International Telecommunication Union

QUESTION 20-1/2

Examination of access technologies for broadband communications

ITU-D STUDY GROUP 2 3rd STUDY PERIOD (2002-2006)

Report on broadband access technologies

International Telecommunication Union

THE STUDY GROUPS OF ITU-D

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Examination of access technologies for broadband communications

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Glossary

3G	Third-Generation Mobile Communications
3GPP	Third-Generation Partnership Project
3GPP2	Third-Generation Partnership Project 2
ADSL	Asymmetric Digital Subscriber Line
ANT	Access Network Transport Scenarios
AP	Access Point
APONs	Asynchronous Passive Optical Networks
ATM	Asynchronous Transfer Mode
ATSC	Advanced Television System Committee
BS	Base Station
BWA	Broadband Wireless Access
CATV	Community Antenna Television
CCK	Complementary Code Keying
CDMA	Code Division Multiple Access
CMTS	Cable Mode Termination System
CO	Central Office
COFDM	Code Orthogonal Frequency Division Multiplex
CPE	Customer Premises Equipment
CWDM	Coarse Wave Division Multiplexing
DBS	Direct Broadcasting by Satellite
DFS	Dynamic Frequency Selection
DMB-T	Digital Multimedia Broadcasting – Terrestrial
DRB	Digital Radio Broadcasting
DSL	Digital Subscriber Line
DSL ISDN	ISDN Based Digital Subscriber Line
DSP	Digital Signal Processing
DSSS	Direct Sequence Spread Spectrum
DVB	Digital Video Broadcasting
DVB-H	Digital Video Broadcasting – Handheld
DVB-T	Digital Video Broadcasting – Terrestrial

DWDM	Dense Wavelength Division Multiplex
DXC	Digital Cross Connect
EPON	Ethernet Passive Optical Network
ETS	European Telecommunications Standard
ETSI	European Telecommunications Standards Institute
FDD	Frequency Division Duplex
FHSS	Frequency Hopping Spread Spectrum
FTTC	Fibre to the Curb
FTTH	Fibre to the Home
FTTP	Fibre to the Premises
FWA	Fixed Wíreless Access
GoS	Grade of Service
GSO	Geostationary Orbit Satellite
HDSL	High-bit Rate Digital Subscriber Line
HEO	Highly-Enclined Elliptical Orbit Satellites
HFC	Hybrid Fibre-Coax
IETF	Internet Engineering Task Force
IDU	Indoor/Internal Unit
IMT-2000	International Mobile Telecommunications
IMT-DS	International Mobile Telecommunications Direct Spread
IMT-FT	International Mobile Telecommunications Frequency Time
IMT-MC	International Mobile Telecommunications Multi Carrier
IMT-SC	International Mobile Telecommunications Single Carrier
IMT-TD	International Mobile Telecommunications Time Division
IMS	IP Multimedia Subsystem
IP	Internet Protocol
ISDB-T	Integrated Services Digital Broadcasting Terrestrial
ISDN	Integrated Services Digital Network
iTV	Interactive Television Broadcasting
LAN	Local Area Network
LEOs	Low Earth Orbit Satellites
MAC	Medium Access Control
MEOs	Medium Earth Orbit Satellites
MEPG	Moving Picture Experts Group

MHP	Multimedia Home Platform
NAC	Network Access Channel
NTN	Network Termination Node
NGSOs	Non-Geostationary Orbit Satellites
NLOS	Non Line-of-Sight
NRN	Network Repeater Node
ODU	Outdoor/External Unit
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiplexing Access Mode
OSI	Open System Interconnect
OSP	Outside Plant
P2MP	Point-to-Multipoint
P2P	Point-to-Point
PC	Personal Computer
PDH	Plesiochronous Digital Hierarchy
PDSN	Packet Data Serving Node
PHY	Physical Layer
PONs	Passive Optical Networks
POTS	Plain Old Telephone Service
PSTN	Public Switched Telephone Network
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
QPSK	Quadrature Phase Shift Key
ROW	Right of Way
RF	Radio Frequency
RLAN	Radio Local Area Network
SDAF	Satellite Dependent Adaptation Function
SHDSL	Single Pair High Bite Rate Digital Subscriber Line
SI-SAP	Satellite-Independent Service Access Point
SMEs	Small and Medium Sized Enterprises
SSMF	Standard Single Mode Fibre
STs	Satellite Terminals
STLs	Studio-to-Transmitter Links
STM	Synchronous Transport Module

TCPAM	Trellis Coded Pulse Amplitude Modulation
TDD	Time Division Duplex
TD-SCDMA	Time Division Synchronous Code Division Multiple Access
TIA	Telecommunications Industry Association (USA)
TMN	Telecommunication Management Network
UHF	Ultra High Frequency
USB	Universal Serial Bus
UWB	Ultra Wide Band
VDSL	Very high Digital Subscriber Line
VHF	Very High Frequency
VoIP	Voice-over-Internet Protocol
VSAT	Very Small Aperture Terminal
WAN	Wide Area Network
WCDMA	Wideband Code Division Multiple Access
WCS	Wireless Communication Services
WDM	Wavelength Division Multiplex
WEP	Wired Equivalent Privacy
Wi-Fi	Wireless Fidelity
WiMAX	Worldwide Interoperability for Microwave Access
WLAN	Wireless Local Area Network
WLL	Wireless Local Loop
WMAN	Wireless Metropolitan Access Network
WPAN	Wireless Personal Access Network
ZWPF	Zero Peak Water Fibres

Introduction

One of the latest trends in enhancing telecommunication systems involves broadband technology. Many people associate broadband with a particular speed of transmission or a certain set of services and/or applications, such as digital subscriber loop (DSL) or wireless local area networks (WLANs). However, since broadband technologies are always changing, the definition of broadband also continues to evolve. Today, the term broadband typically describes recent connections, including internet ones, which range from 5 times to 2000 times faster than earlier Internet dial-up technologies. However, the term broadband does not refer to either a certain speed or a specific service.[1]

Broadband technology allows for high-speed transmission of voice, video, and data over networks. The introduction of broadband technologies, including but not limited to Digital Subscriber Line (DSL), community antenna, optical fibre, satellite, and fixed and mobile wireless, has enabled traditional and new forms of telecommunication to become a reality throughout the world. Because physical infrastructure and geography are vastly different from country to country, technology that works well in one geographic area may not work as well in another. Therefore, it is up to each individual locality – whether it be a village, city, province or country – to determine the technologies that best meet its needs.

This report is intended to inform decision-makers and industry participants from developed countries around the world about the technical, economic, and development factors influencing the effective deployment of broadband access technologies and applications. The Report is organized into three sections:

a) The section on general broadband matters will focus on the economic and social benefits of broadband, strategies for promoting the deployment and use of broadband access technologies and applications along with an analysis of the Questionnaire (CA 25 / Doc. 004) focusing on economic, technical and development factors affecting broadband deployment.

b) The section on technical matters will include a brief synopsis of available technologies that can be utilized to provide broadband access to end-users, a Technology Matrix and will also contain several country experiences.

c) In third section contains several country experiences which illustrate the technological, economic and social factors that both affect and are affected by the deployment of broadband access technologies. For the purposes of this Report, country experiences are extremely useful because they provide real-world examples of situations where governments and organizations have had to implement creative and innovative strategies in order to extend broadband services to their constituents. Upon examining the country experiences included in this report, developing countries will be able to save time, money and resources by learning from the examples of other communities that faced similar challenges with broadband deployment and access.

The countries and technologies mentioned in the report have been chosen because they were detailed in a Question 20-1/2 contribution or have been highlighted in ITU reports on broadband and other public media outlets. Other countries and interested sector members are invited to contribute to the future update of this Report.

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1 ITU Internet Reports: "*Birth of Broadband*"; International Telecommunication Union; September 2003.

Section I – General Broadband Matters

I.1 Social and Economic Benefits of Broadband in Telecommunications

Broadband is extending greater access to the information society, at a lower cost, to more people worldwide. Furthermore, broadband is delivering multiple applications (voice over IP telephony, Internet applications, television/video applications and audio applications) over a single network.[2] For developing countries, access to the internet helps to provide previously unattainable services such as e-learning cheap telecommunications and medical know-how, and broadband has the potential to make these benefits even more achievable by bringing down costs and increasing the quantities of information exchanged. The Internet Report "The Birth of Broadband"[3] identifies some of the ways that broadband is impacting societies around the world:

- The sharing of knowledge is enhanced by ensuring equitable access to the Internet, which is considered as a source of information for educational, scientific, economic, social, political and cultural activities.[4]
- Broadband is becoming a more significant tool that is accessible to all for the attainment of truly pervasive telecommunications. This goes some way towards the fulfilment of access to knowledge for all as a basic human right – a goal that has been evoked in a number of regional and international declarations and that forms one of the main tenets of the Principles developed as part of the United Nations World Summit on the Information Society (WSIS).[5]
- The development of broadband is also bringing about a paradigm shift in levels of informatization, and therefore, accountability, particularly in government processes. Wider public access to government information, and the opening up of information on public networks, underscores a commitment to democracy and good governance.

In addition to its impact on social issues, broadband is considered an accelerator of economic development. With broadband access, it is very common that worker productivity increases. Broadband creates opportunities for bundling services together and enables telecommunication operators to offer more services to consumers at lower prices, creating added efficiencies in both time and money. In addition, new or offshoot industries are created as a result of broadband. As telecommunication broadband penetration rates grow, there will be resulting demand for computer and home network equipment, as well as wireless handheld devices and other equipment that facilitate broadband use. The economic benefits of broadband also can be attributed to indirect factors, including "increased e-commerce applications, reductions in commuting, increased consumption of entertainment, Internet telephony and savings in healthcare as a result reducing the cost of sophisticated telemedicine"[6]. For the distribution enterprise sector, the economic benefits result from efficiencies in the distribution of goods, services and information. Thus, the economic benefits of broadband transcend from both direct and indirect sources.

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[2] ITU Internet Reports: "*Birth of Broadband*"; International Telecommunication Union; September 2003. This publication has been compiled by the ITU General Secretariat.

[3] ITU Internet Reports: "*Birth of Broadband*"; International Telecommunication Union; September 2003.

[4] See: www.itu.int/osg/spu/ni/promotebroadband/PB03-PromoteBroadband.doc

[5] WSIS Declaration of Principles, www.itu.int/wsis

[6] Ben Mackin. "*The value of Widespread Broadband*", Entrepreneur.com, August 13, 2002.

In the United States, for example, several studies have been released detailing the prevailing economic benefits of broadband deployment. A July 2001 study conducted in the U.S. by Robert Crandall and Charles Jackson has estimated the benefit of broadband to the United States to be upwards of USD 500 billion per year within the next fifteen to twenty-five years, if broadband were to become nationally available.[7] In addition, the Corporation for Network Initiatives in California (CENIC) projects the benefits of broadband for the state to be quite substantial. California's "One Gigabit or Bust" broadband initiative promises to add 2 million jobs and an estimated USD 376 billion growth in gross state product (GSP) by 2010. This would equate to a 17 per cent increase in GDP per capita, as opposed to a mere 3 per cent increase without expanded broadband deployment.[8]

Many countries and governments around the world may be concerned about the expenses of deploying broadband networks; however, with economic incentives and a favourable regulatory policy, it may be done both cost effectively and efficiently. Potential fiscal incentives for broadband build-out, such as tax credits, grants, subsidized or low-interest loans, support for research and development on broadband technologies – particularly for rural and underserved areas – can make broadband network deployment a reality.[9]

I.2 Broadband Applications in Telecommunications

With the advent of broadband technologies, a myriad of applications become possible or are enhanced beyond their current capabilities limited only to dial-up Internet access. Some of the applications include:

- E-Health
- E-Working
- E-Government
- E-Agriculture
- E- Learning
- Public Safety
- Applications for persons with disabilities
- Utility applications
- Small business assistance
- Information gathering
- E-Tourism
- E-Commerce
- Entertainment

While this is not an exhaustive list, these applications are some of the most important for broadband use. The next section describes some of the most commonly used broadband applications and provides real-life examples of how broadband has been used globally to facilitate these services.

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7 Robert Crandall and Charles Jackson. "*The $500 Billion Opportunity: The Potential Economic Benefits of Widespread Diffusion of Broadband Internet Access*", Criterion Economics, L.L.C., Washington D.C., July 2001.

8 Corporation for Education Initiative in California. www.cenic.org

9 "Broadband Bringing Home the Bits". Washington D.C., National Academy Press, 2002, p. 168.

I.2.1 E-Health

E-Health (also referred to as telemedicine) has been touted as one of the primary applications made possible by broadband technology. E-Health refers not only to making diagnoses and treating patients using high-speed telecommunication access with two-way voice, video and data transmission, but it can also refer to the ability of consumers to purchase medical supplies or prescription drugs online.

Broadband deployment has led to revolutionary developments in the medical field. E-Health allows patients that are either too elderly, too sick or those in rural or remote areas too far away from medical facilities to "see" a doctor and receive medical attention using medical equipment and digital imagery technology. Thus, e-health enables improved access and better quality medical care to those who cannot visit a doctor in person, as well as offers early diagnosis and medical treatment. E-health also facilitates medical training for persons that can help doctors and patients in the diagnosis process from afar. While not only reducing transportation costs, it encourages the sharing of scarce resources for medical care.

Internationally, there are many examples where e-health has had a significant societal impact. The beauty of e-mail is that, with the appropriate technology, it can be performed anywhere. The following are just a few examples of where and how e-health, using broadband technology, has been employed.

- Tele-radiology in Canada's Buchanan Memorial Hospital used broadband telecommunication technology to help diagnose a problem in a patient over 270 kilometers away, thus allowing for proper patient care without the patient having to be moved.[10]
- Using telecommunication satellite broadband technology, several patients in a remote area in Canada were treated by a dermatologist that was over 900 miles away. Had the technology not been available, those patients would have had to wait several months until the specialist could make it out to this remote area.[11]
- In Ontario, the Canadian Hearing Society has planned several projects using broadband technology in an interactive, broadband technology to support education, employment and telecommunication opportunities for people who are blind and hard of hearing.[12]
- In Russia, the E-health Foundation of Russia is focused on using broadband technology to conduct e-health consultations between Russia and other countries in Europe and North America, as well as within Russia's vast borders.[13]
- The Medical Informatics and Technology Applications Consortium (MedITAC[14]) has made several successful trips to Ecuador in recent years. Teams of medical and technical personnel have completed many projects in Ecuador, including electronic transmission of pre-operative patient data; installation of

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[10] Canadian Broadband Taskforce Report, "*Networking the Nation for Broadband Access*", 2001, p. 29.

[11] Canadian Broadband Taskforce Report, "*Networking the Nation for Broadband Access*", 2001.

[12] Canadian Broadband Taskforce Report, "*Networking the Nation for Broadband Access*", 2001, p. 20.

[13] www.meditac.com/MedITAC/Projects/projects_main.cfm

[14] Stands for The Medical Informatics and Technology Applications Consortium, which has its headquarters on the Medical Campus of the U.S. Virginia Commonwealth University.

Electronic Medical Record (EMR) in Ecuador; training of collaborators in entering, exporting, and importing data; transmission of text files from remote villages to larger cities using high frequency radio; and transmission of live hernia surgery from a mobile surgical truck with images from a laparoscopic camera, while surgeons in Richmond identified key instructions.[15]

- In Turkey, MedITAC sent two people to Turkey with Physicians for Peace (based in Norfolk, Virginia, USA) to assemble a multimedia course on landmine victim rehabilitation. The Physicians for Peace mission focused on developing an on-site multimedia curriculum that can be used for landmine relief efforts anywhere in the world.[16]

- In Uzbekistan the Teleconsultation System for the Republican Centre of Emergency Medicine is one of the largest medical centres in Tashkent, the nation's capital. The principle long-term e-health goal of the centre is to connect via broadband, the primary Emergency Centre with the National Research Centre of Surgery and all 12 regional branches of the Emergency Centre. Initially, e-health transmissions will be based on store-and-forward Internet technology. Later, when the country's telecommunication infrastructure has been upgraded to ISDN, videoconference facilities are also to be implemented. The system will be focused on teleradiology.

For more information on applications for telemedicine and e-health applications, please see the ongoing work under Question 14-1/2, "Application of telecommunications in health care."[17]

I.2.2 E-Working

The ability to work – either work from home or from another location, such as a telecentre that is outside of a person's regular office – is an important telecommunication broadband application using such technology. E-Working can contribute to time and cost savings for both employers and employees, as well as enable persons with disabilities or others that are physically challenged to work. While E-Working is generally thought to mean "working from home," it is not limited to this. It also refers to using virtual or satellite offices to work. In a virtual office, employees may share a reduced office space at a nearby employer facility, use the same facilities on a rotating basis, or participate in a fee-based telework centre arrangement.[18]

Many people believe that E-Working can significantly change their lives. By using broadband technology for teleworking, people spend more time working and less time commuting to and from work. This becomes particularly important both in high-density areas where traffic and traffic-related pollution are both very high, as well as in remote areas that force workers to travel great distances to get to their jobs. E-Working also can improve employee productivity by reducing the number of distractions that people encounter at the office. This is because it can help eliminate competing priorities and interruptions.[19]

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15 www.meditac.com/MedITAC/Projects/projects_main.cfm

16 www.meditac.com/MedITAC/Projects/projects_main.cfm

17 www.itu.int/ITU-D/webdocuments/list_new.asp?question=Q14-1/2&lang=en&period=2002

18 Positively Broadband Campaign, "*Anytime, anyplace, anywhere: Broadband and the Changing Face of Work*", July 2002, p. 5.

19 Positively Broadband Campaign, "*Anytime, anyplace, anywhere: Broadband and the Changing Face of Work*", July 2002, p. 5.

For many companies, teleworking results in significant advantages for both employers and employees, and it can be a low-cost employee benefit provided by companies. E-Working can contribute to reduced office space rental and parking expenses, as well as save on business travel due to the reduced need to travel to physically attend meetings. It also can provide workers the needed flexibility that may induce well-qualified people, who otherwise may not want to work in particular jobs or areas, to accept certain jobs.

E-Working using broadband technology also can facilitate group projects and collaborative projects with professionals in different locations. This helps maximize efficiencies and sometimes-scarce economic and professional resources. With the assistance of videoconferencing, as well as streaming audio and video facilities, teleworking enables employees to collaborate on projects more easily, reduces the need for face-to-face meetings, and therefore reduces the necessity to travel, while accomplishing the same goal of "seeing" people or presentations in real-time.

E-Working may also assist persons with disabilities who currently are underemployed or unemployed due to communication difficulties or trouble with transportation to an office outside of the home or other facility. Because the high connection speeds and the facilitation of two-way voice, video and data transmission, broadband enables the presentation of information in multiple formats, such as audio, video, and captioning, which are well-suited for those with certain disabilities. Thus, broadband technology opens up a range of telecommunication choices that help present information in the most appropriate format for peoples' needs.[20]

Another advantage of using broadband to facilitate teleworking is that it can improve employee retention rates, thereby reducing recruitment costs and other costs, such as advertising, interviewing, and training, that are associated with hiring new employees. It also can reduce absenteeism because it allows people flexibility to balance work and home-related activities more easily, thereby reducing the need for people to take time off from work or use sick leave to accomplish the same goals. Overall, E-Working can be a substantial time- and money-saving application for many different industries.

Companies, both large and small, can reap the benefits of E-Working. A subsidiary of a large multinational company, Siemens Enterprise Networks, has realized substantial savings by promoting teleworking which became a mainstream part of the business model in 1996. By mid-2002, 20 per cent of the 3 000 employees were dedicated full-time E-Workers, and 40 per cent were mobile workers.[21] E-Working enabled the company to decrease office space by 35 per cent nationwide and annual real estate savings have been over USD 3 million in the 3 000-person subsidiary alone.

Many smaller companies and individuals have reaped the rewards of E-Working, as well. In order to assist smaller companies in rural U.S. communities, the United States Government is actively promoting the benefits of E-Working in the United States through the Farm Security and Rural Investment Act of 2002 which was signed into law on May 13, 2002. The law provides grants of USD 500 000 each to rural communities to establish telework sites. Grants will be awarded to non-profit organizations, educational institutions, and Native American tribes. The law also authorizes the U.S. Secretary of Agriculture to establish and operate a national rural E-Work institute. This institute will conduct outreach to rural

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[20] Positively Broadband Campaign, "*Anytime, anyplace, anywhere: Broadband and the Changing Face of Work*", July 2002, p. 5.

[21] Siemens Enterprise Networks – Facts on Teleworking Products and Practices Press Release, 2001.

communities and rural workers; develop innovative, market-driven telework projects and joint ventures with the private sector that employ workers in rural areas in jobs that promote economic self-sufficiency; support private sector businesses that are transitioning to telework; and support and assist telework projects and individuals at the State and local level.[22]

I.2.3 E-Government

As an entity that primarily provides services to others, government is in a prime position to reap the benefits of broadband technologies. Governments can use broadband to help transform legacy systems into customer-friendly systems and create a public-centered service for such public.

E-Government applications can help citizens solve problems. E-Government allows citizens to get information on basic government services to allow citizens to fill out electronic forms and get information through self-service online. With more citizens accessing and using services online, the more expensive paper, voice and face-to-face transactions are likely to shrink, lowering the cost of providing services.[23] This also allows government agencies greater ability to concentrate on providing improved quality of service or expanding the quantity of services they provide.

Broadband allows interaction with the government to be more convenient for citizens because it reduces the time necessary to get information. It can obviate the need to make phone calls or visit government offices during business hours because tasks can be performed at the citizen's convenience. In addition, those who work long hours or shift work, the elderly and those with mobility problems or other disabilities have the same opportunities as others to get the information they need.[24]

Examples of some of the services that can be provided using E-Government include: renewing a driver's licenses; registering to vote and voting; one-stop shopping for government services without having to know which government agency handles specific functions; ordering birth, death, marriage certificates; filing and paying taxes; and obtaining business licenses.[25] Other services include filing for financial aid, as well as filing applications for certain government housing, education and other programs.

Broadband technology -enabled E-Government is a win-win for both citizens and the government itself. Within government, broadband can lead to improved task management, as well as less waste, fraud and abuse. Many internal government transactions can be handled online, including travel reimbursements, changes of address, pension fund modifications, etc.[26] Broadband technology also can enable government to save money on mailing, printing and handling costs. Overall, electronic service delivery can change human resource management patterns and improve organizational performance.[27]

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22 Farm Security and Rural Investment Act of 2002. See www.fsa.usda.gov/dam/BUD/PL107-171.pdf

23 Andrew Leigh and Robert Atkinson, "*Breaking Down Bureaucratic Barriers – The Next Phase of Digital Government*," Progressive Policy Institute, November 2001.

24 Andrew Leigh and Robert Atkinson, "*Breaking Down Bureaucratic Barriers – The Next Phase of Digital Government*," Progressive Policy Institute, November 2001.

25 M. Cook, "*What Citizens Want from E-Government*", Center for Technology in Government, University of Albany/SUNY, www.ctg.albany.edu/resources/htmlrpt/e-government/what_citizens_want.html

26 Leigh Atkinson, "*Breaking Down the Bureaucratic Barriers: The Next Phase of Digital Government*", November 2001, p. 7.

27 S. Cohen. and W. Eimicke, "*The Use of the Internet in Government Service Delivery*", PWC Endowment for the Business of Government, 2001. See www.endowment.pwcglobal.com

There are many examples of countries that have employed broadband technology to create E-Government applications.[28] The following are just a few:

- In the Dhar district in central India, the Gyandoot Project has established community-owned, technologically innovative and sustainable information kiosks in a poverty-stricken, tribal dominated rural area of Madhya Pradesh. Information kiosks have connectivity through local exchanges on optical fibre or UHF links. Citizens can use the kiosks to obtain Agriculture Produce Auction Centre Rates; get copies of land records; conduct online registration to obtain income/caste/ domicile certificates; file an online public grievance redress; conduct auctions for land, agricultural machinery, equipment, and other durable commodities; and obtain updated information regarding beneficiaries of social security pension, rural development schemes and information regarding government grants given to village committees and public distributions.[29]

- In Brazil, the state government of Bahia has created Citizen Assistance Service Centres (SAC), using broadband technology, that bring together federal, state, and municipal agencies in a single location to offer the e-services that citizens most frequently need and use. The centres have been placed in convenient public locations, such as shopping malls and major public transportation hubs.

  They offer citizens significant time savings, while also delivering services with greater courtesy and professionalism. A further benefit has been a reduction in the overhead expenses of government since, in many instances, agencies pay much lower rents for space in the SAC than for the properties they previously rented to interact with the public.[30]

- The Department of Revenue in Karnataka, India, has computerized 20 million records of land ownership of 6.7 million farmers in the state. Previously, farmers had to seek out the village accountant to get a copy of the Record of Rights, Tenancy and Crops (RTC) – a document needed for many tasks such as obtaining bank loans. Currently, for a small fee, a printed copy of the RTC can be obtained online at a computerized land record kiosks (Bhoomi centres) in 140 *taluk* offices. In the next phase, all the *taluk* databases are to be uploaded to a web-enabled central database. RTCs would then be available online at Internet kiosks connected through broadband technologies, which are likely to be set up in rural areas.[31]

- A European Commission study, carried out in April 2002,[32] on E-Government in Europe shows clear progress. Since the measurement in October 2001, the availability and interactivity of public services on the Internet rose by 10 per cent to reach 55 per cent. The study was part of the European Commission's "Benchmarking eEurope" initiative and measured twenty basic public services in the 15 EU Member

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28 See: www.digitalopportunity.org/cgin/index.cgi?root=2822&url=http%3A%2F%2Fwww1%2Eworldbank%2Eorg%2Fpublicsector%2Fegov%2Fservdel%2Ehtm for other examples.

29 See: www.digitalopportunity.org/cgiin/index.cgi?root=2822&url=http%3A%2F%2Fwww1%2Eworldbank%2Eorg%2Fpublicsector%2Fegov%2Fservdel%2Ehtm

30 See: www.digitalopportunity.org/cgibin/index.cgi?root=2822&url=http%3A%2F%2Fwww1%2Eworldbank%2Eorg%2Fpublicsector%2Fegov%2Fservdel%2Ehtm

31 See: www.digitalopportunity.org/cgibin/index.cgi?root=2822&url=http%3A%2F%2Fwww1%2Eworldbank%2Eorg%2Fpublicsector%2Fegov%2Fservdel%2Ehtm

32 See: europa.eu.int/rapid/start/cgi/file.tmp_Foot 1

States, plus Iceland, Norway and Switzerland. In this study, a representative sample of more than 10 000 public service providers in the 18 countries was assessed. The survey found that the overall degree of online availability of public services in the countries through broadband technologies was 55 per cent, compared to 45 per cent in October 2001. The categories of public services that were most prevalent included income-generating services, such as taxes and social contributions (79 per cent), followed by registration services, such as registration of cars and new companies, and social security. Services related to documents and permits, such as drivers' licenses and passports, were the least developed on the web (41 per cent).[33]

- By 2003, the Japanese Government's E-Government Program was expected to result in nearly all applications and procedures being available online.[34] The government would like to deploy public Local Access Networks (LANs) that connect schools, libraries, community centres and city halls across the country by 2005.
- In Canada, the city of Yellowknife now offers many government services online. Citizens can register businesses, obtain lottery licenses, pay parking tickets, book public facilities and find information about local laws. Through a project called CityNET, the city is preparing to offer citizens information through an interactive computerized phone system and an interactive version of cable television.[35]
- In the UK, the www.ukonline.gov.uk portal was created to provide a single access point to UK Government information and services. It was launched in early December 2000 and contains applications and features, such as:

  a) "Quickfind" – a powerful search engine that guides users directly to the right information, allowing people to cut through the maze of government.

  b) "Do It Online" – access to useful online transactions, such as applying for a passport, buying a TV license, paying bills, notifying others of changes of address and filling in self-assessment tax returns.

  c) "Newsroom" – providing an easy way to keep in touch with government news, announcements and advices.

  e) "CitizenSpace" – a section to make it easy for people to find out about government plans and contribute to the formulation of new policies on which the public is invited to comment.

  f) "Easy Access" pages, which give simpler access to the portal for those who are visually impaired or have low reading skills.[36]

I.2.4 E-Agriculture

Agriculture is another ideal candidate for reaping the benefits broadband technology. Broadband access creates a link between buyers and sellers, simplifies pricing determination, offers risk management and forward pricing opportunities and can facilitate improved farm productivity and environmental protection. Broadband also makes possible electronic exchange trading of agricultural commodities, and it enables farmers the ability to conduct better production management, inventory control and better marketing techniques for their commodities and products – both domestically and internationally.

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33 "*Online public services: Europe making progress on eGovernment*", EC Website, Brussels, June 20, 2002.

34 TISP workshop, OECD, Shinichiro Sakata, Deputy Director General for Information and Communications Policy, Ministry of Public Management, Home Affairs and P & T, Japan, December 2001.

35 Canadian BB Taskforce Report, "*Networking the Nation for Broadband Access*", 2001, p. 20.

36 UK Online Strategy Action Plan Report: www.e-envoy.gov.uk/oee/oee.nsf/sections/index/$file/index.htm

Because of the geographical separation between farmers and their markets, the fact that there are far more buyers than sellers, as well as the fact that commodities are often perishable and fungible by time, broadband can play an important role in bringing farmers and their markets together more quickly and getting products to market more quickly and efficiently.

Broadband technology also can provide farmers with an easier ability to earn “off-farm income.” Because the economics of farming do not allow many farmers to live off the proceeds of farming alone, many farmers need to find additional work to supplement their income. Broadband access can give them an opportunity to use their skills to work from home and not leave the farm.

The economic benefits of using broadband in the agricultural sector are significant. “According to Morgan Stanley Dean Witter, B2B e-market opportunity (in the United States) for non-equipment agricultural inputs such as seeds, chemicals, fertilizers and veterinary supplies alone could be USD 34 billion. Moreover, on the farmers’ marketing side, efficient B2B e-commerce structures could cut marketing costs by about five cents per bushel for wheat, oilseeds, and feed grains.”[37]

In addition, broadband networks can provide the agricultural community with many additional advantages. For example, broadband enables the creation of “Virtual Enterprise Zones” (VEZs). These are electronic markets for citizens and businesses that could reap benefits from government assistance. With broadband technology, more rural areas could immediately join existing VEZs or create new VEZs. Precision agriculture is another application made possible by broadband technology. With this, broadband can be used for yield monitoring, soil sample analysis and access to satellite imagery for weather patterns. The information can be stored off-site and analyzed by off-site experts and then relayed back to the farm.

Other applications, such as distance agriculture education and technical services via broadband technology, can assist with crop planning, pest management, input management of goods and equipment servicing. Tele-veterinary applications are also possible with broadband technology. Because of the high cost of door-to-door veterinary services and because many farmers often perform their own routine veterinary care, broadband can deliver more accurate information on health problems in animals and more vital information on insects more quickly. Virtual livestock auctions also are made possible with broadband technology because the potential number of buyers seeing animals increases without having to transport animals from location to location. Furthermore, broadband technology can assist farmers with distributing scarce resources efficiently and effectively in times of draught or crisis by enabling farmers to transmit information quickly about product stockpiles.

An additional application of broadband technology in the agricultural sector is using broadband connections to track the identity of agricultural commodities and products. In other words, broadband connections can be used to track the production and distribution chain of various commodities and products. This can be particularly useful when products need to be recalled for health and safety concerns. In addition, broadband technology can play a role in protecting national security because it can make food tampering less effective by using product tracking to expose potential culprits.

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[37] “*The Importance of Next Generation Internet Access to Agriculture and Rural America*”, World Perspectives, Inc., April 13, 2000, p. 2-3.

In Canada, broadband telecommunication networks are being used to assist with farm management and electronic livestock auctions. In fact, over 60 per cent of the beef cattle sold in Quebec are now sold at electronic auctions. The selling cost for producers of grain-fed calves has dropped from CAD 11 to CAD 4 a head, thus increasing profit margins, and the animals do not have to be shipped twice – first to the auction site and then to the slaughterhouse.[38]

In a major step towards improving rural connectivity in Maharashtra, India, the state government has planned an integrated agricultural project using wireless in local loop (WLL) technology to provide extensive and dynamic information to farmers through internet and video-conferencing. Two pilot locations, at Baramati and Pabal, will have one WLL centre each. The proposed project will extend Internet access to surrounding villages within a 25 km radius. The villages in the vicinity of the WLL centres would be provided with Internet kiosks from where farmers can browse agriculture-related websites, download information on various agro technologies, get meteorological information as well as disaster prevention management plan, pest incidents and remedies. Similarly, farmers will be able to access global and country-wide market information, various government schemes, facilities, agro-processing and marketing information, communicate directly with scientists and other farmers and utilize e-commerce in agriculture.[39]

One example of an agriculture portal is Agmarket, an Indian agriculture website that aims to establish a nation-wide information network for speedy collection and dissemination of market information for its efficient utilization.[40] Agmarket offers computerized data on market fees, market charges, total arrivals, arrivals by agencies, prices (variety wise / quality wise), storage, dispatches with destination, mode of transportation, costs, sold and unsold stocks, sources of supply with destination, method of sale and payment. It also ensures the flow of regular and reliable data to producers, traders and consumers to derive maximum benefit of their sales and purchases.

In the United States, the "Freedom to E-File Act" directs the U.S. Department of Agriculture (USDA) to make its programs accessible via the Internet. USDA officials estimate that up to two million farms could save, at minimum, the one-hour drive from the farm to government office building to fill out forms."[41] In addition, the 2002 U.S. Farm Bill included a specific section on the promotion of rural broadband telecommunication access. Section 601 states that the loans and loans guarantees should be provided to aid in the construction, improvement and acquisition of facilities and equipment for broadband telecommunication service in eligible rural communities. Up to USD 20 million will be made available for each of fiscal years 2002 through 2005, and USD 10 million each for fiscal years 2006 and 2007.

I.2.5 E-Learning

E-Learning is one of the most widely touted applications of broadband technology. Broadband technology enables students of all ages and from any geographic location to take advantage of educational opportunities in schools, universities and other kinds of educational institutions. Broadband can provide students the opportunity to see and interact with professors in real-time, collaborate on group projects when participants

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38 Canadian Broadband Taskforce Report, "*Networking the Nation for Broadband Access*", p. 22.

39 "*Maharashtra draws up plan for WLL-versed villages*", *The Economic Times*, 21st April'03, www.economictimes.com

40 www.agmarknet.nic.in/

41 "*The Importance of Next Generation Internet Access to Agriculture and Rural America*", World Perspectives, Inc., April 13, 2000, p. 6.

are located in different geographic locations, and give the poor, underprivileged, or disabled technology the opportunity to learn a multitude of subjects without the burden of costly and time-consuming travel to educational institutions. Many nations and localities have used broadband technology to provide distance-learning opportunities for their citizens. Below are several examples to illustrate some successful examples.

In Denmark, Sektornett[42], which was established in 1993, is an electronic network for primary, lower and upper secondary schools, vocational schools and institutes of higher education. In addition to Internet access, a number of services are offered, primarily high-security Sektornett manager training at schools and technical support. By 2002, there were more than 3 000 institutions on the Sektornett. Nearly all upper secondary schools, higher preparatory courses, adult education centres, vocational schools and institutes of higher education are now connected through broadband technology.

Also in Denmark, the Research Network (Forskningsnettet) was established in 1997 for the purpose of inter-connecting Danish research institutions using high-speed transmission of text, sound, images and video. The Research Network supports applications such as videoconferencing, distance education and telemedicine.[43]

A virtual university in Pakistan is providing students with an opportunity to learn computer skills. The USD 40 million project provides distance learning using the television, video conferencing and Internet, and it is intended to train nearly 60,000 computer science graduates so that they can help develop an information technology industry in Pakistan. In order to control costs and make the program affordable, educational centres are being set up where students can view the courses and access the Internet.[44]

The Cisco Networking Academy Program evolved out of internal Cisco efforts to meet the training needs of students and teachers in schools being “wired”, having telecommunication networks installed, and being connected to the Internet. The Academy program focuses on training students in the skills necessary to design, implement and operate computer networks. It utilizes web-based learning to facilitate rapid evolution and dissemination of up-to-date curricula. It can also provide widespread availability of information on the strategy and the programs that support it. Currently, the Networking Academy program includes partnerships with many organizations, in addition to ITU, has been established in almost 8 500 locations in over 130 countries, including 28 of the UN’s officially designated Least Developed Countries.[45]

I.2.6 Telecommunications for Public Safety, for Disaster Prevention and Disaster Relief

The use of broadband technology to support public safety initiatives, disaster prevention and disaster relief are increasingly important applications. Since 11 September 2001, U.S. public safety officials and members of the international telecommunications community have focused on the uses of broadband technologies to effectively protect public safety and security in the event of another similar terrorist attack. The ability to roll out and quickly deploy broadband wireless links in order to provide essential telecommunication connectivity to public safety agency was recognized by the entire nation.

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42 www.fsk.dk/fsk/publ/2001/broadband/fromhardware.doc

43 www.fsk.dk/cgi-bin/theme-overview.cgi

44 Alfred Hermida “*Teaching Goes Virtual in Pakistan*”, BBC News Online, May 13, 2002.

45 World Telecommunications Development Conference.

Broadband technology can be used in a variety of ways to assist with public safety protection. Some of these applications include: biometrics screening at designated entry points into a country or locality and at sensitive facilities; enhancing remote surveillance of borders, airports, ports, and train stations to complement local surveillance; restoring public services and public confidence by enabling public officials and their staffs to telework in the event of damage to or destruction of normal work spaces; providing remote access to information systems necessary for either public or private business activities in the event of bio-chemical threats, attacks or quarantines; marshalling geographically dispersed medical expertise and support at crisis scenes; and supporting or replacing letter mail services with high capacity electronic service in the event of a disruption caused by destruction, contamination or quarantine of mail facilities.

