国）、Tharalika Livera（斯里兰卡）、Turhan Muluk（因特尔公司，美利坚合众国）、Laboni Patnaik（美利坚合众国）和Yuki Umezawa（日本）。ITU-D联系人和ITU-D研究组秘书处也协助他们开展工作。

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引言

2014年世界电信发展大会（WTDC）为研究发展中国家特别关注的电信问题，包括国际电联《公约》第211款提及的问题，保留了两个ITU-D研究组。ITU-D研究组应严格遵守《公约》第214、215、215A和215B款。为方便工作，该研究组为研究具体课题或课题的某些部分成立了工作组、报告人组和联合报告人组。

成立ITU-D第1研究组的目的在于向发展中国家展示了解各类可用宽带接入技术的基本要素，这些宽带接入将有线和地面技术用于包括国际移动通信（IMT）在内的地面与卫星通信。ITU-D第1研究组应继续解决部署宽带接入技术过程中出现的技术问题，包括将这些接入网解决方案融入当前和未来的基础设施，为发展宽带接入制定导则，同时还要考虑到宽带接入技术的标准化工作是国际电信联盟（ITU）战略规划的工作重点之一，及对发展中国家的举措进行跟踪（依据世界电信发展大会六次区域筹备会议（RPM）的建议）。

致力于为发展中国家研究包括国际移动通信（IMT）在内的宽带接入技术的第2/1号课题被要求研究如下问题：

- 确定影响有线和无线（包括卫星）宽带接入技术及其应用有效部署的因素；
- 研究宽带接入技术及其未来发展趋势；
- 确定宽带技术过渡规划与实施方法，同时酌情考虑现有网络；
- 考虑不同宽带接入技术趋势、部署、提供的服务和监管方面的考虑；
- 继续确定利用地面链路和卫星链路实施IMT的方法和手段；
- 确定需研究的关键因素，以推动结合了卫星和IMT地面系统的可能部署；
- 提供部署各种宽带接入技术对服务欠缺人群（包括残疾人）具体影响的信息；
- 根据ITU-R第5研究组5D工作组和ITU-R第4研究组各工作组的建议，提供有关IMT-Advanced系统的信息。

第2/1号课题最后报告的内容包括 (i) 分析影响有效部署各种宽带接入技术的因素；和(ii) 制定宽带接入技术部署导则，包括依据国际电联电信发展局相关项目举办培训研讨会。工作方法包括：呼吁相关方提交文稿、召开小组会议、对文稿进行处理、编辑各类报告以及通过电信发展局建立的电子平台实施文件管理。

输入意见来源：

- ITU-R和ITU-T研究组在此领域的技术进步取得的成果，特别是ITU-R第5研究组5D和5A工作组、第4研究组的4A、4B和4C工作组以及ITU-T第15研究组（第1/15号课题）和第13研究组（第15/13号课题）；

- 国际电联有关宽带接入技术的出版物、报告和建议书；
- 发展中国家和发达国家国内或区域性组织起草的相关报告；
- 发达国家和发展中国家有关部署相关网络经验的文稿；
- 部门成员有关发展有线、无线宽带接入技术（包括通过卫星系统接入）的文稿；
- 服务提供商和源设备制造商提出的相关文稿；
- 电信发展局牵头人就宽带和各类宽带接入技术提交的文稿和信息；
- 涉及信息通信技术应用的研究课题的成果和信息。

鉴于上述输入意见来源，本报告总结了下述领域工作取得的成果：

- 分析影响有效部署各种宽带接入技术的因素；和
- 制定宽带接入技术部署导则，该导则可通过依据相关电信发展局项目举办的培训研讨会提供；

此项工作主要可归纳为四点：

- 在考虑到以往研究成果的基础上审议此问题；
- 以电信发展部门成员提交并在ITU-D研究组会议上讨论的若干文稿为依托，对现状加以分析；
- 审议技术发展和部署的模式；
- 审议有利于宽带发展的建议、分析委员会和工作组收到的文件、开展的交流和进行的辩论。

1 第1章 – 一般性问题

宽带的定义

首先，有必要了解什么是“宽带”，因为ITU-R、ITU-T、宽带委员会和其它机构的定义不同且无法就统一的定义达成共识。然而，迄今为止没有修订后的统一定义并未给国际电联的工作造成困扰。有些定义更倾向于界定应支持的业务而不是特定的数据速率。见**附件3**。

全球连通举措[1]

– 当今世界，公民和企业对互联网的获取和使用已成为发展的基本组成部分 – 这与公路、港口、电力和其它基础设施类似。

– 世界有百分之六十的人口无法接入互联网。44亿公民尚无法享受到另外32亿上网人口享有的经济和社会效益。

– 互联网是21世纪的主要经济推动因素之一，如今我们正亲眼目睹互联网的经济效益逐步向发展中国家转移。总体而言，互联网经济在发达国家市场平均约占GDP的6%左右；这一数字在发展中国家市场较低；据估算，这些经济体每年互联网经济的增速在15%至25%。此外，发展中国家宽带普及率每增长10%，GDP便会增加1.4%。

有鉴于此，美国国务院发起了全球连通举措，以促进并支持包括政府、产业、民间团体和技术团体在内的关键利益攸关方采取行动，帮助实现到2020年使上网人口再增加15亿。在此举措之下，各伙伴国或利益攸关方应为实现上述目标竭尽所能，从基础设施技术、优良的监管做法、金融或技术支持等方面贡献力量。[2]

应注意到将卫星手段作为普遍服务和其它面向发展服务的替代手段的考虑[3]。

为实现发展目标，美国在发展可全球接入的电信业务方面义不容辞的义务–包括采纳互联网协议和以国家规划的形式采用宽带部署政策，以便通过同一平台提供话音、视频和数据业务–使其选择了可为非洲大陆大量人口提供接入的卫星解决方案，迄今为止这些人口获取电信服务仅存在理论上的希望。

尽管美国、非洲电信联盟、国际电信联盟和非政府组织为此付出了努力，但在农村和偏远地区、小发展中国家和岛屿社区，获取上述服务仍然存在问题。

近年来，我们看到卫星运营商对参与电信服务竞争表现出了明确且积极的意愿，提出了大量建议，特别是在远程医疗或电子教学平台领域（学习管理系统（LMS））。

此新趋势对美国的关切做出了响应，该国在电信/ICT方面的战略雄心是通过电信网络为众多缀学者提供高品质的远程教育；远程专家服务、远程诊断服务或远程咨询服务；为无法接入银行设施者提供移动金融服务。

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1 1/384号文件，全球连通举措，美国。

2 同上。

3 1/313号文件，“考虑将卫星手段作为普遍服务和其它面向发展服务的替代手段”，（塞内加尔共和国）。

运营商们所提方案和建议属性加以考察后，我们认为卫星解决方案可作为备选。

在一些国家，监管框架仍是启动此类涵盖传输和接入网（回传、前传和接入网）方案的羁绊。此情况对提供普遍服务产生了掣肘效应，使众多发展中国家很难提供普遍服务。

电信卫星运营商将从其提供的成本导向型服务中获益，该服务旨在从以农村和偏远地区有资格使用普遍电信服务发展基金（FDSUT）客户为目标的高速变化的生态系统中获取市场份额。

为继续强化技术中立的原则，并深入考察卫星运营商提供的可作为向存在接入问题地区提供服务备选方案的业务，政府机构和监管部门必须把注意力转向法律框架的审核。

1.1 影响有线和无线宽带接入技术及应用有效部署的因素

这方面存在的各种因素大致可分为两类[4]：

实体因素

a) 移动普及率

尽管许多发达国家的移动业务普及率已超越了100%，但大多数发展中国家尚未达到此水平。此问题在这些国家的农村和偏远地区十分严重。移动业务普及是宽带部署的基本平台，因为它可提供必要的基础设施，并为增强此类部署的可行性划拨资源。

b) 手机生态系统

手机生态系统可促进宽带技术的部署，因为它激励运营商部署宽带。支持不同频段的不同IMT技术是一项关键因素，因为这将为促进部署提供必要的需求因素。

c) 地理条件

地理条件影响有线通信系统的部署，它使部署要面对困难的地形和不断变化的条件。不过，无线部署也可能会受到影响，其原因在于为应对地形条件方面的挑战，需要部署更多基站。

例如[5]，作为中国较偏远的一个西部省份，四川拥有4万余村庄和少数民族地区。中国历史上“最后一个普及程控电话”的普格县的居民却自2015年起享受到了100M的光纤宽带。这巨大的变迁，缘于四川提出的“宽带乡村”建设模式。中国四川的“宽带乡村”创新建设模式，通过规划引领、技术创新、分区域成片开发，解决了运营成本高和用户发展慢难题。政府扶持和企业合作缓解了与农村光网投资有关的主要问题；IPTV已证明是解决四川某些城乡一体化问题的优秀典范，因为它提供了解决农村应用难题的智慧途径。

[4] 1/262号文件，斯里兰卡民主社会主义共和国。

[5] 1/206号文件，农村宽带创新模式 – 创建农村光网新时代，中华人民共和国。

这些创新，一定程度上破解了农村地区宽带接入与发展的现实难题，开创了农村“光网新时代”，很好地实现了企业、用户和社会三者利益的和谐统一，该模式作为农村地区的一个现实实施范例值得推广。

d) 频谱限制

鉴于有限频谱资源的用户众多，特别是在无线领域，因此无线宽带接入技术和应用的频谱可用性已成为宽带部署的瓶颈。制定在国际电联《无线电规则》中为IMT确定的频段内腾出频谱的战略，是成功发展和部署宽带的关键。

社会和政策因素

下述因素以限制互联网普及率和/或与宽带有关的产品的方式，从需求抑制的角度对宽带部署产生了影响。

a) 内容认知

由于网上内容大多使用英语、西班牙语和中文普通话，因此缺乏这些语言的知识和本地内容缺失，再加上互联网是此类部署的主要推动因素，使宽带部署遭受到打击。

b) ICT素养

ICT素养和数字技能的文化属性，从多个角度对宽带产品的成功普及产生了影响。与发达国家相比，发展中国家缺乏ICT素养，这反过来也成为成功推广互联网服务的瓶颈。

c) 政策指令

宽带数字路线图接入技术为成功普及提供了框架，并为实施不同的卫星、有线和无线接入机制提供了一种协作方式。因此，宽带技术的成功部署应考虑到上述因素，并为缓解因上述因素造成的瓶颈提供必要的激励手段。

从斯里兰卡的经验[6]可以看出，目前正在开展的多项行动均可作为社会和政策因素影响的示例。“电子斯里兰卡”希望将斯里兰卡政府变为与人民联系最为紧密的政府，提升全体公民的生活品质，使他们能够享受更好的公共服务、学习机会与更高质量的信息。斯里兰卡的100,000多位听力和视觉受损者，将受益于“残障扶助项目”，该项目通过一套新的、使用本地语言的无障碍获取应用推出了“数字有声读物”。在斯里兰卡各地通过拨打电话短码接入政府信息中心以获取所需信息，是“电子斯里兰卡”实施的另一项目。这两个项目均获得了2009年的世界峰会奖（WSA），该奖项是为选择和推广世界最佳电子内容与应用的全球性举措。斯里兰卡落实的设想之一是创建一个电子社会，为农民、学生和小企业家们打通获取信息、进行学习和使用交易设施的渠道。开展此行动是通过分布于全国各地的名为Nenaselas（Nena=知识+ selas=商店）的远程/知识中心实施，就近为众多从未见过计算机[7]的人们提供计算机技术、互联网和IT技能培训。

固定和移动运营商与教育部和斯里兰卡电信监管委员会（TRCSL）携手，利用高速4G LTE和遍布全岛的光纤网络，实现了首都科伦坡及其郊区主要学校的ICT实验室联网。此举措将利用信息高速公路，为学生接受教育提供无缝的互联网接入。一些教育内容的

6 SG1RGQ/138号文件，“斯里兰卡的宽带”斯里兰卡民主社会主义共和国。

7 http://www.icta.lk。

门户网站亦是在电信运营商的赞助下运营。一个名为Guru.lk的此类门户网站将教育内容分为三大类：学校教育、职业教育和生活方式教育。“Guru学校”涵盖了约60%的学校课程，其中“职业”部分涉及职业教育（例如：银行业考试的课程），而“生活方式”部分包括了美容、烹饪、瑜伽等课程。

1.2 各种宽带接入技术对服务欠缺人群（包括残疾人）的影响

正如**第1.1节**重点阐述的那样，实体和社会因素均会对宽带技术的成功部署造成影响，通过观察不难发现此类部署会产生如下影响。

a) 消除知识和教育获取方面的差距

与发达国家相比，发展中国家在获取教育资源和知识共享方面存在较大差距。宽带发展以通过部署的宽带技术提供虚拟资源接入的方式为发展中国家消除这种差距提供了一个平台。

b) 生活水平

了解他国的信息，使发展中国家人民能够通过接受教育或模仿发达国家树立的模样来提高生活水平。宽带发展令社区各阶层能平等地获得参与发展的机会并从中受益。

c) 数字民主

在宽带层面运作的平台不仅能够分享内容与设想，同时还能让普通公民就政府和非政府活动的开展发表自己的看法和意见。基于用户的媒体内容拓展已使民主超越了数字领域，利用宽带接入技术的发展为公民赋能。

d) 包容

数字包容和金融包容是需要发展中国家关注的多项包容中的两类，可利用宽带技术的合理发展实现。根据上文的解释，宽带部署为开发和运行能够弥合发达国家与发展中国家[8]差距的应用奠定了根基。

eMisr是埃及国家宽带计划，旨在向全国普及宽带服务。[9]eMisr分为两个阶段，第一阶段将于2018年结束，第二阶段于2020年结束。宽带计划的核心战略目标是建设覆盖全国的一流电信基础设施、创造直接/间接就业机会、通过最新的ICT平台提高政府机构效率、以及利用宽带网络通过创新ICT应用改善居民生活。因此，eMisr计划为满足埃及的宽带服务需求提出了不同的战略方针。为此，“eMisr”旨在将宽带服务拓展到整个埃及，包括欠服务的地区。

与埃及类似，在卢旺达宽带接入已成为打破发展壁垒、彻底改变服务提供方式的巨大力量[10]。它还将带来生产力的提高、便利知识的获取，为卢旺达人民打造更美好的未来。

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8 1/262号文件，斯里兰卡民主社会主义共和国。

9 SG1RGQ/63号文件，“‘eMisr’国家宽带规划：从规划向执行的过渡”，阿拉伯埃及共和国。

10 1/165号文件，“卢旺达的宽带接入”，卢旺达共和国。

卢旺达全国分为四个省，共四层结构：30个地区、416个部门、2 148个单元、14 837个村庄，卢旺达政府制定该政策旨在推动宽带接入水平，使宽带能够接入从地区到部门、单元和村庄的各低层级管理实体，以便为整个国家的所有公民提供平等享用宽带服务的机会。

1.3 宽带对大学和创新中心发展产生的影响

刚果的电信基础设施经历了大发展，有效推动了各专业团体、社会和公民使用宽带[11]。该计划过去两年间在大学和培训中心开展了多个项目，其创建的创新中心和技术孵化器使许多年轻人能够利用大学或社区宽带开发项目，大大促进了ICT的使用以及高级培训中心计划的发展。

我们将通过本文稿向大家展示电信基础设施的部署给学生们提供的条件以及新推出的技术举措为青年人提供的宽带服务。

刚果的宽带发展

刚果在全国境内启动了一项覆盖广泛的基础设施部署计划。此项部署为在大学发起相关项目，创建孵化器提供了良机。得到监管机构（邮政和电子通信监管局）支持的这些计划，旨在为青年人展示专业设想提供空间。

因此，宽带支持并实现了：

- 打造一个技术创新中心并为大学提供服务；
- 在Yekolab和BantuHub建立两个孵化器；
- 与大学一起落实远程教育计划。

大学在电信业务中的创新计划

邮政和电子通信监管局（ARPCE）发起的大学在电信业务中的创新计划（PUITS）通过中非骨干网（CAB）项目实施，该项目由世界银行及监管机构邮政和电子通信监管局出资。该项目的目标是改善Marien NGOUABI大学（UMNG），特别是国家高等理工学院教师和学生的工作环境；并促进学术届与企业界的交流。

除学术活动之外，该平台还举办了各类其它活动以及部分有关认识的培训，即：

- 2015年1月：做好准备请1年级和和2年级的研究生学员发微博，为参加协会组织的PRATIC最佳微博竞赛；
- 2015年2月：介绍由该大学教育负责人组成的“互联网五人（5）小组”；及
- 2015年3月：ARPCE举办的有关域名系统安全扩展（DNSSEC）的教育和培训研讨会。

此外，这项计划允许研究人员、教师和学生通过宽带，免费在工作中使用互联网。

[11] 1/266号文件，“宽带对大学和创新中心发展的影响”，刚果共和国。

1.4 ICT用于教育 – 宽带接入技术

为涵盖宽带应在教育中发挥作用的基础领域，可对宽带在教育中发挥的作用下一个宽泛的定义。

a) 内容获取

无论是对实体领域还是对基于宽带技术的虚拟领域而言，获取恰当的内容均是一个重大瓶颈。此类内容既包括课本，也涉及导师等内容提供商。

b) 资源获取

资源的获取是一个需要重点考虑并妥善处理的问题。尽管宽带为建立共享教育和ICT知识的门户提供了一个平台，但诸如计算机、笔记本和记事本电脑等用于传播内容的适当终端设备也必不可少。

c) 包容性

内容创造与资源分配有助于实现包容并缩小发达国家与发展中国家的差距。“ICT用于教育”的主要考虑是要聚焦于各类需求提出的要求和可交付的程度，这些需求大致可分为以下几类：

- 中小学教育；
- 职业教育；以及
- 高等教育。

对发展中国家而言，若要在已部署的宽带技术基础之上成功提供教育平台，本地内容方面的需求将是关键。但必需仔细分析教育行业提出的特殊要求，因为这些因素或许对于成功部署教育平台至关重要。为在宽带接入部署过程中合理地将ICT用于教育，需为规划下载带宽和延迟等属性提供帮助。

目前已为提高利用现有技术发挥信息社会潜能的认识，推出了各类举措。“高通无线连通”（Qualcomm Wireless Reach）发起了多个计划，例如火炉跟踪计划（StoveTrace program）展示了移动电话如何能够帮助个人和社区实现经济、健康和环境目标[12]。低成本的设备和免费应用让孤立的社区能够获取信息并与世界各地人接触。另一个示例是无线心脏健康计划（Wireless Heart Health program）（2011年）与生命呵护网（Life Care Networks）[13]协作，为中国农村社区的心血管疾病（CVD）防治和管理提供支持。无线心脏健康计划的对象为农村医生与患者。此系统包含配备有三个内置心电图（ECG）传感器的智能手机，以及一个能够立即访问患者病历（包括ECG数据）的电子健康档案平台。

d) 宽带接入技术

不同的宽带接入技术[14]可适用于“ICT用于教育”的情况（地面无线、光纤、有线、卫星等）。与发达国家相比，发展中国家的固定宽带接入技术并未充分开发，因此无线

[12] SG1RGQ/374号文件，“印度火炉跟踪案例研究”，高通公司（美国）。
[13] SG1RGQ/376号文件，“无线心脏健康：中国案例研究”，（高通公司（美国）。
[14] 1/176号文件，“ICT用于教育-宽带接入技术”，英特尔公司（美国）。

技术发挥着重要的作用。可用度、适当性和成本是决定互联网采用何种接入方法的关键因素。如果没有固定技术，学校可采用替代性的地面无线宽带技术。在为边远和人烟稀少地区提供服务方面，卫星宽带也可发挥作用。如果学校已有电话线路，可采用数字用户线路（DSL）服务，在不增加任何基础设施投资（除了配备一个DSL调制解调器）的情况下即可使用。其他固定宽带可选方案包括同轴电缆或光纤连接，但是在许多发展中国家这些方案并不可用，或者价格无法承受。

在将ICT用于教育时，很多国家正在用宽带接入技术连通学校和其他教育机构。各国的国情不尽相同，但最重要的一个步骤是制定将ICT用于教育的国家规划以及用宽带连通所有学校的规划。在数据速率方面，或许有着具体的可衡量目标，如5年内以10 Mbps速率，10年内以50 Mbps速率连通所有学校。例如，美国的“ConnectED举措”[15]（奥巴马总统将所有学校接入数字时代的规划）制定了以不低于100 Mbps的速率且以1Gbps的目标速率连通所有学校的目标。南非的“全国宽带政策”[16]确定了2016年前以10 Mbps的速率连通50%学校。2020年前以100 Mbps的速率连通80%学校，2030年前以1Gbps的速率连通所有学校的目标。

各国采用光纤宽带接入连通所有学校和其他教育机构是最理想的方案，但发展中国家在国家层面实现光纤的可用性将耗时多年。因此，制定一个逐步过渡的规划将是有益的。边远农村地区需要采用卫星技术也是一个事实。数据速率决定采用何种宽带接入技术。学生众多的大型城区学校需要的带宽大于农村小型学校。城市和农村地区可以采用的宽带接入类型也存在差异。在初始阶段，如果无法采用光纤技术，可使用现有的xDSL、无线和卫星技术连通学校。带宽的不足也将限制远程教育等部分教育应用的使用。

移动教育（m-learning）是电子教育（ICT用于教育）的一个重要部分，且移动宽带接入技术为在校外任意时间开展教育提供了机遇。现今，3G和4G网络已经在用且IMT-2020 （5G）[17]也将在移动教育方面发挥重要作用。发展中国家移动宽带接入网络的广泛普及也是一个重要的有利因素。

制定国家层面的宽带接入路线图，以评估各地区的现有技术并据此制定规划，为教育系统提供宽带连接，这一点也很重要。

越来越多地采用视频流和互动在线培训需要更大的容量和更高的数据速率。此外，班级中可能包括很多学生且多个班级可能同时开课，导致大量用户在同一时刻要求获得带宽。因此，学校需要高速宽带连接。

我们也需要WLAN宽带接入技术，将宽带分配至不同的教室以及可能位于校区内任意地点的每个学生/老师的互联网设备（平板电脑等）上。WLAN技术和标准也在不断发展，以提供更大的容量和更高的速率（IEEE 802.11ac、IEEE 802.11ad等）。IEEE 802.11ac工作在5 GHz，IEEE 802.11ad工作在60 GHz且两者均提供高达7 Gbps的数据速率。根据“连通学校，连通社区”举措，不仅仅是学生，位于校区中的社区也可在学校连接到宽带，这也会增加对更大容量并采用WLAN新宽带接入技术进行分配的需求。许多大学也在利用WLAN接入技术向学生和教学人员提供免费的Wi-Fi服务。

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[15] 奥巴马总统将所有学校接入数字时代的规划：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 指国际电联的5G标准化工作。

2 第2章 – 宽带接入技术

2.1 宽带接入技术及未来趋势

高质量的连接的特性可通过下述参数描述：[18,19]

– 高速 – 网络必须以高速率传送数据。

– 低延时 – 网络延时必须尽量小。

– 高容量 – 网络必须可满足用户需求“数量”的数据。

– 高可靠性 – 网络宕机的次数要少。

– 经济且可扩容 – 网络的部署、维护必须具有高成本效益，且

– 可随着宽带需求的增长而升级。

2.1.1 部署方面的考虑：有线与无线

随着无线技术在全球通信基础设施中所占的比例越来越高，了解整体宽带发展趋势以及有线和无线技术之间的作用是非常重要的。有线和无线技术有时相互竞争，但在大多数情况下它们互为补充。通常情况下，无线网络的回程传输和核心基础设施是基于有线方法（光纤或铜）实现的。这可以如同适用蜂窝网络一样适用于Wi-Fi网络。[20,21]

移动电话在全球范围内的巨大成功，以及目前日益增长的移动数据使用，展示了对于移动通信的强烈需求。例如GSMA移动智库预计2014-2019年间全球移动数据业务将增长10倍，其主要推动力源自视频点播[22]年增66%的预期。但是，利用无线技术接入的问题更为复杂。[23]

GSMA移动智库2016年报告亦指出2015年移动业务的增长主要集中在发展中国家：预计到2020年，10亿新增移动用户中有超过90%以上将来自发展中国家市场。到2020年全球智能手机用户将增加260万，其中仍有90%左右的增长来自发展区域。

根据设备、配置和距离的不同，网速度差异很大，有些低于1 Mbps有些则超过了1 Gbps。许多专家认为4G LTE的运行接近了频谱效率的理论限值。

在没有更多频谱或具备在现有频谱基础上大幅提速的能力之前，无线运营商通过搭建更多光纤回传塔来满足客户的宽带需求。

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18 1/188号文件，高通公司（美国）。

19 另见ITU-D 2010-2014年研究期的Q25/2号报告。

20 第2.1.1节的案文主要摘自LMH手册第5卷有关BWA系统（RGQ25/2/2号文件“发给ITU-D第2研究组（抄送5A工作组）的联络函：《IMT-2000系统的部署手册-向IMT系统的过渡》补遗1的修订”，ITU-R研究组5D工作组）的部分并进行了一些编辑性修改。

21 另见ITU-D 2010-2014年研究期Q25/2号报告的第22页。

22 “移动经济”；GSMA智库，2015年，和“移动经济”；GSMA智库，2016年。

23 更多详细信息请参见ITU-D 2010-2014年研究期Q25/2号报告。

多个因素会影响无线网络宽带的质量，但这些因素不会给宽带网络造成影响。具体而言，频谱的匮乏同时会造成速度和容量限制。除气象之外，地形等障碍亦会造成无线信号衰减，从而限制网络的可用性并降低可靠性。最后，网速是用户数量以及用户与无线通信塔间距离的函数。这些因素阻碍了以经济的方式通过扩容提升无线技术的宽带网速。

使用2G、3G、4G技术的不同移动网络将在未来很长一段时间内，同时为同一国家提供移动业务[24]。此外，各个网络需要使用自己的频段为现有用户提供最佳服务，根据覆盖范围和所需业务类型的不同（话音或数据），这些用户会在网络间切换。年复一年，移动技术在不断演进以提供更高的数据传输速率，但不幸的是蜂窝站点的数量增长的速率未能跟上数据传输发展的步伐，造成了不良的QoS体验。为解决此问题，可能要求增加蜂窝站点的数量，但解决此问题最重要的方法是增加可用于提高新LTE技术数据管理效率的频率的数量。

第一和第二代无线网络主要提供话音业务，而3G和4G的重点转移到了数据和移动宽带。尽管IMT-2020将继续侧重于提供移动宽带，但预计其将支持更多样化的使用方案。IMT-2020可为发达国家和发展中国家提供新的应用与服务。有些5G应用对发展中国家而言可能重要性更大，例如智能交通系统、电子卫生、教育、智能电网和农业等。

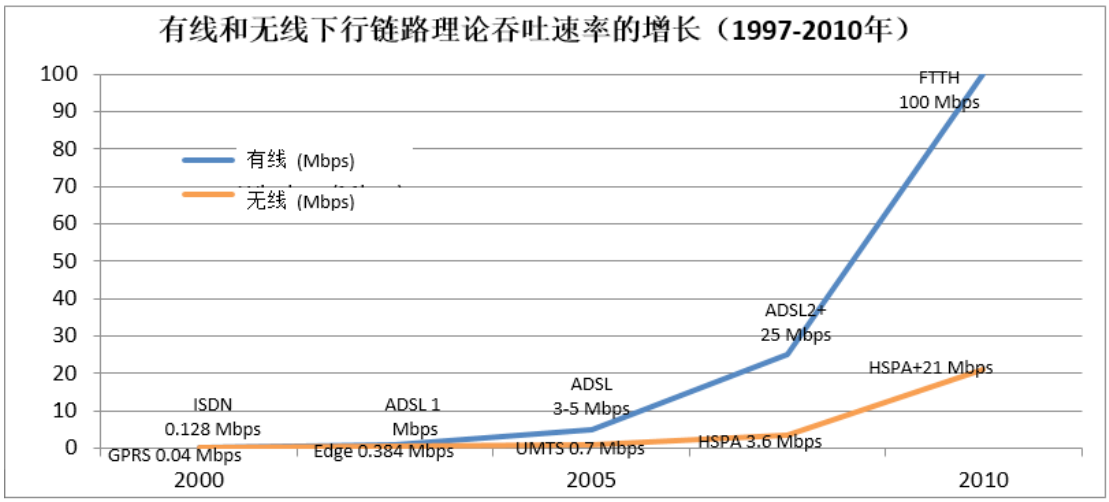
客户端设备的过渡（接入设备）通常会具有挑战性 – 主要源于经济原因以及用支持下一代宽带技术的产品更换客户自有设备时的情感因素。[25]现有网络向NGN过渡是从“基于TDM的网络”向“基于IP的网络”的转换。考虑到“接入网域”与“核心网域”之间的网络归属比例，应在以上两者之一首先启用过渡程序。业界普遍认为“核心网域”的过渡比“接入网域”简单，因为前者对服务提供的影响小于后者。渐近式向NGN迁移的方式可能包括核心网的更新（含路由器和交换机的替换），第二阶段是引入IP多媒体核心网子系统（IMS）或类似的多媒体业务，然后迁移至IP传输网络层，最后实现本地环路和用户层的现代化更新。但这些改变中有许多都具有串连的关系。

必须考虑到无线技术和有线方法在性能和容量方面的比较，有线基础设施可能已提供的功能，以及有线技术的持续发展。尤其是，有线网络一直具有更大的容量，长期以来提供更快的吞吐率。**图1**显示了2000-2010年间典型用户吞吐率的发展，其中有线技术与无线技术相比始终占据优势。

[24] 基于1/189号文件，“移动宽带网络的演进-起草报告的素材”，Telefon AB - LM Ericsson（瑞典）和1/359号文件“5G对于发展中国家的重要性”，英特尔公司（美国）。

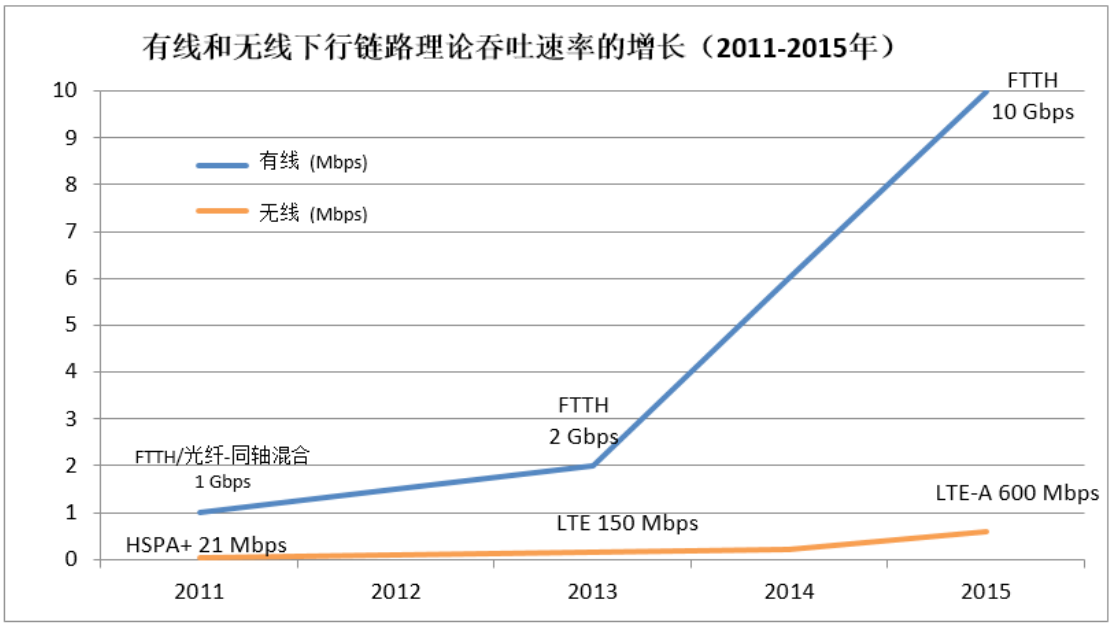
[25] SG1RGQ/90号文件，“尼泊尔制定下一代网络（NGN）的监管框架”，尼泊尔共和国电信管理局（NTA）。

图1：有线和无线下行链路理论吞吐速率的增长（1997-2010年）



如**图2**所示，2010年以来，有线技术仍然保持着对无线数据在速率上的优势，一家提供商于2014年12月开始提供10 Gbps的吉比特有线互联网业务。[26] 如今已有30多个国家提供商用LTE-Advanced，其带宽达到600 Mbps，传输速度接近1 Gbps[27]。

图2：有线和无线下行链路理论吞吐速率的增长（2011-2015年）



在当今世界，海底电缆已成为经济生活与社会架构的基本要素–是连接互联网的国际通道。作为核心通信基础设施，海底电缆承载着98%以上的国际互联网服务、数据、

[26] 美国互联网，光纤入户–家庭用户的规划与价格，见http://fiber.usinternet.com/plans-and-prices/plans-for-the-home/。

[27] 爱立信，爱立信和高通公司通过特斯拉现场展示了LTE第11类智能手机体验，2015年2月26日，见http://www.ericsson.com/thecompany/press/releases/2015/02/1897731；Frank Rayal，增加对3.5 GHz的投资：LTE-Advance实现了1 Gbps，2014年6月22日，见http://frankrayal.com/2014/06/22/raising-the-stakes-in-3-5-ghz-lte-advanced-achieves-1-gbps/。

视频和电话业务[28]。与海底电缆相比，卫星在国际通信方面相形见绌，无论在可靠性、速率、业务量和成本低廉问题上海底电缆均无人能敌。[29]

虽然大多数宽带无线接入（BWA）系统目前正提供约5 Mbit/s的吞吐量 – 这与许多用户使用的基本DSL或电缆调制解调器业务相似--无线系统的整体容量普遍低于有线系统。[30]当无线技术与一些运营商正在部署的光纤入户相比时，这一点尤为明显。随着有线运营商希望通过下一代电缆调制解调器业务、甚高速数字用户线（VDSL）或光纤向用户家庭或企业提供200 Mbit/s到1 Gbit/s的传输速率 – 尤其是4K和8K超高清晰度视频服务 – 新的问题是，是否可能使用无线方法来匹配这些速率？[31]从纯粹的技术角度来看，答案是“是”；但从实际的角度来看，却是“否”。只有通过使用大量频谱（通常多于目前的宽带无线接入系统可用的频谱）用户数量有限、规模相对较小的小区才能达到上述速率。否则，根本不可能每月提供数百吉比特字节，且用户使用广域无线网络的宽带连接很快就可消耗掉这些字节—特别是在用户对视频内容愈发感兴趣的情况下。考虑到今天3840 x 2160像素的4k超高清晰度电视，其内容需要15至25 Mbit/s的持续连接，这意味一个用户可以基本上可消耗掉一个小区扇区的全部容量。[32]即便移动用户不观看完整的高清电影，许多应用也很快将使用视频，其中包括教育、社交、视频会议和远程医疗[33]。但是，鉴于无线网络更为有限的容量，许多移动运营商启用了下载限制或其它工具来防止网络拥塞。

解决这类高数据消耗的一种可行的无线方法是小区分级法，如毫微微（Femto）小区。但这一方法的先决条件是当前已存在有线互联网连接（如DSL）。[34]

有一些无线设备支持的新宽带接入技术，通过动态频谱接入（DSA）使用认知无线电系统（CRS）技术来确定可用的频率。一些国家正在进行这些技术的商业部署和试验，在当地监管机构的允许下，在未经使用的电视频段（“电视空白频谱”）使用这些技术。

ITU-R的几个研究组正在对这种技术解决方案展开研究。评估这种方案实施尤其在发展中国家所涉及的技术、经济学和监管层面时，将有必要结合其他相关研究，考虑研究组的研究结果。

蜂窝移动宽带技术明确针对用户需求以及他们的成功。蜂窝移动宽带的发展路线图中对持续的性能和能力提高做出了预测，并提供了实现行之有效的商业模式的技术手

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28 SG1RGQ/314号文件，Submarine cables in Africa，（Orange（法国））。

29 另见ITU-D 2010-2014年研究期Q25/2号报告的第22页。

30 WiMax论坛常见问题，见http://www.wimaxforum.org/FAQRetrieve.aspx?ID=62698。

31 宽带委员会，2014年的宽带状况：面向全体人民的宽带，第17页（2014年9月）图3，见http://www.broadbandcommission.org/documents/reports/bb-annualreport2014.pdf。

32 国际电联，超高清电视：新时代的门槛，国际电联既定UHDTV标准的建议书，见http://www.itu.int/net/pressoffice/press_releases/2012/31.aspx#.VZwqPM9VhBc；索尼，索尼4K超高清电视是否支持4K流节目？2015年2月23日，见https://us.en.kb.sony.com/app/answers/detail/a_id/45145/c/65,66/kw/internet%20speed%20for%204k；Comcast，超高清（HD）抽样应用的常见问题，2015年3月6日，见http://customer.xfinity.com/help-and-support/cable-tv/uhd-smart-tv；Netflix，关于互联网连接速度的建议书，见https://help.netflix.com/en/node/306。

33 http://4gamericas.org，超越LTE：支持移动宽带的爆炸性发展，2014年8月13日，见http://www.4gamericas.org/files/7514/1021/4070/Beyond_LTE_Enabling_Mobile_Broadband_Explosion_August_2014x.pdf。

34 有关Femtocells的更多信息见ITU-D 2010-2014年研究期的Q25/2号报告。

段。随着移动宽带的应用领域不断拓展，蜂窝技术将继续为今后的新商业机会提供一个具有竞争力的平台。[35]

预计向IMT-2020的过渡将提供更高数据速率（1-20 Gbps），降低延迟，支持物联网（IoT）所需的容量、新业务模型和身临其境的用户体验。[36]

IMT-2020也是一种更快更高效的无线连接，但当前5G亦涉及计算能力。三种主要的使用方案包括：(1) 高级移动宽带；(2) 超高可靠性和低延迟通信；以及 (3) 大量机器类通信。

2.1.2 对比，移动宽带和固定接入网

为广泛对比无线宽带和固定接入网技术，从技术和金融角度，请参考“为发展中国家部署不断演进的电信/ICT基础设施的报告：技术、经济与政策问题”。[37]

2.1.3 无线宽带接入技术

在ITU-T内部，第5、9、13、15和16等不同研究组正在就接入网的传输-室内网-开展研究并起草建议书。此外，ITU-R和其它标准组织、论坛和联盟亦积极地参与了此领域的工作，且第15研究组被指定为负责家庭网络协调工作的牵头研究组。[38]

该组继续挑战以铜缆为主的“最后一英里”（交换点和客户端之间的距离）中存在的网络容量上限。VDSL2矢量达到了250Mbit/s的接入速度，DSL的下一次更新（G.fast）将通过结合光纤网络和DSL的优势，把速度提高到1Gbit/s。

第15研究组还制定光纤到户（FTTH）接入共享接入技术的标准，该技术又称为无源光纤网络（PON）。PON是实现全光纤网络的关键步骤。而且通过消除对昂贵的有源网络元素的依赖，PON帮助运营商实现了大笔节约。10G级无源光纤网络（XG-PON）是ITU-T最新的PON系列标准，它实现了最高可达10Gbit/s的接入速度。

根据为GII开发的方案技术，现已为ANT开发了七种方案：

1) 通过现有基础设施提供话音/数据视频服务；

2) 使用B-ISDN通过有线网络提供话音/数据视频服务；

3) 使用ADSL或VDSL通过铜线提供视频/数据带宽；

4) 光纤接入方案；

5) 无线接入；

6) 使用卫星接入；

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[35] BWA系统的LMH手册第5卷（25/2/4号文件）。

[36] SG1RGQ/359号文件，“5G对于发展中国家的重要性”，英特尔公司（美国）。

[37] SG1RGQ/229号文件，“有关为发展中国家部署不断演进的电信/ICT基础设施的报告：技术、经济与政策问题的最新报告”电信发展局第1/1号课题牵头人，2017年1月；“有关为发展中国家部署不断演进的电信/ICT基础设施的报告：技术、经济与政策问题的完整报告”，2016年。

[38] 摘自ITU-T SG/15出版物：“无线宽带接入网和家庭联网”http://www.itu.int/pub/T-ITU-HOME-2011。

7) 互联网接入示例；

8) 电力线传输（PLT）。

上述方案用作涉及ANT标准的相关性参考，可用以快速检索具体应用（XNI、CATV等）。**表1**展示了七种方案的分析，其分析的角度包括：1) 服务、2) 核心网、3) 接入网、4) 客户所在地的网络，以及5) 信息流。粗线内下画线的特性指出了与其它方案不同的特性。

从此表中可以明显看出，将方案1至6区分开来的主要属性为接入网的传输技术，即有线电视（方案1和2）、ADSL/HDSL、光纤、无线电和卫星。在方案1a) 中，DSB和地面广播亦作为一种视频传播方案包括在内。

方案1和2的不同之处在于，前者的核心网使用现有基础设施，即PSTN/N-ISDN（窄带-ISDN），而后者的核心网为B-ISDN。

方案7展示的是互联网接入，与提供话音/数据和视频的其它方案有些不同。

作为牵头研究组，ITU-T SG15公布并定期充实和完善接入网传输（ANT）、智能电网和家庭网络传输（HNT）标准的概述及工作计划文件，其中包括对已有和现行标准化工作的概述，为国际电联和其它标准制定组织（SDO）未来的发展提出设想。更多细节，请参见**附件4**。