Moreover, broadband telecommunication networks, and particularly wireless networks, can assist police, fire and specialized law enforcement members in many situations. Large data and image files can be quickly and wirelessly transferred, enabling images and fingerprints of wanted or missing persons, video clips of robberies, maps and layouts to be downloaded into police vehicle mobile computers as they leave their precincts. The same technology also can allow wireless uploads of videos, images and reports from the police vehicle to the command centre, enable command centres to employ full motion video for remote-controlled robotics in terrorist and other highly dangerous operations, and monitor officers or suspects in high risk situations to allow on-scene decision making and assistance based on video transmissions.[46]

In addition, broadband networks can supplement conventional circuit-switched wireline and wireless telephony services with survivable, dynamically routed Voice-over-Internet Protocol (VoIP) applications capable of TV-quality videoconferencing and other applications. Broadband also can assist federal and local officials taking part in safety training to do so more cost effectively – enabling training without the expense of the travel associated with going to seminars, etc.

Broadband technology can be particularly useful in times of crisis or before, during and after disasters. With broadband technology, individuals can instantaneously alert family and friends about a person's status. Broadband connections using position location technology, particularly in rural and remote regions, can assist rescuers in recovering victims of accidents or natural disasters. Broadband, particularly wireless or satellite broadband, can assist first-responders in receiving area maps, provide videos on situations like how to pry open a rail passenger door or how to safely shut off electrical power in a facility expectation of a disaster and it can enable all involved responders from numerous agencies to view the same image and data and assist before, during and after the disaster.[47]

Broadband technology also can be used to facilitate mobile robotics. In such cases, robots can be used to help rescue people from hazardous areas, conduct automated inspections of non-accessible areas, and assist with hazardous material, bomb disposal and landmine clearing.

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[46] Motorola. "*4.9 GHz Allocation to Public Safety: Motorola White Paper for Submission to FCC*", July 31, 2001.

[47] Motorola. "*4.9 GHz Allocation to Public Safety: Motorola White Paper for Submission to FCC*", July 31, 2001.

Firefighting is critical field that can use broadband technology very effectively. Broadband technology can help reduce personal risk to firefighters' lives. Using a multitude of detectors, a firefighter's vital signs, as well as high-resolution signals from both visible light and infrared sensitive cameras, can help off-site managers make decisions that can save lives. In addition, the technology can provide accurate three-dimensional positioning used to determine the exact location of a firefighter inside a burning facility.

In January 2001, two international standards development organizations, the Telecommunications Industry Association (TIA) and the European Telecommunications Standards Institute (ETSI), finalized the first international standardization partnership project agreement involving users and organizations from the public protection, disaster response and civil defense sectors (also known as PPDR). The partnership, called Project MESA[48] (Mobility for Emergency and Safety Applications), brings together users, industry and researchers to facilitate advanced, dependable, secure, efficient, effective and interoperable equipment specifications and service applications that are primarily involved with public safety-oriented broadband telecommunication needs. The result of this Public Safety-oriented activity will be harmonized specifications for broadband terrestrial mobility applications and services, driven by common scenarios and spectrum allocations. MESA deliverables are being transposed, as necessary, into regional standards involving next-generation mobile broadband technology for public safety, security and emergency response (before, during and after the disaster) professionals. With the recently Tsunami disaster, this application becomes more than a necessity.

I.2.7 Small Business Applications

For small business owners, broadband technology can assist entrepreneurs with the ability to obtain information about how to establish a small business, apply for permits and licenses online, enable business owners to conduct Internet market research, advertise their products and services and correspond with customers and suppliers more easily. Broadband technology also can enable small business owners to find supplies and purchase materials faster and without the need to spend excessive time and money travelling to various locations to accomplish the same goals.

I.2.8 E-Tourism

Broadband enables people to "visit" tourist spots without having to travel long distances to see attractions in person. Broadband technology connections (video application in particular) can enable people to view art treasures, exhibits, historical landmarks and other types of tourist attractions. In addition, broadband technology can assist fans of sporting and other major events, like the World Cup or the Olympics, to "see" the events as they would in person in real time. This is particularly useful for events that may be too far to travel to and where significant time-zone differences may not enable real-time viewing of these events.

I.2.9 Entertainment Applications

Many people have used broadband to further personal hobbies, browse the Internet for fun, play games, gamble, and download music, videos and movies. In addition, position location technology, combined with broadband, can enable people to obtain restaurant information, local area maps, and museum and tourist information.

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[48] See: www.projectmesa.org/

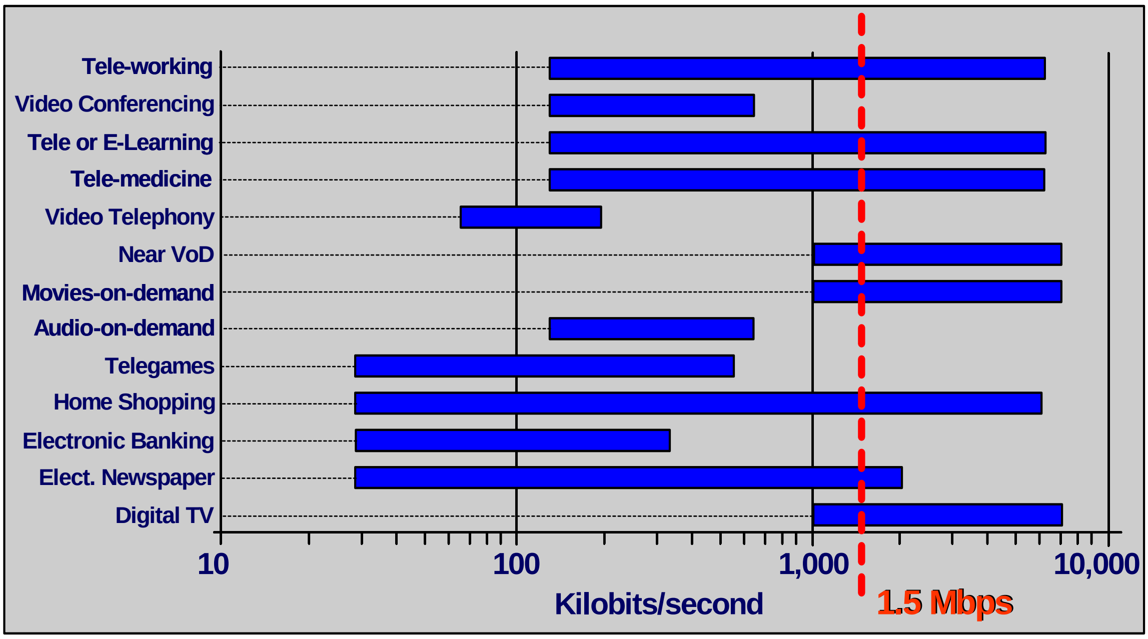
I.2.10 Information Gathering

One of the most popular applications for which broadband technology is used is to access and search for information. The always-on, high-speed broadband telecommunication connection allows users to access more information faster than with slower narrow-band connections. Thus, broadband technology can encourage more people to search for more information online and improve their ability to learn new things.

I.2.11 Capacity Requirements for Selected Applications

While telecommunication bandwidth requirements are subject to change based on technological advancements, the chart provides a general idea of the necessary speeds to perform a variety of applications, many of which are discussed in this Report in great detail.

"Capacity: Required bit rate capacity per application"[49]



* NOTE – Depending on a variety of compression or other techniques, the speeds mentioned in the above table may change.

[49] Chouinard, Gerald; "*Rural & Remote Broadband Access (RRBA)*", Communications Research Center of Canada, www.crc.ca/broadband/

I.3 Broadband Technology Deployment

Potential factors negatively affecting the widespread deployment of broadband access technologies are numerous. Not only do operators face extreme difficulties in installing a network, but acquiring customers and running a profitable business are additional challenges. Attempts at deploying and providing a profitable broadband telecommunication service are difficult for a number of reasons including:

- expensive access technology
- lack of awareness of broadband access technologies
- lack of regulatory framework conducive to network build out and deployment
- continued monopolies and low levels of competition
- lack of competition in the last mile
- state subsidies that produce market distortion
- excessive cross-ownership between telephone and cable TV networks as this reduces the potential for inter-modal competition
- environment with little or no basic infrastructure such as electricity and roads
- high maintenance and operational costs, including security, administrative and labour costs
- high equipment prices
- the imposition of excessive caps on volume that could be downloaded within a flat rate
- lack of technical personnel in area of service
- difficulty in dealing with subscribers with bad debt problems
- poor distribution, sales and customer service presence in area of coverage
- low usage and average revenue per subscriber
- small potential markets
- lack of localized content and applications in national languages besides English
- theft of infrastructure equipment such as cables

I.3.1 Analysis of Broadband Access Questionnaire: Main Findings

A questionnaire was distributed following the Second Rapporteur's Group meeting for Question 20/2: Examination of access technologies for broadband communications questionnaire in March 2003. The questionnaire requested Member States, Sector Members, relevant organizations and industry to identify relevant wireless and wireline broadband access technologies and their attributes. The questionnaire also aimed to identify economic, technical and development factors influencing the effective deployment and accessibility of broadband access technologies and applications. Below represents the summarized results of the responses received by the ITU-D Secretariat by June 2003. An external expert was contracted by BDT to conduct the analysis. By mid-June 2003, fifty-five responses were received from forty-nine countries from the six ITU regions.

Main Findings

The questionnaire was organised into several sections and the main findings from these sections can be summarised in brief, as follows:

Section	Main findings
Technology	The current dominant technology for delivering broadband services over wire line networks is DSL, closely followed by more traditional E1/T1, fibre and cable connections. (NOTE – Cable-TV is ahead of DSL in North-America because of a few years lead in the market.) Satellite, fixed wireless, IMT-2000, and wireless local area networks are leading solutions used to deliver wireless broadband solutions especially where wireline solutions are inappropriate. Other solutions include ISDN, Ethernet, laser free space optics and GPRS.
Competition	Only four countries did not permit competition in Internet services. 28 countries have competition in the local loop and 21 do not. 10 respondent countries did not have competition between differing broadband technologies. There is no regionally dominant technology – broadband solutions vary from country to country depending on operator offerings, local economics and historic investment.
Access	There are huge differences between developed and developing nations when viewing access to broadband services on a business, household and rural telephone subscriber basis. Many developing (and some developed) countries estimate that rural subscriber access to broadband, if it exists at all, is often measured in fractions of a few per cent of the potential subscriber base.
Pricing and usage	Despite the variance in size and nature of the economies of those countries which responded to the question there is a general convergence on the average price for Internet dial up accounts across ITU-D six Regions. However broadband prices show a marked variation between these Regions especially in terms of large bandwidth capacity based services with average broadband access costs being five times as high in the Africa region than in Europe. Unlimited usage plans offered by operators did not show a marked regional bias but rather were governed by the domestic situation facing individual operators. Pricing and Usage models varied between operators, technologies and regions though broad models were identified.
Barriers to broadband deployment	Deployment costs are the single largest barrier followed by lack of demand for broadband service applications. Of the issues limiting the spread of broadband identified by respondents, the most common was that the monthly associated fee was too high. High monthly fees, high installation costs and lack of personal computers when combined result in insufficient demand to justify infrastructure costs and make the business case for deploying broadband services more difficult. The majority of respondent countries do not provide loans or support to enable broadband deployment.
Quality of Service	Average downstream speeds for DSL, cable and wireless vary based on technology constraints and pricing usage model employed.
Miscellaneous	The fastest growing broadband technology area was identified as Wireless, with business applications (e.g. email and access to corporate extranets) as the main adoption driver though personal use (web browsing etc) was a close secondary driver in both developed and developing countries.

Additional and detailed information on the broadband questionnaire are given in Annex II: Analysis of the replies to the questionnaire.

I.3.2 Gender Issues Surrounding Broadband Technology Deployment

Advanced telecommunications technologies such as broadband, when democratically employed, constitute powerful instruments that can contribute to securing the advances in human rights, such as fuller participation of women in all spheres of activity. Nonetheless, access to these technologies may be unequal in different geographic regions and social groups. This is in part a result of women's economic position within their households and communities. This inequality contributes to increasing the gap between those who have access to abundant information resources and those who are deprived of this access, thus reinforcing the marginalization that already exists in terms of development and technical resources. In this context broadband technology, because it promises the delivery of information at lower cost, has the potential to erode financial constraints and narrow the gendered digital divide.

Women in particular, tend to be under-represented in terms of access to these technologies, and especially women from developing countries and from marginalized groups. Ironically, women from these social groups are precisely those who make up the work force that produces computer components, in working conditions that are often damaging to their health; similarly, women in low-grade technical and service jobs also make up the largest group of computer users, while many others have lost their jobs to increasing automation. In contrast, women are less present than men in fields such as computer systems administration and in technical development. They are also proportionally under-represented as users of broadband technologies.

Many women's organizations have come to appreciate the importance for their work of creating and participating in regional and world- wide information exchange fora that enable them to share ideas, proposals, documents and information. Broadband technologies can help make this exchange of information possible. Many portals or exchange networks have arisen on diverse issues of concern to women. For example, women's networks and organisations at the national and regional levels are promoting applications related toe-health, agriculture, distance learning and e-commerce, etc. More specifically, some women's organizations have noted that certain applications, such as telemedicine-health, while virtually reducing distances, can speed up access to health care and increase the health and economic well-being of women in poor communities.

E-commerce applications also positively impact on the welfare of women across economic backgrounds. For example, in Cameroon ASAFE uses ICTs as a tool through which to address the needs of disadvantaged women in the urban and rural sectors by building the capacities of small women-owned businesses. Similarly, SEWA (Self-Employed Women's Association) in India works with women involved in micro enterprises and craft production to market their products internationally. There is increasing recognition that the development of such telecommunication networks will contribute to advancing the cause of gender equality and to promoting greater participation in worldwide fora and decision-making processes.

Many women and women's organizations are therefore eager to access and appropriate this technology. Nonetheless, they often face obstacles that make this endeavour more difficult for them. Such obstacles include: less access to resources (financial and technological), reduced access to training and technical assistance or non-gender sensitive methodologies, social and cultural barriers for women and girls to access technology, educational short- comings, misconceptions about technology and its use, language barriers, etc. Special efforts are required to overcome these problems.

One such organization in the US, Women in Cable & Telecommunications (WICT). Since its founding in 1979, WICT has remained steadfast in its resolve to advance the position and influence of women in technology through proven leadership programs and services at both the national and local level. WICT embraces a spirit of collaboration within its organization and throughout the industry. They partner with cable and telecommunications industry leaders to provide leadership programs and services, and challenge these companies to create professional advancement opportunities for women.[50]

Another organization, Women'sNet, is developing a pilot Women's Online Resource Centre (WORC), an information community building project.[51] WORC will be the place to find gender-related training materials relevant to individuals and organizations active in the struggle for gender justice. It is intended to serve as an online clearinghouse for gender-aware training materials in the area of ICT training, as well as a range of other fields for which there is an expressed need. The goal of WORC is to promote the inclusion of gender analysis in ICT and other areas of training, with a view towards enhancing the quality of training in support of gender justice available at global, regional, and local levels. The Association of Progressive Communications (APC) is an international network of civil society organisations dedicated to empowering and supporting groups and individuals working for peace, human rights, development and protection of the environment through the strategic use of information and communication technologies.

Gender Experience: Broadband adoption is booming in the US with women leading the way

According to figures from Nielsen/NetRatings, as of May 2003, nearly 40 million internet users in the US now connect via broadband networks, up 49 per cent in the last year.[52] The fastest adopters are women, seniors, students and affluent social groups. Women outpace men in broadband adoption slightly at 51 per cent versus 48 per cent. There are still more men (20.1 million) who access the internet via broadband than women (18.9 million), and there continues to be more females (37.8 million) who access the internet via narrowband than males (31.8 million).[53]

I.3.3 Strategies for Promoting Broadband Deployment

Economies that have been successful in facilitating broadband access technologies have several factors in common such as: measures to inform the public about the advantage of broadband technologies effective use of broadband through applications and content, an environment that fosters broadband innovation, a competitive market structure that keeps prices low, and government policies and programs that focus on the broadband technology environment.

Two viable methods for promoting broadband include connecting schools and using community access centres to give users access to broadband without the vast fixed costs of wiring to homes. Economies must also make best use of the existing networks since financial resources to build new networks may be scarce.

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50 www.wict.org

51 www.womensnet.org.za

52 "*Broadband Adoption is Booming in the US*", www.onlinepublishingnews.com/htm/n_olpn20030620.538206.htm

53 ibid.

Other countries have addressed broadband through government initiatives including e-government, e-health, and e-learning applications. Projects include initiatives that focus on teaching teachers how to interact and deliver material via computers and broadband connections.

Establishing an appropriate regulatory framework is also essential to promoting the deployment and market adoption of high-speed data applications. Effective strategies of promoting broadband technology demand and supply as well as the importance of technology flexibility and universal access policies are further described below.

I.3.3.1 Promotion of broadband applications[54]

There is no single method of promoting broadband applications. Promotion strategies and policies will prove most effective when various initiatives and projects are incorporated simultaneously, encompassing all stakeholder groups, and adjusted to contextual and environmental factors. Some central reasons for promoting broadband applications include:

- Benefits to users: increased speeds and always-on nature of broadband technology enables the exchange of richer content, facilitates improved, expanded and more rapid telecommunication, and allows the sharing of a connection with multiple users.
- Benefits to the economy: broadband connectivity encourages innovation, stimulates growth in an economy, and attracts foreign investment.
- Returns on investment: broadband technology holds the promise of new applications and services that will attract users and help recover infrastructure development costs.

Promoting Broadband Demand

In general, there are certain actions that a particular country or region can follow in order to foster a more conducive environment for broadband deployment and expansion. A successful broadband application economy can emerge if the following actions are taken:

Keep the public informed about broadband technology and applications

It is important to make users aware of the benefits that broadband technology and its application can provide. Both governments and the private sector can play an active role in marketing the benefits of broadband. Users should be made aware of the advantages to be gained by adopting key broadband technologies and integrating them into their daily lives. Business and government cultures can also embrace and encourage ideas such as E-working and online transactions.

Promote technological innovation

It is important to promote policies and incentives which serve to foster the development of broadband content and applications. Economies must offer an environment that fosters broadband development by giving careful consideration to intellectual property rights, support for sectors that participate in developing new, high-bandwidth applications, methods for diffusing technology, and measures to ensure security for users.

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54 ITU/SPU, "*Promoting Broadband*" Background Paper, April 2003.

Support broadband usage with compelling applications and content

The types of applications that are available across countries make a big difference in the adoption rates for broadband technology. Applications that have been meshed into successful broadband economies include IP telephony, video chat, audio over broadband and online gaming. Furthermore, application developers must take into consideration the need for content in multiple languages.

Create a competitive market environment

Open and fair competition in broadband will help drive down prices to an affordable rate, thus stimulating greater demand. While other mechanisms, such as subsidies, grants, and regulatory measures help to foster the development of broadband technology, a truly competitive market will be the key stimulus for increased demand. Consumers will only adopt broadband when they can justify its cost in terms of the value it adds.

Promoting Broadband Applications Supply

A broadband application economy, which affectively promotes broadband supply, can be characterized by:

a) *Competition*

Multiple providers offering multiple broadband technologies is key to driving prices down and increasing the broadband options available to users. Furthermore open access policies can help promote service competition. It is also beneficial to have players in the market that are capable of rivalling the incumbent operator.

b) *Maximum utility of current networks and new network investment*

Existing networks must be utilized to their full extent alongside new network investment. Innovative broadband networks such as wireless, satellite, railway and electrical can be used to supply broadband applications. Schools, hospitals, and community access centres can serve as initial broadband anchors in areas, eventually becoming the network access points from which future networks.

I.3.3.2 Flexibility

Establishing an appropriate regulatory framework is essential to promoting the deployment and market adoption of high-speed data applications. The convergence of services, such as data and voice should not lead to additional unnecessary regulations. The importance of technology flexibility is further described below.

Importance of Technology Flexibility

Technology flexibility (also known as technology neutrality or operator choice) is an important aspect in promoting broadband deployment. Technological flexibility in the policy arena means that policies and incentives do not create a preference for any specific technology platforms or modes of providing broadband applications (e.g. satellite, wireline, wireless, etc). Also within a given platform or mode of providing a service, technology neutral policies and incentives do not create a preference for any specific technology products or standards – e.g., circuit- or packet-switched networks, various mobile or cellular telecommunications standards, etc. If possible, it is important that service providers have the flexibility to independently choose the most suitable technology based on commercial and competitive considerations. A transparent regulatory framework, in which the market selects the most appropriate technologies for deployment, may encourage competition, spur innovation and accelerate the deployment of advanced services.

I.3.3.3 Universal Access

A transparent universal access policy aims to promote the availability of quality services at just, reasonable, and affordable rates, increase access to advanced telecommunications services and to advance the availability of such services to all consumers, including those in low income, rural, insular, and high cost areas. It is important that countries continually evaluate their universal access strategies in the face of technological advances and changing market conditions in order to maximize the size, scope, variety and efficiency of telecommunication networks. It is also important that universal access policies encourage the availability of affordable education and health and safety applications to citizens, businesses and government.

Universal access policies that are competitively neutral do not favour any one participant or group of participants. As no one technological solution is necessarily appropriate for an entire country or region, the variety of available technology platforms gives new and innovative alternatives to expanding access to services in developing countries.

I.3.3.4 Public Role in Promoting Broadband

a) Government programs that serve to accelerate broadband supply

Several government sponsored programs at the local, national and regional levels have been successful at increasing the overall supply of broadband. Specifically, governments can invest directly in broadband infrastructure as well as provide tax credits, low-interest loans and subsidies to the industry players looking to provide broadband networks in underdeveloped areas. It is important that in promoting development of broadband “for all” to avoid any direct or cross-subsidy by the country which would give an unfair advantage to some market stakeholders. Governments are invited to assist with the provision of broadband infrastructure and services in areas that are not served by the public sector due to unfavourable market conditions.

b) Public institutions as effective anchors for broadband demand

In areas where individual household connections are not yet viable, schools, hospitals, and community access centres can be utilized to offer broadband connections. The network can then expand incrementally from these key points as the technology and economy allows. Wireless broadband also offers a viable community economic alternative to fixed line solutions such as broadband via DSL or cable modem.

c) Government participation at all levels

National, regional and city-wide initiatives and community participation projects have been successful in expanding access. In some cases, governments have chosen to provide, or to subsidize, infrastructure to stimulate the economic development of a particular area.

d) Best Practice Guidelines for the Promotion of Low-Cost Broadband and Internet Connectivity

In December 2004 the Best Practice Guidelines for the Promotion of Low-Cost Broadband and Internet Connectivity were produced at the Global Symposium for Regulators (organized by the ITU-D on a yearly basis). These guidelines describe what the foundation for an enabling regulatory regime should be and how governments can help to stimulate growth in the telecommunications market for broadband applications.

(Full guidelines can be found in Annex IV.) Some of these are as follows:

- "We encourage political support at the highest government levels with such support expressed in national or regional policy goals. These include an effective, separate regulator insulated from political interference, a transparent regulatory process, and adoption and enforcement of clear rules."
- "We encourage regulators to set policies to stimulate competition among various technologies and industry segments that will lead to the development and deployment of broadband capacity. This includes addressing barriers or bottlenecks that may exist with regard to access to essential facilities on a non-discriminatory basis."
- "We encourage regulators to allocate adequate radio spectrum to facilitate the use of modern, cost effective broadband radiocommunications technologies. We further encourage innovative approaches to managing the spectrum resource such as the ability to share spectrum or allocating on a license-exempt non-interference basis."
- "We urge regulators to conduct periodic public consultations with stakeholders to inform the regulatory decision-making process."
- "We recommend that regulators carefully consider how to minimize licensing hurdles."
- "We encourage regulators to provide a clear regulatory strategy for the private sector in order to reduce uncertainty and risk, and remove any disincentives to investment."

Section II – Technology Matrices

The term matrix is generic and can be used in various ways. In this context the term involves a short description of a particular technology, presenting applications and development of state of the art together with relevant references.

Broadband telecommunications technology can be divided broadly into wireline and wireless technologies. Wireline technologies include traditional telephone lines, community antenna lines, and fibre optic lines. Wireless telecommunications involve cellular and fixed wireless technology, high speed short range telecommunications such as RLAN and free-space optics and satellite transmission. Satellite networks include geostationary orbit satellites (GSOs) and non-geostationary orbit satellites (N-GSOs). The latter includes low-earth orbit satellites (LEOs), medium-earth orbit satellites (MEOs) and highly orbit satellites (HOSs) with a particular application beyond the GSO orbit, which is identified as a high-inclined elliptical satellite (HEOs). Broadband uses wireline or wireless technology or a combination thereof to bring high-speed access to the user.

II.1 Wireline Broadband Access Technologies

In the domain of wide area network access, there are numerous wireline technology options that are presently competing for market share and acceptance. These technology options originate from both the Area Network Wire (WAN) and Local Area Network (LAN) environments and include, e.g. ISDN, ATM, switched Ethernet Frame Relay, several technologies for data transmission over community antenna (CATV) cable, and the family of Digital Subscriber Line technologies.

II.1.1 DSL Technology Matrix

The introduction of new services demanding digital signals with higher and higher bit rates requires either to extend the usable bandwidth of existing subscriber loops with sophisticated technologies or to replace the twisted pairs with broadband transmission media such as, e.g. fibre / coaxial cables or wireless transmission.

Historically wire subscriber loops contain twisted copper pairs assembled in multi-pair cables. Subscriber loops have been under study for many years and are defined by cable type, cable length, loop structure and noise sources. The spectrum of the subscriber loop which is normally used for voice frequency signals of up to 4 kHz can be extended to about 1 100 kHz for the transmission of digital signals using DSL technologies. The extensive cost related to the replacing of existing subscriber loops and at the same time the development in the field of digital signal processing influenced the development of Digital Subscriber Loop (DSL) technologies to achieve better utilization of the available bandwidth and, as a result, the transmission of higher bit rates. The DSL technology allows the digital signals to share the subscriber loop with the telephone voice signal (POTS).

Typical DSL systems are:

– High bit rate Digital Subscriber Line (HDSL);

– Asymmetrical Digital Subscriber Line (ADSL);

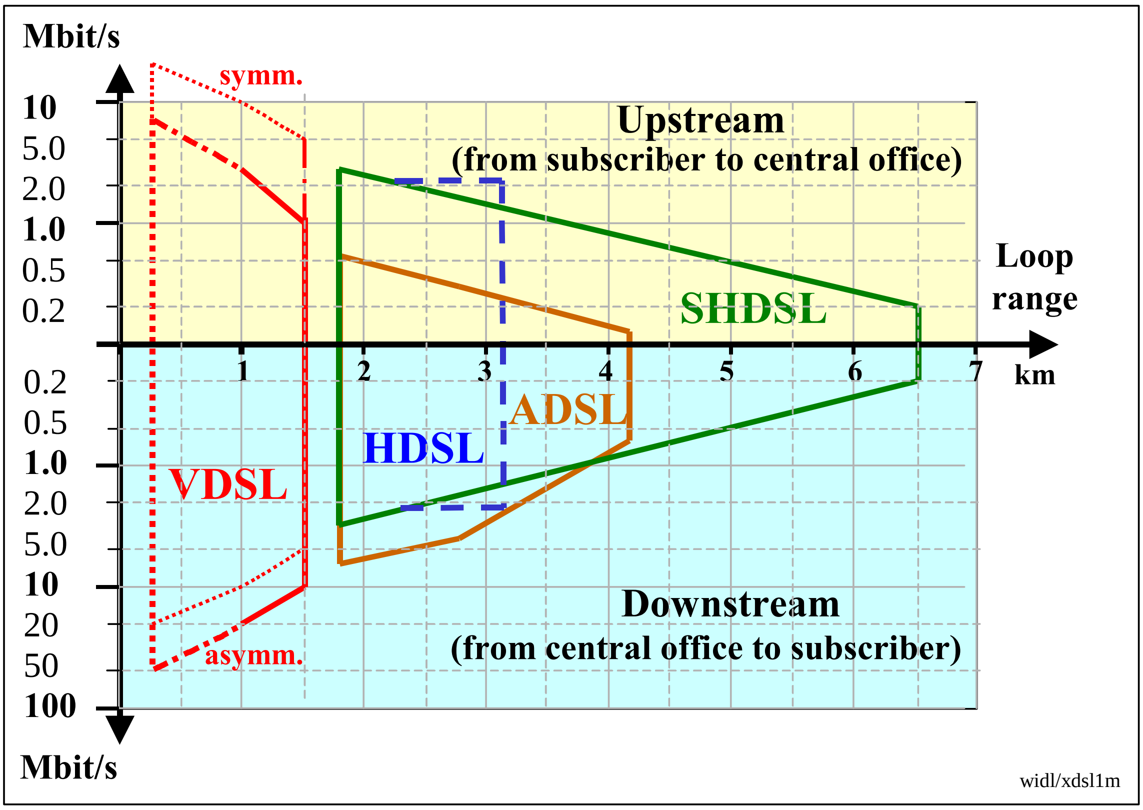
– Very high-speed Digital Subscriber Line (VDSL);

– Single-pair High Speed Digital Subscriber Line (SHDSL);

– ISDN based Digital Subscriber Line (DSL ISDN).

Figure 1 shows typical data rates and related ranges for systems using 1 pair (not using any repeaters, i.e. regenerators).

Figure 1 – Loop range related to various DSL systems



The values shown in the table depend on many parameters, such as, e.g. wire gauge, bridged taps, disturbances including crosstalk between pairs, margins, etc. In addition, due to the continuous development of new technologies the values can change.

HDSL has been the most widely deployed of the DSL technologies and uses two or three copper twisted pairs. Most implementations provide either 1.5 Mbit/s (T1) or 2 Mbit/s (E1) symmetrical at up to 3 000 m from the Central Office. This distance can be increased with Regenerators.

ADSL holds the greatest near term potential for providing broadband access to residential and small office, home office markets. More bandwidth is allocated for traffic from the service provider to the subscriber (downstream) than for the traffic from the subscriber to the service provider (upstream). The bandwidth allocations permit simultaneous Plain Old Telephone Service (POTS) or ISDN traffic. Two ADSL versions exist: Full-rate ADSL using about 1 MHz and ADSL Lite using about ½ MHz bandwidth. Full-rate ADSL requires splitter filter installations, ADSL Lite works without splitter filters or requires simplified in-line filter installations.

VDSL is designed for much higher bit rates and extremely short subscriber loop distances. VDSL often is used in conjunction with fibre installations, e.g. fibre to the Curb. With the aid of splitter filters simultaneous POTs traffic is possible.

SHDSL is expected in future to replace HDSL as the system will normally operate across a single pair. Extended range is possible either using 2 pairs or/and regenerators. The use of advanced coding limits bandwidth requirements leading to coexistence with other DSL systems.

The DSL family of technologies provides a wide variety of schemes to accomplish and satisfy different market needs for present and future infrastructures. In the context of DSL, whether single or two pairs, symmetric or asymmetric, rate-adaptive or multi-channel applications, DSL technologies are tools to meet market challenges. Both market needs and DSL technologies are still evolving.

In addition to speed, DSL systems offer another key benefit: constant connectivity. Because DSL modems use connectionless technology, much like in an office LAN, a subscriber's PC is always online with the network.

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II.1.2 Basic Cable Matrix

With near-ubiquitous coverage of broadband community antenna for cable TV in some countries, community antenna connections provide a powerful platform for providing residences and small business with high-speed data access. However, one-way cable television systems must be upgraded into modern two-way networks to support advanced telecommunications services.

The study of “Cable TV Primer”, originating from ITU-T Study Group 9 could serve as a useful introduction to the cable TV network. Further information on cable TV networks could be found in ITU-D Study Group 2 Fascicule 4 in the following items:

5.3.9 Cable TV Distribution

5.3.9.1 Essential components of cable TV system

5.3.9.2 HFC Cable systems

5.3.9.3 Interactive two-way TV services

5.3.9.4 High speed data using cable system

Cable TV Primer

Cable systems were originally designed to deliver broadcast television signals efficiently to subscribers’ homes. To ensure that consumers could obtain cable service with the same TV sets they use to receive over-the-air broadcast TV signals, cable operators recreate a portion of the over-the-air radio frequency (RF) spectrum within a sealed community antenna line and distributed to subscribers’ homes.

Traditional community antenna systems typically operate with 330 MHz or 450 MHz of capacity, whereas modern hybrid fibre/coax (HFC) systems are expanded to 750 MHz or more.

Logically, downstream video programming signals begin around 50 MHz, the equivalent of channel 2 for over-the-air television signals. The 5 MHz-42 MHz portion of the spectrum is usually reserved for upstream telecommunications from subscribers’ homes.

For example, countries using the National Transmission Standards Committee’s (NTSC, United States) transmission standard, standard television channel occupies 6 MHz of RF spectrum. Thus a traditional cable system with 400 MHz of downstream bandwidth can carry the equivalent of 60 analog TV channels and a modern HFC system with 700 MHz of downstream bandwidth has the capacity for some 110 channels.

Cable Modem Access Networks

To deliver data services over a cable network, one television channel (in the 50-750 MHz range) is typically allocated for downstream traffic to homes and another channel (in the 5-42 MHz band) is used to carry upstream signals.

A headend *cable modem termination system (CMTS)* communicates through these channels with *cable modems* located in subscriber homes to create a virtual local area network (LAN) connection. Most cable modems are external devices that connect to a personal computer (PC) through a standard 10Base-T Ethernet external box or internal PCI or PCMCIA card, or through a Universal Serial Bus (USB) connection.

The cable modem access network operates at Layer 1 (physical) and Layer 2 (media access control/logical link control) of the Open System Interconnect (OSI) Reference Model. Thus, Layer 3 (network) protocols, such as IP traffic, can be seamlessly delivered over the cable modem platform to end-users.

A single downstream 6 MHz television channel may support up to 27 Mbit/s of downstream data throughput from the cable headend using 64 QAM (quadrature amplitude modulation) transmission technology. Speeds can be boosted to 36 Mbit/s using 256 QAM. Upstream channels may deliver 500 kbit/s to 10 Mbit/s from homes using 16 QAM or QPSK (quadrature phase shift key) modulation techniques, depending on the amount of spectrum allocated for service. This upstream and downstream bandwidth is shared by the active data subscribers connected to a given cable network segment, typically 500 to 2 000 homes on a modern HFC network.

In addition to speed, cable modems offer another key benefit: constant connectivity. Because cable modems use connectionless technology, much like in an office LAN, a subscriber's PC is always online with the network.

Cable Internet Delivery

To get into the high-speed Internet business, cable operators must do more than simply install cable modem gear. Rather, they must build a sophisticated end-to-end IP networking infrastructure in each community they serve that is robust enough to support tens of thousands of data subscribers. That includes items like Internet backbone connectivity, routers, servers, network management tools, as well as security and billing systems. In essence, cable operators are faced with the task of building some of the world's largest "intranets", a serious engineering and operations challenge.

Cable operators are focused on providing high-speed *intranet* access instead of straight *Internet* access for a simple reason: a network connection is only as fast as its slowest link. Clearly, the benefit of a 1-Mbit/s cable link is lost if a subscriber tries to access content stored on a Web server that is connected to the Internet through a 56-kbit/s line. The solution to this dilemma is to push content closer to the subscriber, ideally right down to the cable headend. This is done by recording or logging copies of popular Internet content on local servers, so when a cable modem subscriber goes to access a Web page, he or she will be routed to the server in the headend at top-speed, rather than being required to voyage out onto the congested Internet.

A number of companies are offering comprehensive networking and systems integration services to cable operators entering the high-speed Internet needs.

Shared Network Platform Performance

Most cable modem systems rely on a shared access platform, much like an office LAN. Unlike circuit-switched telephone networks where a caller is allocated a dedicated connection, cable modem users do not occupy a fixed amount of bandwidth during their online session. Instead, they share the network with other active users and use the network's resources only when they actually send or receive data in quick bursts. So instead of 200 cable online users each being allocated 135 kbit/s, they are able to grab all the bandwidth available during the millisecond they need to download their data packets – up to many megabits per second.

If congestion does begin to occur due to high usage, cable operators have the flexibility to add more bandwidth for data services. A cable operator can allocate an additional 6 MHz video channel for high-speed data, doubling the downstream bandwidth available to users. Another option for adding bandwidth is to subdivide the physical cable network by running fibre-optic lines deeper into neighbourhoods. This reduces the number of homes served by each network segment, and thus, increases the amount of bandwidth available to end users.

II.1.3 Fibre to the Premises (FTTP) Matrix

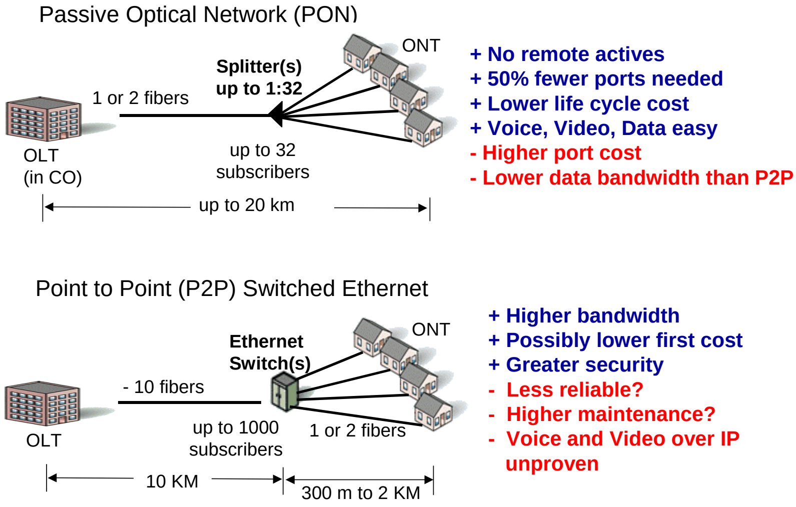
FTTP is becoming the Access Network architecture of choice given tremendous reductions in both the costs of the equipment and the costs of outside plant (OSP) deployment. Several of the largest US incumbent carriers have already announced plans to switch their Greenfield deployments to FTTP. Similarly, the economics of copper network rehabilitation, where the copper plant must be replaced due to degradation, make these “brownfield” deployments increasingly attractive for FTTP deployments. Finally, given the significant expense associated with extending the reach of copper-based networks to rural consumers given its distance-limitations, FTTP is quickly becoming the Access Network architecture of choice for rural service providers seeking to provide consumers with a “triple play” of voice, video, and data services.

FTTP Access Network equipment technologies can be primarily classified as active or passive solutions are typically referred to as Passive Optical Networks or PONs. Active solutions have electronic components deployed in the field and typically are capable of higher bandwidth while passive solutions have no electronic components in the field and save both deployment and operations costs.

These solutions can further be classified as point-to-point (P2P) where there is a direct one-to-one link between the carrier’s central office (CO) and/or head-end and the customer’s location or point-to-multipoint (P2MP) where the signal from the carrier’s central office is split and sent to multiple customer’s locations. Typically, P2P solutions are capable of higher bandwidth while P2MP solutions have lower deployment and operations costs.

Finally, within both active and passive and P2P and P2MP solutions, there is a range of network protocol options available that further differentiates product offerings. For example, within the PON solution space there are APON solutions (and its BPON variants) based on the traditional voice telephony Asynchronous Transfer Mode (ATM) protocol; and EPON solutions based on the widely deployed IP-based Ethernet protocol. BPON/APON is based on the ITU-T Recommendations G.983.3 and its current version offers 622 Mbit/s downstream at 1 490 nm and 155 Mbit/s upstream at 1 310 nm through a 1:32 split ratio (one signal split to 32 customers) with analog cable video offered at 1 550 nm and is offered by vendors such as Optical Solutions, Alcatel, Hitachi, and others. The GPON standard technology (offered by the same vendors) is based on the ITU-T G.984.2 standard and is also based on the traditional ATM protocol but at higher speeds and offers either 2 422 or 1 244 Mbit/s downstream at 1 490 nm and either 155, 622, 1 244 or 2 422 Mbit/s upstream at 1 310 nm with up to a 1:64 split ratio and analog cable video at 1 550 nm. EPON solutions are based on the IEEE 802.3ah standard, completed by IEEE P802.3ah Ethernet in the First Mile Task Force in 2004, and utilize IP for both voice and data services and offer 1 000 Mbit/s downstream at 1 490 nm, 1 000 Mbit/s upstream at 1 310 nm with a 1:32 split ratio and analog cable video at 1 550 nm (vendors include Alloptic, Calix, FlexLight, and others). Figure 2 provides a graphic summary of the FTTP architectural options.

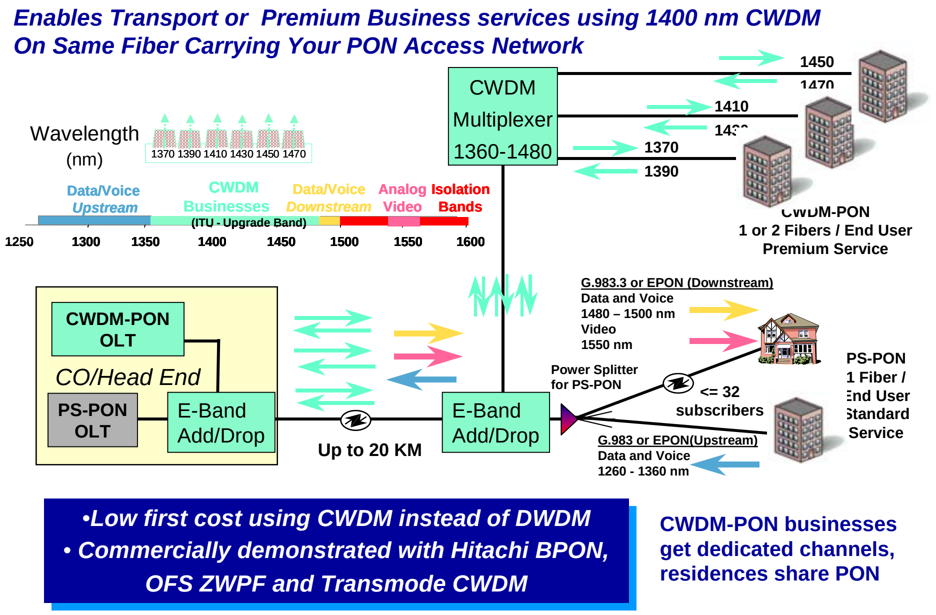
Figure 2 – FTTP Architectures: PON and P2P



Beyond the selection of Active and Passive and APON, BPON, GPON, EPON, there are significant technology developments in outside plant solutions that can significantly affect the costs and benefits associated with FTTP Access Network deployments.

Proper fibre selection can greatly reduce network deployment costs by allowing carriers to fit both the FTTP Access Network component along with their enterprise and transport Edge Network component into a single fibre unit. Today's advanced technology Zero Water Peak Fibres (ZWPF) are displacing historic Standard Single Mode Fibre (SSMF) and enable the deployment of 16-channel Coarse Wave Division Multiplexing (CWDM) Edge Networks on the very same fibre carrying a 1:32 or 1:64 split FTTP network. CWDM channels are 60% less expensive than Dense Wavelength Division Multiplexing (DWDM) channels, so such Access/Edge network deployments not only allow carriers to deploy two networks on one infrastructure, but provide extremely cost effective metro network architectures through the use of much less expensive CWDM channels. Figure 3 shows such a CWDM over PON architecture and the benefits of providing network transport services or premium business wavelength services over the same infrastructure carrying a PON Access Network.

Figure 3 – Zero Water Peak Fibre Enables Coarse Wave Division Multiplexing (CWDM) over PON Two-for-One Networks



Just as selecting the right (ZWPF) fibre can provide the benefit of two networks for the price of one, the selection of low loss fibre and components can allow carriers to reach up to twice the rated distance of commercial equipment. This extended reach means carriers will able to serve up to twice as many customers for a given investment in outside plant, will ensure that carriers will be able to connect all of their customers, and will also allow carriers to realize up to a 30% system costs savings by more providing a more efficient distribution/feeder fibre ratio.

In some cases a number of copper wire pairs are available between service provider and single subscriber. The pairs can be combined, i.e. bundled, as described in the G series of ITU-T recommendations leading to a considerable increase of single stream capacity. Two pairs offer a doubling, three pairs a threefold transmission capacity, up to 32 copper wire pairs can be bundled. The payload on the pairs can be ATM-based, Ethernet-based or involve signals using time-division inverse multiplexing.

II.1.4 Dense Wavelength Division Multiplex Matrix

The invention of low-loss optical fibres in the early 1970s with low-loss windows at about 1 300 nm wavelengths enabled transmission of light signals over distances of tenths of kilometers without regeneration using light emitting diodes and multi-mode fibres. In the 1980s single-mode fibres were introduced connected to Multilongitudinal Mode (MLM) lasers transmitters permitting to transmit about 100 Mbit/s. With dispersion shifted fibres and single longitudinal mode distributed feed-back lasers (SLMFB) systems with up to 100 km repeater sections and about 2.5 Gbit/s transmission speed were feasible. In the 1990s regenerators, containing Erbium-doped fibre amplifiers permitted the simultaneous transmission of many adjacent wavelengths, leading to Dense Wavelength Division Multiplex systems (DWDM). The development permitted to transmit 2 wavelengths across the same fibre, one wave in the window 1 310 m and the other wave in the window 1 550 nm, leading to the first Wavelength Division Multiplex (WDM) systems. However, the optical frequency division multiplex systems inherited some of the copper-bound FDM system problems, such as the limitations of the length of each regenerator section and the number of consecutive regenerator sections. A typical DWDM transmission system offered up to 32 wavelengths, 0.8 nm = 100 GHz between adjacent wavelengths, each wavelength carrying 2.5 Gbit/s across a distance of about 600 km with 6 regenerator sections, resulting in a total transmission capacity of 80 Gbit/s.

Compared to single wave optical transmission DWDM offers significant advantages:

- *Less dispersion effects*. For a given throughput, the individual channel rate can be decreased, thereby lessening the chromatic and polarisation dispersion effects. As a consequence, the distance between regenerators can be increased, although optical amplification is still required to maintain the power budget., and the capacity can be increased on non-ideal installed plant.

- *Improved scalability*. Adding new wavelengths, according to a “pay-per-wavelength” approach, can simply increase the throughput. Additional wavelengths need not be all at the same rate, thus providing added flexibility.

- *Relaxed specifications.* DWDM relaxes the technological constraints on the opto-electronic (O/E) components required to implement a system, since these components need only to be performing at the highest individual wavelength rather than at the total throughput.

- *Full duplex operation* on one single fibre.

With the advent of DWDM systems a number of alternatives exist to increase transmission performance capacity by influencing the number of wavelengths per fibre pair (spacing), the bit rate per wavelength, the optical frequency band and the distance (with or without timing regeneration). Figure 4 illustrates the parameters influencing the expected development of DWDM systems Distance.

- *Increase of bit rate* is limited by physical effects such as, e.g. chromatic dispersion (which might require dispersion management), polarization mode dispersion (critical for existing installed fibres), fibre non-linearities (leading to cross-phase modulation and four-wave mixing) resulting in faster and more costly electronic components (e.g. O/E conversion).
- *Increase of the number of wavelengths* is limited by the total available optical bandwidth (in fibre and amplifiers) and spacing between wavelength (leading to stability problems, bit rate limitation and increased emphasis of non-linearity effects).
- *Increase of distance* is limited by amplifier gain (depending on bandwidth and wavelength dependent gain), number of consecutive regenerator sections (depending on noise and jitter accumulation, and regenerators with or without retiming functions).

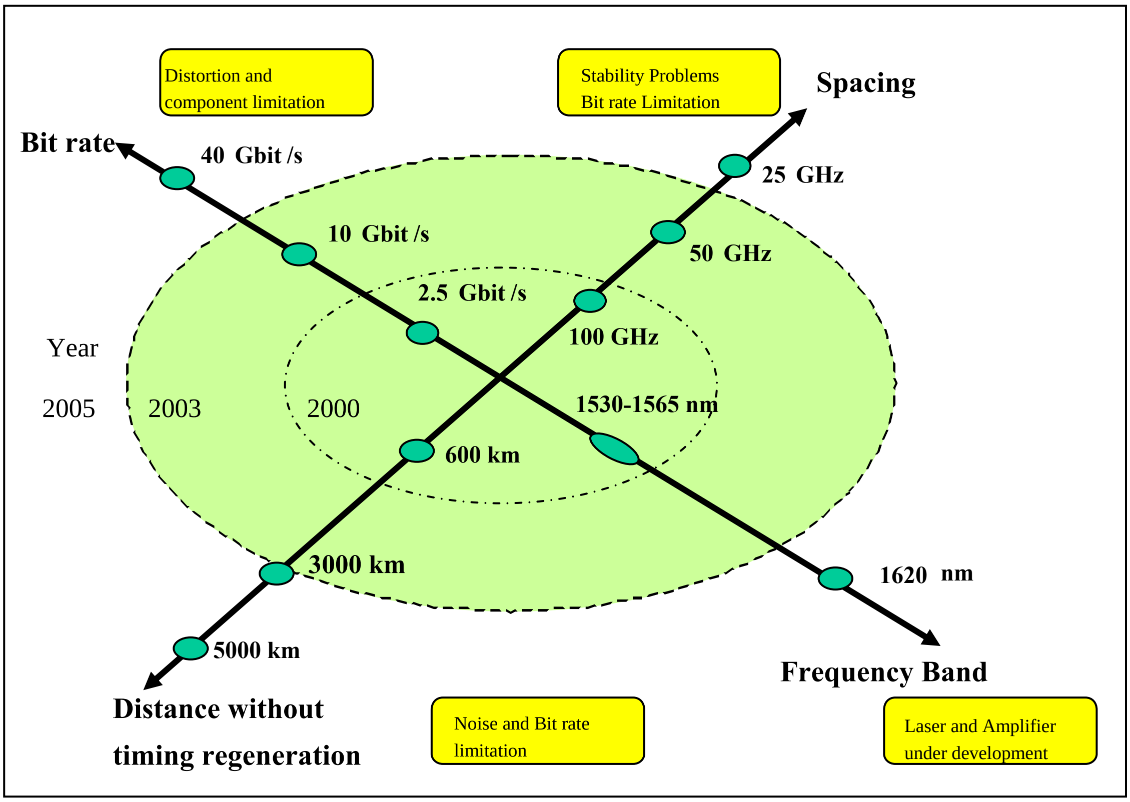
The various parameters depend on each other, i.e. increasing the value of one parameter might decrease the acceptable values of other parameters.

Publications describe high capacity DWDM systems, e.g.:

- 10 Gbit/s signals on 32 wavelengths leading to 320 Gbit/s. Reported Optical Transmission Sections are 80-140 km to achieve Optical Transmission Paths of more than 600 km.
- 20 Gbit/s signals on wavelengths leading to more than 1 Tbit/s on one fibre.
- 10 Gbit/s signals on 150 wavelengths with 50 GHz spacing leading to 1.5 Tbit/s.

  For this system dispersion compensated fibre was necessary to achieve Optical Transmission Sections of 100 km and Optical Transmission Paths of 400 km.

Figure 4 – Development of DWDM systems



In the course of the on-going evolution it is likely that optical switching facilities will be added in the near future, starting from non-reconfigurable add-drop elements, followed by optically protected self-healing rings, and then by optical cross connects for ring interconnection or as a basis for meshed optical networks. However, physical constraints will likely limit the achievable size of photonic networks, which could only be enlarged by the use of partial or total optoelectronic or photonic regenerators.

II.1.5 Synchronous Digital Hierarchy Matrix

The increased demands of higher transmission bit rates, more flexible channel handling together with more elaborate management requirements lead to the concept of synchronous transmission. The concept was first proposed in USA by Bellcore as SONET, Synchronous Optical Network. ITU has further refined and generalized the principles to produce the Synchronous Digital Hierarchy, SDH. The spirit of international cooperation resulted in one worldwide accepted standard for SDH. SDH extends the principles of Plesiochronous Digital Hierarchy (PDH), while avoiding some of the disadvantages of the PDH, resulting in the following driving factors:

- Digital 64 kbit/s channels or groups of channels can be added to or extracted directly from SDH signals without intermediate multiplexing stages leading to economic ADD/DROP equipment.

- Plesiochronous signals of different levels and belonging to different hierarchies (e.g. ETSI-Europe, ANSI-USA) can be mapped to SDH and transmitted as SDH signals.

- Digital 64 kbit/s channels or groups of channels can be switched in Synchronous Digital Cross Connects (DXC).

- The routing in DXC networks can be command controlled permitting in a flexible way different logical network configurations based on the same physical network. Different logical network configurations can appear at different times.

- DXCs permit sorting of traffic, e.g. an incoming digital signal carrying a mixture of data, voice and video can be converted to separate digital signals for data, voice and video.

- DXCs permit packing of traffic, e.g. incoming digital signals with idle time slots can be combined to digital signals without idle time slots, which fully utilize the transmission media.

- DXC can be co-located with a telephone exchange. In this case DXC handles the steady basic traffic load and the exchange covers traffic peaks. which would be more economic than one single telephone switch with increased capacity.

- Last but not least, SDH and DXC are the first equipment types which have been specifically designed for Telecommunication Management Networks (TMN) with ample capacity for management.

The basis unit of the SDH hierarchy is the Synchronous Transport Module, STM-1 containing 19 440 bits. STM-1 is repeated 8 000 times per second leading to the STM-N bit rates shown below:

STM-1	155.520 Mbit/s
STM-4	622.08 Mbit/s
STM-16	2 488.32 Mbit/s
STM-64	9 953.28 Mbit/s

The requirement to transport PDH signals of different hierarchies, together with ATM signals, resulted in a complex multiplexing scheme. One STM-1 System can carry various PDH systems and one ATM system as illustrated below:

3 × 34 or 45 Mbit/s systems	84 × 1.5 Mbit/s systems
21 × 6 Mbit/s systems	1 × 140 Mbit/s system
63 × 2 Mbit/s systems	1 × ATM system

Four basic SDH multiplexer (MUX) types have been standardized:

1) MUX for conversion from plesiochronous signals (according to Rec. G.703) to synchronous STM-N signals. Flexible assignment of a tributary to any position in the STM-N frame can be provided. Suitable for the establishment of SDH links in a plesiochronous environment.

2) MUX for conversion between various STM signals. A number of STM-1 signals can be multiplexed to a higher bit rate. Flexible assignment of a VC-3/4 to any position on one STM-N is possible. Permits to use the capacity of fibre optical cables efficiently.

3) MUX for drop / insert of plesiochronous and synchronous signals to STM-N without demultiplexing and termination of the complete signal. Single channels or groups of channels can be added or dropped from a synchronous bit flow. A typical use are Add/Drop multiplexers in self healing ring configurations.

4) MUX for translation (interworking) to allow C-3 payloads in VC-3s to transit between e.g. USA and e.g. Europe based networks.

Three basic Digital Cross Connect (DXC) types have been standardized with three types of cross-connects have been standardized:

1) DXC cross-connects 140 Mbit/s plesiochronous signals or STM-1 signals

2) DXC cross-connects 2, 34 and 140 Mbit/s plesiochronous signals

3) DXC combines the functionalities of Types 1 and 2.

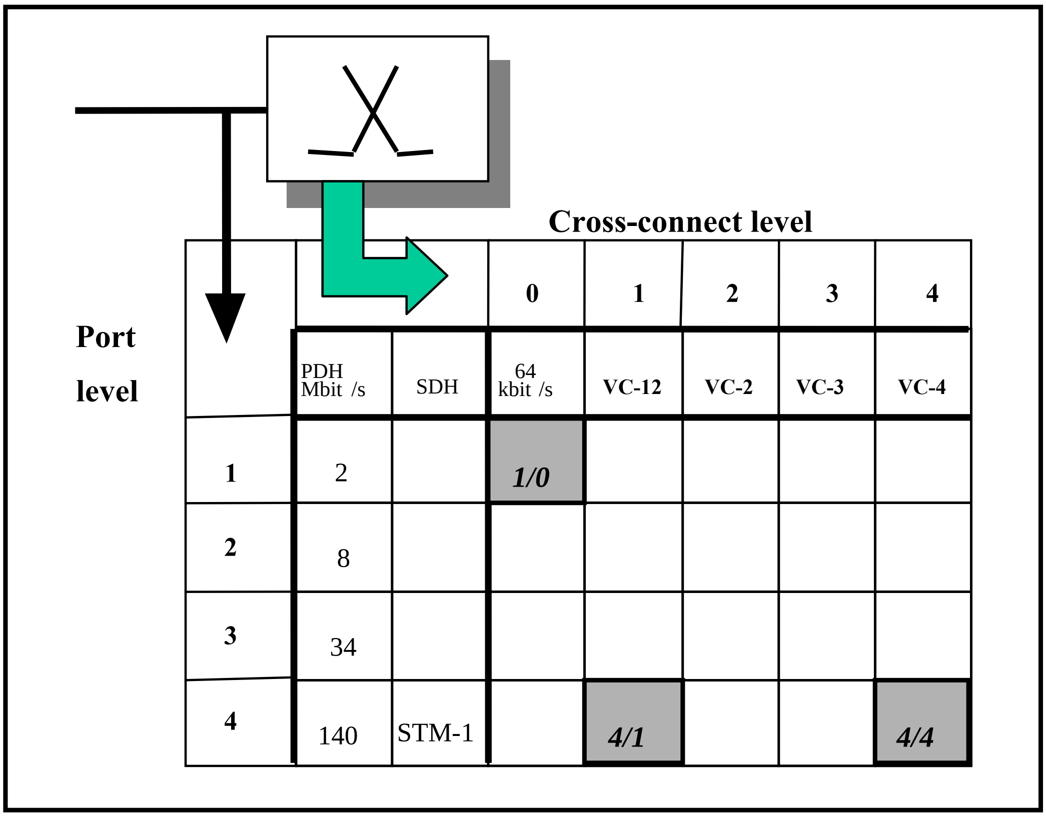
DXCs are characterized by port levels and cross-connect levels, as shown in the example Figure 5.

DXC 1/0 port level 2.048 Mbit/s and cross-connect level 64 kbit/s.
for e.g. 64 kbit/s leased line networks

DXC 4/1 port level 140 Mbit/s and cross-connect level VC-12
for e.g. 2 Mbit/s leased line networks

DXC 4/4 port level 140 Mbit/s or STM-1 and cross-connect level VC-4
for, e.g. network protection, together with DXC 4/1 for network administration.

Figure 5 – Examples of digital cross-connect equipment



An important application of SDH is the use of Multiplex Section Shared Protection (MS-SP) Rings. The total payload in every STM-N link is divided equally into working and protection capacity. The traffic is bi-directional: two fibre rings are used for clock-wise direction and two fibre rings for anti-clock-wise direction. The protection capacity is shared by all the working sections. In case of a link failure a loop back is provided at the nodes adjacent to the failed link or node Typical ring parameters are: 8 VC-4 per link, switch time below 50 ms and up to 16 nodes a ring. In modern network configurations rings are used in tandem, each representing e.g. a network layer. Cable faults and node faults are eliminated using the above described principles In this case the connection of 2 rings via 2 nodes uses the advantages of MS-SP rings leading to fail safe network configurations.

II.2 Wireless Broadband Access Technologies

Wireless telecommunications comprises a wide range of technologies, services and applications that have come into existence to meet the particular needs of different market sectors and user environments. Different systems can be broadly characterized by:

- frequency bands of operation;
- standards (in ITU, Recommendations are used instead of standards) defining the systems;
- data rates supported;

- bidirectional and unidirectional delivery mechanisms;
- degree of mobility;
- content and applications offered;
- regulatory requirements; and
- cost.

Wireless technology is perhaps one of the most potentially viable options for many developing nations and regions seeking high-speed access, or any access at all. Relative to other infrastructure technologies, wireless has fast deployment, and relatively wide geographic coverage. In addition, it allows nations with little or no telecommunications infrastructure to "leapfrog" development, or skip over building a fixed wireline system entirely and to move directly into Internet access. Because of the mobility and portability of wireless technologies, they have the potential to spur demand and incite new ways of accessing and using the Internet.

II.2.1 Radio Local Area Network (RLAN) Technology Matrix

RLAN systems are being marketed all over the world. There are several major standards (not necessarily recognized by ITU in some Recommendations) for broadband RLAN systems and Table 1 provides an overview of these.

As speeds of notebook computers and hand-held computing devices steadily increase over time, they are able to provide interactive telecommunications between users on a wired network; however, several of these devices sacrifice portability when connected. Multimedia applications require broadband telecommunications facilities not only for wired terminals but also for portable and personal telecommunications devices. Wired local area network standards are able to transport high rate, multimedia applications. To maintain portability, future wireless LANs will need to transport higher data rates. Broadband RLANs are generally defined as those that can provide data throughput greater than 10 Mbit/s.

System Architecture

Broadband RLANs are nearly always point-to-multipoint architecture. Point-to-multipoint applications commonly use omnidirectional antennas. The multipoint architecture employs two system configurations:

– point-to-multipoint centralized system (multiple devices connecting to a central device or access point via a radio interface);

– point-to-multipoint non-centralized system (multiple devices communicating in a small area on an ad hoc basis).

RLAN technology is sometimes used to implement fixed point-to-point links between buildings in a campus environment. Point-to-point systems commonly use directional antennas that allow greater distance between devices with a narrow beam width. This allows band sharing via channel reuse with a minimum of interference with other RF systems.

Frequency Spectrum Requirements

RLANs could operate in unlicensed or licence-exempt spectrum and often must allow adjacent uncoordinated networks to coexist whilst providing high service quality to users. For RLANS, 83.5 MHz are already in use in the 2.4 GHz band in some countries on a licence-exempt basis and 455 MHz by RLANS have been newly allocated in the 5 GHz band used by World Radio Conference (WRC) with some restrictions[55]. In the 5 GHz bands, protecting primary services is an obligation. Whilst multiple-access techniques might allow a single frequency channel to be used by several nodes, support of many users with high service quality requires that enough channels are available to ensure access to the radio resource without being limited through excessive queuing, etc. One technique that achieves a flexible sharing of the radio resource among operators in the same band is the Dynamic Frequency Selection (DFS). (For an explanation of this technique, see Annex 2).

Mobility

Broadband RLANs may be either pseudo-fixed as in the case of a desktop computer that may be transported from place to place or portable as in the case of a laptop or palmtop devices working on batteries that are carried in an office environment for example. Relative velocity between devices remains low. In warehousing applications, RLANs may be used to maintain contact with lift trucks at speeds of up to 20 km/h. RLAN devices are generally not designed to be used at automotive or higher speeds.

Operational Environment and Considerations of Interface

Broadband RLANs are predominantly deployed inside compass buildings, in offices, factories, warehouses, etc. For RLAN devices deployed inside buildings, emissions will be attenuated by the structure.

RLANs utilize low power levels because of the short distance nature of inside building operation and as imposed by the Radio Regulation in the ITU. Power spectral density requirements are based on a basic service area of a single RLAN defined by a circle with a radius from 10 to 50 m. When larger networks are required, multi-cell RLANS may be logically concatenated via bridge or router function to form larger networks without increasing their composite power spectral density.

To achieve the coverage areas specified above, it is assumed that RLANs require a peak power spectral density of approximately 12.5 mW/MHz in the 5 GHz operating frequency range. For data transmission, some standards use higher power spectral density for initialization and control the transmit power according to evaluation of the RF link quality. This technique is referred to as transmit power control (TPC). The required power spectral density is typically proportional to the square of the operating frequency. The large scale, average power spectral density will be substantially lower than the peak value. RLAN devices share the frequency spectrum on a time basis. Activity ratio will vary depending on the usage, in terms of application and period of the day.

Compatibility with IMT-2000

RLANs can be synergistic with IMT-2000 and other mobile (cellular) networks. While IMT-2000 capabilities offer extensive mobility features and cost-effective wide-area coverage, RLANS enable high-quality data throughput capacity in specific areas (hotspots), and broadband RLANs currently enable data rates of up to 54 Mbit/s.[56]

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[55] "*RLANS: ITU-R Developments*", presented at the ITU-R WP8A Seminar on New Technology and Services, Geneva, 2 December 2003.

[56] See Resolution 229 (WRC-03) for details.

Dynamic Frequency Selection

In Dynamic Frequency Selection (DFS) all radio resources are available at all RLAN nodes. A node (usually a controller node or access point (AP)) can temporarily allocate a channel and the selection of a suitable channel is performed based on interference detected or certain quality criteria, e.g. received signal strength, *C*/*I*, etc. To obtain relevant quality criteria, both the mobile terminals and the access point make measurements at regular intervals and report this to the entity making the selection.

DFS can be implemented to ensure that all available frequency channels are utilized with equal probability. This maximizes the availability of a channel to node when it is ready to transmit, and it also ensures that the RF energy is spread uniformly over all channels when integrated over a large number of users. The latter effect facilitates sharing with other services that may be sensitive to the aggregated interference in any particular channel, such as satellite-borne receivers.

TPC is intended to reduce unnecessary device power consumption, but also facilitates spectrum reuse by reducing the interference range of RLAN nodes.

Example of a high capacity R-LAN system

The Communications Research Centre, Canada, has developed a high capacity R-LAN experimental system based on the DVB-S PHY technology in the forward (downstream) direction and the 802.11 PHY technology in the return (upstream) direction. It operates in the 5 GHz license-exempt band and its high capacity is due to its large frequency re-use resulting from a base-station rosette antenna generating 24 electromagnetically-isolated microcells (called petals) where 4 frequencies are successively repeated in the horizontal plane. Up to 22 Mbit/s forward and 9 Mbit/s return capacity can be made available to the subscribers in each petal. The system uses cognitive radio technology which monitors the forward and return links bands of operation and automatically adjusts the system’s frequency assignments and e.i.r.p.’s in a manner that mitigates or avoids interference to other nearby systems using the same frequencies. The system incorporates DFS as part of its cognitive radio operation. The complete Customer Premises Equipment is made of a flat plate antenna of 18x18 cm square by 2.5 cm deep and contains all the necessary electronics. Typically the system operates using metropolitan fibre optical backhaul networks to mediate the massive amounts of wireless traffic it passes. Operational radius can extend to 4.8 km, but is nominally about 1 500 metres in LOS and less for occluded deployments, providing TCP/IP services such as video-on-demand, VoIP, and Internet.

Table 1 – Technical parameters for broadband RLAN applications

These requirements are subject to national regulations and regional regulations.

Network standard	IEEE Project 802.11a(1)	IEEE Project 802.11 .11b	IEEE Project 802.11 .11g	ETSI BRAN HIPERLAN 1 ETS 300-652	ETSI BRAN HIPERLAN 2 (1), (2)	MMAC HSWA HiSWAN a(1)
Access method	CSMA/CA	CSMA/CA, SSMA	CSMA/CA	TDMA/EY-NPMA	TDMA/TDD	TDMA/TDD
Modulation	64-QAM-OFDM 16-QAM-OFDM QPSK-OFDM BPSK-OFDM 52 subcarriers (see Figure 1)	CCK (8 complex chip spreading)	64-QAM-OFDM 16-QAM-OFDM QPSK-OFDM BPSK-OFDM 52 subcarriers	GMSK/FSK	64-QAM-OFDM 16-QAM-OFDM QPSK-OFDM BPSK-OFDM 52 subcarriers (see Figure 1)	64-QAM-OFDM 16-QAM-OFDM QPSK-OFDM BPSK-OFDM 52 subcarriers (see Figure 1)
Data rate	6, 9, 12, 18, 24, 36, 48 and 54 Mbit/s	1, 2, 5.5, 6, 9, 11, 12, 18, 24, 36, 48 and 54 Mbit/s		23 Mbit/s (HBR) 1.4 Mbit/s (LBR)	6, 9, 12, 18, 27, 36 and 54 Mbit/s	6, 9, 12, 18, 27, 36 and 54 Mbit/s
Frequency band	5 150-5 250 MHz 5 725-5 825 MHz 5 250-5 350 MHz(3)	2 400-2 483.5 MHz		5 150 to 5 300 MHz Limited in some countries to 5 150 to 5 250 MHz(3)	5 150-5 350 and 5 470-5 725 MHz(3)	5 150 to 5 250 MHz(3),
Channelization	20 MHz channel spacing	25/30 MHz spacing 3 channels		23.5294 MHz (HBR) 3 channels in 100 MHz and 5 channels in 150 MHz 1.4 MHz (LBR)	20 MHz channel spacing 8 channels in 200 MHz 11 channels in 255 MHz	20 MHz channel spacing 4 channels in 100 MHz

(1) Parameters for the physical layer are common between IEEE 802.11a and ETSI BRAN HIPERLAN 2 and HiSWANa.

(2) WATM (Wireless ATM) and advanced IP with QoS are intended for use over ETSI BRAN HIPERLAN 2 physical transport.

(3) For the band 5 150 to 5 250 MHz, No. 5.447 of the Radio Regulations (RR) applies.

Source: Recommendation ITU-R M.1450-2; Characteristics of broadband radio local area networks; (Questions ITU-R 212/8 and ITU-R 142/9).

Technical parameters for broadband RLAN applications *(end)*

Additional 802.11 standards undergoing validation by the national and/or regional organizations[57]

Standard	Description
802.11d	Supplements the 802.11 MAC (Medium Access Control) layer to take account of regulatory constraints that vary from country to country, permit the location of equipment by firmware version selection.
802.11e	Supplements the MAC layer, providing quality of service management functions. Will be applied to different physical layers (802.11a, b and g).
802.11f	Communication between access points to ensure their interoperability in a multi-manufacturer environment, particularly where roaming is concerned.
802.11h	Complement for conformity with European regulations relating to equipment in the 5 GHz band (extensively used for satellite communications). Provides dynamic channel selection and emission power control.
802.11i	Complements the MAC layer to enhance security by offering an alternative to WEP (Wired Equivalent Privacy). Uses 802.1x and will use AES (Advanced Encryption Standard) encrypting. Will be applied to 802.11a, b and g.

II.2.2 Fixed Broadband Wireless Access Systems

II.2.2.1 IEEE 802.16 and ETSI HiperMAN Matrix

Both IEEE 802.16 and ETSI HiperMAN target the broadband access, offering a Wireless DSL connection to residential, SoHo, SME users, for both fixed and nomadic applications, mainly for areas where the DSL connection cannot be offered by wired deployment.

IEEE 802.16 and IEEE 802.16a

In 2003, IEEE has published the 802.16a standard [2], which is an amendment to IEEE 802.16 [1] standard, addressing “Medium Access Control Modifications and Additional Physical Layer Specifications for 2-11 GHz”.

The key feature of the IEEE 802.16 air interface is the medium-access control layer (MAC), which specifies a mechanism for controlling access to the airwaves. The IEEE 802.16 MAC is based on demand-assigned multiple access in which transmissions are scheduled according to priority and availability. This design is driven by the need to support carrier-class last-mile access to public networks, with full QoS support. The system could easily support both generic Internet-type data and real-time data, including two-way applications such as voice, videoconferencing, or interactive games.

The 802.16a standard defines three Physical Layer modes, to be used in 2-11 GHz bands:

- SCa (Single Carrier, for 2-11 GHz);
- Orthogonal Frequency Division Multiplexing (OFDM), based on 256 points FFT; additional Mesh topology is defined for this mode;
- OFDMA, based on 2K points FFT; OFDMA is used on both upstream/return and downstream/forward.

These modes are not interoperable, and a compliant system may use only one of them.

57 Recommendation *ITU-R M.1450-2, “Characteristics of broadband radio local area networks*”, *(Questions ITU-R 212/8 and ITU-R 142/9).*

All the modes provide the following features:

- Both FDD and TDD support, including half-duplex CPE in FDD mode;
- High spectral efficiency and data rates, up to 72 Mbit/s in a 20 MHz channel;
- Adaptive modulation, from QPSK rate 1/2 to 64QAM rate 3/4 for OFDM and OFDMA modes, and even higher modulations for the SC mode;
- Wide range of channel widths, 1.25 MHz to 28 MHz, the actual interoperability profiles are to be defined in 802.16REVd standard;
- High cell radius, up to 50 km in P-MP mode with directive, outdoor mounted, antennae.

Hooks for Advanced Antenna Systems;

- High security Traffic Encryption Hek (TEK) encryption algorithms:
  - 3-DES with 128-bit key (type 1);
  - RSA with 1024-bit key.

Further IEEE 802.16 standardization

As of late 2003, 802.16 is drafting:

- a revision (802.16REVd) to improve the existing Physical Layer (PHY) modes, and define inter-operability profiles;
- an amendment (P802.16e) to support mobile operation, namely hand-off and power saving; the mobile systems will use the improved PHY modes as defined by 802.16REVd; completion is expected in the autumn of 2004.

Future mobile radio systems will support high data rates, high mobility, high capacity, and high QoS. Since the available frequency spectrum is limited, high spectral efficiency is a major challenge of future mobile radio systems. Furthermore, the bit rates and performance should be scalable for various environments and applications (metropolitan, sub-urban and rural areas).

ETSI HiperMAN

ETSI BRAN HiperMAN has produced three standards, already approved:

- TS 102 177, addressing Physical Layer;
- TS 102 178, addressing Data Link Layer;
- TS 102 210, defining interoperability profiles.

ETSI HiperMAN had a two years selection and improvement process:

- adopted as base line the 802.16 and 802.16a standards; this selection allows for having the same features as previously described for 802.16 systems;
- selected the OFDM 256 points FFT mode, as the best cost/performance solution for broadband NLOS operation;
- improved the OFDM mode, by adding upstream/return sub-channelization (OFDMA), 16 sub-channels, using a specific clustered approach, for achieving:
  - 12 dB more uplink system gain, due to power concentration;
  - broadband data rate per sub-channel, at cell margin (150 kbit/s in 3.5 MHz, at QPSK rate 1/2); the data rate decreases with the number of sub-channels;
  - maximum capacity and low delay with a variety of traffic types (IP and TDM);
  - robust operation, frequency diversity, good Advanced Antenna Systems (AAS) support.

HiperMAN DLC has adopted much of the 802.16 MAC – OFDM mode. Supplementary, the HiperMAN DLC standard provides the support of up-link sub-channelization and refined ARQ/ BW request/BW allocation modes.

It is expected that IEEE 802.16REVd (2004), OFDM part, will be aligned with ETSI HiperMAN.