有线宽带网络 – ISDN

综合业务数字网（ISDN）是人们在构建完全数字化电话/电信网络方面的尝试（不同于在模拟交换电路上使用调制解调器）。

1988年，ITU-T I.121建议书发布，该建议书阐述增强型ISDN业务（通过实现多个64 kb/s信道的多路复用并使用异步传送模式（ATM）管理来实现）。此建议书的修订版本于1991年出版，对综合业务数字网（B-ISDN）宽带方面的基础原则加以阐述，并指出了ISDN网络能力未来的发展方向。尽管ISDN在若干领域找到了专门应用，如视频会议和音频记录，但从来未被作为消费宽带接入技术，只有一时间ISDN信道数量达到过2500万的德国是个明显的例外。ISDN的部署不断萎缩[39]。网速为128 kb/s的ISDN如今已被更快、安装价格更低的技术所取代[40]。目前，ISDN主要由无线电台和录音室所用。在美国，Verizon宣布2013年将在该国东北部停止接受ISDN业务的订单[41、42]。

有线宽带网络 – DSL

[39] Leslie Stimson，Verizon的ISDN将于五月做出调整，无线电世界（2013年4月），http://www.radioworld.com/article/expect-verizon-isdn-changes-in-may/219126。

[40] ISDN录音软件的未来，音频概念（2014年6月），http://hearaudioconcepts.com/the-future-isdn-recording。

[41] Thomas Ray，Verizon自5月18日起在东北地区不再接受ISDN业务订单（2013年3月），http://www.talkers.com/2013/03/28/verizon-no-longer-taking-orders-for-isdn-service-in-northeast-starting-may-18/。

[42] 更多信息参见ITU-D 2010-2014年研究期Q25/2号报告第27页。

表1：接入网传输（ANT）方案

	方案1	方案2	方案3	方案4	方案5	方案6	方案7
业务	a) 通过电信网络传输话音/数据和 b) 通过有线、无线和DSB传输视频 c) 通过双向电缆传输话音/数据/视频	a) 通过电信网络传输话音/数据和通过电缆传播视频 b) 通过双向电缆传输话音/数据/视频	通过ADSL/VDSL传输话音/数据和视频	通过光纤网络传输话音/数据和视频	a) 通过电信网络传输无线电话话音/数据和通过电缆传播视频 b) 通过无线电传输 话音/数据/视频 c) DAB和DVB	通过卫星传输 B-ISDN、互联网和移动电话	a) 通过互联网传输数据 b) 通过互联网传输话音/视频
核心网	现有基础设施（PSTN/N-ISDN） 或 NGN（Y-2012建议书）	B-ISDN 或 NGN（Y-2012建议书）	B-ISDN 或 NGN（Y-2012建议书）	B-ISDN 或 NGN（Y-2012建议书）	N-ISDN 或 B-ISDN 或 NGN（Y-2012建议书）	B-ISDN 或 现有（N-ISDN） 或 NGN（Y-2012建议书）	a) POTS/FR/ATM b) ATM骨干网 或 NGN（Y-2012建议书）
接入网	a) 单向有线分配网 b) 双向有线分配网 c) 1 a)中的c) DSB/地面广播		ADSL/VDSL	光纤（光纤到路边/户）	用于话音/数据的无线电/无线 a)视频使用有线	卫星	a) ADSL/VDSL b) PSTN/ISDN、HFC、PON C) 固定无线接入
CPN	接入单元，电视、个人计算机、电话		接入单元 电视、个人计算机、电话	接入单元 电视、个人计算机、电话	接入单元 电视、个人计算机、电话、无线电话	接入单元 电视、个人计算机、电话	接入单元 电视、个人计算机、电话
信息流	a) 通过单向电缆网络分配视频，通过PSTN/ISDN返回				双向无线	双向卫星	

注：在方案8中，一旦详细情况可知，应立即添加电力线传输（PLT）。缩略语（例如ADSL、VDSL）总体而言是指一系列相关应用，而非某特定标准。

ISDN未被作为有线宽带接入技术采纳的原因有几个，包括标准制定工作推迟，未能赶上视频和互动应用的发展步伐，消费解决方案复杂，以及网络运营商的营销有限。然而，对于ISDN部署的致命打击是作为有线宽带技术的数字用户线路（DSL – 最初称作“数字用户环路”）的急速发展和商业化。[43]ITU-T自二十世纪90年后期代便开始发布DSL标准。这些标准的摘要请参见Q25/2号报告（ITU-D 2010-2014年研究期）表3.3-1，该表中还包括了电话调制解调器、ISDN标准和新通过的G.fast标准（G.9701）。

G.fast是一份ITU-T SG15起草的建议书，该建议书开展的研究旨在满足客户对比特率不断增长的数据业务、高速互联网接入和其它创新型业务的需求。

有线宽带网络 – DOCSIS

1997年，经有线业务接口的数据规范（DOCSIS）发布。该规范将高速数据通信增加到现有CATV系统中。MSO采用DOCSIS在其视频网络上提供竞争性数据通信，且随着互联网协议语音（VoIP）的发展，还提供与POTS类似的业务。最新版本标准–DOCSIS 3.1–将网络到终端的8个信道绑定，支持MSO采用该技术向用户提供高达10 Gbit/s的接入速率[44,45]。

有线宽带网络 – FTTx

光纤有线宽带网可有若干不同配置，如，光纤到户（FTTH）、光纤到大楼（FTTB）、光纤到路边（FTTC）、光纤到节点（FTTN）和光纤到案头（FTTD）。在上述各种情况中，光纤网络都在光网络单元（ONU，也称作光网络终端或ONT）上得到终接。

不同FTTx版本由ONU所处地点区分。FTTH中的ONU位于用户所在地，是运营商与客户设施之间的界限。FTTB和FTTC的ONU则是若干用户的共同接口（如，公寓楼的地下室或电话线杆），服务经客户现有TWP分支电缆（drop cables）提供。FTTN的ONU则置于在用网络节点上，为数十到数百用户提供服务（服务通过现有TWP本地环路提供）。

FTTx拥有两种常见架构：“点到点”（PtP）和无源光网络（PON）。在PtP配置中，企业局域网（LAN）被用于电话接入网，并在ONU至电话机之间进行专门光纤连接（一根或两根光纤）。PON网络是一种接入住户网络架构的点到多点光纤，其中使用Brewster角度原理的不加电光分支器使单条光纤能够为多处地址提供服务，通常为32至128个，若干ONU –最多256个，近端用户– 分享网络的单光纤连接，其分支点通常在无源网络节点处[46]。PON包含位于服务提供商中心局（CO）处的光线终端（OLT）以及一批光网络单元（ONU）近端用户。与点对点架构相比，PON配置减少了所需的光纤和CO设备数量[47]。

吉比特无源光网络（GPON）和以太网无源光网络（EPON）这两项标准为厂商和运营商获取新机遇打开了大门。主要厂商已在其宽带接入产品中增加了PON技术，世

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[43] 更多信息参见ITU-D 2010-2014年研究期Q25/2号报告第27-29页。

[44] 有线业务实验室，通过有线传输数据的业务接口规范，DOCSIS 3.1，MAC和上层协议规范，49页，见http://www.cablelabs.com/wp-content/uploads/specdocs/CM-SP-MULPIv3.1-I06-150611.pdf和https://community.cablelabs.com/wiki/plugins/servlet/cablelabs/alfresco/download?id=d38ef93a-df24-45ae-bc2c-40ad16e61c8d;1.0。

[45] 关于DOCSIS的更多信息，见ITU-D 2010-2014年研究期Q25/2号报告第29页。

[46] ITU-T，ITU-T G.989.1建议书，具备40吉比特能力的无源光网络（NG-PON2）：一般性要求，第12页。

[47] ITU-T，ITU-T G.989.1建议书，具备40吉比特能力的无源光网络（NG-PON2）：一般性要求，第11页。

界各地的运营商对与VDSL（光纤到机柜，FTTC）或住宅接入（光纤入户，FTTH）共同应用此技术显示出了浓厚的兴趣。三项主要PON标准为宽带PON（BPON）、GPON和EPON。BPON及其后续GPON是厂商和运营商成立的一个委员会，FSAN发起拟定的ITU-T建议书。EPON是IEEE第一英里以太网（EFM）举措推出的一种IEEE方案。鉴于运营商正在通过FSAN推动GPON的标准化，GPON标准比EPON更能反映运营商的需求。尽管三种系统使用同一原理工作，但它们之间存在若干差异，见**表2**。

表2：主要PON技术和属性

特性	EPON	BPON	GPON	XG-PON	NG-PON2
标准	IEEE 802.3ah	ITU-T G.983	ITU-T G.984	ITU-T G.987	ITU-T G989
协议	以太网	ATM	以太网、TDM		
速率（Mbps）	1250下行/1250上行，8b10b-编码	622下行，155上行	2488下行，1244上行	10 Gbps（下行）	40 Gbps（下行）
跨度（公里）	10	20	20		
分割率	16	32	64		

当今部署的大多数PON系统为基于TDM的PON系统（即B-PON、E-PON和G-PON）。他们几乎全部在单条光纤上工作，使用WDM提供双向传输。下行流的第三条波长有时用于广播视频业务。另一方面，WDM-PON的部署十分有限。与TDM-PON相比，提供专门面向大众市场波长服务的WDM-PON的成本仍然较高。未来，WDM和混合WDM-PON预计将在下一代PON系统中发挥更大作用。

自20世纪90年代起，ITU-T一直在制定有关FTTx的标准，具体反映在ITU-T G.98x系列建议书中 – 本地和接入网的光线路系统。主要ITU-T FTTx标准的摘要见Q25/2号报告（ITU-D 2010-2014年研究期）第30页的表格，补充标准见下表：[48]

ITU-T G.989.x	具备40吉比特能力的无源光网络（NG-PON2）*
*国际电联，传输系统和媒介，数字系统与网络；ITU-T G.989.1、ITU-T G.989.2，见：https://www.itu.int/rec/T-REC-G/en。	

家庭联网

随着家庭宽带有线网络性能的增强，人们对家庭网络的性能也有了更高的期望。在家庭网络中，单个设备能力大为改善。

除非家庭网络可使用现有实体网络（例如，家庭电网、电话或同轴电缆网络），否则建设有线家庭网络对任何家庭而言都价格不菲，亦得不到社会共鸣。

为解决这一问题，ITU-T近期已开始起草ITU-T G.99xx系列建议书。用作家庭网络标准的ITU-T建议书请参见Q25/2号报告第31页中的表格（ITU-D 2010-2014年研究期），其补充标准如下表所示。

ITU-T G.9972:	有线家庭网络收发机的共存机制

[48] 有关FTTX的更多信息，另见Q25/2号报告（ITU-D 2010-2014年研究期）第29-30页。

ITU-T G.9973:	识别家庭网络拓扑结构的协议
ITU-T G.9979:	在IEEE 1905.1a-2014标准中实施一般性机制，以包括可适用的ITU-T建议书
ITU-T G.9980:	宽带网络上客户端设备的远程管理

更多国际电联相关文件见**附件4**，这些文件可能提供有关有线系统的有益参考信息。[49]无线宽带接入技术，包括IMT。

无线宽带接入技术的类型

“目前存在若干基于不同标准的无线宽带接入（BWA）系统和应用，每一种系统和应用是否适合需要取决于用途（固定与牧游/移动）、性能和地理环境情况。在固定基础设施不完善的国家，可以更容易地部署BWA系统，以便在人口密集的城区和较偏远地区向民众提供服务。一些用户可能只需要短距离的互联网接入，其他用户可能要求进行长距离宽带接入。此外，同样还是这些用户，但他们可能要求其BWA应用是牧游式的、移动的、固定的，或是这三种形式的组合。总而言之，目前存在若干多接入解决方案，选择实施哪种方案取决于需求的相互作用、满足这些需求的各种技术的使用、频谱可用性（许可与非许可频谱）和提供BWA应用和服务所需的网络规模（局域网与城域网的综合考虑）”。[50]

ITU-R M.1801建议书包含“在6 GHz以下频段运行的包括移动和游牧式应用在内的移动业务宽带无线接入系统的无线电接口标准”。这些标准支持城区、郊区和农村地区通用宽带互联网数据和实时数据等广泛应用，包括话音和视频会议等应用。关于ITU-R M.1801建议书中包含的标准，请参见Q25/2号报告（ITU-D 2010-2014年研究期）的第32页。

有关IMT和IMT-Advanced的补充信息，请参见第2.2和2.3节。肯尼亚在使用IMT和IMT-Advanced技术促进该宽带业务发展方面的经验[51]，请参见**附件1**。ITU-R M.1450建议书阐述“宽带无线局域网的特性”，其中包含技术参数、有关无线局域网（RLAN）标准的信息和操作特性。ITU-R M.1450建议书中包含的标准和相关附件，请参见Q25/2号报告（ITU-D 2010-2014年研究期）第33页。

有效使用无线通信的技术措施

无线通信不同于有线通信，因此确保容量充足是关键性问题。有鉴于此，无线通信运营商主要关心如何获得足够频谱来满足容量需求。然而，无线通信可用的频谱十分有限，为此，我们必须考虑采用其他措施来确保这一可用频谱得到更有效的使用。

使用更小的蜂窝

宏蜂窝基站通常可用一个基站即覆盖大范围面积。另一方面而言，宏蜂窝基站覆盖的活跃用户数量往往少于在同一地区使用多个微蜂窝基站而服务的用户数量。关于

[49] 关于家庭联网的更多信息，见Q25/2号报告（ITU-D 2010-2014年研究期）第31页。

[50] LMH-BWA。

[51] SG1RGQ/290号文件，“通过补贴和免收频占费提高农村连通性：肯尼亚的经验”，肯尼亚。

使用不同类型的小区规模以及利用其它措施快速增加无线业务量，请参见Q25/2号报告（ITU-D 2010-2014年研究期）第49和50页。

2.1.4 卫星固定业务系统的宽带接入

卫星通信技术正在加速提供高速宽带业务，服务对象包括发展中国家、最不发达国家、内陆国家和岛国以及经济转型国家[52]。本报告阐述的卫星固定业务（FSS）系统技术和操作特性有助于以可承受的价格大规模制造简单的用户终端设备，用于提供高速宽带并为其实施树立榜样；这包括通过小型用户终端实现的高数据速率宽带接入，且现有系统拥有针对其它应用设计的、使用不同频段的不同规格地球站。

基于FSS的宽带接入已经部署于4/6 GHz、11/14 GHz和20/30 GHz的频段划分。预计新系统将很快使用40/50 GHz频段划分进行部署。尽管此项技术特别适用于服务欠缺和未享受服务的区域，但其发展始于工业化区域。为了促进在欠发达的区域部署此项技术，本报告归纳了其支撑环境与技术，同时还提供了一个案例库作为参考。

系统架构

目前有两种系统拓扑可用，且两类架构均可得到任何一种拓扑的支持。一种拓扑为星形拓扑，其每个终端均通过卫星链路与一个“基站”连接。一般而言，在此拓扑内，从基站到终端（前转链路）的流量要远大于各终端到基站（返回链路）的流量。因此基站将安装更大的天线为发射更宽的带宽容纳更高的增益。终端天线尺寸是基于所需返回链路带宽的数量，如第6.1节所述，它可使用甚小或超小孔径天线。第二种拓扑称为“网状”，其任一终端与所有其它终端通过卫星通信。由于没有基站，因此所有地球站的运转是依靠设计类似的上行和下行链路。

在两种拓扑中，一种架构方案是每位用户均有自己的甚小孔径终端（VSAT）或超小孔径终端（USAT）（例如，直接入户业务）。第二种方案采用“社区”地球站天线和本地地面分配。与各本地“社区”地球站相连接的是地面无线电系统，其可为周边3公里左右的用户提供服务。任一时间支持的用户数量取决于他们所用的比特率及其连接的活动因子。这种架构选择亦可在不使用任何VSAT或USAT，也不使用第5节所述点波束技术的情况下实施。

监管考虑

鼓励营造透明且明确的监管环境，方可使技术进步优势得以发挥。卫星系统属于高风险、高成本的投资，因此仅当旨在缓解运营商内在负担并为其提供确定性的政策到位以后，这种风险和投资才能承受。主管部门必须考虑如何为打入市场提供合理的手段，为其方法制定明确的规则。通过创建此机制，卫星宽带可作为地面宽带业务的重要补充，到达那些欠服务和未享受到服务的地区。

让卫星宽带进入市场的一项重要考虑是，在监管负担最小的情况下全面部署地球站的能力。如上节所述，一种架构方案是让每位用户均拥有自己的VSAT或USAT。必须出台一种可大量使用此类地球站，且能够经济高效地授权使用其相关设备的地球站许可机制。

[52] ITU-R S.2361号报告。

最后，也是最重要的，FSS频谱划分必须得到保护。宽带应用需要在低干扰环境内有大量频谱可用。在考虑可能会给经济运行此类应用造成影响的频谱共用方案时必须小心，并允许拓展此类使用来满足消费者的需求。

2.1.5 未来的趋势

未来几年间，宽带发展的主要驱动力预计将是不断增长的数据需求。如第**2.1.1节所述**，GSMA智库预测，2014-2019年间全球移动数据量将增长10倍[53]。思科公司对增长的预计与此类似，即从2014年底的每月2.5艾字节移动数据量增至2019年底每月24.3艾字节[54]。在固定宽带方面，技术进步（例如云技术、互动应用、超高清视频和视频流）和不断增长的需求亦在推动下一代网络的建设[55]。尽管涉及的个人传输量规模不大，与物联网（IoT）和机器间（M2M）通信相关的海量设备预计同样会增加对宽带网络的需求。上述因素将共同导致视频和互动应用等大数据库消耗的增长，同时亦会出现大量相对较小的传输，例如M2M通信中经常出现的情况。

鉴于马达加斯加岛远离设备供应商、并考虑到领土的大小以及构建网络所需的时间，在马达加斯加部署宽带的过程中正遇到某些困难。存在主干网非万能良药，因此监管机构决定推动宽带的运营。最近的文献得以批准通过正是出于此目的[56]。考虑到其地理状况，即它是一个岛国，长1500公里、宽500公里，马达加斯加一直致力于将主要业务部门（工业、银行和旅游等）所在的主要城镇联结起来。这些城镇相隔数十或数百公里，如何将它们联结在一起一直以来是运营商面临的问题。主岛的地形不利于使用微波链路，因此，运营商部署了8000公里长的光缆，当中国家拥有34%的股份。一个国家宽带的发展在一定程度上取决于所用的、将信息从一点“传输”到另一点的手段。存在和在用一个大的传输网络可能是其实现扩张的关键要素之一。马达加斯加未来的发展趋势请参见**附件1**中的国家经验。

固定宽带

下一代宽带网络

下一代宽带网络经过近十几年的发展与部署，预计会越来越多地用于目前正迅猛增长地业务。例如，新加坡正在构建强劲的云基础设施，以期成为一个智慧国度。[57]为此，新加坡宣称国内需要世界级的高速宽带连接且与国外主要城市之间要建立高速连接。[58]目前该国正在建设下一代宽带网络（Next Gen NBN），通过此网络为生机勃勃的云计算生态系统提供支持。[59]

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53 “移动经济”2015年；GSMA智库，2015年。

54 思科公司，“思科可视联网指数：全球移动数据流量预测更新2014–2019年白皮书”（2015年2月3日），见http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white_paper_c11-520862.html。

55 光纤系统，吉比特宽带在欧洲的崛起，2015年冬，见http://www.fibre-systems.com/feature/rise-gigabit-broadband-europe。

56 1/142号文件,“宽带发展的监管”，马达加斯加共和国。

57 信息通信发展局（IDA），新加坡的云计算：驱动创新（2015年）第2页。https://dl.dropboxusercontent.com/u/66814130/Cloud%20Computing%20in%20Singapore%20Booklet/2015%20edition/Cloud%20Computing%20in%20Singapore%20(2015%20Edition).pdf。

58 同上，第6页。

59 同上。

下一代NBN属于超高速光纤网络，预计可在全国范围内提供1 Gbit/s或更高的宽带接入速度。[60]除提升下载和上载速度之外，新加坡信息通信发展局（IDA）坚信高成本效益的超高速宽带的全面普及，将通过软件即服务和其它云服务、带宽密集型远程备份和在线协作，为有助于公司提高运营效率的新服务铺平道路。[61]IDA称相关公司将能够利用高清视频会议与实时协作平台等应用，与身在家中或偏远地点的员工以及世界各地的合作伙伴和潜在客户互动。[62]

除新加坡之外，其它提供商亦在部署下一代网络，其中包括：

– 贝尔加拿大为向多仑多提供1 Gbit/s 的互联网服务投资了10多亿加元（7.7亿美元）并计划于2015年夏开始将此服务拓展到安大略、魁北克和大西洋各省。[63]该公司称其推动的光纤业务将使多伦多成为“世界级的智慧城市”，让各种规模的企业“拓宽经营渠道，制造更多产品”并“吸引更多投资，拉动更多就业”。[64]

– 于2014年通过光纤入户（FTTH）网络启动1 Gbit/s互联网服务的瑞士电信已注意到，高清电视、云服务和视频会议正在推动个人和公司采用超高速宽带。[65]该公司计划于2015年底为230万家庭和企业提供高速宽带服务，并于2020年将此数字提升至500万。