Further ETSI HiperMAN standardization

ETSI is currently drafting four new standards, to support HiperMAN system interoperability and management:

- Conformance Testing for the Data Link Control Layer (DLC) – Part 1: PICS;
- Conformance Testing for the Data Link Control Layer (DLC) – Part 2: Test Suite Structure and Test Purposes (TSS & TP) specification;
- Conformance testing for the Data Link Control Layer (DLC) – Part 3: Abstract Test Suite (ATS);
- Network Management: MIB.

The conformance testing work is lead by ETSI PTCC (Protocol & Testing Competence Centre) specialists.

Interoperability profiles are expected to be produced, in support of 5.8 GHz allocations.

In future, ETSI BRAN may also consider mobile applications.

Deployment example

References

[1] IEEE 802.16 Standard: Air Interface for Fixed Broadband Wireless Access Systems – 2001.

[2] IEEE 802.16a Standard: Amendment 2: Medium Access Control Modifications and Additional Physical Layer Specifications for 2-11 GHz – 2003.

[3] IEEE L802.16-03/16: IEEE 802.16 Liaison Letter to ITU-R: Appendix www.ieee802.org/16/liaison/docs/L80216-03_15.pdf

[4] ETSI TS 102 177 2003-09; Broadband Radio Access Networks (BRAN); HiperMAN; Physical (PHY) Layer.

[5] ETSI TS 102 178 2003-08; Broadband Radio Access Networks (BRAN); HiperMAN; Data Link Control (DLC) Layer.

[6] ETSI TS 102 210 2003-08; Broadband Radio Access Networks (BRAN); HiperMAN; System Profiles.

II.2.2.2 IMT-2000 Wireless Local Loop Broadband Access

The growth of wireless cellular services is continuing at a rapid pace in today's marketplace. Most of the operators have either started or are in the process of deploying WLL systems, also termed as Fixed Wireless Access (FWA) systems, utilizing the IMT-2000 technologies. Even though IMT-2000 technologies are conceived primarily for providing mobile telecommunications, they are capable of providing efficient and cost effective alternatives to fixed Broadband and wire line technologies.

In particular, the use of IMT-2000-based WLL systems can substantially reduce the up-front investment necessary for an operator to deploy a WLL network by utilizing most of the standard network components that constitute a mobile network. This is in addition to the high spectral efficiency and compatibility exhibited by the IMT-2000 technologies. The operator can either complement its existing mobile network to provide WLL services or built a completely new WLL system. The high degree of resilience provided by IMT-2000 systems make them an ideal choice for operators who are planning to provide WLL services.

Although, there are many other IMT-2000 and non-IMT-2000 technologies that are capable of providing WLL services, this section focuses on the adaptability and robustness of CDMA2000 to provide WLL services.

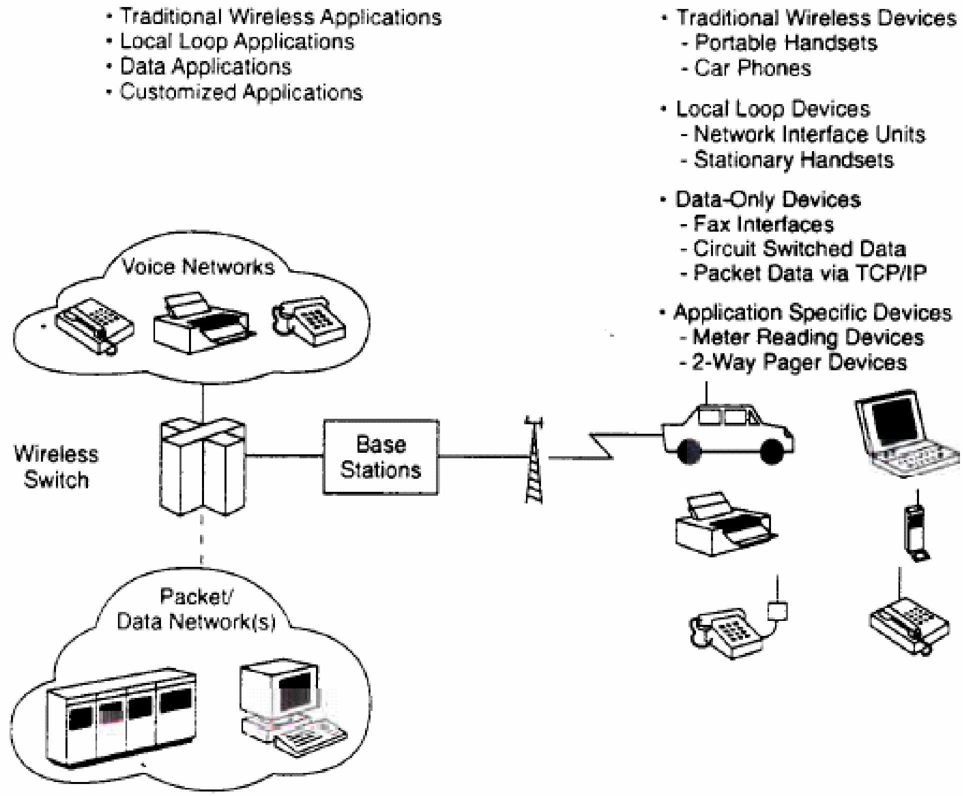
Key Features of CDMA2000-based WLL service include, in addition to those listed under section II.2.3.1 of this report.

- Allows robust evolution to an All-IP (3G and beyond) system utilizing the Multi-Media Domain (MMD) and/or the IP Multimedia Subsystem (IMS) architectures.
- Provides simultaneous voice and high-speed data services. 3 Mbit/s on the DL and 1.8 Mbit/s on the UL, using CDMA2000-1X EV-DO.
- Centralized Architecture.
  - Provides significant benefits with vocoder pooling, frame selection, and power control algorithms.
- Allows for the mixing of CDMA-1X, and 1X-EV carriers.
- Provides custom calling features and billing rates to certain group of users and/or individual users in pre-defined geographical locations.
  - Common billing and customer care.
- Over the Air functionality (OTAF) and software features allow for easy and flexible re-configuration of the networks.
- Location based services.
  - Multiple subscriber rate plans.
  - Tiered services.
  - More revenue per subscriber.
- Provides IP based location services and encrypted packet flow.
- Meets most stringent regulatory roll-out requirements.

Applications of CDMA2000-based Wireless Local Loop are:

The CDMA2000-based WLL system supports a wide variety of applications. Operators can partner with current land-line service providers, such as cable TV providers, power companies and/or with wireless carriers and offer a host of different applications. While these applications can be supported from the same network and software platform, special purpose handsets may be required. The following figure (Figure 3) shows a variety of different applications that can be provided using a CDMA2000-based WLL systems. These WLL services are available to operate in all bands where CDMA2000 system operates, for example, 800 MHz, 1 900 MHz, etc.

Figure 3 – Wireless Local Loop applications using CDMA2000



WLL applications include elements of a mobility infrastructure as well as a few other complementary elements:

- Fixed Subscriber Equipment (Handset, or Customer Premises Equipment (CPE)) – A number of handset vendors are building WLL subscriber units that are compatible with CDMA2000 infrastructure. Fixed wireless equipment options currently include a traditional handset, a fully integrated wireless desktop unit, a wireless network interface, wireless pay-phones, personal base-stations etc. The handset vendors are also planning to include additional features on the subscriber units in order to enhance the user's experience.
- Feature Transparency – To position a WLL device the unit must offer a land-line look and provide services and features that are transparent to the end-user. The features include:
  - Business/ Residential Feature Transparency
    - Consistent look and feel (Dial Tone)
    - Call forwarding
    - Three-way calling
    - Calling line restriction
    - Call waiting and call transfer
  - Operational Transparency
    - Feature codes
    - Dialling plans and conventions
    - Private dialling plans

– Implementation Transparency

  • Voice messaging/messaging centres

  • Service nodes

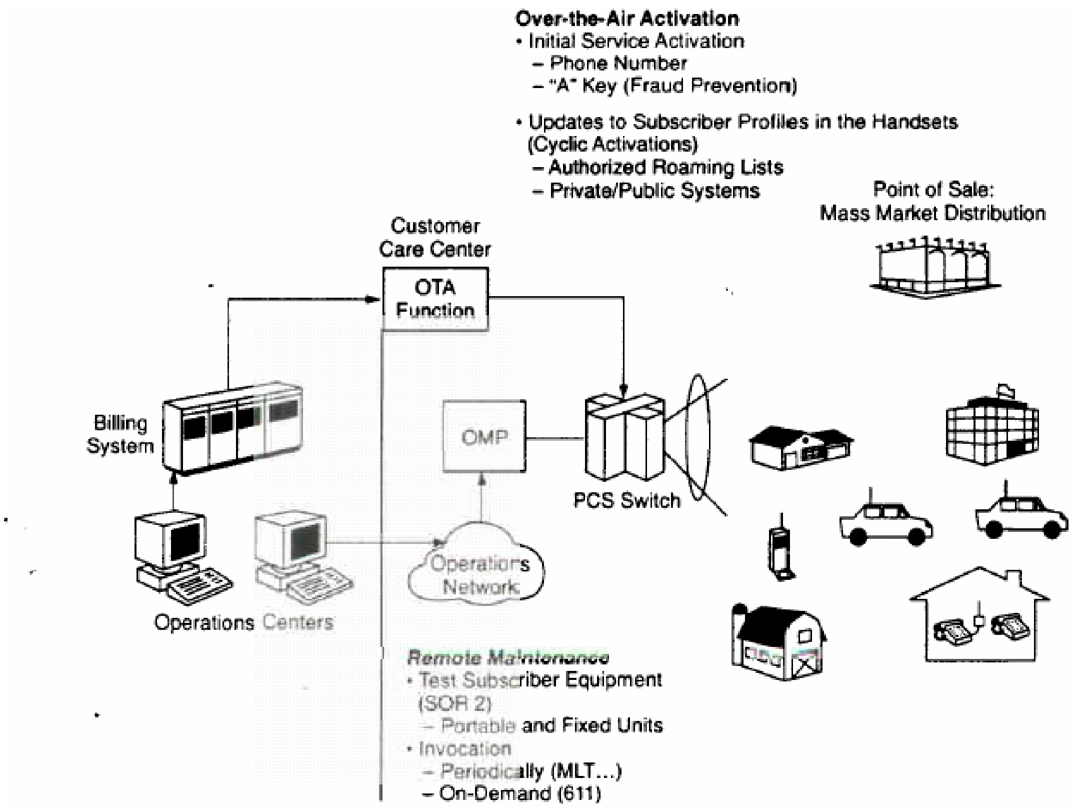
  • Service control points.

Additional features that are expected to be integrated into the WLL devices in the future.

• Service Enabling – One of the key features in providing both fixed and mobile services is the ability of the network to distinguish between both the fixed and the mobile users, for billing purposes. CDMA2000 provides this capability in a robust manner. CDMA private network and user zone features enable partitioning of public networks. Through the use of network ID's, service providers can distinguish among different classes of service and charge subscribers differently from the same physical equipment and location. This allows for personal billing zones with the enhanced capability of the network to alert the user – via a banner display – on the device designating the billing rate(s)/zone(s), as the user moves from one geographical region to another. In addition, the network also provides restricted access that prohibits origination, termination, and handoff of a call outside of the pre-defined area.

  Another important feature of the network is that it provides common billing and customer care capabilities to ease the day-to-day operation of the WLL operator. Figure 4 below shows the manner in which the customer care and billing centres of a CDMA2000-based WLL are converged.

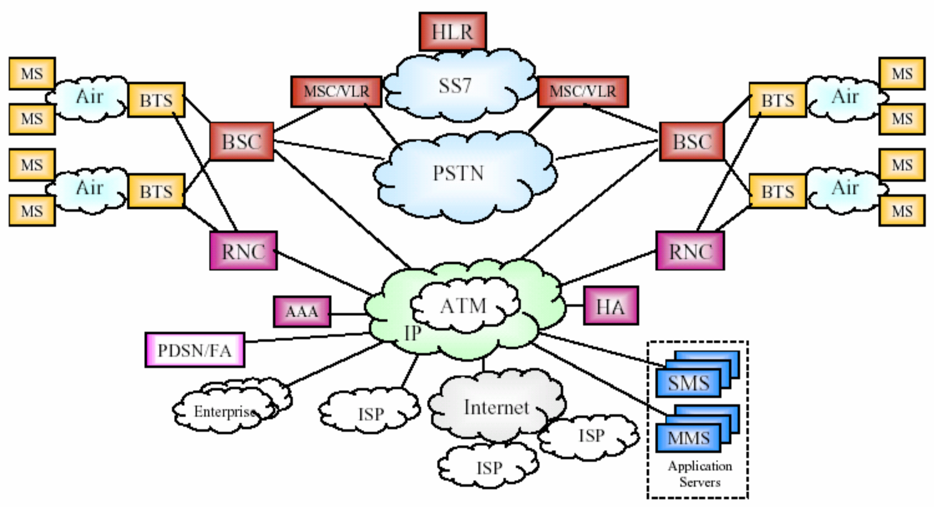
Figure 4 – Converged Custom care and billing centre of a CDMA2000-based WLL system



System Architecture

The typical system architecture with Radio Access Network (RAN) and the IP Core network[58] of a CDMA2000-1X / CDMA2000-1X-EV-DO WLL system is as follows:

Figure 5 – Typical IP core network of CDMA2000-based WLL systems



CDMA2000-based WLL system utilizes a distributed architecture approach consisting of a Base Station (BS), Base Station Controler (BSC), Home Agent (HA) and Authentication, Authorization and Accounting (AAA), and other associated interfaces. This is the same architecture that is used for providing mobility services thus allowing integration of fixed services applications into existing infrastructure. This integration strategy protects the provider's investment in infrastructure, end-users, and services. A brief description of the core network elements is as follows:

- The Base Transceiver System (BTS) is an entity that provides transmission capability across the air interface.
- The Base Station Controller (BSC) is an entity that provides control and management for one or more BTS.
- Packet Data serving Node (PDSN) provides the Radio Access Network (RAN) with access to the IP core network.
- The Authentication, Authorization, and Accounting (AAA) provides IP based authentication, authorization, and accounting functions. It also maintains security associations with peer AAA entities.
- The Home Agent (HA) provides two main functions; it registers the current point of attachment of the user (e.g. the current IP address to be used to transmit and receive IP packets) and forwards IP packets to and from the current point of attachment of the user.
- The Home Location Register (HLR) stores the subscriber information.
- CDMA2000 RAN provides interconnection to the PSTN via the Signalling System No. 7 (SS7) interface.

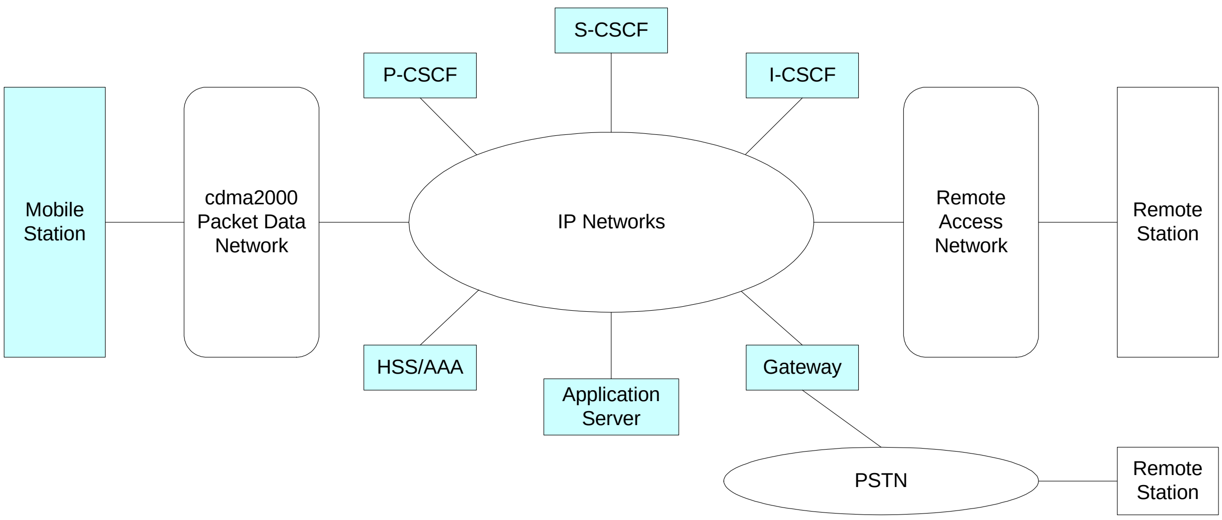
[58] For a complete detail on the IP core network of CDMA2000 systems, please refer to the TIA/EIA/ IS-CDMA2000 standards.

A major benefit for operators using CDMA2000, as a WLL service, is the ability to migrate the network to an all IP network, sometimes referred to as beyond 3G system or Next Generation Networks (NGN). The benefits of an IP core network include:

- Enhanced voice and data services
  - VoIP
  - High speed data transfer
  - Internet access
- Ease of service introduction
- Standard protocols and services
- Cross technology roaming and inter-operability.

The operator can evolve is existing network through the use of the Multi Media Domain (MMD) architecture[59]. The transition is seamless and robust with minimal disruption to existing services. A typical example of a CDMA2000 network utilizing the MMD architecture is sketched below:

Figure 6 – Overview of the MMD architecture



The MMD functional entities are:

- AAA – extension of the HLR to include user data for the IP Multimedia Subsystem.
  - Access from the Call State Control Function (CSCF) uses the IETF protocols (DIAMETER).

59 For a complete description of the MMD architecture and functionality, refer to the appropriate CDMA2000 standards.

- Call Session Control Function (CSCF) – provides call control functions
  - Proxy CSCF
    - SIP proxy server for the mobile, acting on behalf of the UE within IMS
    - Forwards messages between mobile and other SIP servers
  - Serving CSCF
    - SIP registrar with cooperation from AAA (location server)
    - Session control call state machine for the registered end-point
    - Interaction with service platforms for service control, provides service triggers
  - Interrogating CSCF
    - Entry point from other networks
    - Allocates or determines the S-CSCF
    - May hide network topology.

II.2.3 Mobile Broadband Wireless Access Systems

II.2.3.1 IMT-2000 Matrix

Third-Generation wireless solutions (3G) are a relatively new and innovative broadband access solution that can be explored as a substitute to other technologies, such as fibre, digital subscriber line (xDSL) or cable. IMT-2000 "International Mobile Telecommunications" is the term used by the ITU for a set of globally harmonized standards for Third-Generation (3G) mobile telecommunications services and equipment. IMT-2000 envisages a platform for distributing converged fixed, mobile, voice, data, Internet and multimedia applications. IMT-2000 may provide higher "broadband" transmission rates ranging from 144 kbit/s, 500 kbit/s to 2 Mbit/s for mobile, portable and fixed applications respectively. IMT-2000 includes a flexible set of five terrestrial radio interfaces that offers high capacity voice applications and increased data rates. IMT-2000 aims to provide seamless delivery of applications, over a number of media (mobile, satellite and fixed) making this platform convenient from both the operator and consumer point of view. This set of technologies is intended to meet the needs of a lesser deregulated competitive market in the information age, and it is expected to become an integral part of the overall economic growth for both developed and developing countries.

Key features of IMT-2000 are[60]:

- high degree of commonality of design worldwide;
- compatibility of services within IMT-2000 and with the fixed networks;
- high quality;
- small terminal suitable for worldwide use;
- worldwide roaming capability;
- high speed data;
- capability for multimedia applications within a wide range of services and terminals.

IMT-2000 is the result of collaboration of many entities, inside the ITU (ITU-R and ITU-T), and outside the ITU (3GPP, 3GPP2, etc.). IMT-2000 includes technologies simplified by the ITU to be IMT-DS, IMT-MC, IMT-TD, IMT-SC and IMT-FT. Below, in Figure 7, is a diagram of the five IMT-2000 terrestrial radio interface specification standards.

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60 ITU Definition of IMT-2000.

Figure 7 – IMT-2000 Ground Radio Interface Standard

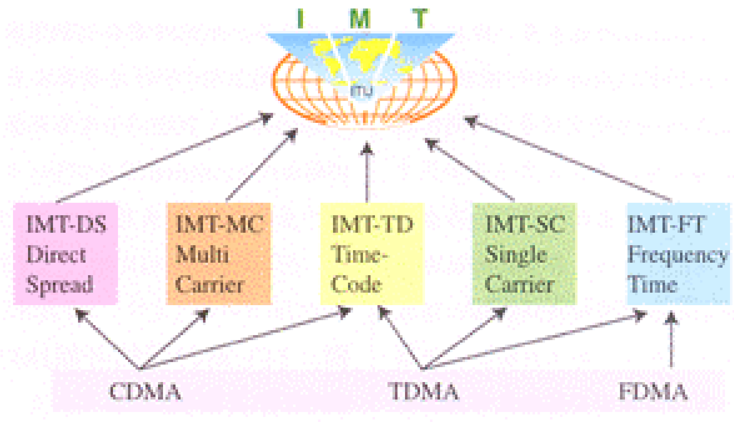

Figure 1 IMT-2000 Ground Radio Interface Standard

The principle on which IMT-2000 technologies are based upon is CDMA (Code Division Multiple Access) which uses spread spectrum technology to break up speech into small, digitized segments and encode them to identify each call. A large number of users can thus share the same band of spectrum and greatly increase system capacity. In other words, CDMA allows wireless service providers to squeeze more digital signals into a particular slice of the radio network.

Generic IMT-2000 technology names include CDMA2000, WCDMA, and TD-SCDMA, whose specifications are defined in a number of ITU Recommendations, most notably Recommendation ITU-R M.1457 and the ITU-T Q.174x series of Recommendations, which respectively describe the radio interfaces and core networks for IMT-2000.

Commercial IMT-2000 technologies today achieve maximum data speeds of 2 Mbit/s while future releases of IMT-2000 technologies will reach data rates of up to 3.1 Mbit/s and beyond. The high data rates resulting from IMT-2000 technologies enable several applications that provide substantial benefits to rural societies. Examples of these applications include e-health care, e-commerce, e-government, position location and emergency assistance. In addition, IMT-2000 technologies deployed in the lower frequency bands provide substantial coverage benefits to rural areas.

Since 2000, over 50 countries (over half of them developing) have launched IMT-2000 technologies[61] many by permitting operators to migrate their existing networks utilizing existing mobile spectrum. A number of countries have also licensed additional spectrum for terrestrial IMT-2000 networks. CDMA2000 and WCDMA have been the primary technologies employed in the IMT-2000 commercial launches. Consumers are utilizing IMT-2000 as a medium for broadband in fixed, portable and/or mobile environments.

IMT-2000 technologies also provide broadband services in a robust manner; originally developed for providing voice and low-to-medium data rates to the users, these technologies can now provide data rates of up to 2 Mbits/s in addition to high quality voice. By employing a commercial IMT-2000 system for providing broadband services, the operator can benefit from the significant pace of innovation in the commercial IMT-2000 cellular marketplace, which include, enhanced broadband data services, spectral efficiency enhancements (adaptive antennas, advanced modulation and coding techniques), enhanced

61 www.3gtoday.com/operators_flash.html

network security and a host of other features into the technologies; all of these will play a significant role in enhancing and improving the experience of broadband users. Furthermore, by employing IMT-2000 technologies, operators can leverage significant economies of scale that will lower the capital and operational expenditures associated with the network.

Extensions to the IMT-2000 technology, both within the standards and in support of the standard, will further allow IMT-2000 technologies to meet the future needs of broadband users, as new requirements and applications emerge. For e.g., the packet-switched IP-based core network employed by the IMT-2000 technologies provides an open and efficient platform for the addition of new features and technologies supporting broadband applications. All of these will further facilitate and ease the distribution of multimedia and broadband content to users, as demand for broadband data rates grow.

IMT-2000 technologies have a significant status among other broadband technologies in that the IMT-2000 technologies are not only capable of providing broadband services in a fixed or portable environment but also continue to provide these services in a mobile environment. The key features of the technologies, such as mobility, the ability to overlay networks, high degree of commonality of design, small terminal sizes, worldwide roaming capabilities, etc enables the technology to provide broadband services to users as they move from one place (fixed or mobile) to another. In addition, IMT-2000 technologies can provide secure and reliable broadband data services today, far exceeding the data service capabilities of today's Land Mobile Radio and some fixed wireless access technologies.

It is important to note that different technologies, such as RLAN, short range connectivity systems, and IMT-2000, may be present in a single device operating across various networks at any particular time. For example, a personal digital assistant may contain multiple radio interfaces enabling it to communicate with a portable terminal (personal area domain); a private or public RLAN (immediate area domain); or a wide-area service provider, such as a mobile (cellular) network (wide area domain).

II.2.3.1.1 Satellite and Terrestrial Components of IMT-2000

The satellite and terrestrial components of IMT-2000 in general complement each other by providing service coverage to areas which either may not economically serve. Each component has particular advantages and constraints. The satellite component can provide coverage to areas which may not be within the economic range of the terrestrial component; this applies particularly to rural and remote regions, in particular for developing countries. Additionally, in providing this complementary satellite coverage, the satellite component may, in more densely populated areas, precede and could encourage later coverage by the terrestrial component. Satellite systems can also provide a multicast layer as a complement to the terrestrial mobile networks. The method of evolution may therefore be regarded in two ways: one to augment the IMT-2000 terrestrial component and the other as a precursor to the IMT-2000 terrestrial component.

There are currently six satellite systems defined as part of the IMT-2000 family through their radio interfaces (see Recommendations ITU-R M.1455-2 and ITU-R M.1457-3) and each can be expected to operate independently from one-another. All aim to provide coverage for regional, multiregional or global service areas and hence there may be several satellite systems, capable of providing service in any country.

There are many scenarios for evolution; in particular the following points are being studied further by ITU-R:

- The effect of the expected large development of the IMT-2000 infrastructure of terrestrial-based components on the implementation and evolution of IMT-2000 mobile satellite systems.
- Initially there is more likely to be commonality at the network levels than other levels. At what level will a system be considered IMT-2000?
- The impact and practicality of dual mode user terminals capable of operating on a number of systems providing voice and data services, whichever the mobile network used (satellite or terrestrial).
- The use of satellite for the internet applications in rural areas, sparsely populated areas, etc., is under study by the ITU-R in response to the Agenda item 1.19 of the next World Radio Conference in 2007.

II.2.3.1.2 IMT-2000 Service Enhancements

It is expected that IMT-2000 standards, technologies and services will also further evolve. Following are several examples of such enhancements that are now being developed.

Further evolution of UMTS is already being considered. The UMTS radio access technology will be enhanced to support High Speed Downlink and Uplink Packet Access, enabling transmission at speeds of up to 14.2 Mbit/s. In the same way that EDGE increases spectral efficiency compared to GPRS, HSDPA increases spectral efficiency compared to IMT-2000 CDMA Direct Spread. The higher spectral efficiency and higher speeds not only enable new classes of applications, but also support a greater number of users accessing the network, with HSDPA providing over twice the capacity. There will be other complementary technologies in order to provide really high data rates and very high user densities, such as would be found in conference centres, including Wireless Local Area Networks (W-LAN), which can complement IMT-2000 technologies in the future, offering theoretical bit-rates up to 54 Mbit/s. Although public WLAN networks will also be deployed independently from the mobile networks, there are built-in advantages for the mobile operators that come from the ability to provide mobility management, subscriber management, high security and roaming.

Another enhancement is the IP Multimedia Subsystem (IMS). It enables real-time, person-to-person services, such as voice or video telephony, to be provided by means of packet switched technology in common with information and data services, by using IP multimedia Call Control. It allows the integration and interaction of telecommunications and information services as well as enabling communications sessions to be established simultaneously between multiple users and devices.

Further evolutions of CDMA2000 are also considered. For example, with the inclusion of new Selectable Mode Vocoders (SMV) and antenna diversity techniques, CDMA2000 1X can provide a voice capacity nearly three times that of the IS-95 Systems[62].

CDMA2000 1xEV-DO is an enhancement to CDMA2000 that is primarily optimized for data services and enables data transmission at higher speeds. The CDMA2000 1xEV-DO air interface is designed to provide complete interoperability with CDMA2000 1X networks and provides peak data rates of up to 3.1 Mbit/s in

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62 "SMV Capacity Increases", Andy Dejaco, Qualcomm Inc., CDG-C11-2000-1016010, October 16, 2000.

the forward link and 1.8 Mbit/s in the reverse link in a frequency carrier bandwidth of 1.25 MHz. In addition, CDMA2000 1xEVDO can now provide multicast/ broadcast (point-to-multipoint), and point-to-point voice, data, and multimedia content. CDMA2000 1xEV-DO allows operators an economical option to deliver the wide range of IMT-2000 data services at affordable costs. The 1xEV-DO systems that are already commercially deployed[63] implement many advanced features of wireless communication system design. The high data capacity of 1xEV-DO is due to incorporation of higher order modulation schemes such as 16-QAM, dynamic link adaptation, adaptive modulation, incremental redundancy, multi-user diversity, receive diversity, turbo coding and other channel-controlling mechanisms[64].

CDMA2000 1xEV-DV is an enhancement to the IMT-2000 CDMA Multi-Carrier systems that combines the features of CDMA2000 1X and CDMA2000 1xEV-DO systems. Thus, it provides an option to provide either the higher voice capacity of CDMA2000 1X systems or the higher data capacity of CDMA2000 1xEV-DO systems or even provide a balanced mix of high capacity voice and data in one single carrier of 1.25 MHz.

Just as the IP Multimedia Subsystem (IMS) of IMT-2000 Direct Spread enables real-time, person-to-person services, such as voice or video telephony, provided by means of packet switched technology, so does the Multimedia Domain (MMD) in IMT-2000 Multi-Carrier by enabling distribution of a suite of multimedia and data intensive applications, such as VoIP, point-to-point and multicast distribution of images, voice, music content, video etc, using a common packet-switched IP core network, to users. All of these provide significant benefits and capabilities to operators who desire to offer a combination of applications and services, using the same radio platform, to multiple users and devices.

ITU-D Question 18/2 has a thorough set of guidelines it has prepared on the transition of existing systems to IMT-2000. This report is available on the ITU-D Study Group 2 website.

II.2.3.2 IEEE 802.16 – 2000 (2k) OFDMA mode – Mobile Extension Matrix

This is an OFDMA extension of ETSI EN-301958 (DVB-RCT, DVB-T which is widely used worldwide) by using the 2K FFT. 2k OFDMA supports both fixed and mobile operation, under 802.16REVd standard although not yet recognized in any ITU-R recommendation.

OFDMA combines FDMA and TDMA access schemes with spread spectrum concept. OFDMA divides the BW resources among users by assigning multiple sub-channels and multiple time slots per user. Sub carriers are pseudo randomly spread over the entire spectrum for achieving frequency diversity.

The 2K OFDMA has all the state of the art features needed for possible future Mobile BWA IP systems as follows:

- High number of sub-channels – 80 (processing gain factor of 19 dB)
- Low overhead – max 15%
- Large FFT size – high frequency selectivity, enables support of long delay spread; for large cells and low frequency operation, high BW capability (2.5–28 MHz) and very high throughput (peak of 4 bit/(s*Hz)).

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63 As of May 1st, 2003, these include operators in 3 continents such as: SK Telecom (S. Korea), KTF (S. Korea), Monet Mobile (USA), Giro (Brazil). Source: www.3gtoday.com

64 "*CDMA/HDR: a bandwidth efficient high speed wireless data service for nomadic users*", Bender, P., Black, P., Grob, M., Padovani, R., Sindhushyana, N., Viterbi, S., Communications Magazine, IEEE , Volume: 38 Issue: 7, July 2000. Page(s): 70-77.

- Supports new antennas schemes like MIMO, STC, AAS (Adaptive Antenna System) and regular MRC antenna diversity
- Short frames for small round trip delay and all ITU levels of mobility (including the 250 km)
- Adaptive Efficient coding schemes (Turbo schemes)
- Low delay ARQ schemes
- Adaptive Modulations and coding rates (QPSK, 16QAM, 64QAM and 5/6, ¾. 2/3 ½, 1/3. ¼, 1/6, 1/8, 1/12) which enable to extend the range and working with negative SNR (–5 dB)
- QoS support (several levels) taking the advantage of the small granularity of the sub-channels (6 bytes)
- Adaptive Sub-channel Control
- Fast Fourier Transform (FFT) for covering holes
- Highly efficient Power safe mode
- Forward and backward APC
- Highly efficient handoff which includes mobile IP
- Soft handoff (HO) capabilities in the PHY level (macro diversity)
- Smooth HO above layer 2 (no loss of packets)
- Single Frequency Network for broadcasting information to the entire network, like Video/Audio
- Broadcasting for converging of Broadcasting and Telecom Network and applications.

System performance

In reuse 1 (all sectors and cells are using the same frequency) capacity is 0.7-1.1 bit (single/Hz) sector using SISO or open loop MIMO solution. In case of 6 sectors the capacity can go up to 6 bit (single/Hz) cell and in more aggressive 24 sectors, the capacity expected is ~18 bit/(single/Hz)/Cell. This performance can be achieved under conditions better than 95% coverage, including ITU-R vehicular B conditions, log-normal 10 dB and Rayleigh fading.

The cell size is similar to current cellular systems (in different scenarios and transmit power but with higher data rates) with small and large cell radii for urban, sub-urban and rural including out-door to in-door. The 2k OFDMA supports all other system requirements – Security and IP mode. Using a directional antenna in fixed operation on the user side, the range can be extended to 50 km and system capacity can be increased by a factor of 4.

II.2.3.3 High Capacity-Spatial Division Multiple Access (HC-SDMA) Radio Interface Technology and iBurst™ Broadband Wireless System Matrix

II.2.3.3.1 The HC-SDMA Overview

HC-SDMA is a new ANSI standard developed by the Alliance of Telecommunications Industry Solutions (ATIS), formerly Committee T1, adhering to its Wideband Wireless Internet Network Access (WWINA) requirements and embodied in the iBurst Broadband Wireless system already deployed commercially on several continents. Based on a commercially proven technology, the HC-SDMA standard specifies the radio interface for the wide-area mobile broadband iBurst system offering a combination of high speed, wide range and high base-station capacity. An iBurst system is an end-to-end, standards-based, pure IP solution for wireless data and VoIP, with equipment that is available from major manufacturers. Today’s commercially available end-user devices include PCMCIA cards targeted at laptop and PDA users, and desktop units for home and small business applications. Off-the-shelf routers and access points can also connect directly to the desktop unit. The iBurst solution offers per-user data rates in excess of 1 Mbit/s today. iBurst base stations, which operate in unpaired spectrum, provide 20 Mbit/s net usable throughput in 5 MHz and 40 Mbit/s throughput in 10 MHz. The iBurst system is commercially deployed in Australia and South Africa, and has several trial deployments in the Americas, Asia, Europe and Africa.

The HC-SDMA standard leverages Time Division Duplex (TDD) and Adaptive Antenna (AA) technologies, along with state of the art spatial processing algorithms to produce one of the world's most spectrally efficient mobile telecommunications system that can provide a mobile broadband service deployed in as little as a single (unpaired) 5 MHz band of spectrum licensed for mobile services. iBurst is designed to operate in licensed spectrum below 3 GHz to offer full mobility and wide area coverage which is the best suited for mobile applications. Because it is based on TDD technology and does not require symmetrical paired bands separated by an appropriate band gap or duplexer spacing, iBurst can easily be re-banded for different frequency bands.

II.2.3.3.2 Description of the HC-SDMA Radio Interface

The key features of the HC-SDMA radio interface are:

- TDD/TDMA, 625 kHz channel spacing
- Peak per-user data rates of up to 16 Mbit/s downlink, 5.5 Mbit/s uplink[65]
- 4 bit/s/Hz/cell spectral efficiency (20 Mbit/s in 5 MHz)
- 3:1 downlink/uplink throughput asymmetry
- Tiered modulation and channel coding for link quality adaptation
- Forward error correction (FEC) and automatic repeat request (ARQ) for error-free link within coverage area
- Bandwidth on demand, dynamic resource allocation
- Adaptive Antenna spatial processing for enhanced signal quality, resource management and collision resolution
- Mobility (handover) support
- Built-in air interface quality of service (QOS) support.

Air Interface Handover

Handover of an end-to-end IP session is the combined result of handover in the radio network from one cell to another with re-routing of the end-user's IP session to reflect the new serving cell. One type of carriage supported by the HC-SDMA air interface is Point to Point Protocol (PPP) encapsulated IP data between an IP Service Provider and an end-user device such as a laptop. PPP (cf. IETF RFC 1661, *et al*) is a low-overhead – one to two bytes per IP packet – tunnelling protocol with the advantages of near-universal

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[65] Peak rates are achieved via carrier aggregation. The PCMCIA and desktop modems currently available support a single carrier corresponding to a peak per-user rate of 1 Mbit/s downlink, 345 kbit/s uplink. Carrier aggregating modems are expected to be available in late 2005.

availability on IP devices, combined with universal deployment of equipment for PPP termination, provisioning, billing, rating and so forth in Service Provider networks. PPP also has the advantage of segregating IP sessions in the transport network, thereby allowing overlapping address spaces as typically used by corporate VPNs. One type of handover currently supported by the air interface is the lightweight Simple IP model employed by 3GPP2 (cf. 3GPP2 P.S0001-B, "Wireless IP Network Standard") for micro-mobility, complemented when necessary by Mobile IP (cf. IETF RFC 2002, *et al*), for example when handing over to a dissimilar access network such as 802.11.