– Orange法国分公司希望于2016年底在九个城市提供100%的FTTH覆盖。包括里昂、蒙彼利埃、尼斯和巴黎在内的这九座城市，将成为Orange提出的“100%光纤”城市。此举措是该公司更大计划的组成部分，这一计划拟于2015年4月通过光纤连通400万家庭，2018年达到1200家庭，到2022年则使此数量超过2000万户家庭。

尽管当前实施Gbit/s互联网服务的项目都在使用光纤，但重要是要注意到DOCSIS 3.1与DOCSIS 3.0相比，预计将能提供一种高性价比的方式，使有线运营商于2015年下半年对混合光纤同轴网做出必要升级，以达到与之相类似的速率。[66]

关闭铜线网络

随着基于IP的下一代网络部署不断增加且客户对传统话音和数据需求不断下降，以及其相对高昂的维护成本，有线领域的另一新趋势是服务提供商正在关闭其铜线网络。2015年1月，AT&T宣布，随着公司向IP网络的过渡，将关闭某些铜线网络[67]。虽然该提供商没有具体指出放弃铜线资产市场，但其拟于2020年将网络移植至全IP的基础设施之上。2014年，AT&T在两个位置开展IP过渡试点，在过渡进程伊始为联邦通信委员会

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60 iDA，下一代NBN，见http://www.ida.gov.sg/Tech-Scene-News/Infrastructure/Wired/Next-Gen-NBN。

61 iDA，下一代NBN，针对企业的部分，见http://www.ida.gov.sg/Tech-Scene-News/Infrastructure/Wired/Next-Gen-NBN/For-Enterprises。

62 同上。

63 贝尔，吉比特光纤很快将会进入多伦多，见http://www.bell.ca/Gigabit-Fibe-Internet#demoToggleJs。

64 CBCnews，贝尔保证为多伦多提供最快速的互联网，2015年6月25日，见http://www.cbc.ca/news/canada/toronto/bell-promises-to-bring-fastest-internet-possible-to-toronto-1.3127407。

65 瑞士电信，网络扩容：已有1百万以上的家庭和企业与超高速互联网连接，2014年7月30日，见https://www.swisscom.ch/en/about/medien/press-releases/2014/07/20140730-Netzausbau-Ultrabreitband.html。

66 光纤系统，吉比特宽带在欧洲的崛起，2015年冬，见http://www.fibre-systems.com/feature/rise-gigabit-broadband-europe。

67 SEC，AT&T表格8-K，2015年1月16日，见http://www.sec.gov/Archives/edgar/data/732717/000073271715000003/january16_8k.htm。

（FCC）提供一些补充信息。[68]Telenor和Telstra等其它国家的运营商，亦宣布了逐步放弃铜线网络的计划。[69]

无线宽带网络

异构网络和小蜂窝

如第**2.1.4节所述**，运营商可采用不同规模的小区，以提高容量并提供最佳无线覆盖。小蜂窝特别适用于3.5 GHz等更高频段，业内对为此频段开发小蜂窝技术解决方案的兴趣日渐浓厚。但是，小蜂窝亦对干扰保护提出了挑战，要求所有利益攸关方都采取适当的缓解技术。

此外，多项技术 – 例如IMT-2000、IMT-Advanced和Wi-Fi – 或可混合使用，以便为用户提供最佳的移动数据体验。运营商、生产商甚至是政府正为开发异构网络（或HetNet）投入资源，以满足覆盖和容量需求。例如，新加坡目前正在制定信息通信媒体总体规划，该规划将把异构网络作为主要特征之一。新加坡认为，当前处于分割状态的移动和Wi-Fi网络应更加紧密的结合，将使“通过任何设备随时随地”连接成为可能[70]。为此，新加坡认为HetNet应包括以下三个特征：

– 网络间的智能无缝接入；

– 不同网络拥有一致的质量体验；和

– 创新和动态的资源管理。

尽管并非推行HetNets的明确举措，但美国联邦通信委员会（FCC）于2014年重新修订了移动网络建设的规则，特别是在实施必要的环境审核和历史古迹保护方面。[71]此项命令的目的是减少规则障碍并提高无线设施选址的效率。为改善并扩大移动覆盖，在对小蜂窝和分布式天线需求与日俱增的情况下，已将上述做法考虑在内。

爱立信介绍了一种提供高质量用户体验的常规方法，通过三个步骤发展HetNet。运营商能够：

– 通过采用更多频谱、先进的天线、接收和/或发射机分集水平的提高，以及节点内和节点间的基带处理能力，改善现有的宏蜂窝；

– 通过在某区域内部署更多的宏蜂窝来强化宏蜂窝网，例如将由三个蜂窝覆盖的区域变成由六个或更多蜂窝覆盖的区域；和

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[68] AT&T公共政策博客，在阿拉巴马实现全IP，佛罗里达，2014年2月28日，见http://www.attpublicpolicy.com/wireless/going-all-ip-in-alabama-florida/；FCC，IP过渡，见https://www.fcc.gov/guides/ip-transition。

[69] Telenor，Telenor集团–花旗欧洲与新兴电信公司大会，第8页，2013年，见http://www.telenor.com/wp-content/uploads/2013/01/Telenor-Citi-TMT-Conference-March-2013.pdf；NBN Co延迟了58个地区的终止铜线连接工作，2014年8月21日，见http://www.itnews.com.au/News/391254,nbn-co-delays-copper-disconnections-in-58-areas.aspx。

[70] 通信和信息部（新加坡），“异构网络”，见https://www.mci.gov.sg/portfolios/infocomm-media/initiatives/infrastructure/hetnet。

[71] 联邦通信委员会，无线基础设施报告和命令（FCC 14-153）（2014年10月21日），见https://www.fcc.gov/document/wireless-infrastructure-report-and-order。

– 增加小蜂窝– 移动或Wi-Fi – 作为对宏蜂窝的补充。[72]

无许可频谱使用的增长

业界对使用无许可频谱为IMT-Advanced网络提供补充容量愈来愈感兴趣。无许可频谱内的LTE Advanced，特别是针对小蜂窝，可用于增强4G网络的容量。[73]使用公共的LTE核心，可将有许可和无许可频谱内的频率整合，以提高最终用户数据容量，例如用于流媒体和获取其它内容丰富的数据。综合LTE网提供统一的移动性、鉴权、安全性和管理能力。这种将有许可和无许可频谱共同用于部署LTE网络的方式亦被称为“无许可LTE（LTE-U）和得到许可帮助的接入（LAA）”，且这种方式将被纳入即将推出的3GPP Rel. 13[74]。

无许可频谱在3GPP中的使用应依照2014年6月确定的优先工作导则实施：

– GHz频段；

– 全球化方案可跨区工作；

– 得到许可帮助的接入操作。

3GPP预计于2016年最终定稿Rel. 13，这或可为将无许可频谱用于商业移动宽带服务提供更多动力。

2.2 使用地面和卫星链路实施IMT的方法和手段

人们已经注意到有关利用固定卫星在自然灾害后恢复移动业务的案例研究。[75]但是，有些设想被认为适合从零基础做起（例如，农村通信）。自然灾害中，大片区域内为数众多的移动基站可能遭到破坏。即便基站未毁，地面线路也可能损坏，从而导致移动基站业务终断。移动通信为人们共同广泛使用，在我们的日常生活中发挥着重要作用。救灾阶段，恢复移动基站属于紧急任务，为得是能够了解失踪人员安全、恢复并重建受损或被毁道路、公共设施、建筑等。在这些情况下，具备卫星回程功能的移动基站是最为妥当且是唯一能够快速建立并提供移动业务的手段，特别是在灾后的短时间内。

同时使用地面和卫星链路的部分移动网络配置示例请参见本文稿和案例研究库。由于多种原因，有些国家的互联网普及率仍然很低，即使运营商具有满足客户需求的技术潜力且能够跟上创新型ICT解决方案使用的全球发展趋势，低互联网普及率仍会阻碍相关国家的互联网发展。造成如此低普及率的原因包括：家庭收入有限支付不起联网的成本和网费，技术方面的教育不够和宽带质量无法保障。[76]

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[72] 爱立信“异构网络”，见http://www.ericsson.com/us/ourportfolio/telecom-operators/heterogeneous-networks。

[73] 高通公司“让LET Advanced惠及无许可频谱”见https://www.qualcomm.com/invention/technologies/lte/unlicensed。

[74] 参见“LTE的演进版本13”（2015年2月18日），网址http://www.3gpp.org/news-events/3gpp-news/1628-rel13。

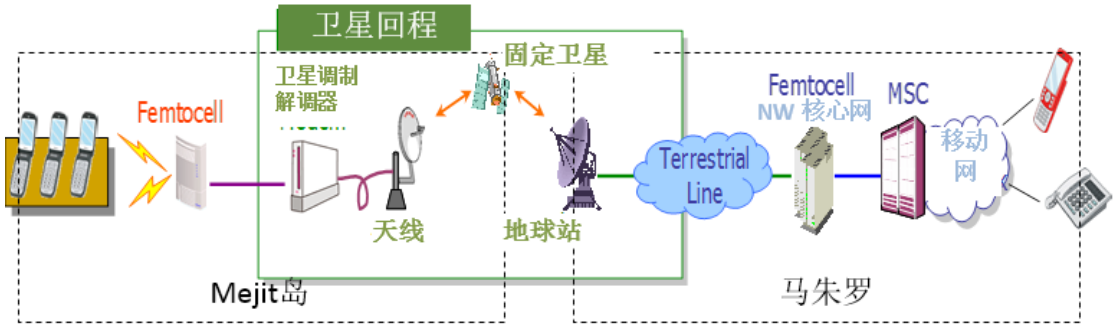
[75] SG1RGQ/94号文件，“Example of mobile base stations with satellite backhauls”和1/187号文件，KDDI公司（日本）。

[76] SG1RGQ/287号文件，“Broadband access technology”，马达加斯加。

马绍尔群岛的案例研究是利用地面和卫星链路实施IMT的另一良好示例。在此案例中，偏远的Mejit岛利用DAMA卫星链路与马绍尔群岛首都马朱罗群岛相连，其中在Mejit岛一侧使用了VSAT天线。在Mejit岛，Femto基站使利用普通GSM终端拨打GSM呼叫并同时用于互联网接入成为可能。使用Femtocell基站特别适用于面积不大的、Mejit这样的小规模通信。这是因为尽管同时通话的数量受限且Femtocell蜂窝的规模也有限，但Femtocell价格低廉且能耗极低。

ITU-D研究组[77]的文稿中已多次阐述，使用VSAT和Femto基站组合的卫星通信将是农村通信最有效的方法之一。[78]

图3：使用具备卫星回程功能的Femtocell网络配置



2.3 IMT-Advanced系统

IMT-Advanced

2012年1月16-20日于日内瓦召开的无线电通信全会（RA-12）[79]达成共识，决定通过制定新IMT-Advanced标准拓展IMT无线接口家族。全体成员国批准了处理IMT问题的ITU-R M.2012[80]建议书。

先进国际移动通信（IMT-Advanced）系统是包含比IMT-2000更先进的新IMT功能的移动系统。IMT-Advanced系统根据多用户环境中的用户和服务需求，支持移动性从低到高的各种应用和范围广泛的数据速率；IMT-Advanced还在范围广泛的服务和平台内具备实施高质量多媒体应用能力，使性能和服务质量得到显著改善。[81]

IMT-Advanced的主要特征是能够满足用户需求和能力，这些需求和能力将随着用户的发展趋势和技术进步而不断增长：

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77 2006-2010年研究期的文件：RGQ10-2/2/94、2/177、2/232。

78 有关此案例研究的细节，见案例研究库。

79 IMT-Advanced网页：http://itu.int/go/QJ9R 和 为发展中国家部署不断演进的电信/ICT基础设施的报告：技术、经济与政策问题，SG1RGQ/229号文件，为发展中国家部署不断演进的电信/ICT基础设施的报告：技术、经济与政策问题，2016年3月，修正于2017年，1月。

80 ITU-R M.2012：先进国际移动通信（IMT-Advanced）地面无线接口的详细规范，2015年。

81 1/203(Rev.1)号文件，阿尔卡特-朗讯国际公司（法国）。

– 其功能在世界范围内具有高度通用性，同时又具备灵活性，能以低成本、高效益的方式支持范围广泛的服务和应用；

– 与IMT内的服务和固定网络的服务兼容；

– 与其他无线接入系统互通的能力；

– 高质量移动服务；

– 适合世界范围内使用的用户设备；

– 方便用户的应用、服务和设备；

– 世界范围内的漫游能力；

– 支持先进服务和应用的强增强的高峰数据速率（已确定100 Mbit/s为高移动性研究目标，1 Gbit/s为低移动性研究目标）；[82]

IMT-Advanced的功能网络架构包含下述通用原则：[83]

– 基于IP技术的网络

通过各类有线和无线接入技术提供丰富接入机制的接入网，不再具有第二层链路的特性，并向核心网提供了基于IP的连接。与这些接入网连接的核心网和应用服务器是基于IP。

– 使用可扩容组件的模块化架构

  - 子系统自身，例如接入网、核心网和应用服务器；以及在此基础上建立的系统均是分层的。

  - 各子系统的接入是依据各运营商的政策分别加以控制。

– 各类系统间的开放接口

同质网络与异构网络的互操作是通过各级子系统间的开放接口实现。

IMT-Advanced架构应在[ITU-T Q.1703]定义的业务和网络能力框架中有关网络规定的基础之上，支持多个接入网、融合网络中的融合业务、更高的安全性和保护水平以及全业务接入。IMT-Advanced架构是基于[ITU-T Y.2011]定义的通用原则。

2.3.1 LTE Advanced

LTE Advanced指的是在3GPP发布10及后续发布中引入的增强型LTE版本。它提供了更高的比特率，以满足国际电联为IMT Advanced设定的要求并提供经过改进的用户体验。

发布10提供了以下峰值速率（实际速率取决于所部属的功能）：

– 峰值数据速率：下行(DL) 3 Gbps，上行(UL) 1.5 Gbps；

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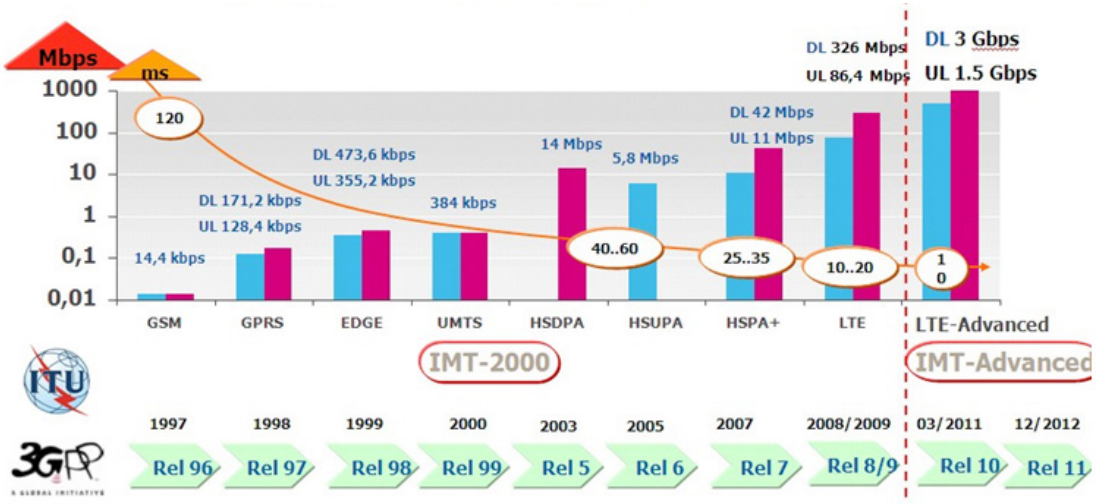
[82] 数据速率以ITU-R M.1645建议书为来源 – IMT-2000和后IMT-2000系统未来发展的框架和总体目标。

[83] ITU-T Q.1704：IMT-Advanced的功能网络架构（2008年）。

– 峰值频谱效率：DL 30 bps/Hz，UL 16.8 bps/Hz)。

这些峰值速率由新的用户设备（UE）类别-第8类；其他新用户设备类别，第6和7类，即增强的支持子集提供支持（详见1/203 (Rev.1)号文件附录1）。**图4**显示了与3GPP系统相比，LTE- Advanced所提供的增速峰值速率。

图4：与先前的3GPP系统相比，LTE- Advanced所提供的增速峰值速率



来源：1/203 (Rev.1)号文件，阿尔卡特-朗讯国际（法国）。

在LTE-Advanced发布10中引入的无线接入网（RAN）重要功能包括：

– 载波聚合（CA）；

– 用于多天线发射的先进多入多出（MIMO）；

– 异构网络及蜂窝间干扰协调（eICIC）；

– 增强型网络节能和中继；

– 增强型自组织网络（SON）

LTE-Advanced发布11引入的进一步增强包括：

– 协同多点（CoMP）运作，改进的下行控制信道；

– 载波聚合增强；

– 干扰消除增强。

LTE-Advanced发布12已获通过，用于IMT-Advanced发布2，可提供以下改进：

– 公共安全（群通信/设备到设备）；

– 机器对机器（低成本）；

– 小蜂窝（双连接/SON）；

– LTE/Wi-Fi互联；

– 多媒体广播/组播（MBMS）增强。

发布10规范的功能于2011年冻结，发布11规范的功能于2012年12月冻结，发布12规范的功能于2014年9月冻结。

LTE-Advanced重要功能的优势如**表3**所示：

表3：LTE-Advanced的重要功能

	技术	优势
载波聚合	频谱聚合，以支持更大的带宽	提高了峰值数据速率、频谱灵活性和业务吞吐量
先进MIMO技术	在DL方向扩展至8层传输 在UL中引入了多大4层传输的SU MIMO	提高了数据速率、容量和蜂窝边缘用户的业务吞吐量
CoMP	DL和UL中协作的多点传输	提高了蜂窝边缘用户的业务吞吐量、覆盖和部署灵活性
异构网络及eICIC	发射功率不同的重叠蜂窝部署的干扰协调	提高了峰值数据速率，改善了QoE和频谱灵活性
SON 增强	无线网络的自动化、配置和优化，以适应不同的电波条件	更好的网络性能、更低的费用、部署灵活性
中继	有线回传费用昂贵或不可用时，创建独立的蜂窝	增加了服务区的覆盖和灵活性，部署成本低、效益高

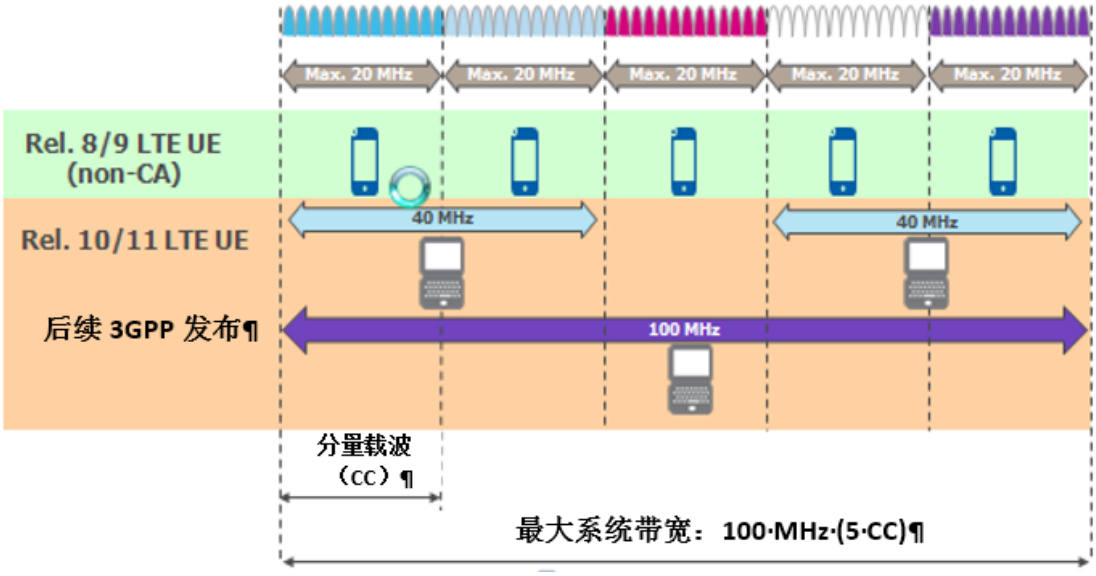
来源：1/203 (Rev.1)号文件，阿尔卡特-朗讯国际（法国）。

载波聚合

LTE-Advanced旨在在下行支持1 Gbps，在上行支持500 Mbps的峰值数据速率，以满足IMT-Advanced的要求。但是，需要高达100 MHz的传输带宽，因为最大的载波为20MHz，需要聚合多个载波才能实现这一峰值速率。LTE-Advanced采用多个分量载波（CC）的载波聚合来实现大带宽传输。