The HC-SDMA air interface's make-before-break handover scheme is User Terminal (UT)-directed. Each UT monitors the broadcast channels from surrounding Base Stations (BSs) and ranks candidates based on signal power and other factors. A UT can perform these measurements as well as register with a candidate new serving BS while exchanging TCH data with its current serving BS. The handover for user data is make-before-break with the TCH data being redirected to the new serving BS after successful registration.

Adaptive Antenna (AA) Technology

At the core of the HC-SDMA standard is adaptive antenna (spatial processing) technology that dramatically increases the efficient use of radio spectrum and results in exceptional improvements in the capacity, coverage and service quality of wireless networks.

AA technology creates these significant benefits through interference management and signal quality enhancement. A typical base station uses a single antenna or pair of antennas to communicate with its users. An AA-equipped base station employs a small collection of simple antennas, an "antenna array," with sophisticated signal processing to greatly reduce the amount of excess energy radiated by the base station. At the same time, the signal processing allows the base station to listen selectively to its users, mitigating the effects of interference presented by other users in the network. The antenna array also provides a gain in signal power, improving the quality of the radio link for the same amount of total power radiated by the base station and user terminal. Improved link quality translates into higher data rates, extended range and longer battery lifetimes at the user terminals.

With AA technology, each cell in a network can use the same frequency allocation by eliminating inter-cell interference. In fact, AA technology even enables a system to reuse a frequency allocation multiple times within a given cell by directing energy only where it is required.

Spectral Efficiency of the HC-SDMA Radio Interface

Spectral efficiency measures the ability of a wireless system to deliver information, "data services," with a given amount of radio spectrum. In cellular radio systems, spectral efficiency is measured in bits/second/Hertz/cell (bit/s/Hz/cell). Many factors contribute to the spectral efficiency of a system, including the modulation formats, air interface "overhead" (signalling information other than user data), multiple access method, and usage model, among others. These factors all contribute to the bits/second/Hertz dimensions of the unit. The appearance of a "per cell" dimension may seem surprising, but the throughput of a particular cell's base station in a cellular network is almost always substantially less than that of a single cell in isolation. The reason is self-interference generated in the network, requiring the operator to allocate frequencies in blocks that are separated in space by one or more cells. This separation is represented by a reuse factor, where a lower number is representative of a more efficient system.

The HC-SDMA system's spectral efficiency is represented in the calculation below:

- 625 kHz carriers
- Three time slots per carrier
- 475 kbit/s of user data per slot
- Effective frequency reuse pattern of 1/2;

which yields the following spectral efficiency:

$$(3 \text{ slots} \times 475 \text{ kbit/s/slot}) / 625 \text{ kHz} / 0.5 \text{ reuse} = 4.28 \text{ bit/s/Hz/cell}$$

Radio System Capacity & Economics

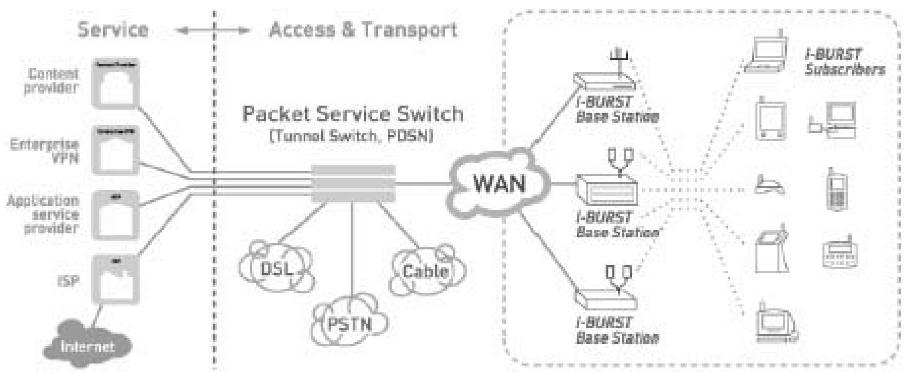
An HC-SDMA system's spectral efficiency of 4 bit/s/Hz/cell means that an HC-SDMA radio network can support a given mobile customer base with far fewer sites and far less spectrum than would be required with other technologies and, hence, with greatly reduced capital and operating costs. With 10 MHz of usable spectrum, for example, each HC-SDMA base station would provide 40 Mbit/s of access capacity. AA technology's improvement in link quality or signal strength translates roughly into a doubling of range (or a quadrupling of area) for the HC-SDMA system.

II.2.3.3.3 iBurst Network Architecture

A Common Access and Transport Network Architecture

Figure 8 depicts a common access and transport iBurst network allowing several service providers to simultaneously provide branded services to their respective end users. A separate business unit of the access and transport operator could, itself, be one of those service providers.

Figure 8 – Common Access and Transport Network



The access and transport operator aggregates a variety of "last mile" access technologies and then switches end-user sessions to the appropriate service provider. Key to this scheme is the packet services switch (PSS), which acts as an aggregation point and as a "switchboard" to route user sessions. The switching decisions are typically made on the basis of structured usernames provided by the user during PPP authentication. For example, logging in as "joe@aol.com" would cause the user session to be directed to AOL's site and request authentication for user "joe", while logging in as "mary@hercompany.com" would cause the user session to be connected to her company's site, perhaps for corporate VPN access, and request authentication for user "mary". PSS technology is widely deployed in the networks of major ISPs and carriers. In addition to aggregating user sessions from a variety of media, the PSS presents these sessions in a unified fashion to the service provider's network, freeing the service provider of the need to maintain different content and service bases for each access class.

II.2.3.3.4 iBurst Protocol Stack

The iBurst system enables end-to-end IP-over-PPP connectivity between the service providers and their customers, consistent with the predominant service model in the wired access world. Moving left to right in Figure 9, one can see that a user's PPP session is carried by a variety of different media and protocols.

Figure 9 – iBurst User Data Network Elements and Protocol Stack

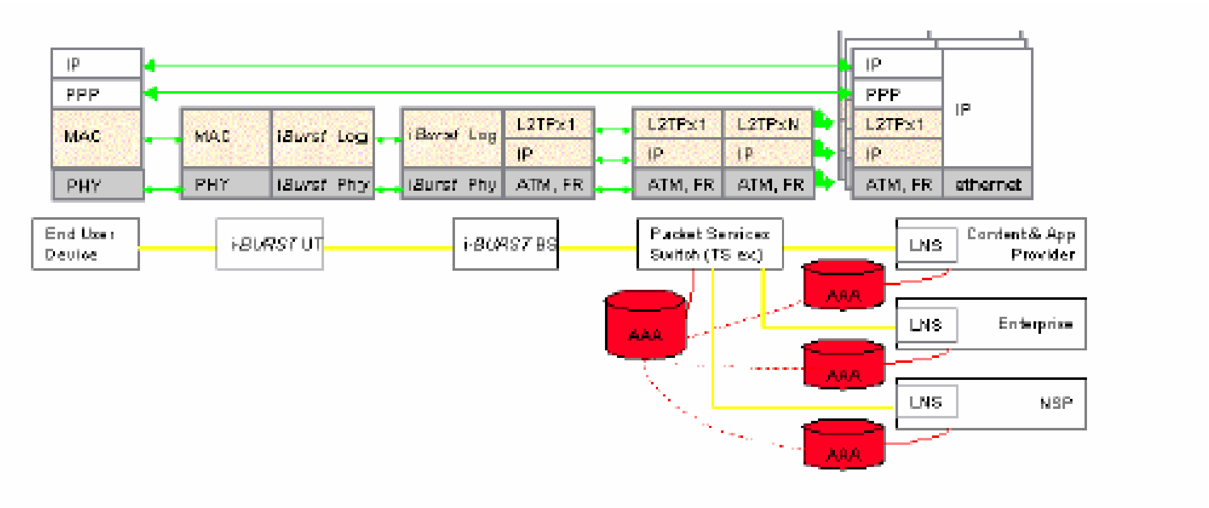


Figure 9 also depicts Authentication, Authorization, Accounting (AAA) servers and AAA connections between the access and transport domain and the service domain.

II.2.3.3.5 iBurst Network Service Offerings

Mobile Service Offering

Mobile connectivity is provided through the iBurst Access Card. When connected to a mobile device such as a laptop or PDA, it provides connectivity on the move as long as the device remains inside the network coverage area.

Fixed/Portal Service Offering

The iBurst Access Bridge provides connectivity in a primarily fixed mode. The device looks similar to a traditional modem. It has a connection to mains power, a small extending aerial and ports allowing connectivity through either Ethernet or USB. This provides the benefits of a fixed broadband connection with the addition of portability, allowing the service to be disconnected by simply unplugging it from the mains and moving it to a new location to be reconnected by powering up the iBurst Access Bridge again. The iBurst Access Bridge can be connected to a single computer for access or attached to a local area network or a wireless network for the access to be shared between several devices in a home or office.

ArrayComm is a registered trademark, and iBurst is a trademark of ArrayComm, Inc.

II.2.4 Broadband access as a possible solution for interactive Digital Television Broadcasting

The broadband radio access for interactive digital TV broadcasting (iTV) has the main characteristics:

- Large data capacity: up to 20 Mbits/s per 5, 6,7 or 8 MHz channel. (ASTC, DVB, DMB-T, ISDB-T standards in compliance with ITU-R Recommendation BT.1306).
- Large coverage.

A Interactive TV

- Broadband access technologies are very important for Interactive TV applications.
- It is usually understood that interactive TV system is a firmware package connecting the TV services provider and the viewer with two communication channels – broadcasting and interactive. The most illustrative generalized block diagram of interactive TV system is given in European Telecommunication Standards (ETS 300 800 – ETS 300 802) from ETSI.
- In the interactive TV system a TV signal is mixed in the network adapter with the data of the interactive services provider and via the delivery facility goes into the interactive TV end user terminal. In the terminal the content including video, audio and data is decoded and represented on the usual TV set screen with extensions in the form of graphic menus, inquiry entry fields, etc.
- The end user is able to choose a menu item with the help of a distance control panel or through entering data with the help of a wireless keyboard.
- The interactive TV user terminal (usually called Set Top Box or STB) that turns a usual TV set into a Smart TV set occupies the central place in the platform. All the known STBs are usually divided into three categories: broadcast TV STB, enhanced TV STB and advanced services STB. STBs of the last category resemble multimedia tabletop PCs. Their computing power is times greater and they usually have a hard disc to record video information and data.
- The delivery protocols are currently developed by ETSI, trials of such protocols are ongoing.

B Basic technologies of TV broadband

There is an established classification of main types of radio access networks:

– WPAN personal wireless access networks are used for wireless connection of devices within the framework of a workstation. Bluetooth is an example of such technology.

– WLAN wireless local networks. Their main designation is to provide access to information resources inside a building. Their second important purpose is to organize commercial community access points (hot spots) in public places such as hotels, airports, cafes and organization of temporary networks for the period of such events as workshops, exhibitions, etc. WLAN wireless local networks are based on IEEE 802.11 standards. Such networks are also known as Wi-Fi (Wireless Fidelity).

– Wireless Access distributed wireless networks and urban networks WMAN and WiMAX (IEEE 802.16).

– MMDS (Microwave Multipoint Distribution Service) is a broadband wireless access option and front of cable networks.

B.1 WiMAX specific position among wireless access technologies

Unlike other types of networks distributed networks Wireless Access (other names are BWA, WiMAX) are networks of a metropolitan scale WMAN (Wireless Metropolitan Access Network), regional scale and operator class networks. Networks of the class are primarily designed for other user categories and radically differ from, say, Wi-Fi, as concerns the tasks they solve.

The distributed network technologies (unlike WLAN, Wi-Fi) from the very beginning use non-collision access method that allows providing to the customer a fixed data transmission channel with fixed delay (minimum jitter) that is an indispensable requirement for building operator class networks.

Equipment standardization

Up to now equipment for building WMAN networks worked on some proprietary brand protocols of equipment manufacturers that were not standardized or compatible. The way to standardize manufactured equipment of broadband wireless access was opened when in summer 2004 standard IEEE 802.16 final release appeared and equipment of different manufacturers underwent certification.

IEEE 802.16 standard

IEEE 802.16 is the first standard (group of standards) designed for distributed wireless networks (Wireless Access).

The standard is designed for constructing wireless networks of metropolitan scale providing to subscribers all types of modern services currently accessible via cable connections. It is the first standard for wireless systems of the Wireless MAN, Broadband Wireless Access class.

The standard describes base stations and subscriber sets.

Comparative table of standards 802.16 group

Standard	802.16	802.16a
Approved	December 2001	January 2003
Frequency range, GHz	10-66	2-11
Working conditions	Direct visibility	Possibility of operation in the absence of direct visibility
Transmission bit-rate, Mbit/s	32-134	1.0-75
Modulation	QAM, one subcarrier	QAM, one subcarrier, OFDM, 256 subcarriers, OFDM, 2 048 subcarriers
Cell radius, km	2-5	4-6

The starting version of the standard embraces the frequency range of 10-66 GHz and operation in single frequency mode (Single Carrier, SC – one subcarrier). The particular mode of propagation of radio waves in the band restricts operation of the systems by direct visibility range limits.

In typical urban environment it allows connecting about half of the subscribers. For the remaining 50% there is no direct visibility as a rule. This prodded development of a supplement to standard 802.16 referring to the 2-1 GHz band and in addition to single frequency operation envisages the use of orthogonal frequency multiplexing (OFDM) and multiple access on the basis of the latter. (Orthogonal Frequency Division Multiple Access, OFDMA).

The OFDM mode simultaneous transmission of 256 subcarriers becomes possible allowing simultaneous reception of direct and reflected signals or operates on reflected signals only beyond direct visibility limits.

In 2004 the IEEE Institute ratified 802.16-2004 standard that replaced the previous 802.16, 802.16a and 802.16REVd versions.

Now the way is open for WiMAX Consortium that prepares specifications designed to ensure compatibility of equipment by different manufacturers on the basis of the final standard 802.16-2004.

Thus WiMAX technology is an operator class technology to provide high quality services of multimedia broadband wireless access to the population.

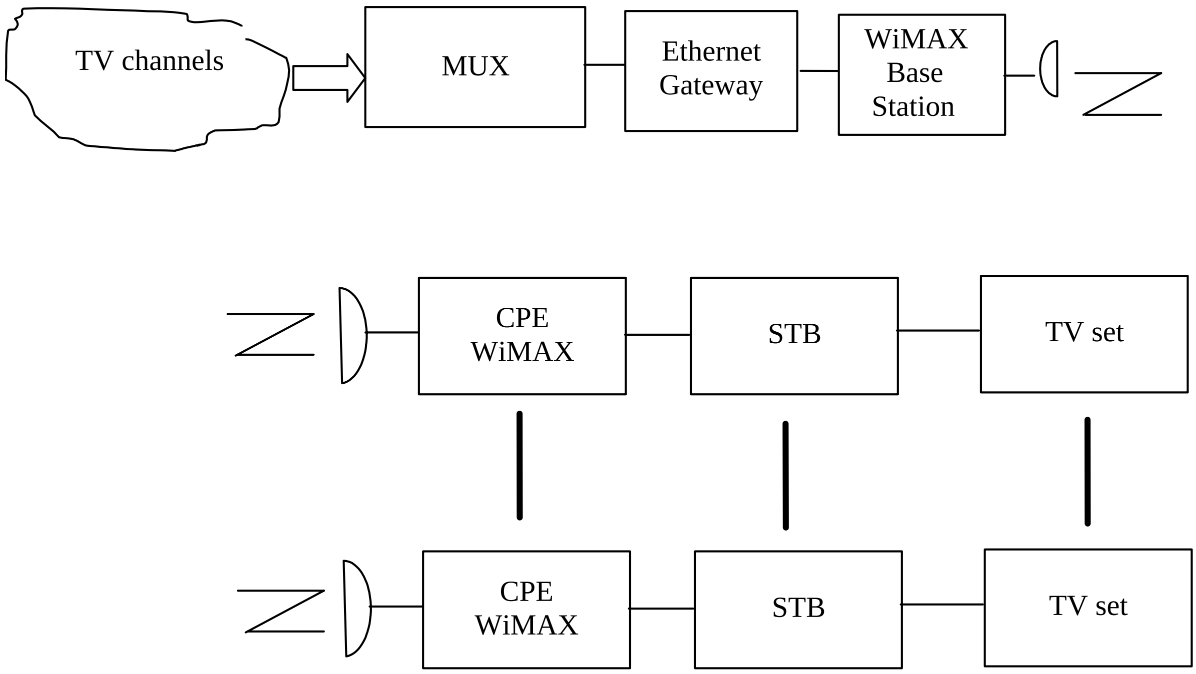
It is multiserviceness and consequently broadbandedness that characterize modern trends of development of wireless access.

Ideally a modern user should not feel any restrictions on any types of services currently accessible via cable connections such as SDH or Ethernet. It is assumed that the newest systems certified as WiMAX will enable operators of broadband access networks to provide to the users such services as IP and E1 and replace the infrastructure of ADSL access and allocated lines as such.

Interactive TV on the basis of WiMAX technology.

The block – diagram of interactive TV on the basis of WiMAX is given in Figure 10.

Figure 10 – The block – diagram of interactive TV on the basis of WiMAX



Main equipment components

1) Base station equipment:

– External radio module with N-type connector for switching in a sector aerial or several aerials through a divider. The option is to use several radio modules with sector aerials corresponding to the number of sectors.

– Internal network processing module with a base station controller that controls all the base station equipment components and subscriber devices.

– DVB equipment for formation of colour signals at the WiMAX hardware entry and a DVB-Ethernet gateway.

2) Subscriber equipment:

– External transceiver module with an integrated aerial or external transceiver module with an N-type connector to switch in an aerial to ensure maximum coverage with an individual aerial.

– Internal module with the functions of an interactive TV set top box and the necessary interfaces for connection with the subscriber TV set.

– In the simplest case in direct visibility from the base station it is possible to use single block structure with a built-in aerial.

B.2 MMDS technology

- **Definition**

In the past years MMDS systems (Microwave Multipoint Distribution Service) have become widely spread as an alternative to classical cable networks in which the distribution network is constructed with coaxial or optical cables.

By now in the western hemisphere dozens of MMDS systems have been implemented that provide access to the Internet, provide interactive TV and other broadband services with wireless access technology. Several companies in the world manufacture equipment that allows ensuring high-speed access to the Internet to any remote subscriber within the coverage zone that installs a MMDS transceiver aerial.

According to the study carried out by US Group demand on the part of the mass consumer for the broadband access services is growing and by 2006 in the USA alone the number of MMDS systems subscribers is expected to reach 900 thousand (in 2000 the number was just 20 thousand).

MMDS systems (2.5-2.7 GHz) are included in the European DVB project alongside with satellite, cable and terrestrial networks.

- **Interactive digital MMDS**

The number of TV channels in traditional MMDS is limited by the relatively narrow width of the frequency band 2 500-2 700 MHz, i.e. 200 MHz only. For example, it is possible to fit in maximum 25 channels in the Russian D standard (8 MHz to each channel). Broadcasting of TV programs in the digital DVB standard allows transmitting from 5 to 7 digital programs in each TV channel band. In digital MMDS 64QAM modulation system is used adopted for DVB-C cable digital TV. To receive digital programs each MMDS subscriber should have a digital cable STB installed. It is the only drawback of digital MMDS systems while their advantages include:

1) Large number of channels (150 and more).

2) High quality of sound and image.

3) Additional services envisaged by DVB standard: stereo and/or multi-channel sound, electronic guide, automatic tuning, choosing channels from the list, teletext, eliminated sub-titles, etc.

4) Possibility of simultaneous broadcasting of analog and digital programs in one system.

- **Interactive digital MMDS**

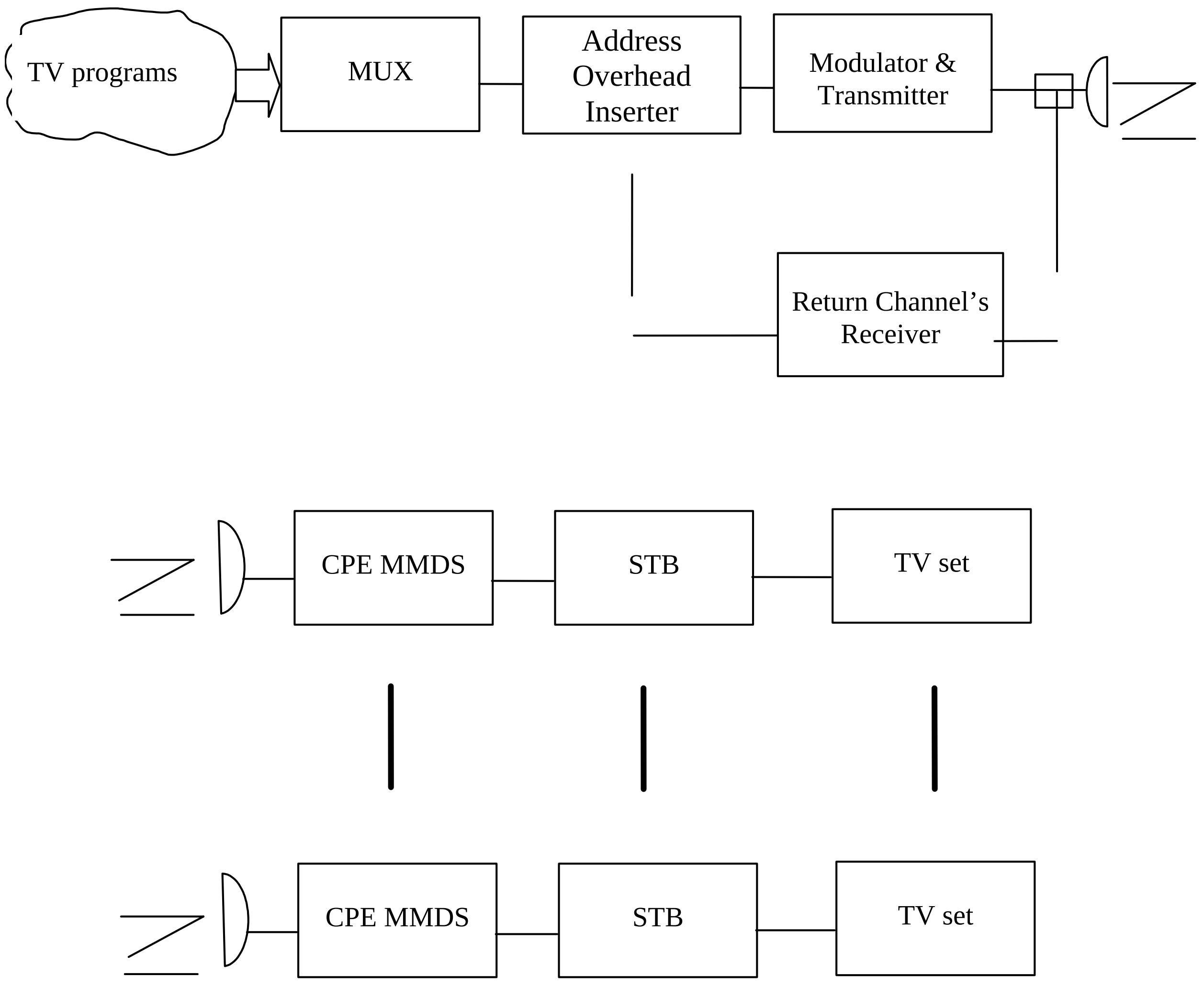
MMDS system may be used to organize interactive digital TV broadcasting. For this a return channel for subscriber outgoing traffic ("call channel") should be organized. A subscriber transceiver is installed at subscribers of interactive MMDS instead of the receiving aerial with a converter.

To organize a return channel the MMDS return channel with QPSK modulation is used. The return channel has lower capacity than the direct channel but ensures greater transmission distance with lower power of the transmitter. In this case a receiver and a QPSK-modulator are installed on the distribution node. It is also possible to increase the number of users through dividing the service zone into sectors.

- **Main components of digital MMDS equipment**

The block – diagram of interactive TV on the basis of digital MMDS is given in Figure 11.

Figure 11 – The block – diagram of interactive TV on the basis of digital MMDS



Equipment set

Digital MMDS system equipment set includes the following components:

- modulators;
- transmitters (or one group transmitter to N channels);
- channel summer;
- network management system;
- automatic or manual reservation system;
- broadband transponders (if necessary);
- aerials;
- DVB equipment to form digital signals at the MMDS transmitter entry.

DVB equipment is needed to form digital signals at MMDS transmitter entry and should perform the following functions:

- Reception of digital programs from satellites (demodulation)
- Decoding (descrambling) of encoded programs
- Formation of data streams out of analog signals of TV studios (MPEG-2 encoding)
- Formation of own digital streams our of programs of various data streams coming from different sources (multiplexing and re-multiplexing)
- Regeneration of DVB service information (channel tables, adjustment tables, etc)
- Encoding (scrambling) of digital TV programs – organization of pay TV
- Formation of radio frequency signals (modulation) out of data streams to supply to the transmitter.

Subscriber equipment

The subscriber equipment set of digital interactive MMDS may consist of an internal, usually tabletop block (cable DVB-C digital terminal with a built-in system of decoding pay content) and the external transceiver module – subscriber transceiver with an aerial. To manage the interactive applications it is necessary to have an interactive TV top box.

II.3 Satellite Systems Matrix

II.3.1 Broadband Access via Satellite

Technical and operational characteristics of the user terminals.

The inherent properties of satellite communications, that is their wide-coverage, broadcast mode of operation and multicasting, are capable of providing high-speed Internet connection and multimedia long-distance transmissions.

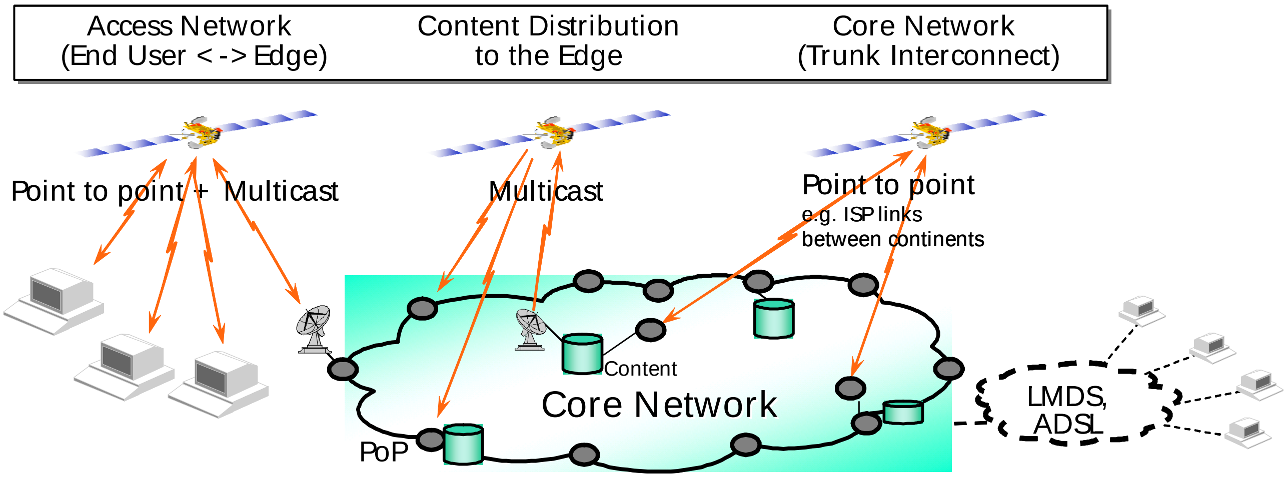
The following drawing (Figure 12) provides a general overview of the overall scenarios where high speed Internet services can be provided. It has to be borne in mind that the overall network can address individual households as well as collective households and interconnection with other telecom networks in an attempt to reach economies of scales for users disperse or in very thin routes of traffic. Interconnection with terrestrial networks in a seamless fashion will add to the success of global broadband satellite services provided by satellite systems.

a) Network architecture

A global broadband satellite system can be separated into three main scenarios as illustrated in Figure 12:

- Access network, providing services to end users.
- Distribution network, providing content distribution to the edge.
- Core network, providing trunking services.

Figure 12 – Global broadband satellite network scenarios

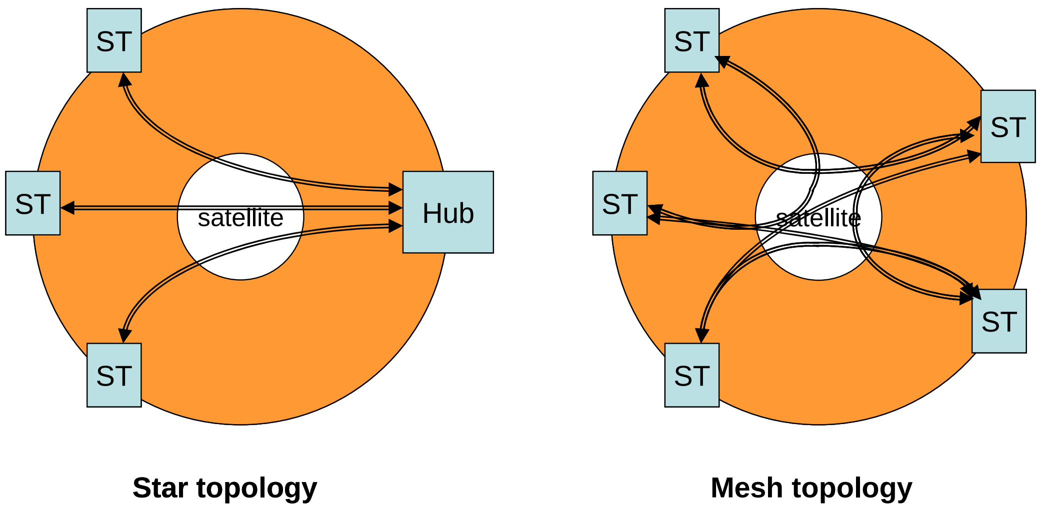


The current work is focused on the access network scenarios, using GSO satellites and fixed satellite terminals (STs).

The network may use either a mesh or star topology as illustrated in Figure 13:

- A star network topology is defined by the star arrangement of links between the hub station (or Internet access point) and multiple remote stations. A remote station can only establish a direct link with the hub station and cannot establish a direct link to another remote station.
- A mesh network is defined by the mesh arrangement of links between the stations, where any station can link directly to any other station. The star topology can be considered as one special case of the mesh topology.

Figure 13 – Star and mesh topology



NOTE – A star topology can be used to provide mesh connectivity by establishing an indirect link between remote stations via the Hub station.

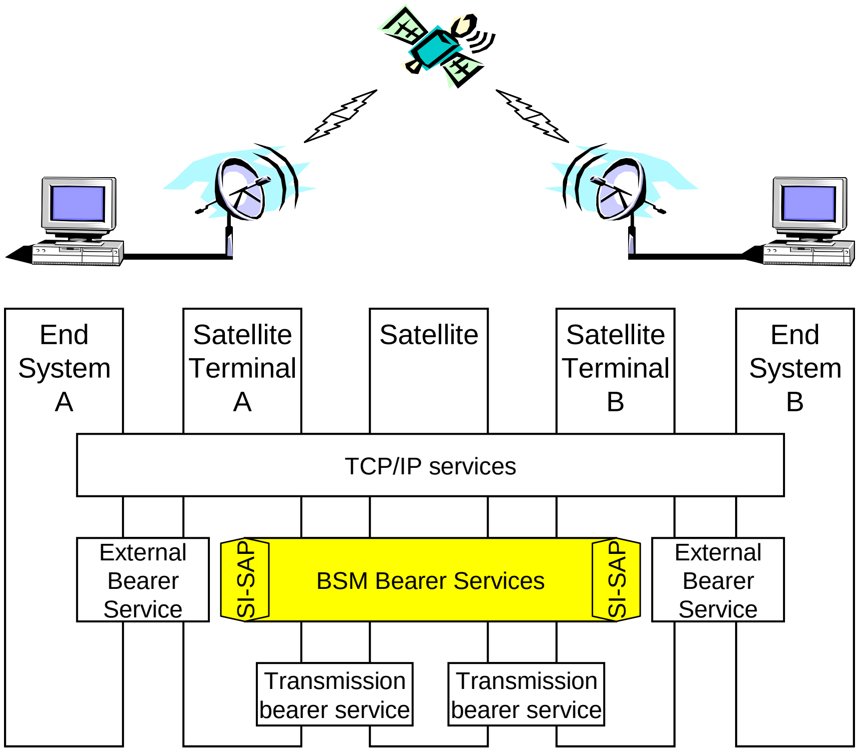
A global broadband satellite system network may use either a non-regenerative or a regenerative satellite architecture:

- A non-regenerative architecture refers to a single architecture, commonly called a "bent-pipe architecture". This architecture does not terminate any layers of the air interface protocol stack in the satellite – the satellite simply transfers the signals from the user links to the feeder links transparently.
- A regenerative architecture is the range of other architectures that provide additional functionality in the satellite. In these architectures, the satellite functions terminate one or more layers of the air interface protocol stack in the satellite.

b) Services architecture

The Broadband Satellite Medium (BSM) architecture separates the transport stratum into an upper part that contains standard IP services, and a lower part that contains the global broadband satellite system bearer services and the underlying radio transmission bearer services as illustrated in Figure 14.

Figure 14 – Global broadband satellite service architecture



In order to separate the services that are common to all satellite systems from those that are specific to a given satellite technology, the service architecture defines a satellite-independent service access point (SI-SAP) as the interface between these upper and lower layers. This interface corresponds to the ends of the global broadband satellite system bearer services as shown in Figure 14.

c) Protocol architecture

The global broadband satellite system identifies three groups of protocols:

- IETF IP network protocols;
- adapted global broadband satellite system protocols that are satellite system independent; and
- satellite technology dependent protocols.

The global broadband satellite system protocol architecture defines the Satellite Independent – Service Access Point SI-SAP interface that lies between the IP network layer and the lower layers. Immediately above and below the interface, the architecture defines two new adaptation layers that contain global broadband satellite system functions associated with the interface as shown in Figure 15.

Figure 15 – Global broadband satellite system protocol architecture

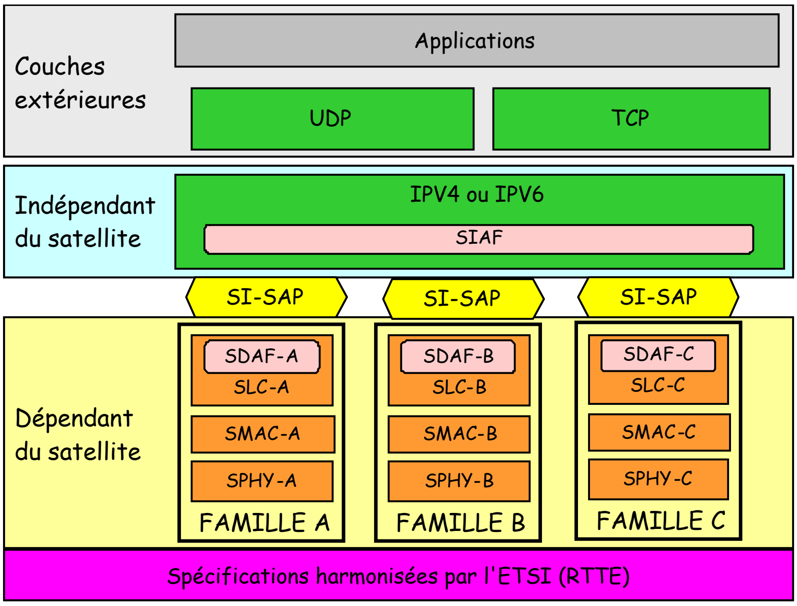
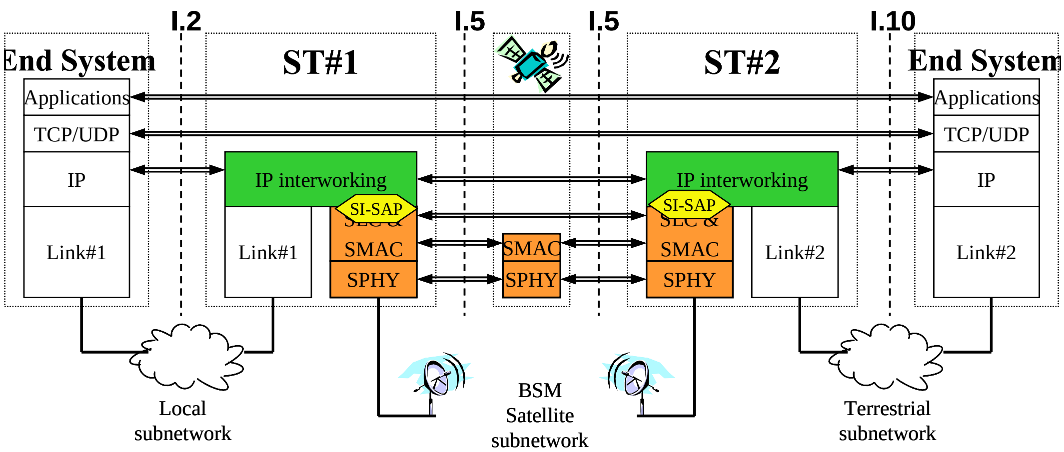


Figure 15 shows how the global broadband satellite system architecture supports multiple alternative families of satellite dependent lower layer protocols. Each family corresponds to a different satellite technology, including both transparent and regenerative satellite and both mesh and star topologies. Each of the families of satellite dependent lower layers can support these generic SI-SAP functions in different ways. Each family defines a satellite dependent adaptation function (SDAF) that is used to provide the mapping to and from the SI-SAP interface.

The SI-SAP defines a satellite independent interface that can be used to provide essentially the same services across all implementations of the BSMS. The current work focuses on interworking the IP suite of protocols as illustrated in Figure 16.

Figure 16 – IP interworking



II.3.2 Very Small Aperture Terminal (VSAT) Network Matrix

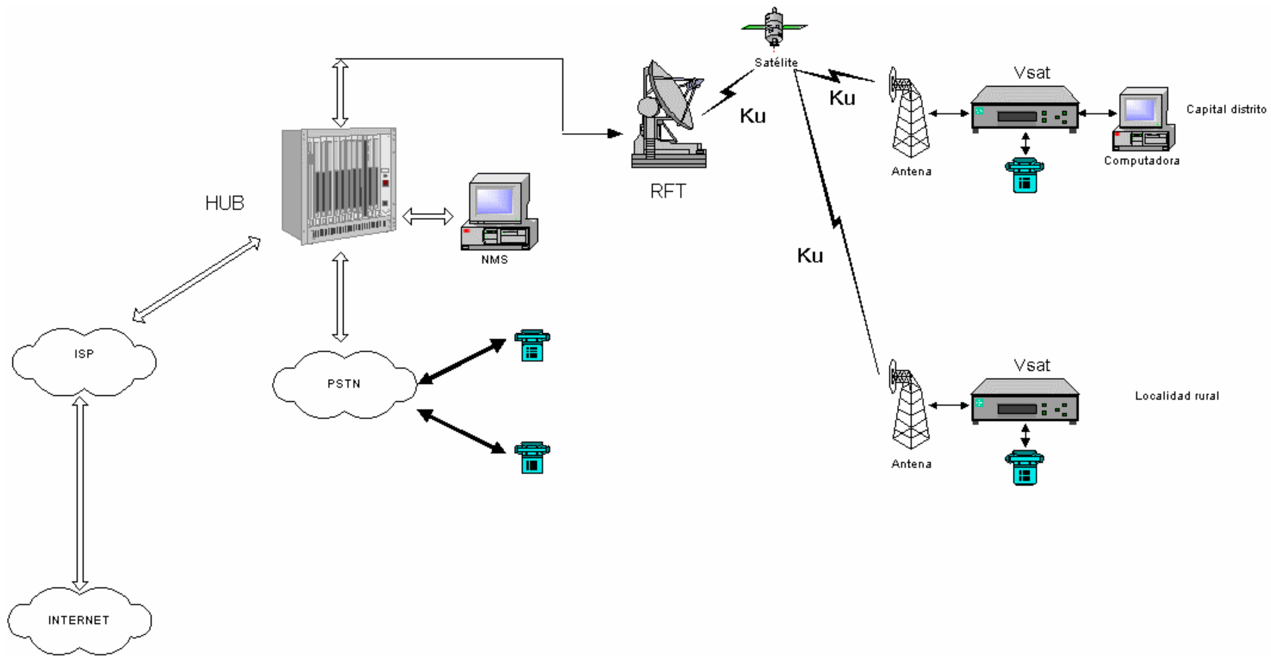
VSAT satellite networks implemented for rural areas usually operate within the 10-20 GHz band.

VSAT networks have a star-like topology, with multiple remote stations that communicate through a Main Hub with a FDMA/TDMA DAMA access scheme.

Current data transmission speed reaches 256 kbit/s for the carrier from the Hub to the remote stations (Outbound – downstream – forward), with QPSK and 38.4 kbit/s modulation for the carrier from the remote stations to the Hub (Inbound – upstream – return) with a MSK modulation. Usually, a LAN Ethernet port is also provided to interface with other equipment.

The VSAT network's main components are the following: i) multiple remote stations, ii) nodal station (Hub), iii) prepayment[66] subsystem, iv) network management system. Figure 17 shows the simplified diagram of the VSAT network.

Figure 17 – Simplified scheme of a VSAT network



Remote stations are constituted basically by two modules: the external unit (Outdoor Unit – ODU) and the internal unit (Indoor Unit – IDU), that includes the VSAT. Apart from the energy subsystem and protection subsystem.

66 The prepayment system uses cards with codes (PIN) to make calls. It is necessary for the operator to have an adequate card distribution plan, as well as ensuring adequate training for the rural population to use the service. The procedure to make a call can be found in the back of the prepayment cards, and a procedure poster can be found inside the telephone booths, and also the operator trains users on the proper use of the public telephone and Internet access (if necessary).

The external unit (ODU) is comprised of the antenna and radio frequency elements that enable communication between the internal unit (IDU) and the satellite. Some of its components include: i) an antenna that varies in size from 1.2 to 1.8 m[67], ii) a high-power converter, with power that varies from 500 mW to 1 W[68] and iii) a low noise converter block.

Services[69] provided can include the following: i) voice, ii) fax (Group 3) low speed data, iii) free calls to emergency centres and iv) Internet access in rural district capitals at a speed of 9 600 Baud.

II.4 Terrestrial Technologies in the Process of Standardisation

II.4.1 Canopy Solution for Fixed Broadband Wireless Access Matrix

For many businesses, domestically and, especially, internationally, reasonably priced broadband is not readily available, sometimes not at any price. The expense of building out new DSL networks, re-working or conditioning the lines that exist, or converting existing cable plants to carry two-way traffic might be expensive. This section provides information on BWA technology characteristics which make this broadband approach accessible.

The majority of the world is still unable to receive reliable high-speed data and/or voice connections. The promising access medium to meet this need, broadband wireless access (BWA), accounts for less than five per cent of the total broadband access connections.

Nevertheless, BWA is developing new approaches to solving the issues that had previously stalled its growth. A big issue for service providers, for example, has been the lack of ability to avoid RF interference. This has resulted in higher costs due to additional equipment and an inability to meet service agreements with their customers.

The key challenge to making BWA ubiquitous broadband access is interference. Customers must be assured that the technology chosen is hassle-free and always available. With BWA, the number one threat is interference.

When licensed bands are designated for BWA, typically a limited number per region are granted. On the surface, this means that BWA will only be deployed in those places where the license fee can be recouped and only by a few players. Such a situation effectively reduces the number of potential competitors and, hence, reduces options available to the end customer, freezing out competing BWA options. The rules should be designed to allow multiple networks to co-exist with minimal interference, enabling multiple operators to serve a given geographic region. The bands below in Figure 18 are examples of such use on a national level in a few countries.

---

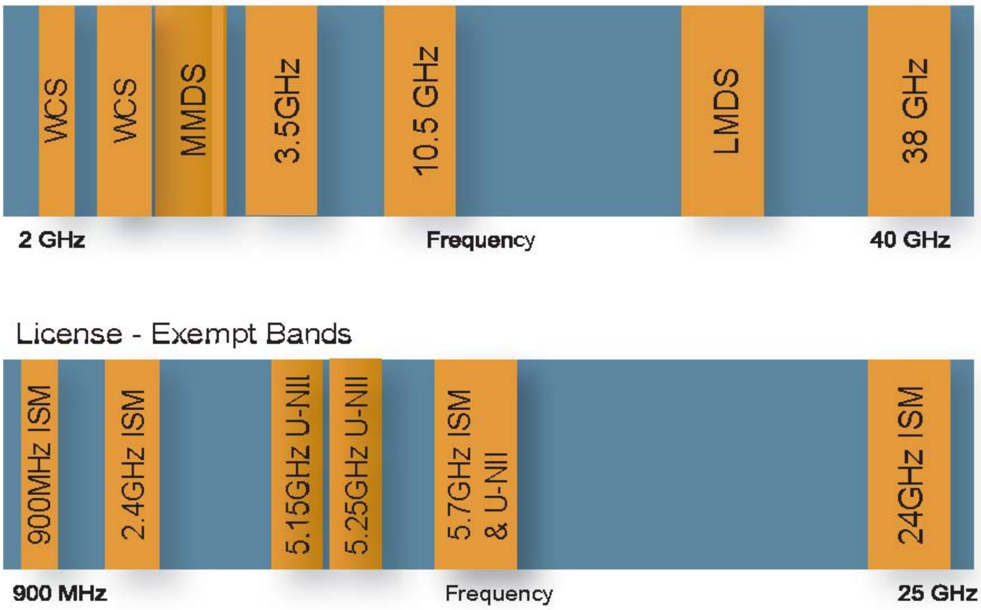
67 The size of the antenna depends on many factors (geographic location, satellite coverage, precipitation levels, speed of data requested, etc). Depending on the case, antennas with a greater diameter are used to improve the system's performance.

68 1W of power in some towns in the Peruvian jungle mainly due to the satellite's coverage and precipitation levels).

69 Currently, all services rendered by rural operators run through prepayment platforms, except for Internet access, which is being provided freely to this date.

Broadband Wireless Frequencies Licensed Bands

Figure 18 – Global Frequency Bands



The overriding design goal of the Canopy technology has been to deliver an interference robust simple-to-use BWA system. Interference lies at the heart of the reliability design challenge, and interference in the license-exempt bands can be a much greater factor than that faced by licensed band systems.

To that end, it is critical that BWA solutions designed for the license-exempt bands address this issue head on. It is also clear that in order to do so, proper design at a very detailed level must be accommodated in the core of the product. Solid, reliable BWA networks do not happen by chance; they are a result of keeping a focus on the issues and delivering the right solutions.

The BWA Canopy solution has the following characteristics:

– Access Method: TDD/TDMA

– Modulation: High Index BFSK (Optimized for interference rejection)

– Data Rate: 10 and 20 Mbit/s (signalling rate)

– Frequency Band: 2 400-2 483.5 MHz, 5 250-5 350 MHz, 5 725-5 850 MHz

– Channelization: 3 non-overlapping channels at 2 400-2 483.5 MHz (18 overlapping channels)

– 3 non-overlapping channels at 5 250-5 350 MHz (11 overlapping channels)

– 6 non-overlapping channels at 5 725-5 850 MHz (22 overlapping channels)

– Network Standard: IPV4, UDP, TCP, ICMP, Telnet, HTTP, FTP, SNMP

– Transmitter power: Meets FCC ISM/UNII EIRP limits.

The interference effectiveness of Canopy is accomplished by:

- Employing BFSK for modulation. With this modulation the C/I ratio necessary to operate properly with an error rate of 1×10^{-4} bits per second is only 3 dB; i.e. the wanted signal needs to be only 3 dB higher in power than the unwanted interferers. A system operating with 16 QAM at these levels would require a *C*/*I* ratio of roughly 12 to 14 dB.

- Deploying networks in a cellular topology; the performance of the antenna in rejecting unwanted signals from behind is an important feature. The Canopy system, with its integrated antennas at the AP, has a front-to-back ratio of 20 dB. Coupled with the excellent *C*/*I* ratio, this means a Canopy AP receiving a signal at threshold (the weakest signal it can still detect) can be hit with an interfering signal from behind, either internal or external, on the order of –60 dBm and still support connections at an acceptable error rate.

- Delivering tight synchronization across potentially hundreds of square miles. With the Canopy system, designed for large scale, dense network deployments, TDD synchronization is a critical requirement. This has been solved with the use of a GPS signal. These precise satellite signals are used for timing and, ultimately, transmit/receive synchronization, thus tying all sectors in a Canopy network to the same "clock".

Recognizing the dilemma of combining TCP/IP with wireless networks and the attendant error rates, the Canopy system solves the problem with a feature called Automatic Retransmission request or ARQ. ARQ actually inspects the RDPs that come into the receiving SM and looks for errors. If an error is detected, the SM (or AP) will send a request to the sending entity to re-send the RDP.

II.4.2 *Airstar*: A Multi-Service Broadband Fixed Wireless Access System

Summary of the "*airstar*™" system

airstar™ is a point-to-multipoint fixed wireless access system specially designed for residential, Small Offices/Home Offices (SOHO) and Small and Medium-sized Enterprise (SME) users in urban, suburban and rural areas.

airstar™ is a high capacity solution for service providers that effectively handles applications ranging from toll-quality voice and data transmission to mobile base station backhaul on a single platform. Operating in the 3.5, 10, 26 and 28 GHz frequency bands, the system uses an ATM/TDMA/FDD air interface with dynamic bandwidth allocation delivering a high level of Quality of Service (QoS) for voice and data.

airstar™ is a field proven solution: more than 80 systems have been deployed in 37 countries and are in operation for now more than 5 years.

Applications

The ***airstar***™ system is a high flexible platform that supports multiple applications.

- 2G/3G mobile backhaul.

  Mobile operators upgrading to 3G technologies face significant increases in the capacity requirements of their transmission networks, as well as a need to migrate from TDM to ATM and IP. The system provides the transmission link to backhaul 2G and 3G mobile base stations from a single customer premises equipment. In addition, the native ATM air interface provides a future-proof backhaul infrastructure solution for supporting future 3G mobile services.

- Access for Small and Medium-sized Enterprises (SMEs).

  Given the large variety of equipment and applications within a typical SME, delivering multiple services is an essential part of any service provider's business case. The system enables the delivery of E1/T1-based voice, Internet access, virtual private network (VPN), and Frame Relay services from a single Customer Premise Equipment (CPE).

- Multi-tenant unit access.

  In residential multi-dwelling units, the system provides scalable and versatile solution for multi-tenant unit access and enables the delivery of Internet access and toll-quality voice or VoIP services.

- Wireless local loop backhaul.

  At 3.5 and 10.5 GHz, it provides backhaul links up to 20 Kms, enabling remote towns and villages to be served with the wireless local loop and backhauled to a larger city for connection to the Public Switched telephone Network (PSTN).

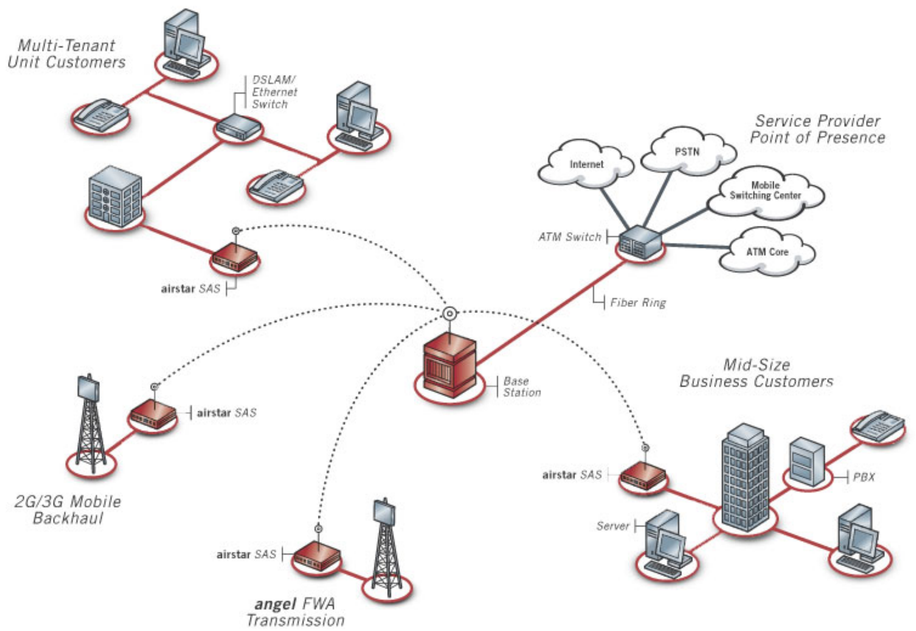
- Wi-Fi hotspot backhaul.

  The system also provides backhaul for Wi-Fi hotspots using the CPE 10/100 Mbit/s Ethernet interface. All backhaul links are aggregated over the airlink and delivered on a single ATM network connection at the base station. The ATM QoS implemented on the airlink guarantees the necessary bandwidth for Wi-Fi hotspots.

Architecture

Figure 19 represents an example of the Architecture of "***airstar***™" system.

Figure 19 – Airstar™ Architecture



Main features and benefits

- **Service flexibility**

The platform efficiently supports the following voice and data services, enabling service providers to offer personalized solutions to their customers:

Voice Services:

– ***E1 Lease Line*** – Both unstructured and structured modes are supported. For structured E1s, only provisioned time slots are carried over the air.

– ***PRI-ISDN*** – with dynamic bandwidth allocation on a call by call basis.

– ***Voice over IP/FR/DSL*** – with statistical multiplexing gain and differentiated QoS to enable POTS and BRI-ISDN services.

Data Services:

Dynamic Bandwidth Allocation is provided for all data services.

– ***Internet Access*** – Without the need for external router

– ***LAN to LAN Interconnection*** – Through bridged Ethernet or a Frame Relay service

– ***Frame Relay*** – Over E1 or X.21/V.35 Serial interfaces

– ***VLAN*** – For providing IP services to dozens of end customers while maintaining individualized QoS.

Unique Service Offerings via Wireless

– ***4xE1 Leased Line*** – For an AirStar CPE, the incremental cost per customer is less than 20% for providing 2xE1 per building or 4xE1 per building.

– ***8 Mbit/s IP Service*** – With the 3000 Series SAS-XP, the AirStar system can deliver near wirespeed throughput on the SAS Ethernet interface.

• The Wireless	+ ATM benefits
Quick to deploy	High speed switching and transport
Low initial costs	One network for all traffic types
Flexible and scaleable	Bandwidth sharing of services
Easy to maintain	Simple network management
	Long architecture lifetime

- Service level agreement

  The platform enables service providers to reserve bandwidth for their different customers according to the service level agreement they have purchased.

- Service availability equivalent to fibre

  Features such as base station redundancy and error correction algorithms are combined to achieve a high level of reliability. This allows the system to provide up to 99.999% availability.

- Ease of deployment

  CPE configurations can be pre-provisioned prior to installation to accelerate the deployment.

- Efficient spectrum utilization

  The system features dynamic bandwidth allocation to enable dynamic bandwidth sharing over the airlink for the delivery of bandwidth-on-demand applications such as voice and Internet traffic.

"*Airstar*™" technical characteristics

- Access method: TDMA
- Modulation: 4 or 16 QAM
- Frequency bands:
  - 3.5, 10, 26 and 28 GHz with Frequency Division Duplex (FDD) channel arrangement
  - multiple frequencies can be deployed from the same base station platform, and aggregated onto a single network interface.
- Base station capacity:
  - A single base station can cover 40 km^2 at 26 to 28 GHz, and up to 400 km^2 at 3.5 and 10.5 GHz, enabling hundreds or thousands of potential customers to be addressed from a single base station.
  - up to 28 Mbit/s of capacity per radio channel
  - from 2 to 12 sectors (48 at 10 GHz)
  - a total capacity of 384 E1s or 1½ STM-4s with only 28 MHz of available spectrum.
  - capacity is provisioned based on average utilization rather than peak utilization as is the case with fibre enabling a wireless base station configured for an STM-1 to provide the same effective capacity as an STM-4 fibre ring.
- Subscriber Access System:
  - User Interface: E1/T1 lines, 10/100BaseT port, Serial Port
  - Radio Interface: TNC connector for coax cable carrying transmit and receive IF signals, radio DC power, reference clock signal and telemetry control channel.
- Environmental specifications:
  - Indoor equipment operating temperature: 0°C to +40°C
  - Outdoor equipment operating temperature: – 33°C to + 55°C
- Power:
  - all system components operate from a nominal –48 VDC source.
- Typical Power consumption:
  - Subscriber Access System: 38 W (–48 VDC)
- Network management:
  - A scalable carrier-class suite of tools that allows operators to easily manage their networks.

II.4.3 *angel*: A Non-Line-Of-Sight Broadband Fixed Wireless Access System

angel™ is a point-to-multipoint fixed wireless access system specially designed for residential, Small Offices/Home Offices (SOHO) and Small and Medium-sized Enterprise (SME) users in urban, suburban and rural areas.

It is the first and only field-proven access network solution to use Non-Line-Of-Sight (NLOS) Orthogonal Frequency Division Multiplexing (OFDM) technology to deliver carrier-class voice and data services up to 1 Mbit/s per subscriber on a single platform.

Therefore it is a natural evolutionary path to WiMax using also NLOS – OFDM technology.

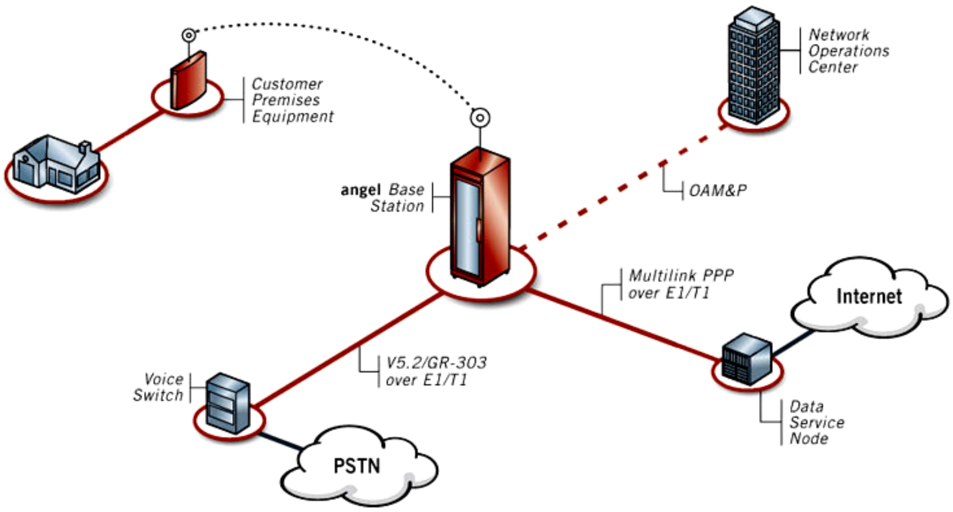
Over 100 000 subscriber lines connected to over 500 base stations are commercially operational today in the US as well as in the world..

Operating in the 2.3 and 3.5 GHz frequency bands, NLOS technology provides up to 95% predictability of coverage and penetration in a given cell, while, thanks to OFDM, layouts can range from 1 to 30 km radius cells, resulting in reduced operational and installation costs .

Architecture

Figure 20 represents an example of the Architecture of angel.

Figure 20 – Angel Architecture



Main features and benefits

- **Non-line-of-sight technology to maximize coverage and revenues**

  OFDM technology enables angel to provide 95% predictability of coverage in a given cell, which ensures high installation success rates and controls deployment costs. Thanks to this NLOS technology there is no requirement for a direct, unobstructed view of the base antenna. More customers can be served and precise alignment of the Customer Premise Equipment (CPE) antenna with the base antenna is unnecessary. High base station antennas are not required, allowing deployments in markets that have zoning restrictions on tower heights.

- **High spectral efficiency**

  The net spectral efficiency of the system is 3.4 bit/s/Hz. For maximum spectral efficiency, the system adapts its modulation to the channel conditions it supports. The maximum throughput is typically available even at the edge of the cell, which enables the system to offer high data rates in smaller 1 MHz channels. Because frequencies can be re-used in adjacent cells, operators can deploy hundreds of base stations in a city or region using only 4 MHz of spectrum.

- **Flexible services**

  The system enables operators to significantly enhance their revenues by providing a variety of voice and broadband data services to subscribers. As well as providing carrier-class voice that is equal to the quality and reliability of wireline service, the system supports revenue generating CLASS services, such as Call Waiting, Call ID, Three-way Calling and Voicemail.

  Broadband data connectivity provides Internet access for multiple IP devices from a single subscriber unit, without impacting voice traffic. It also provides broadband data support for PCs and IP devices and enables subscribers to use standard modem and fax protocols for interoperability with legacy devices.

- **Grade of Service levels**

  Service providers can offer multiple Grade Of Services (GOS) that can be customized to meet residential, SOHO or small business customers' unique needs. The data channel can be partitioned into as many as four sub-channels, called "service grades". Each service grade utilizes a portion of the available channel and can be tailored to the size that the operator chooses. Each subscriber is provisioned a maximum data rate (such as 64 kbit/s or 128 kbit/s, up to 1 Mbit/s), and is assigned to one of the grades. Thus, rigid, simple Grades of service enable operators to easily develop data "products" that can be targeted to specific segments of their diverse subscriber base. For example, a channel could be divided between business and residential subscriber "products".

- **V90 over Data IP**

  A unique MAC architecture and voice coding enables the system to transmit modem traffic over packet data portion of the wireless channel. While traditional modem solutions use precious bandwidth even during idle periods, the *angel*™ solution frees that bandwidth for other modem and data subscribers. The amount of bandwidth used for a voice call and a modem are virtually identical. This means that the voice capacity of the airlink remains constant, regardless of modem usage. Constant capacity is imperative for the delivery of reliable voice service.

Technical characteristics

- Access method:
  - OFDM provides maximum throughput at maximum range, improve spectral efficiency and multipath robustness and thanks to NLOS gives 95% predictability of coverage in a given cell.
- Modulation: 64-, 16-, 8-QAM, and QPSK:
  - Adaptive modulation to adjust signal modulation, depending on the signal-to-noise ratio, and overcome fading in order to maximize throughput and signal quality.
  - Network Access Channel (NAC/HCC) is always QPSK modulated for robustness.
  - Voice calls typically are 64-QAM modulated – hand-off to lower-order modulation if necessary during the call.
  - Data traffic is typically 64-QAM modulations – modulation adapts on a slot-by-slot, link-by-link basis if necessary.
- Frequency bands:
  - 2.3 and 3.5 GHz with Frequency Division Duplex (FDD) channel of 1 MHz for each link direction.

- Base station capacity:
  - Over 3 600 Voice lines or up to 12 Mbit/s of data per Base Station using as little as a single 4 MHz pair of frequency blocks.
  - Up to 4 sectors with cell radius of up to 30 km.
  - Channels can be configured to support voice-centric, data-centric or combined voice and data networks.
- Customer Premise equipment (CPE):
  - Installation without line-of-sight between the base station and the CPE.
  - Data rate:
    - Over 3 Mbit/s symmetric data rate (aggregate).
    - Up to 1 Mbit/s downstream, 256 kbit/s upstream per Customer Premise Equipment.
    - Ethernet data interface.
  - Voice capacity:
    - 1 to 6 POTS per CPE.
    - 312 active calls per base station.
  - Fax, V90, CLASS services, dial-tone from the V5.2 switch.
  - IP access: Up to 5 IP addresses per CPE.
  - Battery back-up.
- Power consumption: all lines active:
  - Base station: 2000 W, 176-264 VAC or –48 VDC.
  - Subscriber Integrated terminal (SSU 4000): 25W, 85-264 VAC or 176-264 VAC.
- Environmental specifications:
  - Indoor equipment operating temperature: – 5°C to + 50°C (Base station ABS 3000).
  - Outdoor equipment operating temperature: –40°C to + 60°C (Single Subs. Unit).
- Network management:
  - A scalable carrier-class suite of tools that allows operators to easily manage their Fixed Wireless Access network.

II.4.4 *SR 500-ip*: A Broadband Fixed Wireless Access System for Remote Areas

Brief description of the SR 500-*ip* system

SR 500-*ip* is a broadband, high-capacity wireless access system for operators and service providers serving rural and remote areas. It is the first point-to-multipoint (PMP) microwave system to economically combine highly scalable voice capacity with broadband Internet access. With **SR 500-*ip***, service providers can evolve their rural networks to offer leading edge services such as ADSL at 1.5 Mbit/s, while preserving scarce spectrum resources through efficient handling of voice traffic. **SR 500-*ip*** makes broadband access in low-teledensity areas a reality and enables service providers to comply with universal access initiatives at the lowest cost. With ADSL capability it is the ideal solution to bring broadband Internet and voice services to rural communities. It can also overlay or replace legacy access networks to add capacity or provide broadband Internet access.

Architecture

As a packet-based PMP microwave access system with network repeater capability, the system can be configured in star, branched or linear network topologies, see Figure 21.

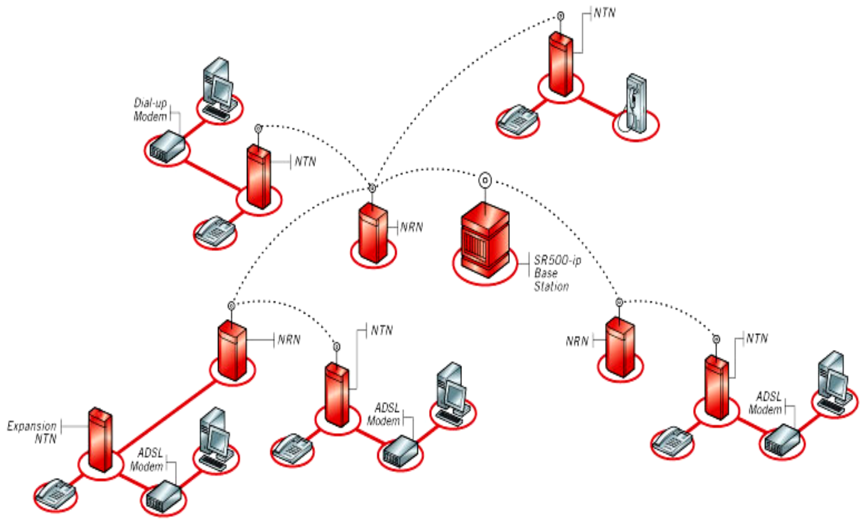
The base station (BS) provides the network interfaces to connect to the core network, and communicates will all remote radio nodes. Network interfaces are PPP over Ethernet for Internet services and V 5.2 over E1 for voice-band services. The base station can accommodate up to two 4 Mbit/s air links for a total system bandwidth of 8 Mbit/s.

The Network Termination Node (NTN) provides the subscriber interfaces. The NTN is a multi-line, multi-service, outdoor unit that serve a large number of subscribers through copper loops. Subscribers connect to the network using a 2-wire equipment, including ADSL modems, standard or payphone sets, as well as V90 modem and faxes. Subscriber capacity can be increased using an extension cabinet that is cabled directly to the main NTN.

The Network Repeater Node (NRN) is an outdoor unit that is used when line-of-sight between the **SR 500-*ip*** Base Station and NTN is compromised by rough terrain, man-made objects or distance. The NRN can also provide subscriber services using an expansion cabinet.

The system is centrally managed by insight NMS, which handles all operation, administration, maintenance and provisioning (OAM&P) and support over-the-air software downloads.

Figure 21 – Architecture of SR 500-*ip*



Main features and benefits

- **Wide Area Coverage**

  The system offers log-range microwave links and network repeaters to ensure coverage in difficult to reach areas spread over hundred of kilometres.

- **Broadband IP access**

  The system enables service providers to meet universal Internet access mandates and promote development in rural communities.

- **Advance services**

  With full CLASS support, transparency to fax and V90 modem traffic and payphone support, the system enables service providers to maximize voice service revenue. Flexible dial-up and ADSL interfaces offer service provider a choice of high-speed Internet solutions.

- **Future proof**

  Based on a packet switch architecture, the system is a long-term solution for IP-based services that reduces operators' technical and financial risk. With such a system, service providers will have access to future IP-based subscriber services while maintaining network stability.

- **Low cost of ownership**

  The system offers high capacity and linear scalability, which results in decreased costs on hardware and support. Standard interfaces facilitate network integration, while minimal infrastructure requirements reduce capital costs. In addition, **SR 500-*ip*** is centrally managed by insight Network Management System (NMS) to maximize staff productivity and reduce travels to remote locations.

- **High availability and field-proven reliability**

  SR 500-*ip* builds on the technology of **SR 500**, the most widely deployed rural wireless access system in the world. Reliable in-service performance ensures subscriber satisfaction and preserves revenues streams while minimizing maintenance expenses.

Technical characteristics

- General
  - Capacity: up to 2 air links / 8 Mbit/s per base station
  - Frequency bands: 1.5, 2.5, 3.5, 10.5 GHz
  - Access method: TDMA
  - Duplexing technique: FDD
  - V5.2 PSTN interface: Complies with ITU-T recommendation G.965
  - IP interface: PPPoE over 10Base-T
- NTN Services and Capacity
  - Voice: 2-wire VF — 48 lines
  - Payphone: All 2-wire standards and prepay (12 or 16 KHz) services — 48 lines
  - Dial-up Internet: V.90 modem support (up to 56 kbit/s) — 48 lines
  - Broadband Internet: 2-wire ADSL, always-on, bandwidth-on-demand — 5 lines
- Power
  - Base station: –48 VDC
  - Network repeater node: –48 VDC
  - Network termination node: –48 VDC or 120/240 VAC (+/– 12 VDC optional).

- Power consumption:
  - Radio Base station: 110 W (average DC per sector 1.5 GHz, 30 dBm, all trunks busy)
  - Network Repeater: 59 W (average DC at 1.5 GHz, 30 dBm, 25% traffic load)
  - Termination node: 43 W (average DC at 1.5 GHz, 30 dBm, 10% traffic load)
- Environmental specifications:
  - Radio Base station (Indoor) operating temperature: 0°C to + 45°C, forced air cooling
  - Repeater and termination nodes (Outdoor) operating temperature: –40°C to + 55°C
- Standards Compliance:
  - Ethernet: IEE 802.3, 10Base-T
  - V 5.2 PSTN: ITU-T G.965
  - Voice: ITU-T G.711(PCM voice coding), G.726 ADPCM 32 kbit/s voice coding A-law and µ-law, G.165 echo cancellation.
  - ADSL: ITU-T G.992.2
  - Safety: IEC 60950
  - EMI/EMC: ETSI EN 300 385
  - Environment: ETSI EN 300 01.

Technology Section Conclusion

A similarity of services and applications across different systems is beneficial to users, and this has stimulated the current trend towards convergence. Furthermore, a broadly similar user experience across different systems leads to a large-scale take-up of products and services, common applications and content and an ease and efficiency of use. However, such convergence should not preclude opportunities for competitive innovation. Access to a service or an application may be performed using one system or may be performed using multiple systems simultaneously (e.g. a digital broadcast channel and a return channel using IMT-2000).

The increasing prevalence of IP-based applications is a key driver for this convergence and facilitates the establishment of relationships between previously separate platforms. What form these relationships will take depends on market requirements, but they might include, for example, hardware integration within a device, network interworking, common access, authentication, accounting, common man-machine interfaces, portals, roaming and handover between systems.

Section III – Country Experiences

III.1 Africa

III.1.1 Deployment of Broadband Wireless Access in Mali, Africa

Mali is a landlocked country in western sub-Saharan Africa with 80 per cent of the more than 11 million people living in rural areas. The country experiences extreme climate changes, very arid to a heavy rainy season. It also is very hot and humid. The cost of bandwidth in this country is very high and traditional hard-wire solutions for delivering high-speed Internet often leads to higher support costs and disgruntled customers, both of which can affect the bottom line. It also makes the availability of Internet service to residential customers almost non-existent. Afribone Mali began installing Motorola's Canopy 5.8 GigaHertz radios in 2003 for business and non-government offices. By deploying Motorola's Canopy solution, Afribone Mali SA was able to increase quality of service, keep customers satisfied, and reduce radio frequency cable problems. Afribone is now working on sharing bandwidth with other companies.

III.1.2 Deployment of Mobile Broadband Wireless Access in South Africa

Wireless Business Solutions (WBS) is a dynamic South African company established to provide mobile data network services to meet corporate, government and domestic requirements. It was licensed by SATRA in 1997, to provide National Mobile Data Services and is South Africa's fourth Telecommunication licensee. WBS has deployed a wireless packet switching network with 700 point-to-multipoint radio base stations. This network currently supports over 8 000 radios with which WBS has been providing a service to Uthingo, for the data telecommunications of their Lotto terminals to the Host system. A VSAT network is used to backhaul the traffic from the base stations to the Network Host.

Having gained knowledge and success by being the backbone network behind the National Lottery and providing nationwide wireless data services covering 95% of the population, WBS is rolling out a commercial mobile wireless broadband data network using iBurst technology (see section II.2.3.3.3). This network will provide customers with high-speed access to the Internet and corporate information wherever and whenever they want. By using the iBurst system, WBS intends to unshackle broadband and to liberate data telecommunications in the same way the mobile phone liberated voice telephony. WBS operates as a wholesale provider of iBurst connectivity, concentrating on its strengths of establishing and managing the infrastructure. It will rely on its channel partners to disseminate the service to the community. This will be the second implementation of iBurst in the world following the successful launch in Australia by Personal Broadband Australia early in 2004.

III.2 Americas

III.2.1 Canada

1) Broadband for Rural and Northern Development Pilot Programme

Canada is taking steps to provide broadband Internet access for all Canadian communities, including those in rural and northern communities. The *Broadband for Rural and Northern Development* Pilot Programme aims to fulfil this commitment through partnership with local communities, the provinces, territories and the private sector.

The programme is being delivered through two rounds of business plan development funding, followed by two rounds of implementation funding. In a recent announcement (October 2003) by the Government of Canada, it was stated that a total of 33 organizations have been selected to receive financial assistance from the Department of Industry (Industry Canada) in deploying broadband or high-capacity Internet to their communities. These organizations, representing an estimated 768 First Nations, northern and rural communities across Canada, will have access to funds from the Broadband for Rural and Northern Development Pilot Programme's first round of implementation funding. The deadline for submission of business plans to compete for the second round of implementation funds was November 2003, and the results were announced in April 2004. The business plans selected for implementation funding were based on the following criteria: level of community engagement, assessment of community need, experience and/or ability in project management, technology and implementation, and sustainability of business plan. For more information, visit: www.broadband.gc.ca.