如**图5**所示，这些分量载波或者是连续的，或者是非连续的。下行和上行载波聚合可独立配置和部署。

图5：LTE-Advanced多个分量载波（CC）的载波聚合



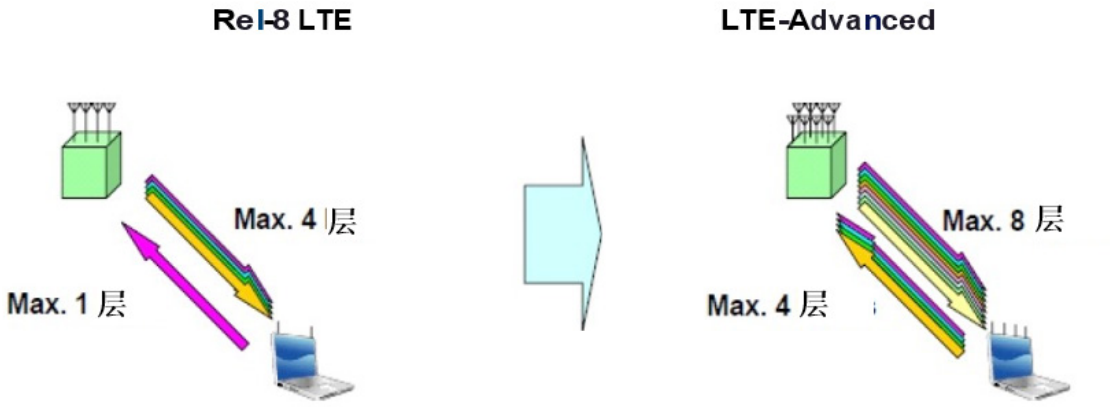
来源：1/203 (Rev.1)号文件，阿尔卡特-朗讯国际（法国）

先进MIMO

3GPP的发布8和9支持最多4层的空间复用和单层波束赋形。发布9进一步支持双层波束赋形，该技术综合了2层空间复用和波束赋形能力。LTE-Advanced在发布10引入了对多达8层的波束赋形单用户空间复用。

图6显示了与发布8相比，在LTE-Advanced中支持的最大单用户空间复用。

图6：与发布8相比，在LTE-Advanced中支持的最大单用户空间复用



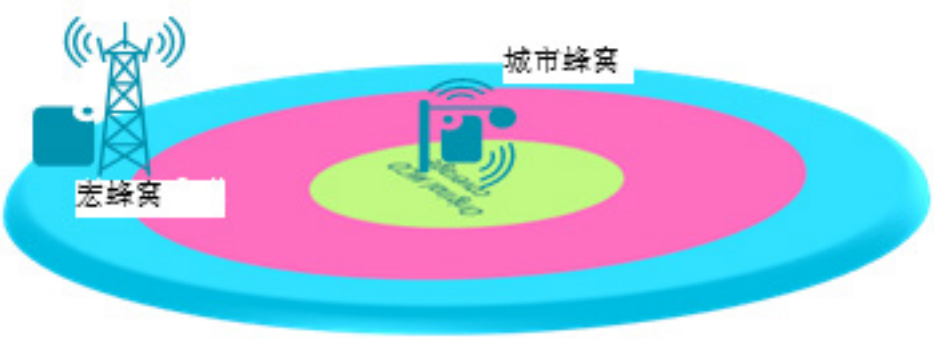
来源：1/203 (Rev.1)号文件，阿尔卡特-朗讯国际（法国）。

异构网络和改进后的蜂窝间干扰协调

在异构网络部署中，宏蜂窝覆盖中的扩展城市蜂窝导致了严重的干扰环境。发布10中的LTE-Advanced引入了时间域蜂窝间干扰协调（ICIC，亦称为增强型ICIC，简称

eICIC），以消除下行控制最重要信道的干扰。小型城市蜂窝是增加网络容量，满足数据业务量指数级增长需求的单一技术：部署的城市蜂窝越多，容量就越大，因此可以比多天线技术提供更大数量级的容量增长。此外，即使不能增加载波，不能使用载波聚合，城市蜂窝也可增加容量。

图7：宏蜂窝和城市蜂窝



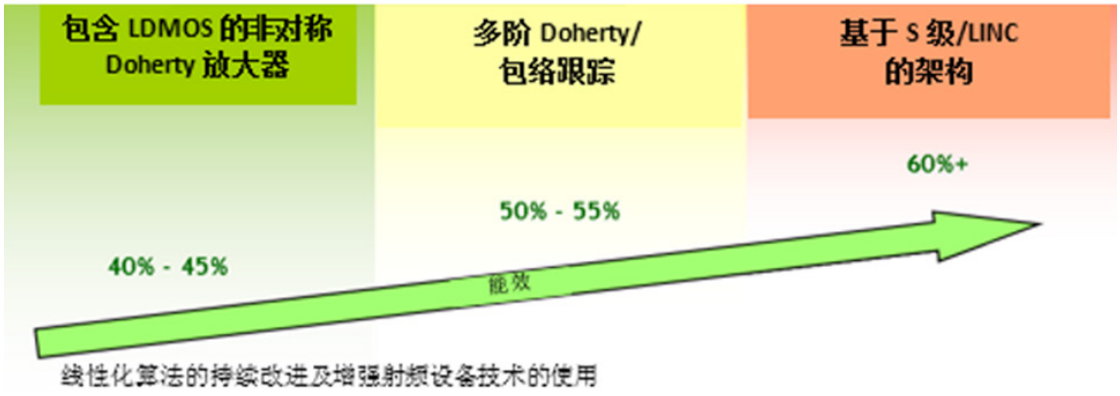
节能

硬件节能功能

这个行业正在努力提高功放（PA）的能效，尤其是在PA架构、设备技术和线性化算法及降低峰值/平均功率比（PAPR）算法方面开展工作。

近期取得进展的典型说明示于**图8**中：

图8：功率放大器（PA）节能



来源：1/203 (Rev.1)号文件，阿尔卡特-朗讯国际（法国）

– **软件节能功能**

软件技术也用于节能：

PA功率倾向于调整电压，以控制供电电压并控制作为业务负载函数的PA传输功率，可实现10-15%的节能。

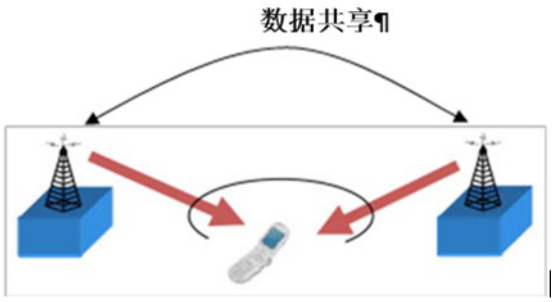
PA动态切换：当没有数据/信号可发送时，PA被关闭。通常可在农村环境中节省7%的电力。

蜂窝关闭：当部署城市蜂窝增加容量时，可执行自主关闭，不再需要容量时将蜂窝置于休眠状态，以降低能耗。

协作多点

在发布11中引入的一项重要新功能为协作多点（CoMP），可适用于DL和UL方向。它是一种协调多个蜂窝或传输点发射或在多个接收点接收来自一个单一用户设备发射的方法（参见**图9**）。该技术主要旨在改善蜂窝边缘的吞吐量。

图9：协作多点（CoMP）



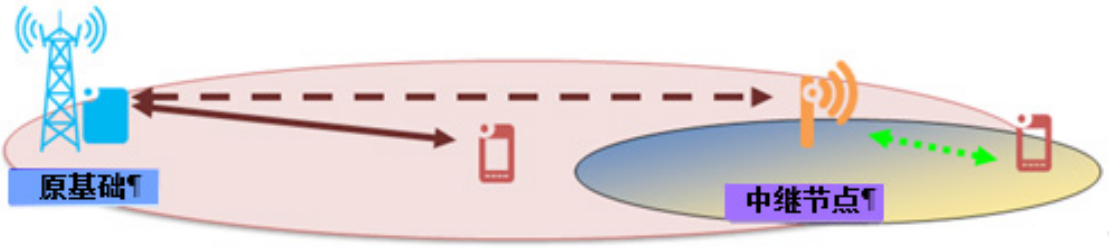
来源：1/203 (Rev.1)号文件，阿尔卡特-朗讯国际（法国）。

中继

在发布10中引入了中继节点（RN），以实现业务量/信令的转发。RN增强了高数据速率的覆盖并/或扩展了蜂窝范围以外的覆盖。

除固定RN外，发布11还支持移动RN（即在火车中）。

图10：中继节点（RN）



来源：1/203 (Rev.1)号文件，阿尔卡特-朗讯国际（法国）。

2.3.2 WirelessMAN Advanced

WirelessMAN-Advanced无线接口由IEEE制定。基于WirelessMAN-Advanced的完整端到端系统称为WiMAX 2，由WiMAX论坛制定。

“WirelessMAN-Advanced系统”全球核心规范由IEEE 802.16-2009及随后修正的IEEE 802.16j-2009、IEEE Std 802.16h-2010和IEEE Std 802.16m-2011组成并进一步详述于ITU-R M.2012-1建议书中。但是，WirlessMAN-Advanced并未更新，以纳入最新的IMT-Advanced详细规范（ITU-R M.2012-2建议书）。

2.3.3 IMT-Advanced的卫星部分

IMT-Advanced的地面和卫星部分相互补充。ITU-R M.2176-1报告叙述了IMT-Advanced卫星部分在应用情境、业务、系统、无线接口和网络方面的愿景及所考虑的具体功能。由于地面部分不会在全球各地部署，IMT-Advanced卫星部分的系统将与其形成互补，以便在全球范围内提供无缝隙服务[84]。卫星和地面综合网络可有助于下一代网络（NGN）的问世和使用，向需要全面移动的最终用户提供泛在和普遍、可无缝接入的宽带多用途IP业务并最终通过市场力量予以实现。因此，IMT的广泛覆盖只能采用卫星和地面综合的无线接口予以实现。[85]

系统方面[86]：预计IMT-Advanced卫星部分具备足够的功率和接收机灵敏度建立与最终用户设备的通信，这种通信与地面部分的通信并无区别。提供高增益、可重新配置的多波束大型卫星天线是综合系统的一个重要特性。综合系统的用户设备应具备在接收信号电平和网络可用性方面选择相关部分-或者卫星，或者地面-的能力，以便在广泛且连续的业务区内保证给定的服务质量。

详细信息见**附件5**。

2.3.4 IMT-Advanced之后：IMT-2020

2012初，ITU-R启动了制定“2020年及以后的IMT”[87]的计划，规划世界各地开始开展的“IMT-2020”研究活动。

– 通过5D工作组承担的牵头工作，国际电联无线电通信局部门正在确定针对“IMT-2020”时间节点的意见。“IMT-2020”关键要素的详细研究正在开展中。

– 2015年，ITU-R最终确定了“IMT-2020”移动宽带联网社会的“愿景”。未来移动技术支持IMT发展的宏观展望述于ITU-R M.2083建议书中。

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[84] 有关IMT-Advance卫星部分的更多信息，请参见：
- ITU-R M.2047建议书 – 先进国际移动通信（IMT-Advanced）卫星无线电接口的详细指标（2013）；
- ITU-R M.2279报告 – IMT-Advanced卫星程序（步骤4-7）的评估、协商和决定成果（包括IMT-Advanced卫星无线电接口特性）（2013）；
- 有关发展中国家实施演进的电信/ICT基础设施的报告：技术、经济和政策问题。

[85] 有关IMT卫星终端全球流通的更多信息，请参见ITU-R M.2014-1（2015）建议书。

[86] ITU-R M.2176-1报告 – IMT-Advanced卫星无线接口的构想和要求(2012)以及有关发展中国家实施演进的电信/ICT基础设施的报告：技术、经济和政策问题、SG1RGQ/229号文件，2016年3月，并于2017年1月修正。

[87] ITU-R网页：http://www.itu.int/en/ITU-R/study-groups/rsg5/rwp5d/imt-2020/Pages/default.aspx；有关发展中国家实施演进的电信/ICT基础设施的报告：技术、经济和政策问题以及SG1RGQ/229号文件+附件“有关发展中国家实施演进的电信/ICT基础设施的最新报告：技术、经济和政策问题”，电信发展局第1/1号课题牵头人，2017年1月修正，有关发展中国家实施演进的电信/ICT基础设施的完整报告：技术、经济和政策问题，2016年。

ITU-R 5D工作组实施“2020年及以后的IMT”的交付成果

- 愿景和技术发展趋势：
- ITU-R M.2320报告：该项活动涉及考虑2015-2020年及以后这一大概时间段的情况下，地面IMT系统部署的技术方面和有利因素，其中也包括有关WRC-15研究的地面IMT系统问题作为其研究范围。
- ITU-R M.2083建议书：该项活动涉及2020年及以后的长期愿景，并将提供IMT未来发展的框架和整体目标。
- ITU-R M.2376报告：该报告旨在提供有关研究在6GHz以上频段开展IMT的技术可行性的信息。
- 国际电联名为《国际移动通信全球趋势手册》的手册（2015年5月版）总结了针对IMT-2020所开展的工作及取得的进展。该手册界定了IMT并提供了业务要求、应用发展趋势、系统特性等一般性信息以及大量有关频谱、规则问题的信息、演进和迁移及IMT核心网演进的导则。
- 有关IMT-2020“5G”性能要求的ITU-R报告。预计ITU-R M.[IMT-2020.TECH PERF REQ]新报告草案将由ITU-R第5研究组在其2017年11月的会议上最终批准http://www.itu.int/en/mediacentre/Pages/2017-PR04.aspx。

可从ITU-R 5D工作组的网站http://www.itu.int/en/ITU-R/study-groups/rsg5/rwp5d/Pages/default.aspx获取有关IMT-2020研究进展的其他参考文件及所有与IMT相关的文件。

ITU-T第13研究组有关“2020年及以后的IMT”的决定

IMT-2020焦点组（FG IMT-2020）（成立于2015年5月，终止于2016年12月）。IMT-2020网络问题焦点组于2015年5月成立，旨在分析新兴5G技术在未来网络中的的交互方式，这也是为支持5G系统发展所需网络创新的初步研究。焦点组从生态系统角度对5G发展进行研究，并在向上级研究组ITU-T第13研究组[88]提交的报告中公布了分析结果。

世界电信标准化全会，2016年10月25日-11月3日：第93号决议 – 4G、IMT-2020及之后网络的互连互通[89]

做出决议

须尽快推动制定涉及4G、IMT-2020及之后网络互联互通网络架构、漫游原则、码号问题、安全和计费机制以及兼容性和一致性测试的ITU-T建议书，

责成电信标准化局主任

1) 必要时继续在电信运营商中开展探索活动，以便确定和重点解决IP网络（4G、IMT-2020及之后网络）在实现互联互通方面面临的问题；

[88] IMT-2020焦点组计划在2015年12月之前结束其研究。更多信息，请参见http://itu.int/go/B08Y。

[89] WTSA-2016 第93号决议。

2) 将这些活动的结果提交国际电联理事会，供其审议并采取必要的行动，

责成各研究组

1) 尽快确定未来需要制定的与4G、IMT-2020及之后网络互联互通有关的ITU-T建议书；

2) 酌情与感兴趣的利益攸关方和联盟开展合作，优化就此开展的研究，

进一步责成第11研究组

制定规定4G、IMT-2020及之后网络互联互通，以实现全球互操作的框架和信令架构的ITU-T建议书，

进一步责成第2研究组

制定规定用于4G、IMT-2020及之后网络互联互通的ENUM架构（其中也包括有关国际电信资源（包括命名、编号、寻址和路由）的行政管理）的ITU-T建议书。

2.3.5 结论

在IMT-Advanced的不断开发过程中，IMT一直是移动通信容量最主要的先进解决方案。IMT-Advanced在频谱效率、先进多天线传输、灵活频谱聚合、小蜂窝和节能等方面提供的支持确保了技术能够可持续且经济地满足未来几十年内日益增长的数据业务量的需求。这对于发展中国家尤其有用，他们可利用频谱/节能领域的最新进展并“跳过”更加昂贵的陈旧技术。

未来对更多功能（其中包括改进后的与其他无线接入技术的互联、特别用于公共安全应用的设备到设备的通信等）的支持将进一步增加部署IMT网络可带来的优势。[90]

[90] “LTE – UMTS的长期演进：从理论到实践”，S. Sesia、I. Toufik、M. Baker、John Wiley & Sons、2011年第二版。附录1：LTE-Advanced设备的生态系统。

图11：支持更大吞吐量的设备演进

来源：1/203 (Rev.1)号文件，阿尔卡特-朗讯国际（法国）。

3 第3章 – 宽带接入的部署

3.1 在考虑现有网络情况下规划和实施宽带技术迁移的方法

在向宽带技术迁移及在宽带技术范围内向更先进技术发展时有许多需要考虑的因素[91]。

a) 物理基础设施

传输等现有的物理基础设施不仅是接入相关基础设施，也是核心相关基础设施的瓶颈。但是，应注意到，从接入到核心基础设施的过程中，困难程度在降低。这一局限性适用于有线和无线发展，但变化程度不同。

b) 频谱局限性

一个国家的可用频谱有许多用户，其中航空、军事使用占支配地位，为宽带技术的频谱使用带来了局限性。此外，随着IMT技术演进的下载和上传速率的增加，对频谱的需求增大了。网络向宽带技术演进版本或基础版本的迁移需在考虑所确定频段的频谱路线图和可用性后再予以实施。

c) 设备生态系统

支持陈旧ATM技术设备的减少或支持更新IMT技术的设备的增多，鼓励运营商积极考虑网络的迁移。

尽管如此，运营商的逐步发展或监管机构的大力鼓励将引导或迫使电信市场选择从陈旧的版本转向更新的宽带技术。

大体而言，有以下两种规划网络从旧向新迁移的方法：

a) 软切换

这种方法中，旧网络与新网络同时运营很长一段时间，或计划继续将旧网络用于宽带需求以外的业务。在这种方法中，网络和运营存在冗余，但陈旧技术浪费了频谱。但是，这种方法允许运营商在阻力最小的情况下向更新的技术迁移，同时考虑上述因素。

b) 硬切换

这种方法中，监管机构与运营商一起确定陈旧设备的关停日期，在此日期之后不再允许陈旧网络进行计划运作。这种方法可节省频谱等宝贵资源并减少运营工作，但需要政策层面驱动的框架，因为满足通信需求需要替换现有的手机。

应注意到，容纳不同的宽带技术应采取的方法可能取决于变化程度。

a) 演进性变革

[91] 1/262号文件，斯里兰卡民主社会主义共和国。

当某种技术中的基本网络运作随着此类技术的使用变化时，即为演进性变革。IMT技术GSM与UMTS之间或从1G向GSM技术的过渡就是演进性变革的最好示例。

b) 革命性变革

对于革命性变革的迁移，尽管迁移可大大改进用户行为，但对网络进行基础性变革的要求并不强烈。

监管机构需制定具体的激励措施，鼓励运营商采用最新的宽带技术。

a) 频谱

因为频谱是可用资源中最为宝贵的资源，适当的指导及在最合适的频段中提供频谱可允许运营商迁移其网络而无需面对频谱领域的诸多局限性。

b) 手机补贴

如上所述，手机在迁移中发挥了重要作用，增加了向更新IMT基础技术迁移的灵活性。

c) 基础设施补贴

可采取一些措施，向运营商提供适当的基础设施补贴，鼓励他们在农村和边远地区建设相关宽带基础设施。

d) IMT和IMT Advanced技术作为各国宽带业务的促进因素

肯尼亚和刚果（布拉扎维）等国家已认识到IMT技术在向民众提供移动业务方面可发挥的作用，目前由三家移动运营商构成的ICT行业继续推广2G、3G和去年年末才开始的4G-LTE混合业务。这些业务得到了公共和私营部门作为骨干线路及最后一英里解决方案建设的光纤基础设施的支持。最终目标是在话音业务以外提供高速互联网业务，供民众使用，改善这个国家所有生活领域公共服务的提供。[92]

为促进ICT行业的投资和增长，开放接入和竞争供给战略可成为规范ICT提供商获取基础性无源和基础性有源基础设施的法律框架的一部分并规范各项有关批准现有和未来ICT提供商建设、选址、拥有和运营物理基础设施（其中也包括国际网关和互联网交换点（IXP））[93]的政府政策和行动。这一方法应确保透明且非歧视性地接入网络基础设施，在零售和批发层面实现有效竞争，确保向最终用户提供有竞争力且价格可承受的业务。

该方法的主要目标是：

– 鼓励向服务欠缺地区提供宽带业务；

– 在光纤和宽带市场实现自由和公平的竞争；

– 透明且非歧视性地提供基础性有源和无源基础设施的开放获取；

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[92] 1/290号文件，“IMT和IMT Advanced技术推动肯尼亚宽带业务发展”，肯尼亚共和国；第25/2号课题的报告ITU-D 2010-2014年研究期。

[93] SG1RGQ/300号文件，“阿富汗光纤和宽带行业开放接入政策和竞争供给”，阿富汗。

– 为私营企业、公共实体或两者之间的伙伴关系建设、拥有并运营光纤和宽带基础设施提供便利；

– 为新参与方进入市场提供便利；

– 向私营和公共参与方开放国际网关和互联网交换点（IXP），引入私营竞争、价格谈判和合作；

– 创建没有垄断和卡特尔的ICT行业；以及

– 为民众提供价格可承受且可靠的宽带接入。

国家确保向民众提供通信服务是发展中国家农村地区监管部门和政府面临的最大挑战之一，[94]这些监管部门和政府在利用普遍服务基金（USF）的金融支持和借助五年内频谱免费实现的监管介入方面富有经验。预计该战略将降低扩展业务的初期费用并为运营商提供一个实现投资回报宽限期。

3.2 政策原则

斯里兰卡等一些国家制定的国家宽带政策基于以下重要原则和假定：

a) 政策并不仅仅是经济领域ICT行业的政策，它触及了斯里兰卡整个经济并涉及商品和服务的生产和交付及整个经济领域中的相关交易；

b) 政策在民众与社会机构及他们之间的往来和社会参与方面关乎到所有斯里兰卡人民 – 其覆盖面为整个社会；

c) 政策影响到整个政府 – 它辐射到政府提供的所有服务尤其是可以在线提供或支持的服务；

d) 政策取得成功将取决于面向宽带生态系统的所有组成部分并认识到计划需支持并强化生态系统的供应和需求两方面以及社会经济变革的吸收能力；

e) 宽带取得成功将取决于政府强有力的领导及ICT行业获得明确的鼓励公共和私营部门投资的政策环境支持；

f) 监管和政策环境将有助于宽带市场中新兴业务和应用的竞争和发展。尤其是预期将最大限度地在可持续商业基础上提供服务和应用，享受补贴的供给将局限于成本高、需求少的环境且将是对市场的一次性或过渡性干预；以及

g) 这些宽带业务须可为斯里兰卡所有民众和社区获取且需要解决可获取性的所有问题（可用性、价格可承受性和可用容量）。[95]

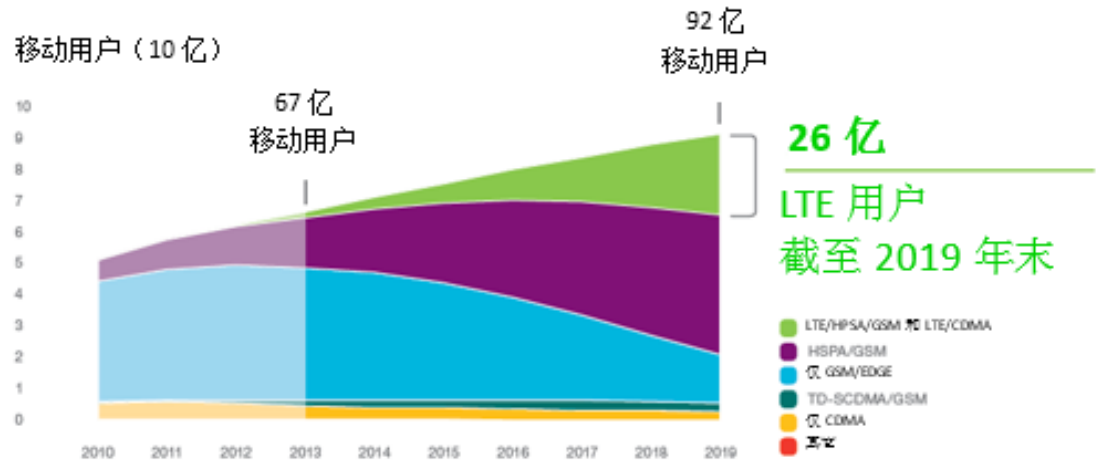
[94] SG1RGQ290号文件，“通过补贴和免收频占费提高农村连通性：肯尼亚的经验”，肯尼亚。
[95] SG1RGQ/288号文件，“斯里兰卡的国家宽带政策”，斯里兰卡民主社会会议共和国。

3.3 各种宽带部署、所提供业务和监管考虑的发展趋势

3.3.1 部署NGA面临的挑战

图12显示了移动业务的迁移将继续从GSM网络发展到LTE网络，以满足更高的数据需求。LTE需要更多的频率通过智能电话、平板电脑和各种连接到MBB网络的新设备来提供需要的最高数据传输以及更多的基础设施来提供用户要求的服务质量（QoS），提供机器对机器（M2M）业务[96,97]。

图12：各种技术的移动用户增长预测



如**图12**所示，采用2G、3G和4G的不同移动网络将继续在同一个国家同时长期提供移动业务，各个网络需要自己的频率向现有用户提供最好的服务。这些用户根据不同网络的覆盖和所需业务类型（话音或数据）从不同的网络获取服务。

为努力发展NGA，埃及国家电信监管机构NTRA根据其国家宽带规划（e-Misr）雄心勃勃地制定了以上**1.2节**中所述的提高埃及互联网可用性的计划[98]。

3.3.2 宽带网络借助联网社会的演进

联网社会的愿景-任何可从联网获益的事物均应联网-对连通性提出了新的要求。LTE是满足这些要求的一个重要组成部分，且LTE发布13是LTE演进的下一步。LTE发布13将在几个方面增强LTE并强化其作为联网社会平台的能力。该次发布中的增强包括经许可的有助接入，该技术采用载波聚合框架将未经许可的频谱作为一个组成部分加以利用，多天线增强则利用水平和垂直两个领域。这些增强将提高整体容量及用户数据速率。发布13的时延也将帮助TCP等更高层协议利用这些很高的数据速率。

与此同时，LTE将为低成本和节能型的大量机器类通信通过减小的射频带宽提供经过改进的支持，由此扩展进入新的使用情形。设备到设备的直接通信的改进将为公共安全

[96] SG1RGQ/161号文件，（法国阿尔卡特-朗讯国际）、（美国阿尔卡特-朗讯）。
[97] 1/189号文件，“移动宽带网络的演进-起草报告的素材”，瑞典爱立信。
[98] SG1RGQ/75号文件，“宽带的下一代接入”，埃及。

及各种商业使用案例提供经过改进的支持。LTE是一种不断演进，以应对新需求和新情形的灵活平台。这种LTE演进可在实现联网社会方面发挥重要作用。

根据哈萨克斯坦无线电频率跨部门委员会（ICRF）2015年12月7日的建议，蜂窝通信运营商（Kcell、Kar-Tel、MTS和Altel）可使用根据GSM、DCS-1800 (GSM-1800)和UMTS/WCDMA (3G)标准分配给他们的频率，用于组织LTE (4G)和LTE Advanced蜂窝通信，即采用技术中立的原则[99]。

此外，由于蜂窝通信运营商的数目有限，ICRF还通过了一项决定，在现有的蜂窝通信运营商中分配10 MHz的上行/下行带宽，一次性付费且无需竞争。

这一原则已在多国引入且鉴于业务的融合及各技术之间的互操作性，在当前尤其适宜。

以降低网络能耗为目标的高效节能是IMT-2020网络的一项重要要求。它可降低拥有网络的总体成本，有助于向边远和农村地区扩展网络的连通性并可持续且更加节能地提供网络接入。

长期以来，能耗性能一直在移动通信设备方面发挥着重要作用。设备的高效节能可实现更长的电池寿命，一直是移动演进背后的一个重要组成部分。但是，高效节能也成为网络基础设施的一个关键因素。此时的挑战是降低网络的整体能耗，同时管理好业务和用户数量的急剧增长。

实现高效节能需要彻底改变移动行业的设计原则并采取措施。一个注重于提供大业务容量和高数据速率的行业，现在也认识到了在只有很少或根本没有数据可传输或处理时高效节能的重要性。

高效节能的IMT-2020系统应以以下设计原则为基础：只有在需要时才激活并传输。这将实现可复制、可管理和灵活的网络设计，既有利于真正独立于负荷的节能，也可最大限度地节能。

实现这一目标的重要技术包括超简洁的设计、先进的波束赋形技术、在无线接口上分离用户数据和系统控制平面以及虚拟化的网络功能和云技术。

总而言之，LTE等新移动宽带网络的部署将协助主管部门支持未来的大业务量需求，鉴于现有的频率用于现有的移动网络，有必要为这些技术准备足够的专用新频谱。一些ITU-R研究已表明，到2020年，移动业务应对预期的数据业务量需要约1900 MHz的频谱[100]。

3.3.3 为农村地区提供宽带的主要考虑因素

在发展中国家，考虑到农村地区的地理分布和经济情况，提供宽带业务是一项挑战。[101]鉴于移动网络的技术特性，它们是恰当的解决方案。当前，有技术解决方案协助

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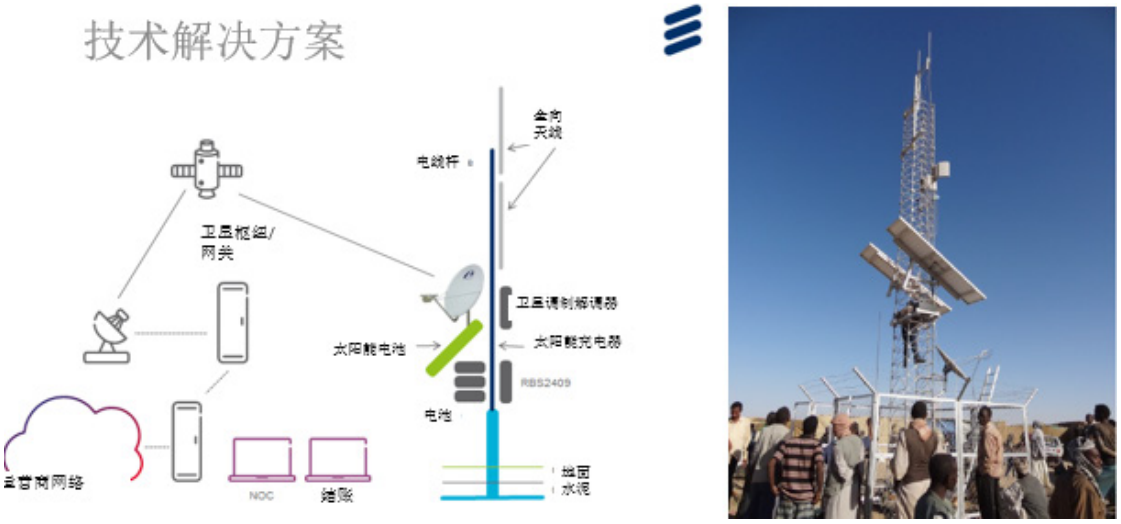
[99] SG1RGQ/152号文件，哈萨克斯坦共和国。

[100] 可从以下链接获取更详细的信息：http://www.anatel.org.mx/docs/interes/Ericsson_Mobility_Report.pdf和http://www.ericsson.com/res/docs/2015/ericsson-mobility-report-feb-2015-interim.pdf。

[101] 1/189号文件，“移动宽带网络的演进 – 起草报告的素材”，瑞典爱立信。

主管部门在最边远地区提供宽带业务。便宜且快速的技术解决方案直接在电线杆或塔架上安装完整的蜂窝站址，将安装费用和时间降至最低。**图13**显示了农村地区技术解决方案的详情及部署的真正蜂窝。有了这一解决方案，如果部署的LTE解决方案可达到36.7 Mbps的峰值速率，则一个国家最后尚未覆盖的地区即可纳入到数字时代。

图13：在农村/边远地区提供宽带业务的技术解决方案

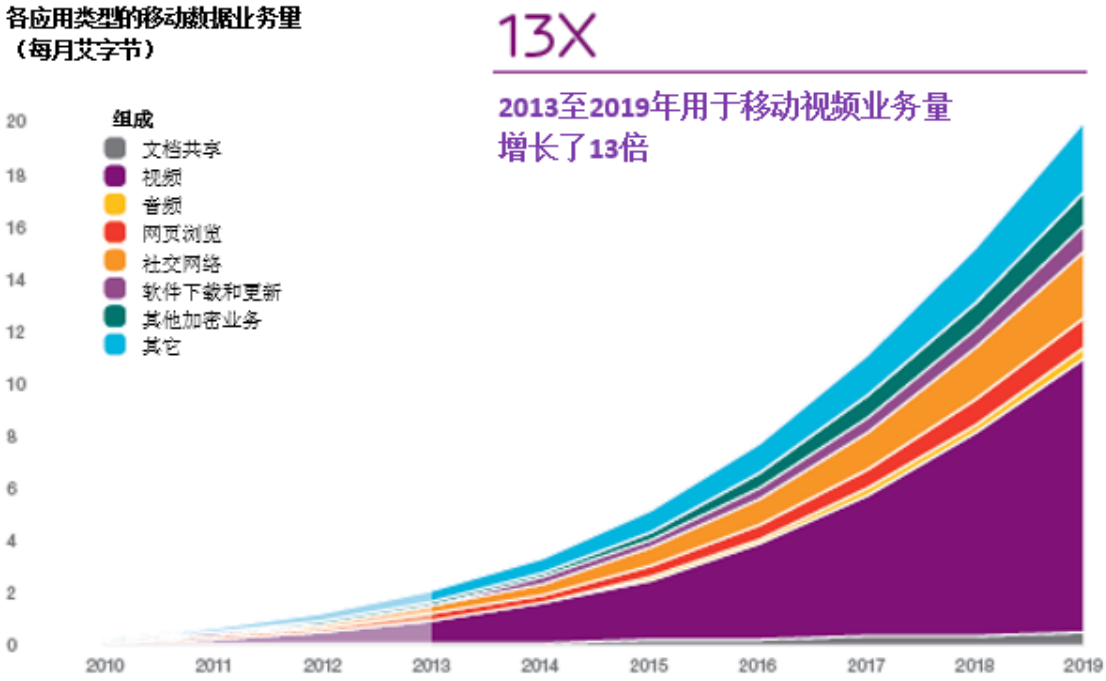


鉴于LTE和3G移动网络的时延很低，它们有能力为物联网（IoT）和机器对机器通信（M2M）等应用和服务提供服务（这是这些应用的技术要求之一）且这些网络覆盖物联网业务的所有需覆盖区域。

3.3.4 下一代网络的监管

在**图14**中说明了移动数据业务量如何随着时间增长。视频是需求最旺盛的应用，因此有必要促进部署4G网络，为最终用户下载和上传视频提供最佳的服务质量。

图14：各种应用类型的移动数据业务量



3.3.5 农村地区宽带部署的小蜂窝

不可否认，为农村地区提供基本的连通性[102]是发展中国家各国政府（如拉丁美洲各国政府）面临的挑战之一。同时注意到，基本连通性无疑并非局限于话音，而且也包括作为其他几项业务促进因素，应在任何宽带发展项目中提供的数据业务。[103]

（各国政府和业务提供商）覆盖没有任何通信网络的人口的一个主要障碍是与部署固定基础设施及相关IMT传输基站（BTS）有关的费用。通过传统的解决方案（如宏BTS）形成的商业案例需要的足够用户数量超出了任何单个农村村庄的人口 – 不要忘记，对于居民数量少于500（根据各国不同的政策，该数目可能更高）的区域，绝大多数监管将覆盖作为最次要的重点。尽管商业案例可能具有挑战性，但这些社区亟需连通性，以实现增长并对国内生产总值（GDP）做出贡献，加之物联网在农村地区发展（涉及农业和公用事业）等潜在机遇，使得采用不同技术解决方案成为各国政府、业务提供商和电信销售商的必然要求。

拉丁美洲多个业务提供商已经试验了按照将服务地区的人口成比例缩小的可选方案，以实现成本仅为宏BTS部署一小部分的目标。这些可选方案基于室外小蜂窝（Small Cells Outdoor），为农村社区提供了良好覆盖。

考虑到绝大多数考虑用于户外的小蜂窝的低功率特性（5W），覆盖范围构成了挑战。为解决这一问题，测试情形包括将小蜂窝与方向性天线结合，以便在采用850MHz等低频率时覆盖达到近1公里范围，在采用2100 MHz频段时达到700米覆盖范围。所以，根据不同的村庄及要求的不同覆盖，多个小蜂窝和方向性天线的设计可提供整个目标区

[102] 农村连通性是一个全球性问题。已向法国Champagne的小村庄建议了与本节所述类似的解决方案。

[103] SG1RGQ/161，法国阿尔卡特-朗讯国际，美国阿尔卡特-朗讯。

域的所需覆盖，或至少满足公共中心（绝大多数人口可在此获得学校、医院、警察局、娱乐公园等开放接入）的需求。

这种设计可允许提供所需的覆盖，但仍需解决两个主要问题。第一个问题是回传可用性，可有两种解决方案：

– 菊花链方式的分组无线电微波链路，连接到最近的IMT宏网络基站上，目标是在农村地区与基站之间实现最大3-4跳。这种方法的主要优点是，通过使用这样一种回程方案，可带来与微波无线电有关的较低成本以及与IMT连接相关的较低延迟。

– 卫星连接。方案1在小国家表现良好，可实现大于90%的宏覆盖；但在农村地区与第一个无线链路直接的距离超过上述3-4跳的大国，卫星连接仍是为这些小蜂窝提供回传的优秀方案。延迟仍然是这种方法面临的主要挑战，不过，拉丁美洲的一些服务提供商在Ka波段上利用带有回程卫星连接的户外IMT小蜂窝进行了测试，获得了非常好的结果。[104]

第二个同样重要的问题与没有公共电力的村庄整体解决方案（小蜂窝和微波设备）要求的功率有关。依赖低能耗的解决方案非常重要（某些服务提供商要求网络解决方案的功率低于100W），以便站点可依靠以电池为备份的太阳能电池（根据地区的不同，也可探索其他能源，如风能）。除提供的备选来源外，考虑到这些地区较为偏远且运营非常困难，这一目标也是保证3天的自主能力，以维持并确保业务的连续性。

一旦成功测试了各种技术情形，再次考虑到所研究农村地区的偏远条件，另一项挑战即是所部署基础设施的运营和维护。目前，不同的业务提供商正在研究有趣的方法，例如为社区提供初级支持活动培训，以便任何现场需要初级协助的情况可由村内或附近村庄的社区签约人员提供支持。或通过农村地区的特许计划，即分包商拥有该基础设施并负责其运营维护，同时向现有服务提供商支付费用，后者准许其使用3G频谱。

总之，本节所述技术要素（带定向天线的3G小蜂窝、分组无线回传解决方案或卫星链路以及实现备选电源的低功耗）形成了可行的技术解决方案，同时其费用只占此类地区部署宏BTS总体费用的一小部分。监管机构无疑也可有助于加速采用此类解决方案，作为获得频谱划分应承担义务的一部分，保证在较短时限内为人口少于500的社区提供连通性。

3.4 促进部署IMT卫星和地面部分综合系统的关键要素

在促进此类部署时有很多需要考虑的因素，现列举如下。[105]

a) 监管限制

上述将是部署中的一个主要局限性，因为存在规范地面IMT和卫星实施的监管框架的两个不同领域，需要对上述限制进行融合。以上局限性需解决许可、频谱使用及运营应遵循的质量标准。

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[104] 由于通过卫星连接完美建立了经由IpSEC隧道的IuH无线电接口，因此也建立了语音通话，并在若干数据应用中体验到了18 mbps的下行链路吞吐量，传输层的延迟约为 680毫秒、抖动约为15毫秒。

[105] 1/263号文件，斯里兰卡民主社会会议共和国。

b) Hetnet网络的要求

现有地面IMT正在实施中，以管理不同技术（如UMTS、LTE、LTE-A）中的宽带实施、不同的频谱且增加卫星系统需进行定义，以便与现有的Hetnet网络架构保持兼容。这将是一项重要要求，因为融合将取决于系统之间的相互兼容性。

c) 多模设备的采用

如b)所述，现有网络采用Hetnet架构以便引入与不同技术和不同运作模式兼容的设备。部署此类卫星和地面综合系统需配以很高的、多接入模式设备普及率。

d) 伙伴关系要求

与对监管领域的限制类似，分布存在着IMT和卫星领域的重要利益攸关方，需要开展更多的协作。这种协作应促进提高管理部门、运营商的合作水平，实现卫星和地面宽带覆盖的和谐部署这一终极目标。

e) 相互补充的生态系统兼容性

宽带部署可由提供接入的IMT技术和提供回传要求的卫星运营商实施。这种宽带部署方法是有益的，尤其是在回传是主要瓶颈问题的农村和边远地区部署时。

IMT包含地面部分和卫星部分无线接口。地面和卫星部分互为补充。[106]地面部分为人口密集，足以经济地提供地面系统的陆地区域提供覆盖。另一方面，卫星部分通过接近全球的覆盖为其他区域提供服务，尤其在为海洋、岛屿、山区和地广人稀地区提供覆盖方面具有优势。因此，可采用综合卫星和地面无线接口的方法实现IMT的泛在覆盖。

IMT卫星部分包括IMT-2000、IMT-Advanced和IMT-2020。ITU-R M.1850-1建议书确定了“国际移动通信-2000(IMT-2000)卫星部分无线电接口的详细技术要求”。