2) National Satellite Initiative

An announcement was made by the Government of Canada (October 2003) to provide funding, over a period of 10 years, for the provision of broadband access to remote communities over satellite channels. Some 400 communities were initially identified for this programme. The objective of the National Satellite Initiative is to acquire satellite capacity (and possibly) some satellite ground infrastructure to provide remote broadband connectivity to rural, remote or isolated communities. This will bring broadband access to the remote communities at a cost that is comparable to that in the southern urban areas. Services that will be supported by this programme will principally be telehealth, e-business, distance learning and access to the Internet. This programme includes two C-band (4-6 GHz) public benefit transponders managed by Industry Canada (the first one became available in 2002 and the second one in 2003), Ka-band (20-30 GHz) satellite transmission capacity on the ANIK-F2 satellite (to be launched in mid-2004) as service credit to the Canadian Space Agency, and further satellite transmission capacity to be purchased on the open market.

3) Promoting Broadband: The Case of Canada

Under the New Initiatives programme of the Office of the Secretary General of the ITU, a series of Telecommunication Case Studies were produced. One of the cases studied was an examination of Canada's experience in promoting broadband. The study, prepared by Eric Lie, Project Manager, International Telecommunication Union, is entitled "Promoting Broadband: The Case of Canada".

The report of this study provides comprehensive information on the country's background, an overview of the origins of the Internet in Canada, the distribution of Internet and broadband infrastructure in the country and the demographics of Internet and broadband usage, the broadband market, the regulatory environment, and main strategies and initiatives that have been put in place by communities and governments to promote broadband. For more information, visit: www.itu.int/osg/spu/ni/promotebroadband/casestudies/canada.doc.

4) Fixed wireless access systems in the 900 MHz range

In Canada, the band 953-960 MHz is shared by Studio-to-Transmitter Links (STLs) and fixed wireless access systems on a geographical basis.

The operation of STLs had been limited to the band 956-960 MHz. With the introduction of digital radio broadcasting (DRB), there was a need for additional spectrum for STLs in the band 953-956 MHz, particularly in urban areas where there may be a large number of AM, FM and potential DRB stations. The deployment of these STLs will not be extensive in rural areas. The spectrum in these areas could be utilized by other radio applications to ensure efficient use of the frequency spectrum. In this regard and with the objectives of making information and knowledge-based infrastructure available to all Canadians, the band 953-960 MHz was also designated for radio services such as fixed wireless access systems (FWAs) that could be deployed outside of the areas of intense use of STLs.

In order to facilitate sharing between STLs and FWAs on a geographical basis, certain criteria were used including the establishment of geographical zones to give priority access to STLs where the future use of STLs could be most intense. As well, as a general practice, the provision of new STL licences begins from the upper frequency limit of the band 953-960 MHz, whereas the provision of new FWA licences begins from the lower frequency limit of the band.

The band 953-960 MHz is divided into 55 RF channels with 125 kHz spacing between centre frequencies. For FWA applications, a minimum of five contiguous 125 kHz channels are necessary. The transmitter power delivered to the antenna input is limited to 5 watts per RF carrier. Specific spectrum mask and FWA subscriber antenna characteristics also apply. For more information, visit:

www.strategis.ic.gc.ca/epic/internet/insmt-gst.nsf/vwGeneratedInterE/sf01613e.html and
www.strategis.ic.gc.ca/epic/internet/insmt-gst.nsf/vwGeneratedInterE/sf02144e.html.

5) Subscriber radio systems in the 1.4 GHz range

Fixed wireless systems in the 1 427-1 525 GHz bands are deployed in many rural areas of Canada to provide access to voice and data services. These systems are based on point-to-multipoint TDMA/FDD technology using 3.5 MHz channel bandwidth to provide a payload capacity of 4 Mbits/s per central station equipment, and up to 28 Mbits/s per system (7 central stations).

A typical system consists of central stations, repeaters, and terminal stations that can be configured in radial, branched, or linear topology with a maximum range of up to 720 km.

A typical central station has capacities of 400 to 600 subscribers depending on the grade-of-service objective and type of data service, which could be $n \times 64$ kbit/s dedicated lines.

Some systems also have integrated sub-systems that operate in the radio frequency band of 950 MHz.

6) Wireless communication systems in the 2.3 GHz and 3.5 GHz range

A spectrum auction took place in Canada in early 2004 for the Auction of Spectrum Licences in the 2 300 MHz and 3 500 MHz bands. Five licences in each of 172 service areas across most of Canada, totalling 848 licences, were auctioned for companies to provide innovative wireless services, such as high-speed Internet. In each service area, one WCS licence will be available, totalling 15+15 MHz in the band 2 305-2 320/2 345-2 360 MHz. Four licences will be available in the band 3 475-3 650 MHz in each service area, three licences of 25+25 MHz plus one licence of just 25 MHz. The purpose of this licensing process was to facilitate the growth of Wireless Communications Services (WCS) in the 2 300 MHz band and Fixed Wireless Access (FWA) in the 3 500 MHz band in both rural and urban areas, as well as to facilitate the implementation of new and innovative services.

Equipment in these bands is typically capable of providing data rates from 64 kbit/s to 1.5 Mbit/s or more to each subscriber. Many of these products are also capable of providing traditional telephone services. Where there is a direct line-of-sight from the base to the subscriber station, these systems may be capable of providing service at ranges of 20 km or more. Some of these systems are also capable of operating without a clear line-of-sight, albeit at significantly reduced ranges. For further information: www://strategis.ic.gc.ca/epic/internet/insmt-gst.nsf/vwGeneratedInterE/sf05472e.html.

7) 2.4 GHz and 5 GHz wireless access systems including radio local area networks

Wireless access systems deployed in 2.4 GHz and 5 GHz (5 250-5 350 MHz, or 5 470-5 825 MHz) are increasingly being used in urban areas for local area network connections as well as hot spot applications. However, many of these systems are also being used in rural areas. For example, in the band 5 725-5 825 MHz, some companies deploy point-to-point or point-to-multipoint systems in rural parts of Canada with e.i.r.p. as high as 4 Watts (consistent with Canada’s domestic technical rules).

In other cases, companies are taking advantage of using 2.4 GHz and 5 GHz technologies to form a comprehensive network that provides the transmission range necessary to reach some of the rural communities. In particular, in one case, 2.4 GHz systems are being used as the last mile connection to homes and offices, while the access points are interconnected using the 5 GHz IEEE 802.11a technology. The 5 GHz transit links are part of a self-configuring wireless mesh network. This enables a wireless backhaul network to be deployed quickly with increased network reliability and at reduced infrastructure costs.

8) Research and development efforts in Canada

To support the government of Canada’s priorities for connecting Canadians, the Communications Research Centre (CRC), an agency of Industry Canada, established an R&D programme called the Rural and Remote Broadband Access (RRBA) Programme. The Programme began in April 2002 and will run until March 2007. The RRBA Programme’s mandate is to conduct innovative R&D on technologies and systems that will facilitate rural and remote access to interactive broadband multimedia services.

The RRBA Programme focuses on finding technological solutions in areas of satellite communications, terrestrial wireless, fibre optics, etc., that can extend broadband services to rural and remote areas in a cost effective manner; especially where there is currently little interest by the private industry because of the perceived small return on investment. Proof-of-concept systems and subsystems will be developed with the participation of public- and private-sector partners to demonstrate the feasibility and advantages of broadband access in rural and remote areas. Collaborative demonstrations of broadband applications will also be conducted. Participation in international standards activities will take place with the aim of lowering the costs of broadband equipment through harmonized operating rules and large-volume manufacturing.

A number of critical issues have been identified by the programme; these include equipment cost, flexibility, reach, spectrum availability and interference, standardization and potential international markets. This results in the need to support a variety of R&D projects dealing with:

– Terrestrial wireless technologies such as WiFi, WiMax and other similar technologies for transport and “last mile” access.

– Wireless broadband access using frequencies below 1 GHz for better reach in rural and remote areas due to better propagation characteristics.

– Broadcast transmission technologies such as the use of DTV and an adequate wireless return channel for broadband access.

– Satellite broadband access technologies, especially related to low cost bidirectional Ka-band (20-30 GHz) terminals.

– Other broadband technologies such as distribution of RF signals over optical fibre and application of Software Defined Radio to flexible broadband access terminal.

More details are available from the programme website: http://www.crc.ca/broadband.

9) Nemiah Valley, British Columbia, Canada[70]

The Nemiah Aboriginal Wilderness Reserve, in isolated mountain-rimmed Nemiah Valley in central British Columbia, Canada is the homeland of the Xeni Gwet'in (pronounced "Awney Gwateen") Native American Indian community. Within the Reserve, the community government prohibits construction of paved roads, electric power and telephone pole lines, and commercial logging. To replace the sole narrowband radio-telephone link then available to community government and residents, the Canadian and British Columbia governments two years ago jointly funded deployment of wireless medium-speed Internet access (including feeder/backhaul) to the medical clinic, the school, the community and tourist office (www.xnigwetin.com), and to several clusters of residences. Telus Communications deployed by helicopter solar-plus-battery-powered broadband wireless equipment that included one 40-mile, 3.5 GHz feeder/backhaul link, and four 950 MHz Mbit/s "WL500" multi-sector, point-to-multipoint fixed-access links. The government and many residents now enjoy Internet services plus multi-channel fax and voice applications. Telus Communications' mobile business recently announced a USD 20 million expansion to bring high-speed mobile voice and data communications to 90% of Canadian communities.[71]

10) Wi-Fi in Ontario Canada"[72]

In rural and remote areas where population density prohibits the cost-effective use of wireline broadband distribution, inexpensive wireless solutions have been used to create broadband access networks of sufficient size to achieve the economies necessary to sustain the network. Being scaleable, portable, and easy to deploy, fixed wireless in particular has proven to be a popular technology choice for a number of demand aggregation community initiatives such as those in Leeds and Grenville Country, South Dundas and Simcoe County in Ontario.

Although still in a nascent state of deployment, cooperative solutions based on "Wi-Fi" technology present a possible avenue through which high-speed network access can be deployed at low cost. 44 Informal Internet access-sharing cooperatives, grounded in websites, at which information on participating is exchanged and provided, have already sprung up in a number of cities in Canada. Examples include cooperatives such as the Waterloo Wireless project, whose users have attempted to create a mesh of uninterrupted connectivity via a dense clustering of nodes, or "hot spots", and the BC Wireless project which, alongside the usual node maps and do-it-yourself deployment instructions, has declared an interest in using high-gain antennae to create point-to-point intercity links that would cobble together community networks into an interconnected system 45. Current attempts in Canada to extend Wi-Fi networking to the 10 km and even 20 km range on a

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70 Loi, Linda and Kreig, Andrew, "*International Wireless Broadband Success Stories*", WCAI, July 2003.

71 "*TELUS Mobility's Heartland Expansion brings digital wireless phone and data service to small and remote communities in British Columbia*", Canada English Newswire, July 16th, 2003.

72 ITU/SPU, Reynolds, Tad, "*Promoting Broadband*", Background Paper, 2003. www.itu.int/osg/spu/ni/promotebroadband/PB03-PromotingBroadband.pdf

point-to-point basis indicate the possible extension of Wi-Fi as an alternative means for remote community-dwellers to aggregate demand and share backbone connectivity. Stretching the reach of “Wi-Fi” technology in a point-to-multipoint arrangement is also being investigated by CRC. One appealing approach is to down-convert “Wi-Fi” transmission to lower frequencies in the UHF range to take advantage of better RF propagation characteristics (see subsection 8).

Conclusion

A number of programmes and initiatives are being carried out in Canada to deliver wireless broadband connections to Canadians in rural and remote communities. Government programmes such as the *Broadband for Rural and Northern Development* Pilot Programme and the *National Satellite Initiative* are only two of the many programmes that Canada has initiated to promote broadband connections in rural communities. A number of frequency bands are currently being used, in Canada, for broadband transmission to rural areas including the 900 MHz, 1.4 GHz, 2.3 GHz, 2.4 GHz, 3.5 GHz and 5 GHz bands. Nonetheless, a number of issues including cost, climate and propagation (the need for spectrum with propagation characteristics more suitable for rural areas) can be challenging in the deployment of systems in rural areas.

III.2.2 Ecuador

Broadband Wireless Point-to-Point Enterprise Network, Banco del Pichincha, Machala Zone, Ecuador

The Banco Del Pichincha, the largest bank in Ecuador, has established 200 branch offices spread across Ecuador. To interconnect these, the bank has deployed an extensive private network, containing many wireless links. The bank stipulates that each link be available 365 days of the year, 24 hours per day, with reliability at least 99.96%. For many critical links, the bank has deployed “VIP 110-24” broadband wireless links offered by Wi-LAN. Installed in 2001, these wireless links now have demonstrated reliability exceeding that stipulation. The VIP 110-24 product incorporates routers, are called “anypoint-to-multipoint”, or “VINE” routers, which have enabled Banco Del Pichincha to adopt a deployment approach wherein any endpoint or repeater node already in the network can become the centre of one or more point-to-multipoint branches. This approach minimizes up-front costs for its evolving network.

III.2.3 Mexico

Fixed Wireless Access, Mexico City, Mexico

Mexico City, containing 20 million residents, is one of the densest, largest urban markets in the world. Fast Internet access (Mbit/s) has not been readily available within much of the metropolitan area. MVS Comunicaciones, for many years a principal deliverer of TV programming throughout the metropolitan area and the nation, now is delivering high speed fixed wireless Internet access within the city, across 220 sq. miles encompassing approximately 10 million of its residents, and including its central business district. Within Mexico City, many prospective customers are located down in high-building street canyons or mountain-ridge canyons, and many behind extensive foliage, thus not within wireless line-of-sight of current and prospective base stations. Hence MVS sought a NLOS wireless technology effective in demanding terrain. It deployed the MMDS-band 2.5-2.686 GHz broadband NLOS wireless equipment. Within forthcoming months, the MVS Mexico City network likely will become the world’s largest NLOS network.

III.2.4 Peru

"USE OF VSAT SYSTEMS FOR TELECOMMUNICATIONS SERVICE RENDERING IN RURAL AREAS IN PERU"

Introduction

In August 1998, the Guidelines for Telecommunications Market Opening in Peru were approved through the Supreme Act No. 20-98-MTC, which defined the universal access as a group of essential telecommunications services to promote the development and integration of the furthermost areas in Perú.

Additionally, the following universal access goals were defined until the year 2003:

- The installation of 5 000 public telephones in an equal number of rural towns lacking this service, capable of transmitting voice, fax and data at a low speed, as well as making free calls to emergency centres.
- The installation of Internet access in 500 rural district capitals[73] comprised in the 5 000 towns previously mentioned.

The Telecommunications Private Investment Supervising Organization (OSIPTEL) through the Telecommunications Investment Fund (FITEL) designed a series of projects under these guidelines, which aimed at providing fixed telephone services through public telephones and Internet access in district capitals.

FITEL called for International Public Bids, in which participating bidders committed themselves to oversee: i) installation, ii) operation and iii) maintenance of specific services utilizing the most efficient technology to allow them to comply with technical specifications.

Peru has particular characteristics that include a great geographic unevenness. Rural operators in charge of selecting the most adequate technology to comply with technical requirements took this into consideration. In the end, satellite technology through the implementation of VSAT networks was chosen by participating bidders.

This document presents a general perspective of the deployment of VSAT networks in Peru through FITEL.

Description of the VSAT network

The VSAT satellite network implemented in Peru's rural areas operates in the band 10-20 GHz, with a 11,7 to 12,2 GHz up-link and a 14 a 14,5 GHz down link, utilizing a PAS-1R satellite.

The VSAT network has a star-like topology, with multiple remote stations that communicate through a Main Hub with a FDMA/TDMA DAMA access scheme.

Current data transmission speed reaches 256 kbit/s for the carrier from the Hub to the remote stations (Outbound – up link), with QPSK and 38,4 kbit/s modulation for the carrier from the remote stations to the Hub (Inbound – down link) with a MSK modulation. Additionally, a LAN Ethernet port is included which can reach speeds of up to 10 Mbit/s.

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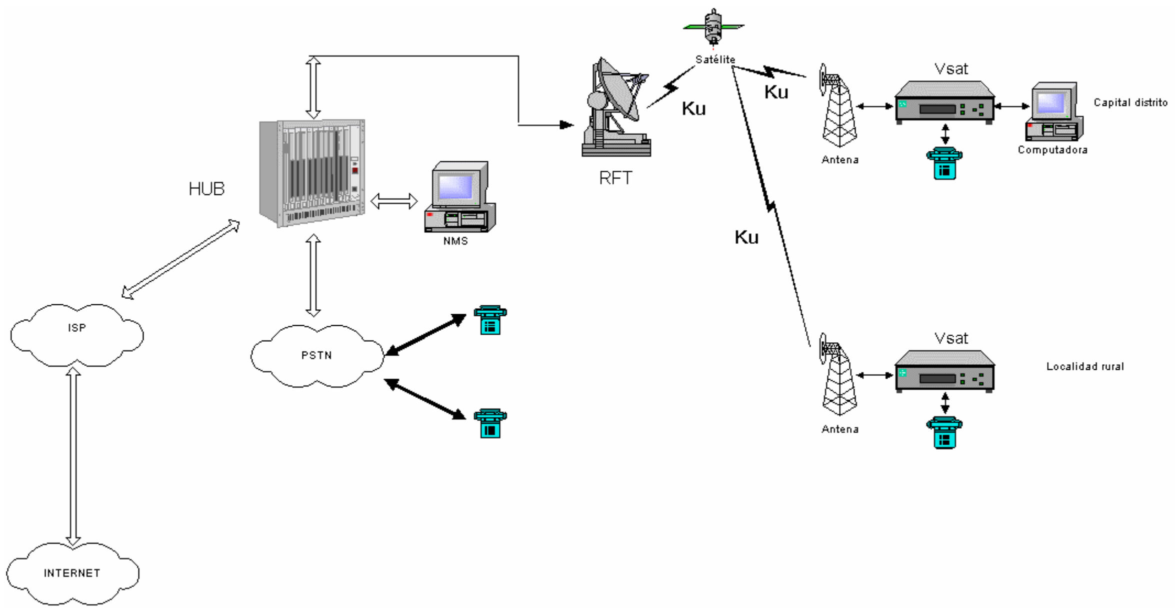
[73] According to the definition of the IT and Statistics National Institute, district is the smallest territorial division in the country. It is generally subdivided into urban and rural areas.

Among the VSAT network's main components we can mention the following: i) multiple remote stations, ii) nodal station (Hub), iii) prepayment[74] subsystem, iv) network management system. Figure 1 shows the simplified diagram of the VSAT network.

Figure 1 – Simplified scheme of the VSAT network



Remote stations are constituted basically by two modules: the external unit (Outdoor Unit – ODU) and the internal unit (Indoor Unit – IDU), that includes the VSAT. Apart from the energy subsystem and protection subsystem.

The external unit (ODU) is comprised of the antenna and radio frequency elements that enable communication between the internal unit (IDU) and the satellite. Some of its components include: i) an antenna that varies in size from 1,2 to 1,8m[75], ii) a high potency converter, with potency that varies from 500 mW to 1 W[76] and iii) low noise converter block.

Services[77] currently being provided include the following: i) voice, ii) fax (Group 3) low speed data, iii) free calls to emergency centres and iv) Internet access in rural district capitals at a speed of 9 600 Bauds.

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74 The prepayment system uses cards with codes (PIN) to make calls. It is necessary for the operator to have an adequate card distribution plan, as web as ensuring adequate training for the rural population to use the service. The procedure to make a call can be found in the back of the prepayment cards, and a procedure poster can be found inside the telephone booths, and also the operator trains users on the proper use of the public telephone and Internet access (if necessary).

75 The size of the antenna depends on many factors (geographic location, satellite coverage, precipitation levels, speed of data requested, etc). Depending on the case, antennas with a greater diameter are used to improve the system's performance.

76 1W of power in some towns in the Peruvian jungle mainly due to the satellite's coverage and precipitation levels).

77 Currently, all services rendered by rural operators run through prepayment platforms, except for Internet access, which is being provided freely to this date.

Rural operators

As a result of the International Public Bids the subprojects have been awarded to two operators: Gilat To Home Peru S.A. (formerly named Global Village Telecom.) and Rural Telecom. S.A.C. Table 2 shows the distribution of subprojects per rural operator.

III.2.5 United States

1) Fibre to the Home Rural Community Project, Grant County, Washington, US [78]

The Grant County Public Utility District (GCPUD) is building fibre-to-the-home (FTTH) in a rural community in Washington State. According to the GCPUD, FTTH is assisting small business, educational institutions, medical facilities and others where other telecom services are offered in a limited capacity. In March 2000, Washington State passed a state law that allowed public utilities to build fibre-optic networks. As of March 2003, more than 10 000 meters were passed, and more than 9 200 homes were passed by the fibre build-out in Grant County. The Grant County Public Utility District had a 43 per cent penetration rate, with about 4 000 subscribers, as of March 2003. Nearly 100 per cent of the homes have Internet access. And, nineteen ISPs, two video companies, one telephone company and one security company are providing high-speed voice, video and data applications. As a result of its broadband buildout, the economic impact has been significant.

- Over 100 new jobs have been created as a result of the network, creating a USD 9 million economic benefit for the region.
- As a result of the network, 25% of people with access have purchased a new computer or related equipment, 72% of people with access have purchased goods or services online and 62% believe that broadband access improves their children’s education.
- A local chemical plant has reduced executive visits to Sweden from once a month to twice a year because of video conferencing.
- Point-of-service entities, like gas stations, have decreased credit card processing time.
- Farmers are using the applications to track the market prices of their products and do livestock and crop research.
- County schools are using the FTTH connection for distance learning, distributing programming, financial aid information and advising information.
- Medical facilities are transmitting more medical information to doctors and patients faster.
- GCPUD also estimated that every 300 new employees attracted to the region as a result of the FTTH networks would translate into USD 72 million for the local economy because of the multiplier effect of consumer spending.

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[78] Donna Keegan. “*Great Needs: Fiber-to-the-home drives development in Grant County, Wash*”, Opastco Roundtable, July/ August 2002, pp. 50-51.

High Speed Satellite Broadband Service for Medical Purpose, Columbia, South Carolina, US[79]

On July 1, 2002, Hughes Network Systems, Inc. (HNS), the Advanced Technology Institute (ATI), and the Columbia Eye Clinic launched a high-speed, satellite broadband service linking medical professionals at the Columbia Eye Clinic with patients at Beaufort-Jasper-Hampton Community Health Centre in Ridgeland, South Carolina. The service allows clinic experts to screen the eyes of patients over 100 miles away for diabetic retinopathy. In the coming years, they plan to screen patients in other parts of South Carolina and then expand to screenings for glaucoma and other anterior segment diseases. Broadband access will facilitate the collection of epidemiological data and aid in patient education.

2) Municipal Fibre Optic Network, Kutztown, Pennsylvania, US[80]

The city of Kutztown, Pennsylvania built Pennsylvania's first municipal fibre-optic network. It is a USD 4.6 million project, which the city began building in 2001. The network has created competition for high-speed Internet access, cable TV and telephone service in Kutztown. Kutztown is one of only a handful of US cities to run fibre to every home and business. The network offers speeds up to 100 megabytes per second. The network provides residents the ability to monitor home security, pay water and sewer bills and track their electricity use. Officials also envision video-on-demand and music-on-demand, distance learning and e-health as applications to be deployed using the new fibre-optic network. In addition, the network will provide Kutztown's electric utility the ability to automatically detect the location of power outages and equipment failures. It also will let the utility use automated meter reading technology. That will eliminate the need for time-consuming manual checks of the borough's several thousand electric meters each month.

3) Point-to-point Wireless Broadband Program Turtle Mountain & Fort Berthold, ND & Fort Peck, MT, US[81]

Fast Internet access (Mbit/s) has become available within but few of the U.S. Native American Indian Reservations. To accelerate availability, the U.S. National Science Foundation, through its EDUCAUSE (www.educause.edu) affiliate and AN-MSI project (www.an-msi.org), recently funded deployment of wireless fast Internet access to community colleges at several reservations, including necessary feeder/backhaul. At three, including Fort Peck Community College (MT), the Fort Berthold Community College (ND), and the Turtle Mountain Community College (ND), the AN-MSI project, led by Dandin Group CEO Dewayne Hendricks, deployed U-NII band (5 GHz) "Canopy" broadband wireless equipment offered by Motorola, both 20 Mbit/s feeder/backhaul links and 10 Mbit/s access links. Each network soon will be extended to more community sites, perhaps then households.

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79 "*Healthcare Groups and Broadband Satellite Provider Collaborate to Help Save Eyesight in Rural South Carolina*", HNS Press Release, July 1, 2002.

80 "*Wired in Kutztown – Municipality sells Internet, cable TV and phone service through its own lines*", Christian Berg, The Morning Call (online), August 4, 2002.

81 Courtesy of Motorola and Linda Loi, WCAI.

4) Example of Fixed Broadband Wireless Implementation in the United States

The city of Forth Wayne, Indiana, is the second largest city in the state of Indiana. The local government and private sector of this city concluded that it was necessary to establish a regional capability to provide businesses and residents in the metro area access to high-speed broadband services at reasonable cost as such a capability was essential to economic development. It was considered that ubiquitous broadband deployment would bring valuable services to businesses and consumers, stimulate economic activity, improve local productivity, and improve education.

This was accomplished through the Indiana Data Centre. The criteria for the technology to implement this were: 1) No public financing, but use of public facilities; 2) digital structure; 3) Always on and ubiquitous, 4) able to evolve new users; 5) able to address interference issues.

After much evaluation of alternative technology solutions, the Motorola Canopy product was selected. This BWA concept:

- Uses a cellular-like concept with more access points close to the ground.
- Mitigates interference in unlicensed bands.
- Provides a modular design for expanding the system with ease of installation (one day).
- Very cost effective.
- Scaleable bandwidth on demand up to 2 Mbit/s.

III.3 Asia

III.3.1 Australia

1) "Networking the Nation" Broadband Program and Regional Mobile Phone Program

Also in Australia, the government took a step toward creating demand for broadband-delivered applications through its "Networking the Nation" program. Part of the overall Commonwealth of Australia's National Broadband Strategy, the Networking the Nation Program Australia program that provided nearly AUUSD 180 million Australian dollars to non-profit organizations to support activities and projects designed to address a range of telecommunications needs in rural, regional and remote Australia.[82] It included a strategy for deploying public Internet access, videoconferencing facilities to the general public and female health facilities, training, building parts of a new telecom backbone, helping municipal and county councils provide government services, and providing money for community telecommunications centres that will assist people with disabilities to access the Internet.[83]

Another initiative by the Australian government designed to improve the level of telecommunications services in rural and regional Australia is the Regional Mobile Phone Program. This AUUSD 50.5 million program provided AUUSD 20.4 million improved 3rd Generation CDMA mobile voice and high-speed data

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[82] See: www.dcita.gov.au/Article/0,,0_1-2_3-4_106337,00.html and www.newconnections.gov.au/download/0,6183,4_113958,00.doc for more information.

[83] OECD Report, "*Broadband Infrastructure Deployment: The Role of Government Assistance*", November 14, 2001.

coverage to 31 towns that currently have inadequate coverage and to 24 towns that have no existing coverage. Other mobile phone coverage provided under the USD 50.5 million Regional Mobile Phone program includes:

- spot coverage for selected regional highways;
- funding to improve mobile phone coverage in the south west of Western Australia under the Wireless West project; and
- a satellite mobile phone handset subsidy scheme.

2) Telstra's Broadband Acceleration Program, Australia

Telstra, a major telecommunications operator in Australia, has established a broadband policy which allocated up to AUUSD 30 million in cash and bandwidth to accelerate the development of technology that will stimulate broadband growth in Australia.[84] Under the deal, Telstra will contribute AUUSD 10 million in cash, AUUSD 20 million in bandwidth, and it has committed to match equivalent industry contributions to the program with further support of up to AUUSD 15 million over five years. The goal of the Telstra Broadband Strategy is to stimulate and accelerate the development of new and innovative applications, tools or technologies with wide appeal for broadband delivery to Australian businesses and consumers. This in turn will stimulate subscriber growth and ultimately mean more revenues for Telstra resulting in a win-win situation for both consumers and the private sector.[85]

3) "Reach for the Clouds" Broadband Program, Melbourne, Australia

In Melbourne, a local initiative of GreenPC, called "Reach For The Clouds," aims to deliver to each of 770 homes in the low-income housing project called Atherton Gardens a refurbished computer completely free of charge and the chance to get online. All of Atherton Gardens has been wired with an ADSL broadband system. Residents are able to use e-mail and a community intranet service free, but they pay to connect to the web. The project is using refurbished computers to enable a whole community to access the web. The project's aims are to provide all residents with free access to a PC in their own home, establish a local community computer network (Intranet), provide access to Internet telecommunications (Internet), train residents in computer use, enable community management of the network and establish social enterprise opportunities. If successful, GreenPC will deploy similar networks in Melbourne's 13 other poor housing developments.

4) Personal Broadband Australia

In March 2001 the Australian Communications Authority (ACA) conducted an auction of 2 GHz (3G) licenses covering all major cities in Australia and applying for 15 years from October 2002. ACA's 2 GHz spectrum allocation was consistent with the ITU's recommended frequency arrangement for spectrum identified for IMT-2000[86] and adhered to their technology neutral spectrum policy that allows Australian licensees to deploy any technology that meets the adopted emissions and coexistence requirements. The ACA awarded five licenses as a result of this auction, including a license to CKW Wireless which was established in February 2001 with the objective to roll out the iBurst™ technology across Australia.

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[84] "*Telstra Sets Up Broadband Fund*", www.dialelectronics.com.au/articles/8f/0c00e78f.asp, June 21, 2002.

[85] See: www.broadbandfund.telstra.com/about_home.htm for more information, as well as a list of funded projects.

[86] See 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*".

By June 2002, CKW had been renamed *Personal Broadband Australia* (PBA) and formed into a consortium partnership that includes Ozemail, Vodafone, Crown Castle, TCI, UT Starcom as well as the shareholders. After a one-year trial that was successfully completed in November 2003, a "soft launch" was initiated in December 2004 and the fully commercial iBurst service was launched on March 19, 2004.

PBA is delivering a new paradigm for access to the Internet and corporate information where people are able to rely on secure high-speed connectivity wherever they are and whenever they want. Not only does this greatly enhance the utility of many existing data applications, it enables the development of exciting new applications that could not exist until iBurst came into existence. PBA is a network builder and service provider. Its iBurst network offers the first commercially available service of its kind in the world. Based on patented technology from ArrayComm and using equipment supplied by Kyocera Corporation, the iBurst network uses state of the art High Capacity-Spatial Diversity Multiple Access (HC-SDMA) technology that is being standardized by the Alliance of Telecommunications Industry Solutions (ATIS), an ANSI-accredited standards development organization. HC-SDMA systems make far more efficient use of radio spectrum than previously developed mobile radio telecommunications systems, allowing each radio node to provide up to 1 Mbit/s broadband service to thousands of users simultaneously. With PBA's iBurst service subscribers can maintain their connection whether moving between rooms or between suburbs – the network supports seamless handover between radio nodes at vehicular speeds, thereby providing a fully mobile service.

PBA is a wholesale provider of iBurst connectivity, concentrating on its strengths of establishing and managing its network infrastructure. It re-sells its service via selected Channel Partners who are specialists in the provision of ISP and mobile services. PBA is positioned to be the market leader for mobile broadband Internet services in Australia. With its unique iBurst technology, PBA is able to offer connectivity to the Internet or corporate data at a cost and quality that has previously only been available though fixed connections.

III.3.2 China: The Development of Broadband Services and Applications in China

Broadband Service Development in China

Vigorously driven by such leading Chinese broadband operators as China Telecom and China Netcom, the Chinese broadband service market is progressing from the phase of market cultivation to one of rapid expansion. According to statistics provided by China's Information Industry Ministry, there were only 3.34 million broadband subscribers in the entire telecom market in 2002. A year later, however, the figure had shot up to 11.15 million, and a further 6.58 million new subscribers were added in the first six months of 2004, bringing the total up to 17.73 million (source: www.mii.gov.cn/mii/hyzw/tongji/yb/tongjiyuebao200406.htm), with some 80 per cent of them being ADSL subscribers.

Thanks to the strong impetus given by China Telecom, China Netcom and other broadband operators, the Chinese broadband market is rapidly entering a period of fast growth, as evidenced by:

– the broadband subscriber base having topped the ten million mark by the end of 2003;

– China's Internet international gateway bandwidth having reached 27 GB in 2003;

– the gradual spread of broadband applications, including numerous varieties of high-capacity video software, gaming applications, etc.;

– the diligent efforts on the part of Internet application suppliers and operators in search of a cooperative mechanism, which have led to the mushrooming of businesses specialized in broadband application content, the emergence of an eco-chain for the broadband Internet industry, and considerable progress in the quest for an operating model for value-added network services.

The subscriber base explosion has fuelled the expansion of the broadband equipment market, where operators have found incentives to engage in volume procurement that has resulted in constant cost-cutting. The price per ADSL line has fallen consistently, from as high as 1 800 RMB yuan (about USD 200) in 2000 to 1 000 RMB yuan (about USD 120) in the second half of 2001, and thereafter to 600 RMB yuan (USD 72) in the first half of 2002, 550 RMB yuan (USD 66) in the second half of 2002, 430 RMB yuan (USD 52) in the first half of 2003, and finally to as low as 320 RMB yuan (USD 39) in the second half of the same year. The low price of broadband equipment has led to a significant reduction in the operating costs of the operators, leaving room for them to cut prices and thus further whet the appetite of consumers. It is evident that the Chinese broadband subscriber base has embarked on a period of self-sustainable growth.

According to a report by the Academy of Telecommunication Research under the Information Industry Ministry of China, the number of subscribers nationwide is expected to reach 51.15 to 58.40 million in 2006, representing a 358 to 423 per cent increase over the 2003 figure.

Table 1 – Forecast of Chinese broadband subscriber growth in the period 2004-2006 in millions

		2004	2005	2006
Optimistic estimate	Broadband access users	25.28	40.79	58.40
	Annual growth rate	107%	61%	43%
Conservative estimate	Broadband access users	23.19	36.32	51.15
	Annual growth rate	90%	57%	41%

Source: Academy of Telecommunication Research under the Information Industry Ministry of China.

Broadband application development in China

Several years of stiff competition in the Chinese broadband market have brought home to operators the fact that the key driver for broadband service development is the application side rather than access alone, and that it is therefore imperative to put in place an integrated broadband industrial chain model to enable sound and sustainable development of the broadband market. Out of the competition and consolidation that took place in both 2003 and 2004, there emerged in the Chinese broadband market a broadband value chain composed of equipment suppliers, telecom operators, value-added service providers and content suppliers.

During 2003 and 2004, the Chinese broadband industrial chain made good progress with China Telecom's "ChinaVNet", China Netcom's "TTZX" and other broadband brands and operating models introduced and brought into operation, and with the broadband market shifting its focus from increasing access to developing broadband applications. The consolidation of the broadband industrial chain implemented by both China Telecom and China Netcom, two leading suppliers in the Chinese broadband market, will have a decisive impact on the development of that market.

- **China Telecom's "ChinaVNet"**

As a nationally unified application service brand and a charging model for information and application services, ChinaVNet (www.chinavnet.com/chpage/c1/), by making use of a mutually beneficial model, helps value-added Internet service providers, content providers and telecom operators achieve their business value together.

By taking full advantage of its subscriber, network and application support platform resources as well as its sales network, customer service and promotion channels, China Telecom hopes to create a friendly ecosystem for Internet industry development, develop a new business model for Internet services and provide its Internet users with a rich array of content and information application services by consolidating the content and applications from its partners, with a view to bringing benefit to all parties concerned, namely users, ChinaVNet partners and China Telecom itself.

Aiming to be at the same time entertaining, informative and of practical use, ChinaVNet's content and applications cover a wide range of trades and sectors, including entertainment, education, securities, consulting, e-commerce, public services, business applications, etc. Advocating the concept of "sharing resources, drawing on each other's strengths and working for the common good", and adhering to the principle of "openness" and "consolidation", ChinaVNet has created a win-win business model through which the service providers and a host of other partners who make up the links in the industrial chain are able to fulfil their own business targets. Meanwhile, China Telecom has also made publicly available its resources, such as its network, subscriber base, charging channel, extensive sales network, customer care and promotion channels, and has provided service providers with such services as user authentication, authorization and fee collection on their behalf. Moreover, China Telecom will do all it can to deliver to service providers a package of convenient services including, among others, network access, IDC, media distribution network and media exchange.

Since China Telecom declared it ready for commercial use on 15 September 2003, ChinaVNet has been commissioned in Guangdong, Zhejiang, Jiangsu and other provinces and municipalities. By the end of December 2003, China Telecom had become the largest operator in the domestic broadband market, with a total of 7.35 million broadband subscribers of whom nearly 3 million were registered ChinaVNet subscribers. Over 260 partners have entered into contract with ChinaVNet. Of the 263 SP partners nation-wide, 28 work directly with ChinaVNet's national centre. In 2004, ChinaVNet will access more than 100 SPs via its national centre platform and give priority to the launch of four product lines, namely broadband entertainment, online gaming, instant communications and enterprise applications, to which end it will build the largest broadband entertainment platform, online movie supermarket and music library in China, establish a unified online gaming prepaid credit system in an endeavour to bring under its coverage 80 online games from operators including the top 40 online operators in China by the end of 2004, and intensify efforts to develop services such as instant communications, e-mail, online anti-virus protection and distance learning.