有关IMT-Advanced卫星部分无线接口的更多信息，请参考ITU-R M.2047建议书“先进国际移动通信（IMT-Advanced）卫星无线电接口的详细指标”和ITU-R M.2279报告“IMT-Advanced卫星程序（步骤4-7）的评估、协商和决定成果（包括IMT-Advanced卫星无线电接口特性）”。

卫星部分将仍然是网络向IMT-2020过渡的组成部分。ITU-T 的IMT-2020焦点组起草了“IMT-2020网络软件化的实施工作报告”（IMT-O-041），在其向ITU-T第13研究组的建议中强调“IMT-2020网络架构需要包括卫星等多种无线接入网技术”并建议研究“将卫星技术综合纳入IMT-2020网络架构中”。肯尼亚使用IMT和IMT-Advanced技术促进肯尼亚宽带业务发展的经验见**附件1**。[107]

[106] 1/187号文件，日本KDDI公司。

[107] 1/290号文件，“IMT和IMT Advanced技术推动肯尼亚宽带业务发展”，肯尼亚共和国。

3.5 光纤的边境互联协议

为促进非洲宽带的发展，在中非启动了国家间互联计划。该计划因缺乏监管框架而遭受挫折，它是基础设施部署一项重大突破。[108]

在落实中非的部分中非骨干项目时，刚果和加蓬之间的互联实例为次区域国家带来了启示，这些国家于2014年通过了一项决议，将次区域国家连通起来并制定谅解备忘录（MOU）。

制定MoU的内容

中部非洲经济和货币共同体（CEMAC）国家和政府首脑宣言最终将根据CEMAC2010-201年区域经济计划（REP）第三支柱（涉及成员国的物理互联）连通所有次区域的成员国。

考虑到CEMAC国家和政府首脑明确确认将完善EU整合进程，以实现和谐统一的次区域经济发展。考虑到信息通信技术的重要性及2013年10月7和8日在利伯维尔举行的刚果和加蓬光纤网络之间第一次互联互通讲习班（国际电联代表出席了该次讲习班）上提出的建议，双方同意制定互联互通协议。

协议的宗旨

两国同意签署一份谅解备忘录，规定刚果共和国与加蓬共和国的合作总框架。该签署的协议侧重于以下领域：

- 两国物理互联逻辑和光纤网络；
- 电路和带宽的协调；
- 落实能力建设项目过程中资源的筹措；
- 满足确保双方网络通信需要的互惠。

[108] 1/267号文件，“Cross-border fibre-optic interconnection agreement”，刚果共和国。

图15：刚果河加蓬共和国之间的互联

来源：1/267号文件，“Cross-border fibre-optic interconnection agreement”，刚果共和国

安排协议的架构

在几次筹备会议后，MoU的内容在双方定义的几点做出了决定：

- 前言：合作宗旨、战略领域，两国在次区域整合方面追求的目标，项目管理办公室为团队分配的职责；
- 光纤管理模式：所有权、运营、维护、批发营销：规范产权公司和运营公司（如果与前者不同的话）活动的机制、各利益攸关方承担的义务、各自的服务质量标准、营销的业务类型；
- 各方在创建上述国家联合委员会方面的承诺和职责、委员会的组成、职权和义务、与国家有关部门（监管机构、部委）的沟通；
- 网络安全和物理完整性：国际标准、设定冗余。
- 投资的可持续性：定价原则确保为O&M带来足够的收入和更新投资。

落实

协议涵盖网络寿命期的两个阶段：建设和运营。项目不同参与方为每个项目阶段联合分配工作。

- 网络建设

协议规定每个国家负责该国的基础设施建设且将向另一国家提供技术信息，确保两个网络的可运作性。

- 网络运营

网络运营由两个独立的运营商各自在其境内开展。

管理

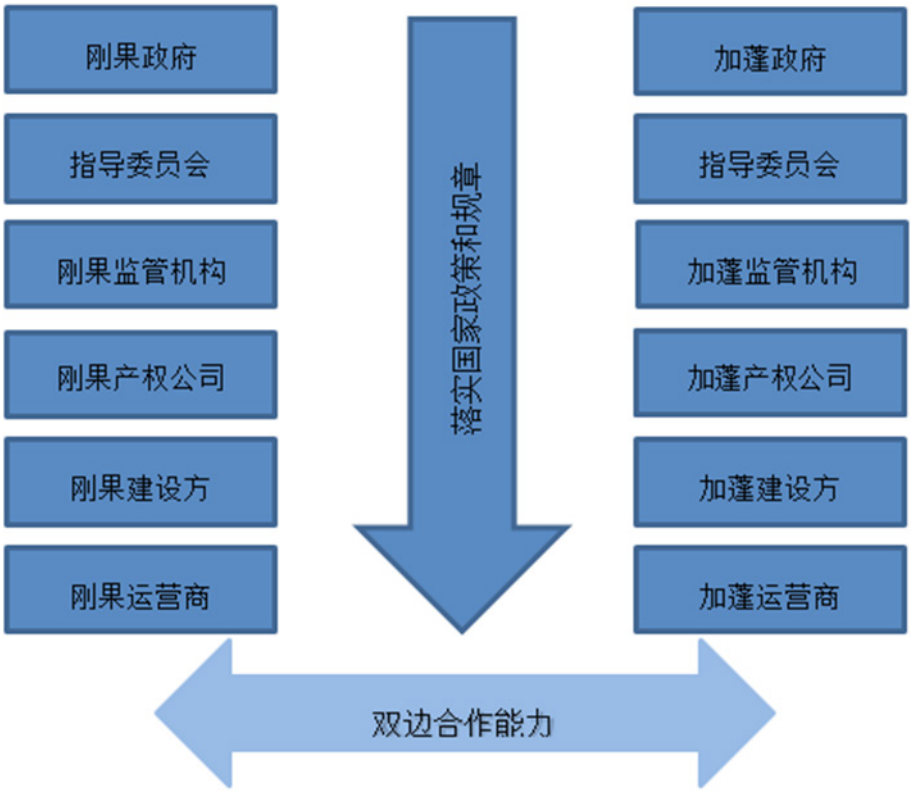
设置的联合委员会负责监督该协议。当地政府机构负责执行私营运营商必须遵守的现行规章。公共部门需要与伙伴国家的对等部门接洽。

功能安排

实行纵向的双边合作和管辖权。该目标是为了统一每个国家所做出的选择，建立管理和管控潜在冲突的共同框架。

在每个国家横向开展此项工作，以确保遵守各国现行法规。

图16：功能安排



3.6 电力企业如何参与光纤到户网络的建设

主要有两种业务模式[109]。其一，电力公司可以以资金+管道资源的形式部分参与国家光纤网络的建设，其二，也可以跟电信运营商成立合作公司建设光纤网络。第一种模式，主要以国家ICT大的战略建设国家宽带项目，国家为了节省投资总额，同时现有运营商之间的竞争，尤其是促进ILEC的进一步开放，国家主动邀请电力公司参与全国光纤网络的建设。这些国家的电力公司以资金+管道资源的形式参与国家光纤网络的建设，然后批

[109] 1/278号文件“电力公司借助自身优势参与光纤网络建设模式探讨”，中华人民共和国。

发出租给所有电信运营商。全球我们看到新西兰国家宽带光纤网络的建设中，当地电力公司North Power fiber，Waikato Networks Ltd都投资一部分资金+在某个区域的管道优势参与国家光纤网络建设，然后在这些区域公平地将光纤租给所有电信运营商。在意大利，电力公司ENEL借助自己的光纤，电力杆，管道等优势，主要参与国家光纤网络的建设（投资部分资金+自身管道资源），最后将光纤批发给其他运营商。

第二种模式，一些国家的电力公司自己主动采取与运营商成立合资公司建设光纤网络的方式，这种方式可以借助电力公司（现有管道，光纤，电力杆，运维人员等优势）和电信运营商（电信运维经验，电信技术优势）两者的优势，更容易解决光纤网络建设技术上的困难问题，但是，合作分成的比例和合资公司成立初期出资比例的问题至关重要。否则，合资公司运营到一定阶段，存在资金的继续投入和收益分成的分歧就会越来越突出，导致后续公司运行下去存在种种困难。在**爱尔兰**，电力公司ESB跟当地运营商VDF成立合资公司SIRO联合运营，未来3年在50个地区城镇提供光纤批发业务，其他运营商比如VDF、UPC、Eircom都可以从SIRO租用光纤提供1Gbps带宽业务。合资公司在电力公司（优势：路权容易获取+管道，电杆资源丰富）和运营商VDF（优势：电信运营方面非常有经验，技术实力强）强强联合下，经过充分市场调研，确定目标区域。同时制定了可行SIRO商业计划，提供有竞争力的资费，从商业模式来看，比较值得大家借鉴。在**肯尼亚**，电力公司免费出租多余电线杆和现有管道资源，由当地运营商VDF负责铺设光纤和建设FTTH网络，一半光纤免费提供给电力公司去批发出租给其他ISP。在**中国**，一些小区的光纤网络是电力公司在房子建设的时候跟电力线一起铺设的，运营商采用跟电力公司采取‘合作运营’模式。

基于电力公司现有光纤，管道资源的优势，建设好的光纤网络成本会比运营商独自建设会便宜很多，同时光纤入户难的问题相对容易。所以，上述国家的光纤批发价格比先前大大降低，批发出租给其他运营商在当地也非常受欢迎。

但是，基于电力公司的现有光纤，管道，电力杆等资源建设光纤网络，在技术上也有一些需要特殊考虑的问题。比如，有源设备的强电保护。无源设备要求都是非金属的，这样，不用考虑接地问题等。

4 第4章 – 结论和总体建议

宽带技术、社区天线、光纤、卫星及固定和移动无线的引入使得传统和新型电信在社会、经济和技术状况迅速变化的全球成为可能。

由于各国物理基础设施和地理状况迥异，在某个地区表现优异的技术不一定在另一个地区可行。此外，安装和运营电信基础设施的高昂成本可能影响到新技术的部署，而新技术可为需求更高的应用提供更高的数据速率。

部署宽带接入网需要克服许多困难，例如政策、遗留问题、现有基础设施、经济和社会影响、教育问题、意识和知识、边远和农村地区、频谱限制、生活标准、数字民主、数字和金融包容性等。

就许多国家的经验而言，实施电信宽带接入网的技术和战略非常宝贵且多种多样。物联网（IoT）和家庭联网等新前沿需要最优化的光纤/铜缆、IMT技术的物理支持和频谱使用，以便为有需求的业务划分更大的带宽，同时考虑遗留问题和成本。

公共政策和监管措施非常有助于加速核心网提供接入的业务及电信/ICT业务的发展，尤其是农村地区和边远地区的电信/ICT使用。成功案例述于有关国别经验的**附件1**中。

技术进步的有利部署只有鼓励建立透明且明确的监管环境才能实现。卫星系统高风险、高成本，只有制定了克服内在阻力并为运营商提供确定性的政策才能负担得起。

长久以来，能效在移动通信设备方面发挥着重要作用。设备的高效节能是移动演进的一个重要组成部分。但是，高效节能的必要性也已成为网络基础设施的一个重要因素。此时的挑战是降低网络的整体能耗，同时管控业务量和用户数量的急剧增长。

可采用多跳、小蜂窝、天线和微波链路（短距离）或卫星连接（广域）从IMT宏基站连接到边远地区。

以下结论包含了可有助于发展中国家如何落实IMT等宽带接入技术的总体建议：

- 决策机构应制定并定期修订国家总体规划，以创建监管框架，鼓励部署宽带接入技术。
- 请发展中国家实施鼓励性政策，刺激电信网络的发展。可实施电信中心等公共接入点的基础设施共享，以避免发展中国家农村和边远地区的重复投资。
- 应制定并实施初等、中等和高等教育规划。这将为农村人提供帮助并因此阻止农村向城市的人口流失。也可能需要协助规划宽带接入部署中适当落实ICT教育。光纤无法覆盖的偏远农村社区将从卫星连接中获益。
- 在实施各国面向各层面人群的电信/ICT时，可能需要建立政府、监管机构、运营商和其他利益攸关方之间的合作伙伴关系。
- 项目的技术、经济和地理方面至关重要。此时应考虑技术中立性。对于接入技术而言，2G、3G、LTE、Wi-Fi和WiMax等无线技术使用最为广泛，但对于需要很高数据速率的情况，应采用有线解决方案。

- 建议特别研究旨在将降低网络能耗的高效节能作为IMT-2020网络的一项重要要求。它可降低拥有网络的总体成本，有助于向农村地区扩展网络连通性并以更加可持续、更加节约资源的方式提供网络接入。高效节能的IMT-2020系统只在必要时才激活发射。
- 由于户外环境小蜂窝的低功耗（5W），应研究将小蜂窝与方向性天线结合，以便覆盖达到近1公里范围的可能性，既适于农村地区和小村庄，人口也可获得（学校、医院、警察局、娱乐公园等）开放接入。
- 鼓励各国在可能时签署有关边境互联总体合作框架的谅解备忘录。签署国际链路MoU是通过协商一致的设计、落实、运营和维护实现次区域经济协调统一发展的关键。

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
DCC	Data Communication Centre
DDoS	Distributed Denial of Service

Abbreviation/acronym	Description
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
GPON	Gigabit-capable Passive Optical Networks
GSM	Global System for Mobile Communications
GUILAB	Guinéenne de la Large Band
HARQ	Hybrid Automatic Repeat reQuest

Abbreviation/acronym	Description
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
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)

Abbreviation/acronym	Description
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
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

Abbreviation/acronym	Description
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
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

Abbreviation/acronym	Description
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)	**SG1**RGQ/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.
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.

Country/ Entity	Source Document	Title	Summary
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.
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.

Country/ Entity	Source Document	Title	Summary
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

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

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.

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.

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

– 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 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;

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

- 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]

"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

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

- 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

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

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.

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.

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

- 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.

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

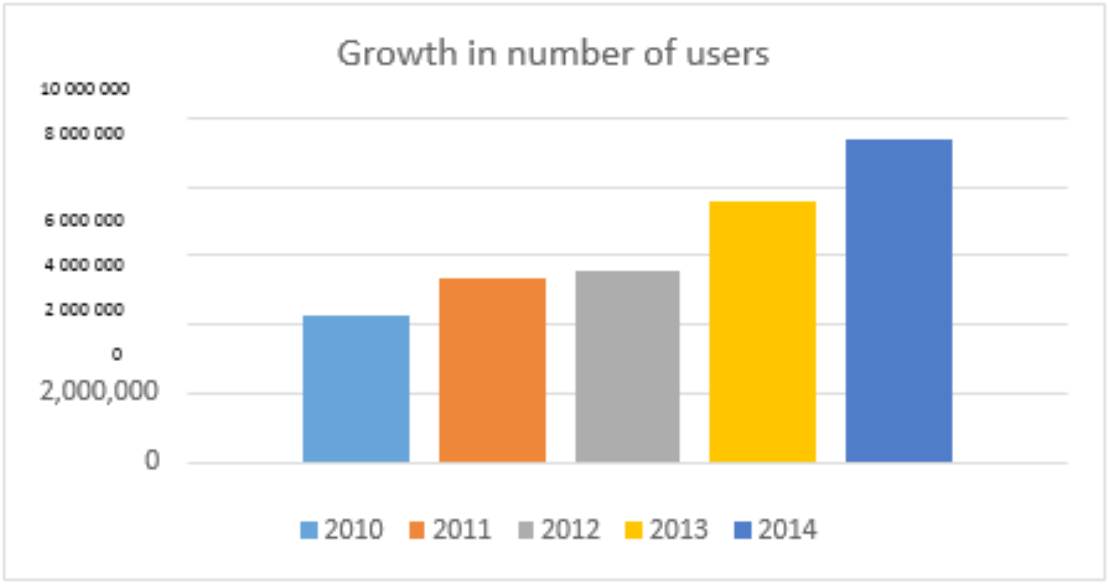
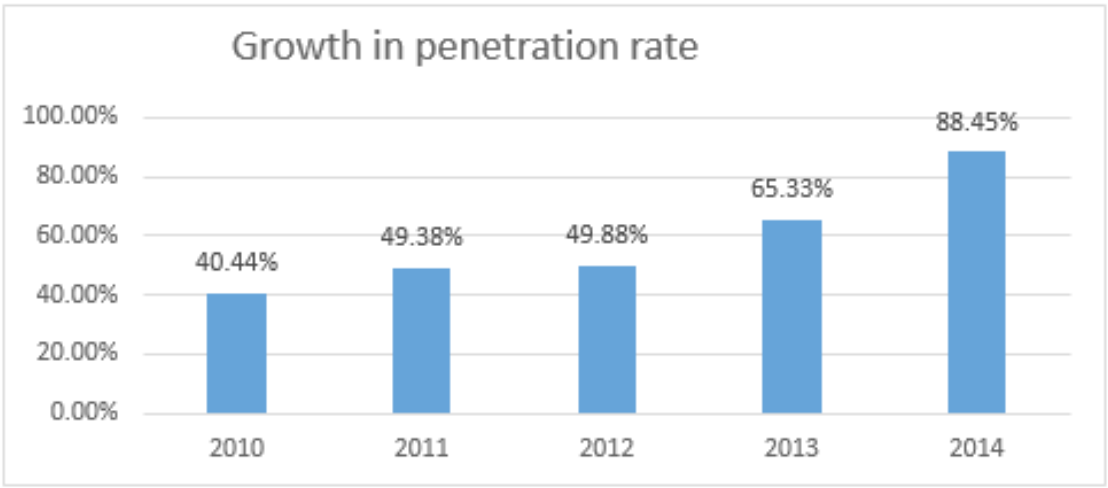


Figure 4A: Growth in penetration rate



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

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

(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 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

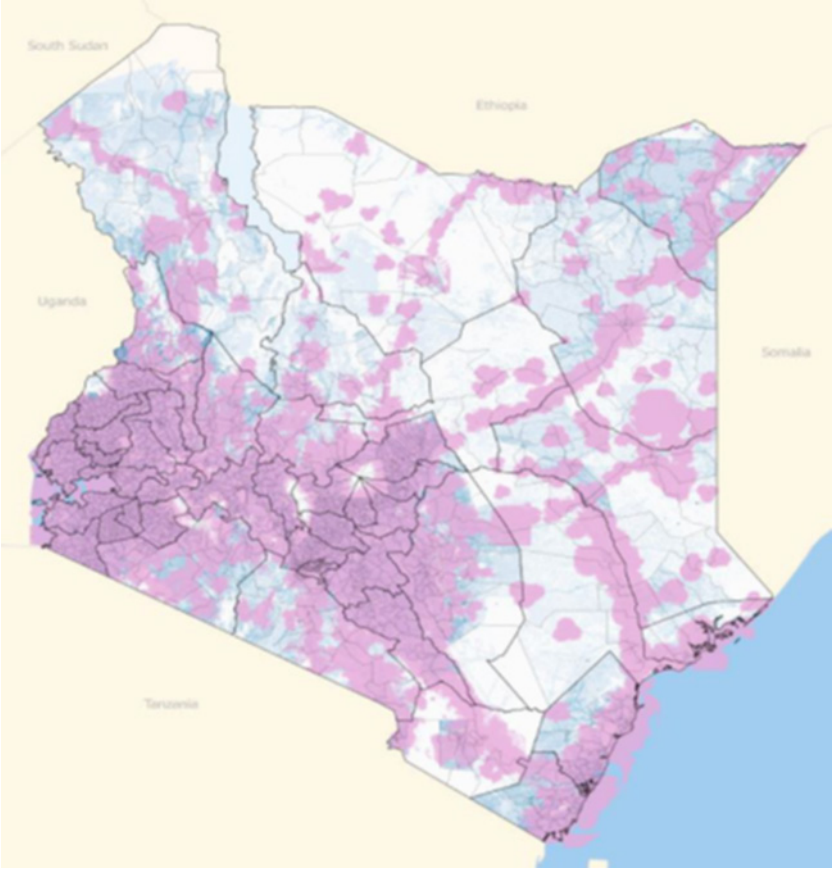
1. Overview of broadband services in Kenya

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.



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

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.

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**

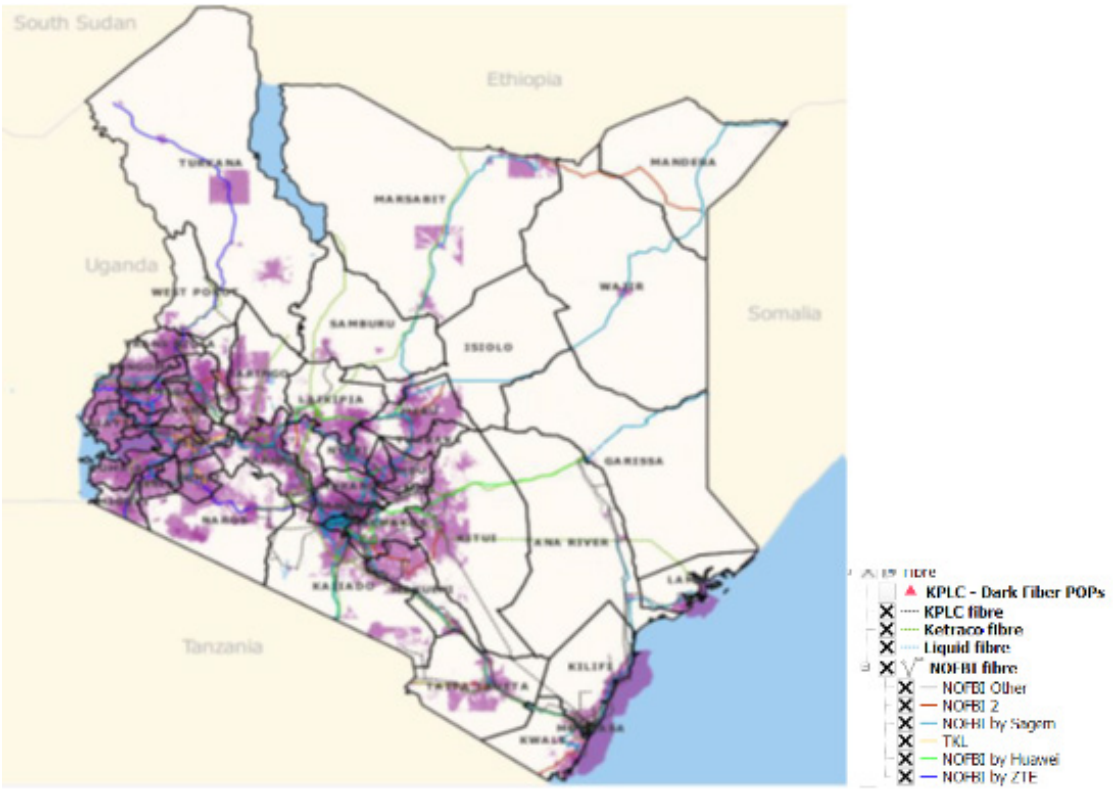
As indicated in **Figure 5A**, virtually all of the major unserved areas are in the North and East regions of the country, as well as in the Southwest border counties of Kajiado and Narok.

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.

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

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

– 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

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

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.

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;

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

– 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.

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

[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.

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.

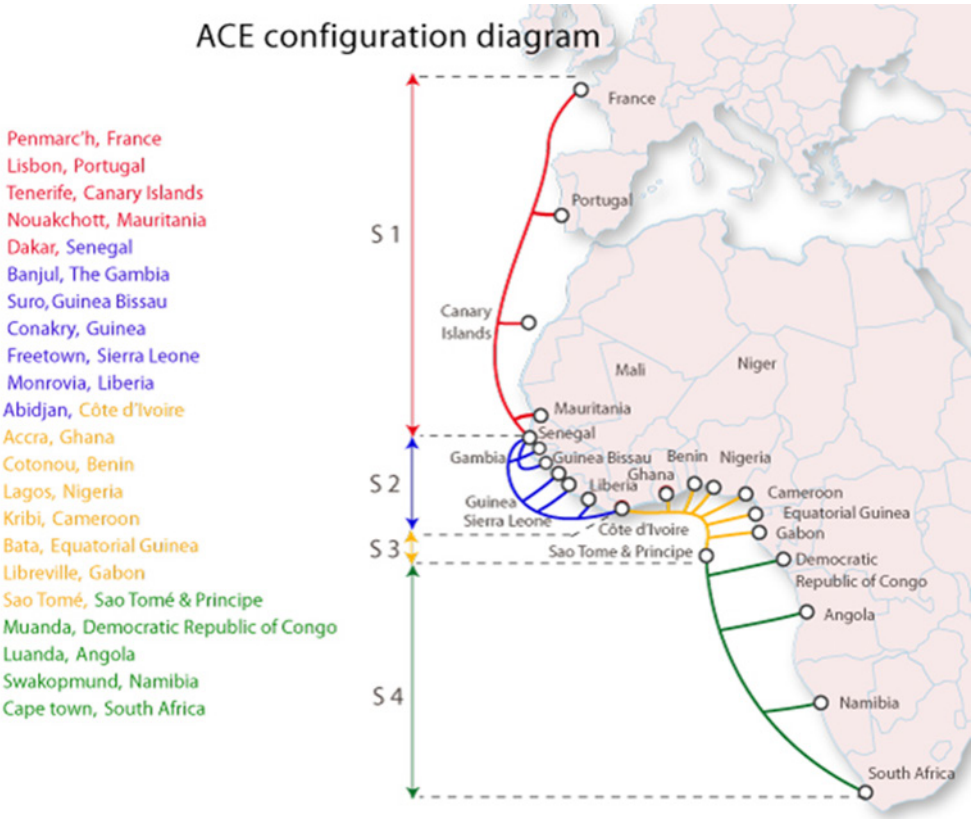
To implement this exceptional project – representing a cost of $700 million – the Orange Group teamed up with selected partners. It formed a consortium – the prevalent business model for construction of submarine cables – initially comprising 15 major players, all with a direct stake in the arrival of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

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,

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

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

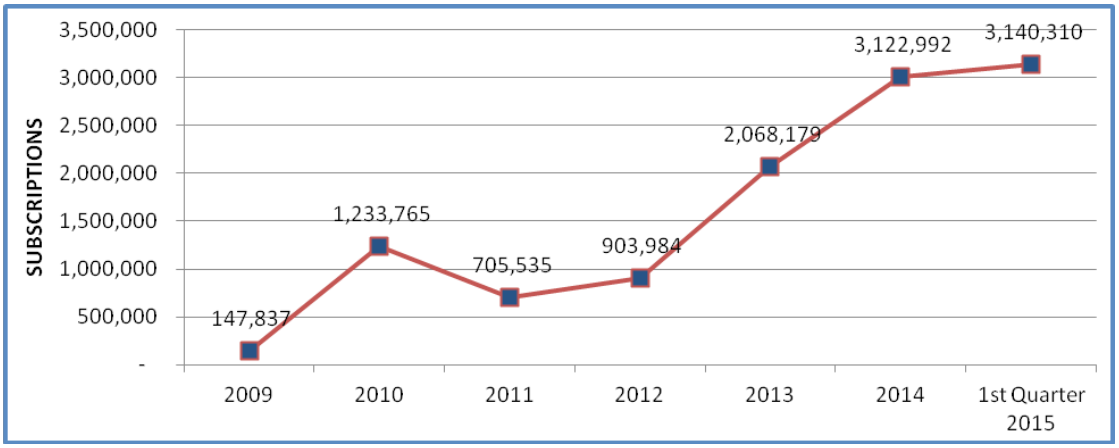
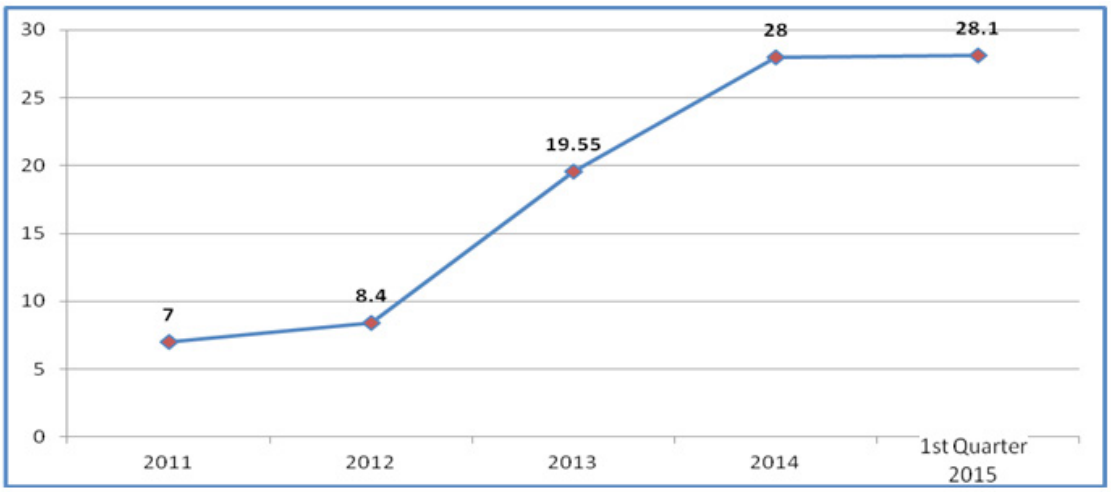


Figure 9A: Internet penetration rate trend as of March 2015



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 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

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

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), Wavelength 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]

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

[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.

[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.

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 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

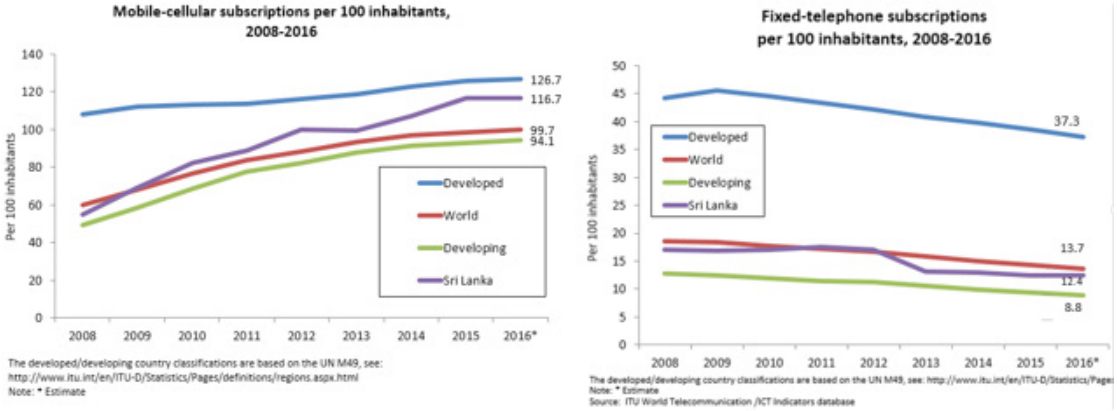
[128] http://www.icta.lk.
[129] Document SG1RGQ/288, "National Broadband Policy of Sri Lanka", Democratic Socialist Republic of Sri Lanka.

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; 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**

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

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.

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.

[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.

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."

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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.

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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)

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.

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
ITU-R Recommendation	M.1645	Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000	2013

[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.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, regulatory 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 existing 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 information-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, regulatory 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

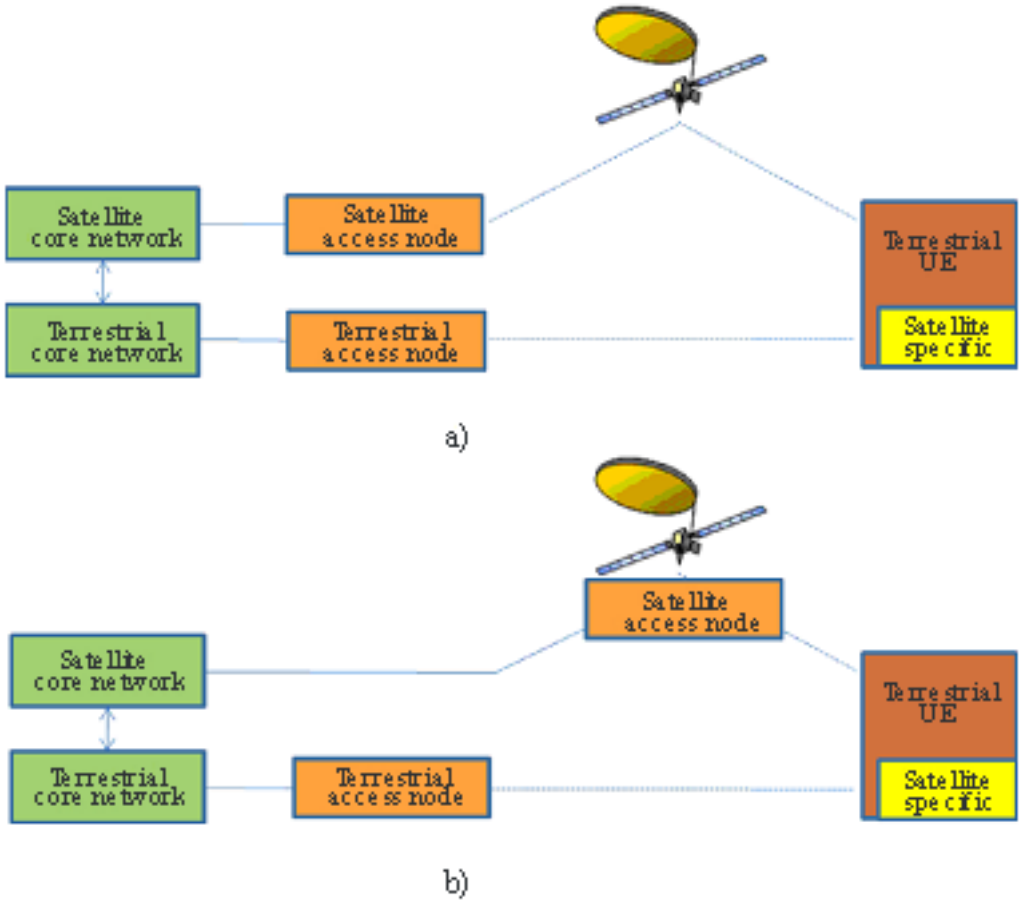
ITU-T Recommendation	Y.2012	Functional requirements and architecture of next generation networks	2006

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.

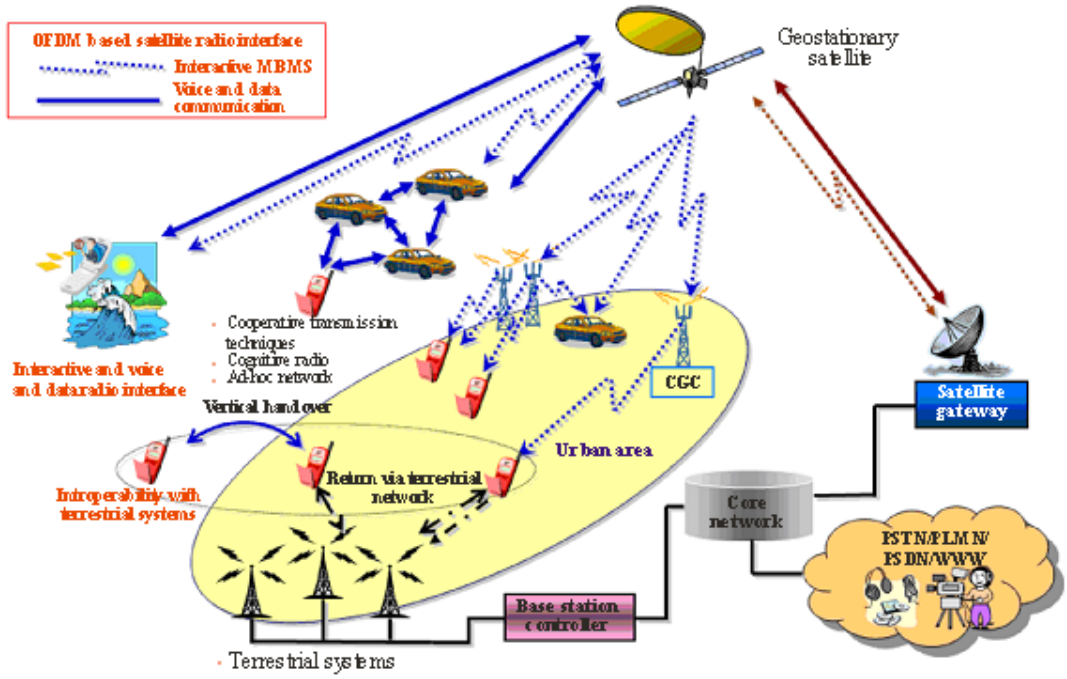
– Advanced technologies: the following “IMT-Advanced enabling technologies” can be considered in enhancing the cost-effectiveness and competitiveness of the satellite component.

  • 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)



国际电信联盟（ITU）
电信发展局（BDT）
主任办公室
Place des Nations
CH-1211 Geneva 20 – Switzerland
电子邮件： bdtdirector@itu.int
电话： +41 22 730 5035/5435
传真： +41 22 730 5484

副主任
兼行政和运营协调部负责人（DDR）
电子邮件： bdtdeputydir@itu.int
电话： +41 22 730 5784
传真： +41 22 730 5484

基础设施、环境建设和
电子应用部（IEE）
电子邮件： bdtiee@itu.int
电话： +41 22 730 5421
传真： +41 22 730 5484

创新和
合作伙伴部（IP）
电子邮件： bdtip@itu.int
电话： +41 22 730 5900
传真： +41 22 730 5484

项目和
知识管理部（PKM）
电子邮件： bdtpkm@itu.int
电话： +41 22 730 5447
传真： +41 22 730 5484

非洲

埃塞俄比亚
国际电联
区域代表处
P.O. Box 60 005
Gambia Rd., Leghar ETC Building
3rd floor
Addis Ababa – Ethiopia

电子邮件： ituaddis@itu.int
电话： +251 11 551 4977
电话： +251 11 551 4855
电话： +251 11 551 8328
传真： +251 11 551 7299

喀麦隆
国际电联
地区办事处
Immeuble CAMPOST, 3e étage
Boulevard du 20 mai
Boîte postale 11017
Yaoundé – Cameroon

电子邮件： itu-yaounde@itu.int
电话： + 237 22 22 9292
电话： + 237 22 22 9291
传真： + 237 22 22 9297

塞内加尔
国际电联
地区办事处
8, Route du Méridien
Immeuble Rokhaya
B.P. 29471 Dakar-YoffDakar – Sénégal

电子邮件： itu-dakar@itu.int
电话： +221 33 859 7010
电话： +221 33 859 7021
传真： +221 33 868 6386

津巴布韦
国际电联
地区办事处
TelOne Centre for Learning
Corner Samora Machel and
Hampton Road
P.O. Box BE 792 Belvedere
Harare – Zimbabwe

电子邮件： itu-harare@itu.int
电话： +263 4 77 5939
电话： +263 4 77 5941
传真： +263 4 77 1257

美洲

巴西
国际电联
区域代表处
SAUS Quadra 06, Bloco “E”
10º andar, Ala Sul
Ed. Luis Eduardo Magalhães (Anatel)
70070-940 Brasilia, DF – Brazil

电子邮件： itubrasilia@itu.int
电话： +55 61 2312 2730-1
电话： +55 61 2312 2733-5
传真： +55 61 2312 2738

巴巴多斯
国际电联
地区办事处
United Nations House
Marine Gardens
Hastings, Christ Church
P.O. Box 1047
Bridgetown – Barbados

电子邮件： itubridgetown@itu.int
电话： +1 246 431 0343/4
传真： +1 246 437 7403

智利
国际电联
地区办事处
Merced 753, Piso 4
Casilla 50484, Plaza de Armas
Santiago de Chile – Chile

电子邮件： itusantiago@itu.int
电话： +56 2 632 6134/6147
传真： +56 2 632 6154

洪都拉斯
国际电联
地区办事处
Colonia Palmira, Avenida Brasil
Ed. COMTELCA/UIT, 4.º piso
P.O. Box 976
Tegucigalpa – Honduras

电子邮件： itutegucigalpa@itu.int
电话： +504 22 201 074
传真： +504 22 201 075

阿拉伯国家

埃及
国际电联
区域代表处
Smart Village, Building B 147, 3rd floor
Km 28 Cairo – Alexandria Desert Road
Giza Governorate
Cairo – Egypt

电子邮件： itu-ro-arabstates@itu.int
电话： +202 3537 1777
传真： +202 3537 1888

亚太

泰国
国际电联
区域代表处
Thailand Post Training Center, 5th floor,
111 Chaengwattana Road, Laksi
Bangkok 10210 – Thailand

邮寄地址：
P.O. Box 178, Laksi Post Office
Laksi, Bangkok 10210 – Thailand

电子邮件： itubangkok@itu.int
电话： +66 2 575 0055
传真： +66 2 575 3507

印度尼西亚
国际电联
地区办事处
Sapta Pesona Building, 13th floor
Jl. Merdan Merdeka Barat No. 17
Jakarta 10110 – Indonesia

邮寄地址：
c/o UNDP – P.O. Box 2338
Jakarta 10110 – Indonesia

电子邮件： itujakarta@itu.int
电话： +62 21 381 3572
电话： +62 21 380 2322/2324
传真： +62 21 389 05521

独联体国家

俄罗斯联邦
国际电联
地区办事处
4, Building 1
Sergiy Radonezhsky Str.
Moscow 105120
Russian Federation

邮寄地址：
P.O. Box 47 – Moscow 105120
Russian Federation

电子邮件： itumoskow@itu.int
电话： +7 495 926 6070
传真： +7 495 926 6073

欧洲

瑞士
国际电联
电信发展局（BDT）地区办事处
Place des Nations
CH-1211 Geneva 20 – Switzerland
Switzerland
电子邮件： eurregion@itu.int
电话： +41 22 730 6065

国际电信联盟
电信发展局
Place des Nations
CH-1211 Geneva 20
Switzerland
www.itu.int

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