- **China Netcom's China Byte**

As a countermeasure in response to China Telecom's ChinaVNet, China Netcom joined forces with a number of investment companies to set up the China Byte Corporation in Beijing in February 2004. "TTZX", a broadband portal built through meticulous effort on the part of China Netcom, went into operation at the same time, marking the initial move by China Netcom towards broadening its value-added broadband service strategy. The TTZX website targets ordinary Internet users and delivers specialized broadband information services through a TV-channel-like mechanism with unique content that is "TV-centric, entertaining, family-based and high in quality". What TTZX aims to achieve is, first, to address the needs of ordinary consumers and home users; second, to develop a service and specialized content delivery system that is as easy to operate as TV channels, in order to facilitate user network access; and third, to supply an ever-increasing number of broadband multimedia video services.

China Byte is a limited liability company incorporated by China Netcom, IDG and a number of other world-renowned investment companies, mainly providing such services as Internet content, broadband content, game channels billed to calling parties, the channel-based China Netcom broadband portal and value-added telecommunications.

The China Byte Corporation will offer three categories of service, namely broadband portal, value-added voice services (such as the nationwide voice service mainly accessed by a centralized number 116XX, telephone commerce, calling centre and telephone information inquiry service, etc.) and value-added wireless services (mainly SMS and meeting coordination services), of which the voice services and the broadband portal will be launched first. China Byte will adopt the same operating approach as China Mobile's "Montenet" and will partner with numerous SPs across the country in an effort to supply a massive amount of multimedia information in addition to the narrow-band information already delivered, thereby fully reflecting its business concept of giving overriding importance to the application side in rendering content service.

Following the principle of taking on projects on a selective basis, China Netcom has been diligently looking for a cooperation model of benefit to all. Apart from TTZX, it has explored other ways of cooperation in its search for still greater breakthroughs in broadband applications.

Cooperation model 1: In the light of the market situation and service capabilities, China Netcom is engaged in further development of the already consolidated software, modem and other products from user-end equipment suppliers in order to provide a better quality of service to broadband access users. In conjunction with well-established computer and terminal vendors, China Netcom has started to develop simple network access terminals to lower the access threshold for users. As a result, China Netcom and its partners have introduced co-branded computers with embedded broadband access capabilities, bundling the sales of terminal equipment with that of broadband services.

Cooperation model 2: China Netcom cooperates extensively with the outside world and gives full consideration to user needs in its development, upgrading and management of content channels.

Cooperation model 3: By creating an industrial chain, China Netcom and the provincial communications companies will jointly build a centralized network service platform to provide access, authentication and billing services to other enterprises, and to promote bundled sales of terminals and broadband services in cooperation with ICPs/ISPs and terminal manufacturers.

III.4 Europe

III.4.1 eEurope Action Plan 2005

The eEurope initiative was first proposed by DG INFSO (Direction Générale – Information Society) at the end of 1999 and endorsed by the European Council in Feira in June 2000. The main objective of eEurope is an ambitious one: to bring every citizen, school and business online and to exploit the potential of the new economy for growth, employment, and inclusion. The first eEurope Action Plan, 2000-2002, had three aims: a cheaper, faster, more secure Internet; investment in people and skills, and greater use of the Internet. It consisted of 64 objectives and nearly all were successfully reached by the end of 2002.

The second stage is the **eEurope 2005 Action Plan**, which was endorsed by the European Council in Seville, 2002. The eEurope 2005 objective is that Europe should have modern online public services (e.g. E-Government, eLearning, eHealth) and a dynamic eBusiness environment. As an enabler for these, there needs to be widespread availability of **broadband access** at competitive prices and a secure information infrastructure.

eEurope 2005 objectives

The objective of the new Action Plan is to provide a favourable environment for private investment and for the creation of new jobs, to boost productivity, to modernise public services, and to give everyone the opportunity to play a role in a global Information Society. eEurope 2005 aims to stimulate secure services, applications and content based on a widely available broadband infrastructure.

The challenges of eEurope 2005

The Information Society has a vast untapped potential for improving productivity and quality of life. This potential is growing due to the technological developments of broadband and multi-platform access, i.e. the possibility of connecting to the Internet via other means than the PC, such as digital TV and 3G mobile phones. These developments are creating significant economic and social opportunities. New services, applications and content will create new markets and provide the means to increase productivity and, as a direct result, growth and employment throughout the economy. They will also provide citizens with more convenient access to information and communication tools.

The targets of eEurope 2005

eEurope 2005 applies a number of measures to address both sides of the equation simultaneously. On the demand side, actions on eGovernment, eHealth, eLearning and eBusiness are designed to foster the development of new service. In addition to providing better and cheaper services to citizens, public authorities can use their purchasing power to aggregate demand and provide a crucial pull for new networks. On the supply side, actions on broadband and security should advance the roll-out of infrastructure.

One of the key areas covered by eEurope 2003 is broadband:

Currently, the most common way to access the Internet is through dial-up connections, a narrowband service, which uses the existing local telephone network and is mostly charged on the basis of time. The main challenge ahead is to accelerate the transition from communications based on narrowband networks to communications based on broadband networks, providing high-speed and always-on access to the Internet. While large corporations have completed their transition to broadband, the focus must now be on the mass market to ensure that broadband becomes available to all homes and SMEs.

Broadband stimulates the use of the Internet and enables the usage of rich applications and services. Its benefits spill over to the areas of e-business, e-learning, e-health and e-government, improving the functionality and performance of those services, and further extending the use of the Internet. As such, it is considered the crucial infrastructure for realising the productivity gains that a more effective use of the Internet can deliver.

To reach everybody, broadband policy must also take into account the potential of the emerging alternative communication platforms such as 3G and digital TV. This multiplies the channels through which people can access broadband and benefit from it, contributing to the achievement of an Information Society for all.

Measures taken under the eEurope 2005 Action

The eEurope action plan is based on two groups of measures which reinforce each other. On the one hand, it aims to stimulate services, applications and content, covering both online public services and e-business. On the other hand it addresses underlying broadband infrastructure and security matters.

(see www.europa.eu.int/information_society/eeurope/index_en.htm) *eEurope Action Plan Implementation in Spain: Program "Internet Rural"*

In March of 2002, the European Council of Barcelona put together a strategic plan for the development of an Information Society throughout Europe by the year 2005. In June of 2002 the plan of action for eEurope was approved and at this time the program "Internet Rural" was established. The goal of this project was to install a series of public internet access points that would permit all citizens within their given regions to access the internet, preferably using a broadband connection.

The objectives of project Internet Rural are to establish the following:

- Connectivity to broadband internet services
- Centrally located public access points
- Installation and maintenance services
- Central command and control centre
- Service portals for rural areas
- Optional extensions for connectivity
- Financial Resources.

A simulation of "Internet Rural" was conducted based on the following criteria:

- Simulation was carried out in municipalities that are not covered by ADSL or Cable
- To guarantee the coverage of no less than 40% of the population that does not have present access to Broadband Internet
- This study and the above criteria were established for municipalities of 1 200 inhabitants or greater. In the event that municipalities were smaller, such as 800 or 500 inhabitants, expectations were lowered with regards to the 40% or more coverage target.

The total impact of the program is summarized in the following figures:

	Present State Without DSL	**Implementation of the Program**	**% Implemented**	**Final State Without Access to Broadband**
Population	5.177.305	3.808.231	73.56%	1.369.074
Municipalities	6.414	1.853	28.89%	4.561

III.4.2 Ireland

South West Regional Authority Broadband, Ireland[87]

The South West Region of Ireland comprises an area of 12 100 sq. kilometres and has a population of 580 000 people, over half of whom live in the City of Cork and its immediate environs. As with many modern economies, a high level of the region's commercial and industrial activity is centered in the regional capital and it's Metropolitan Area. The agricultural economy is under pressure and the sector no longer provides a means of sustainable livelihood for many farmers, particularly those in the more remote areas. In regions such as these telecom companies have concentrated on the core populated areas since they provide the best commercial or financial returns.

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87 McAleer, John, "*Local communities providing broadband for themselves*", www.swra.ie/broadband, jmcaleer@swra.ie, June 2003.

The South West Regional Authority (SWRA) has twenty four elected representatives and has responsibility to promote the coordinated delivery of Public Services in the region. In the course of its work in the development of the Information Society, the SWRA recognized that even with completely free market operations, telecommunications providers are not likely to be prepared to bring broadband to marginalized areas since the chances of profitability are slim. They also realized that financial incentives to attract new market entrants are also not always successful, particularly when the rural market is small. These were the circumstances which moved the South West Regional Authority to try and do something for itself – something different.

Its research pointed to the slow rollout of DSL technology only planned for towns with a population in excess of 6 000 persons. Since the majority of towns in South West Ireland have populations far less than 6 000, the SWRA further looked at the growing preference for wireless around the globe, and the availability of broadband from satellites. The SWRA decided to try and combine both, with an intelligent interface. In late 2002, the Regional Authority made a proposal to the European Space Agency to undertake a research program relating to the combined usage of Satellite and wireless technologies, the results of which would be of value to many regions experiencing difficulties in getting broadband to remote towns. This proposal was accepted and the SWRA began work on the South West Broadband Project, in February, 2003.

The proposal was to test satellite as a means of accessing broadband, to validate the technology across a range of field trials in areas of e-government, business support, e-Medicine and Distant Education. SWRA was fortunate to receive many offers from major players in the satellite and wireless communications field to participate in the program. Fourteen field trials are now operational and satellite technology is used in conjunction with wireless local area networks to provide broadband access.

A principal economic advantage of its program is that typically a satellite/ wireless system can be installed in just a few days and the total cost of creating a satellite fed wireless LAN is of the order of € 25 000. The SWRA contrasted the rollout of this technology with that of fibre where the cost of laying a plastic duct is of the order of € 150 000 per kilometer and then further substantial costs are involved in providing the fibre, lighting it and then making the "last mile" connection to users. The economics of SWRA's approach are such that the annual cost, including installation, of operating a satellite/wireless local area network, can be as low as € 20 000 per annum. On this basis with a total of 40 customers, connection charges can be as low as € 25 per month for home users and € 60 per month for small businesses.

The SWRA market approach is one of product and service sustainability, on a not for profit basis, reinvesting revenues from the service into the rollout of Satellite and Wireless Broadband to even smaller communities. The SWRA has also adopted a highly inclusive approach with local communities, who will partner with them in each town, to develop and agree on terms and conditions of service, in consultation with local community representatives. The Local Authorities in the region are also partners and provide premises for housing the equipment. The success of the broadband program undertaken by the South West Regional Authority has led the agency to seek its own telecom operator license and one of its main conclusions is "think about doing it for yourselves" and advises any interested partners to speak to them for more information.

III.4.3 Norway

1) eNorway Action Plan

Also in Norway, according to the eNorway Action Plan, the government's goal is that broadband is available on the market in all regions of Norway. Primary schools, public libraries and local authority administrative services shall be given the option of broadband connection at a competitive price during the course of 2005.

By the end of 2003, all colleges of secondary education shall also be offered an equivalent scheme[88]. A key priority of the government also will be to stimulate broadband rollout in Norwegian municipalities for use by local authorities. The public sector's extended use of broadband communication is supposed to significantly contribute to a well-functioning broadband services market, making the broadband services more available for small and medium-size enterprises, as well as consumers.[89]

2) Modalen Project, Norway

In Norway, the Modalen Project, which was started in 2000-2001 by a consortium of information technology companies in Modalen, Norway, provides Internet through broadband networks. Because the closest major city to Modalen is over an hour away, the project's intent was to provide every family, company, public department, organization, school and institution in the 400-person city access to broadband technology using the TV set as its user interface. As a result of the project, a May 2001 Gallup poll showed that Internet access on the job, at home and at school was higher in Modalen than in the rest of Norway, and Modalen residents were online more than the rest of Norway.[90]

III.4.4 Sweden

Sweden has a long and strong tradition in IT and Telecommunication. It was an early user and a leader in fibre optics in the end of 80:ies and beginning of the 90:ies very much depending on efforts made by Ericsson and Telia in cooperation with University Research. Sweden was early in using PC :s at home and has today one of the highest PC penetrations per capita in the world. In mobile communication Sweden was one of the early adopters together with the other Nordic countries and Ericsson together with Nokia from Finland are among the leading suppliers in mobile system and terminals. During the 90:ies the government took a number of steps to deregulate the market in telecommunication and Sweden is today one of the most deregulated countries in the world with the market supervised by the regulating authority PTS (Post och Telestyrelsen).

The situation in Sweden today is characterized by a fierce competition in the broadband marketplace, 20% of the private households have got broadband and the biggest operator is TeliaSonera with a market share of 42%. TeliaSonera uses dominantly DSL and has almost monopoly on the cupper access network but must by law offer it to its competitors. The second largest operator is Bredbandbolaget with 23% and the biggest FTTH network in Sweden. In the enterprise sector TeliaSonera, Song Network and Telenor are the major players. Sweden has more than 200 operators, the majority of them are owned by communities or their energy companies serving the local city region. The major access technologies are DSL (market share of 55%) and FTTH, (almost 20%, based on LAN and Ethernet technology). In connection with the government supported broadband program a separation exists between the role of being a network owner and a service provider i.e. an end user can choose between many different service providers and vice verse.

Sweden is on the threshold to introduce a multi service converged network offering Internet, telephony and TV, triple play, all based on IP. Some DSL operators include VoIP in their service package today and are

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88 See: www.odin.dep.no/archive/nhdvedlegg/01/03/eNorw040.pdf.

89 See: www.hoykom.net.

90 Norwegian Gallup Presentation, OECD workshop on broadband, December 5, 2001.

even discussing TV, the TV operators on the other hands that today offers normal TV and Internet access have started to implement VoIP over their coaxial network. FTTH access with triple play services is available for some small scale commercial operations.

Broadband access is in Sweden a cornerstone for implementing 24 h e-governance services, to be able to rationalize the health sector by e-health, to offer remote education and to strengthen the local democracy and access to local information.

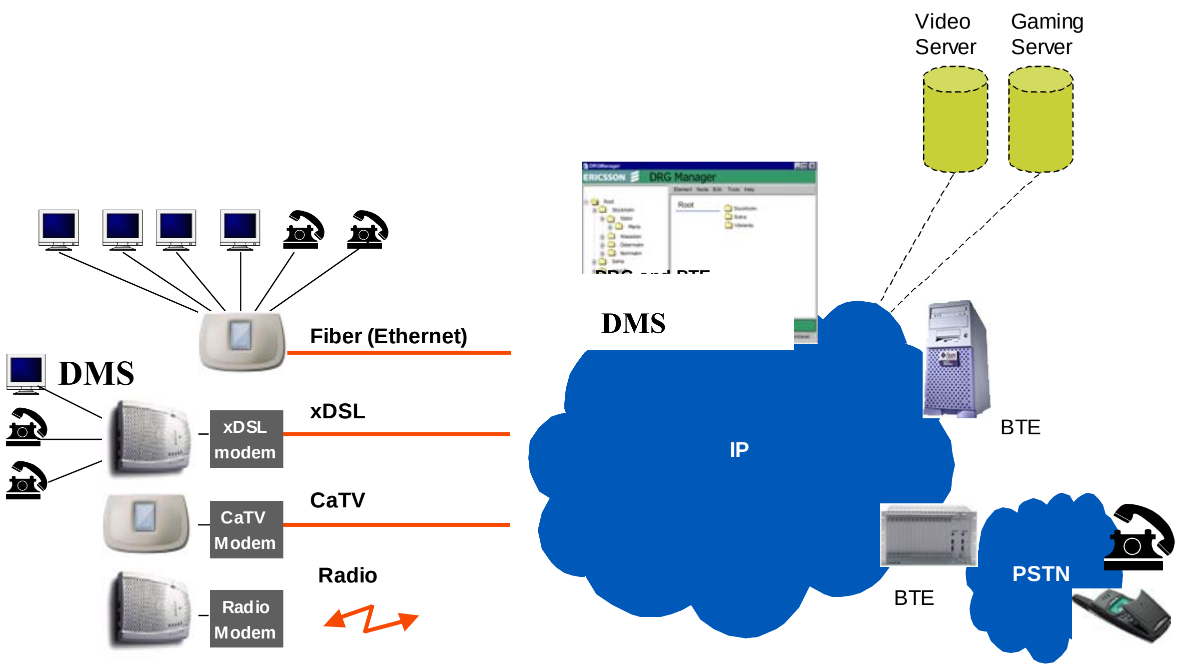
The introduction of triple play has opened up a market for companies developing IP based Set Top Boxes and Home Gateways as spin off from Ericsson and Telia research activities. As example 42 networks together with Ericsson developed an end-to-end broadband access solution for the connection of various types of subscriber equipment to the Internet.

The move to a broadband network based on IP that is a convergence between Internet, Telecommunication and Broadcasting creates of course a number of challenges for the research community. To verify the service and infrastructure requirements various testbeds with real end users have been implemented in Sweden. As example the research institute Acreo's national broadband testbed involves more than 15 vendors, more than 15 operators, more than 10 universities and a number of public authorities.

As an example of a broadband installation in the north of Stockholm Sollentuna Energy provides a network with more than 12 000 installed broadband access terminals. Examples of current services are: Internet (with 4 ISP:s), TV (up to 18 channels), movies (video on demand), Intranet for local information and broadband telephony.

Typical broadband access installations are based on a 42 Networks broadband access solution providing end-to-end quality, security, simplicity and management. Ericsson's end-to-end broadband solutions enable operators and service providers to build a base for Fast Internet, Video on demand, telephony (VoIP) and other broadband services. The portfolio consists of 3 parts: the Digital Residential Gateway (DRG), the Broadband Telephony Enabler (BTE) and Device Management System (DMS), as illustrated in Figure 1.

Figure 1 – 42 Networks Managed Broadband Telephony Solution



Digital Residential Gateway (DRG)

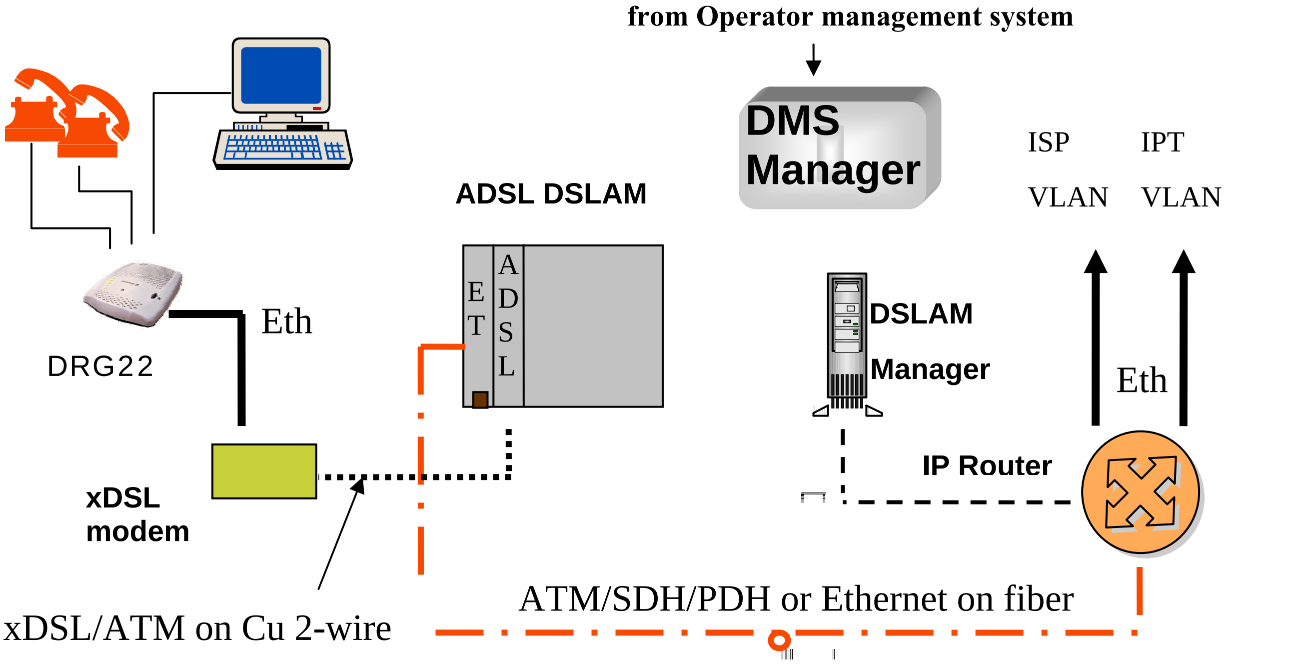
Digital Residential Gateway (DRG) units can be connected to the IP-network either with modems (e.g. for xDSL, CaTV or Radio transmission) or optical/electrical converters for single or multimode fibres (e.g. for Ethernet connection). DRG units allow end users to continue with their existing analog phones or fax machines, while calling with high quality over an IP-Network. To each telephony port up to 5 telephone sets can be connected in tandem. By connecting a set top box to one of the Ethernet ports e.g. Video on Demand can be delivered simultaneously with telephony and fast Internet. The ports also give the end user possibility of connecting several computers and printers to the unit. DRG units with built-in optical/electrical converters allow fibre To The Home/SoHo installations.

For various applications a number of different DRG versions of plug-and-play units have been developed with up to four Ethernet ports and two telephone ports suitable for the connection with Unshielded Twisted Pairs (up to 100 m) or multimode fibres (up to 2 000 m) or single mode fibres (up to 15 000 m).

The DRG Element Manager enables an operator or service provider to manage and configure up to 200 000 installed DRG units remotely. An operator can set parameters regarding e.g. VLAN, IP-telephony and packet filter using SNMPv1 messages as well as initiate remote software updates.

The residential network in Figure 2 is connected across copper wire to a Digital Subscriber Line Access Multiplexer (DSLAM) using an Ethernet connection between the xDSL modem and the DRG22 unit. The Exchange terminal (ET) signals are transmitted on a fibre net to the IP router and Virtual LAN. The operators management system controls the DRG and DSLAM managers to secure end-to–end management.

Figure 2 – Example of DRG implementation



The Broadband Telephone Enabler (BTE) is the central component in an end-to-end VoIP solution, consisting of a carrier class Gatekeeper, Gateway and Element Manager. The solution is based on the most common standards today. Some of the outstanding facilities are scalability, capacity, redundancy and range of services.

A number of Ericsson/42 Networks solutions can be integrated with the end-to-en VoIP solution product portfolio, including Public Ethernet equipment, active and passive equipment for fibre networks and Ethernet xDSL Access solutions.

The DRG and BTE Systems together with the DRG/BTE Element Managers are one of the few solutions for broadband telephony and services on the market focusing on the network aspects to achieve a high level of security, high quality of service (QoS) and a business case based on remote management and software updates of the Customer Premises Equipment (CPE).

III.4.5 Israel: 802.16 Deployment in Rural Areas

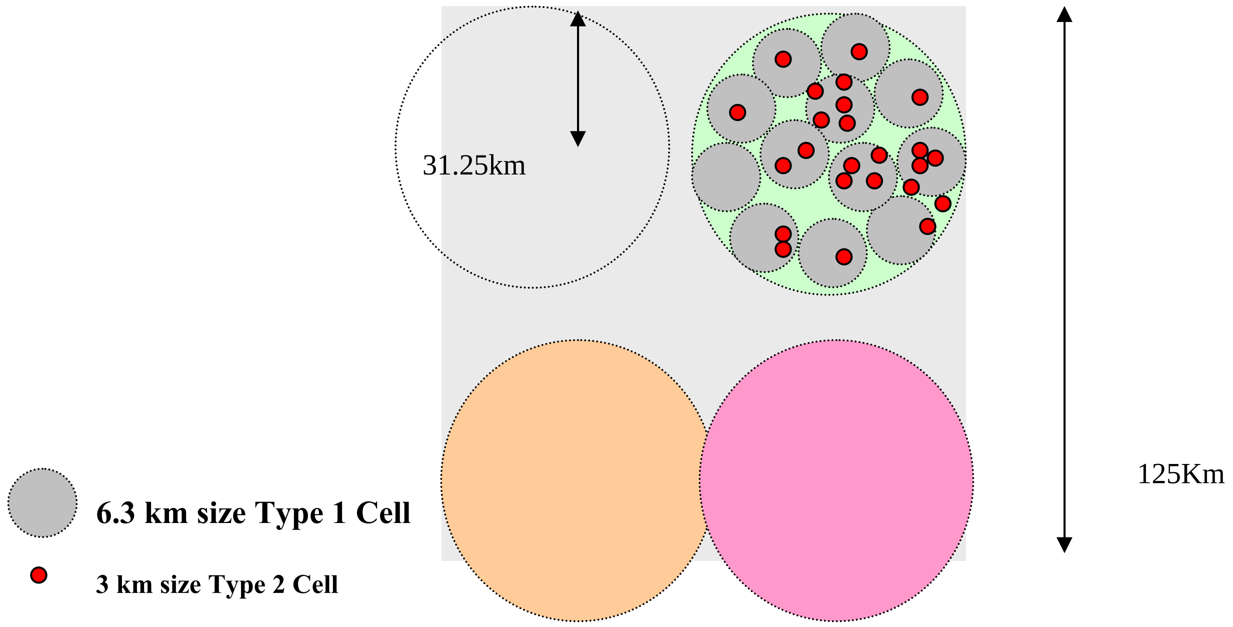
IEEE 802.16a is a high capacity standard utilizing OFDM/OFDMA technology on both the Upstream/return and Downstream/forward, with the potential of delivery of a high aggregated data rate in excess of 18 Mbit/s on a channel of 8 MHz bandwidth (average of 2.2 bit/(s*Hz)). Compared to known advanced generation system in stationary applications (2 Mbit/s), IEEE 802.16a has tenfold capacity which can be shared by a large community of users, spread over a wide geographical area, ideally used in rural areas or in highly populated areas.

The system is a highly adaptive system, employing different modulation schemes (nQAMs) and error correction codes (Viterbi, RS and Turbo Codes) with different coding rates. Dynamic resource allocation ensures optimal allocation of the required bandwidth, which fits current user application. The system can support a wide range of telecommunication applications, such as fast internet, video conferencing, VoIP, e-commerce, VoD, etc. The following contribution describes a typical multi-phase deployment of the infra-structure for developing countries, where the laid down infrastructure – of Base Stations (BS) and networking among Base Stations– is optimised to keep infrastructure cost to a minimum level, while supplying IP telephony and reliable Internet services. In addition, the design is modular and scalable in order to allow multiplication of the deployment to additional areas without resorting to any changes, on the system level design and/or the frequency planning.

Basic assumptions for rural deployment:

- Deployment in a typical rural area in low populated where 100-200 people live per sq. km (20-40 households), a penetration rate of 80%, and 25% of the subscribers (households) are active in the same time (4-8 households per sq. km).
- Suppose that the total area of coverage extends over 125 km by 125 km divided into four 62.5 km radius areas. Initial launch will start in one of the four areas.
- The Infrastructure should support an initial launch for 31 250 active households (in two phases).
- The Infrastructure should be scalable to support up to 125 000 households in the four regions. Data rate allocated for each household is 128 kbit/s.
- In Phase-1, 15 625 households in one area will be serviced by 31 Base Stations (providing full telecom-munication services); each deployed in a cell of 6.3 km radius. Four channels in the 2.4-2.6 GHz band (each 8 MHz bandwidth) will be needed for the Downlink, and an additional 4 channels (8 MHz each) on the Uplink.
- In Phase-2, Additional Base Stations will be deployed in the same region to extend services to additional 15 625 households and to support full symmetric services, within certain parts of the coverage area; each one of them will cover a 3 km radius.
- The CPE (Customer Premises Equipment) supplied to subscribers will have to use out-door directional antenna;
- A minimum data rate between 128 kbit/s will be committed at peak hours;
- An average data rate between 160 to 425 kbit/s will be delivered at off-peak hours;
- Up to 18 Mbit/s burst peak rate will be achieved in some CPE’s.

Figure 3 – Typical deployment in rural and sub-urban areas



System Description

The deployment is designed to start with one out of four areas, assume a gradual growth of subscribers community, starting with the initial launch of 15 625, followed by successive deployments of Base Stations, to cope with the increase of the number of subscribers (Households), where more than one user is expected in some percentage of households.

The area is divided into four large regions with comparable area size. The area spans an area of 125 × 125 km, which when divided into four regions we get a region extending to a radius of 31.25 km.

System Deployment considerations

Optimal design – to achieve a full coverage of one of the areas and keep number of the Base Station to a minimum – is based on cellular approach where the Base Stations are installed in cells of 6.3 km radius. Total number of Base Stations needed to achieve full coverage of one area serving 31 250 users is 62 BSs (assuming 25% active households in the same time).

Each Base station is comprised of two parts from the spectrum partition and services provided point of view as described below:

Part 1 – The first deployment of Base Stations in one of the four areas will target 15 650 households. The aggregated data rate achievable on DL or UL is 64 Mbit/s, which is shared among 500 subscribers (households). Total number of subscribers with the deployment of 31 BSs can reach 15 625 households.

Part 2 – A second phase of BSs deployment will be followed to extend system capacity for the delivery of symmetric services to additional subscribers in the same region. The second tier of BSs will be based on same type of Base Station. Each BS is deployed in a denser network of cells, each 3 km radius. Deployment of additional BSs, within the larger cells of 6.3 km radius will also support delivery of 64 Mbit/s/Base Station.

Assuming average simultaneous usage of 25%, a data rate of 128 kbit/s can be committed, subscribers with favourable link budget will be able to enjoy data rates 2.5 times faster, and by utilizing statistical multiplexing techniques the factor can grow to 20 times faster.

Design Consideration

- Frequency band: 2.4-2.6 GHz
- BST transmit power: 37 dBm
- BST Tx, Rx Antenna gain: 16 dBi
- CPE Transmit power: 23 dBm
- CPE Tx, Rx Antenna gain: 18 dB
- UL, DL propagation model: near LOS
- DL, UL aggregated data rate: 18 Mbit/s
- No diversity is attempted on BS or CPE

Economical Aspect

BWA system based on IEEE 802.16a has a potential for deployment in rural or underserved areas, for delivery of a wide range of telecommunication services. An initial investment of less than 350 USD/household will be required for the supply of CPE`s and deploying infrastructure for the first 31 250 subscribers in one area (rural, suburban), the Return on Investment (ROI) is estimated to be less than 2 years. This calculation does not take into account expenses such as: spectrum license cost, and the cost of the equipment needed to supply the services such as routers, gateways, switches and intra-cell networking equipment.

III.5 Asia Pacific

III.5.1 Niue: Wi-Fi in Niue, South Pacific

The South Pacific island of Niue is about 100 square miles, has 1 750 residents, and its economy suffers from the typical Pacific island problems of geographic isolation, few resources, and a small population. Tourism is an import source of revenue and until recently, has declined severely. Additionally, the island in recent years has suffered a serious loss of population because of its economic downturn. In an effort to revive its tourism, economy, and population the tiny island of Niue has launched the world's first nationwide WiFi Internet access service. After introducing free email service to Niue in 1997, The Internet Users Society of Niue launched free Internet access service for the island in 1999. The group was initially set up to fund the high cost of satellite-based Internet connections on the remote island. However, WiFi was chosen as a better fit for the island, where harsh weather conditions of rain, lightning, salt water, and high humidity causes major problems with satellite and underground copper lines. The Internet Users Society of Niue built a comprehensive network that includes solar-powered repeaters in coconut trees to give everyone on the island and its visitors' open and free Internet access. Full Internet access from all parts of the island was an important aspect of the tourist revival scheme. A substantial portion of Niue's tourism comes from visiting yacht traffic during the non-cyclone season. The vast wireless coverage created an even more attractive proposition for visitors. Yachts with onboard computer equipment are able to park in the harbour and access full Internet services from their vessels, free of charge. In addition, consultants and other visitors who carry laptops with WiFi capabilities are also able to connect. Through wireless broadband connectivity, Niue has become an extremely diverse communications technology home, and in turn, the island has been able to attract and generate more tourism and investment.

ANNEX I

Definition of the Question

Question 20-1/2 – Examination of access technologies for broadband communications

This study should include an economic analysis of the factors affecting the deployment of various broadband access-technologies. The study should also include an examination of the benefits of using broadband technologies taking into account the gender perspective.

1 Statement of problem or situation

During the Study Period 1998-2002, Study Group 2 Question 12-1/2 analysed broadband communications over traditional copper wire, or digital subscriber line (DSLN), principally because of its ability to leverage existing investments made by telecommunication administrations. Given the rapid advancement of telecommunications technologies since 1998, other broadband access technologies, wired and wireless, have become available that provide similar or improved performance to DSL. Broadband technologies permit the deployment of applications, such as e-health, distance learning, e-government, tele-working, public safety, national security, Internet access, and intranet access.

The ITU-D can play a role in assisting Member States and Sector Members in understanding the appropriateness of different technologies available for broadband access communications. The ITU-D can also assist Member States and Sector Members in analyzing the economic issues involved in deploying broadband access technologies, including the integration of these access network solutions with existing or future network infrastructure.

2 Question or issue proposed for study

Identify the technical, economic, and development factors influencing the effective deployment of broadband access technologies and applications.

3 Specification of the expected output

A report, incorporating the results of Question 12-1/2, should be published by early 2004, followed by regular updates.

Analysis of the economic, technical and development factors influencing the effective deployment of broadband access technologies. This will also include an assessment of the demands for these technologies and services in developing countries with reflection to gender issues.

A matrix of different broadband access technologies and their attributes.

4 Required timing of the expected output

The course of the next ITU-D study period.

5 "Proposers/Sponsors"

Developed and developing countries.

6 Input required in carrying out the study

1) Collection of related contributions and data from ITU-D Member States, Sector Members and Associates, and those organizations and groups listed below in Part 9 of this document.
2) Examination of ITU-T and ITU-R study group Questions related to this issue.
3) Discussion of the relevant ITU-D study groups.

7 Target audience for the output

a)

	Developed countries	Developing countries	LDCs
Telecom policy-makers	Y	Y	Y
Telecom regulators	Y	Y	Y
Service providers	Y	Y	Y
Manufacturers	Y	Y	Y

b) Target audience – Who specifically will use the output?

Users of the output will be manufacturers, operators, regulatory agencies and service providers worldwide, including those in developing countries and LDCs.

8 Proposed method of handling this question/issue

It is proposed that this Question be handled within a **study group**.

9 Coordination requirements of the study

The ITU-D Rapporteur's Group dealing with this question should coordinate closely with:

- the relevant study groups in ITU-T and ITU-R;
- other International and Regional Organizations, as appropriate.

ANNEX II

Analysis of the replies to the questionnaire

Action required

Participants are invited to send their comments to BDT Secretariat **by January 2004 at the latest**. After inclusion of the comments received, the analysis will be finalised and put on the Study Group Web site.

Action demandée

Les participants sont invités à envoyer leurs commentaires au Secrétariat du BDT **au plus tard à la fin du mois de janvier 2004**. Après l'insertion des commentaires reçus, l'analyse sera définitivement mise au point et affichée sur le site web de la Commission d'études.

Acción requerida

Se invita a los participantes a que envíen sus comentarios a la Secretaría de la BDT **en enero de 2004 a más tardar**. Una vez incluidos los comentarios que se reciban se hará el correspondiente análisis, que se comunicará en el sitio web de la Comisión de Estudio.

Abstract

The contribution is the draft analysis of the replies to the Questionnaire sent on broadband communications. It has been prepared by a BDT external expert[91].

CONTENTS OF ANNEX II

List of Tables

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91 Mr. Phillip Trotter, tel: +33450201703, e-mail: PhillipTrotter@handprint.ch

List of Figures

Introduction

In March, 2003, a questionnaire was distributed by ITU-D circular letter CA/25 following the Rapporteur's Group meeting for Question 20/2: Examination of access technologies for broadband communications questionnaire on march 3rd 2003 (see appendix of Annex 2). The questionnaire requested Member States, Sector Members, relevant organizations and industry to identify relevant wireless and wireline broadband access technologies and their attributes. The questionnaire also aimed to identify economic, technical and development factors influencing the effective deployment and accessibility of broadband access technologies and applications. This report represents the summarized results of the responses received by the ITU by June 2003.

By mid June 2003 fifty-five responses were received from forty-nine countries from the five ITU regions. Table 1, below gives a list of countries and indicates using parenthesis which countries responded with more than once.

Table 1 – Respondent Countries

Africa	Americas	Asia-Pacific	Arab States	Europe
Chad	Barbados	Israel (2)	Egypt	Armenia
Côte d'Ivoire (2)	Bolivia	Japan (2)	United Arab Emirates	Belarus
Ethiopia	Brazil	Korea (Rep.)		Belgium
Malawi	Canada	Maldives		Bosnia
Mauritius	Chile	Myanmar		Bulgaria
Nigeria	Costa Rica	Nepal		Denmark
South Africa	Dominican Rep.	Pakistan		Estonia
Uganda	Ecuador	Philippines (3)		Hungary
	Guyana	Sri Lanka		Lithuania
	Honduras	Thailand		Malta
	Mexico	Tonga		Norway
		China		Poland
		India		Portugal
				Spain
				Switzerland (2)

Methodology

In terms of workflow, MySql Server was used as a data repository for questionnaire responses and ToolMagic's MySQL Tools along with Microsoft Access were used to extract and summarise data with Microsoft Excel being used for graph generation and numeric analysis and the final report written in Microsoft Word.

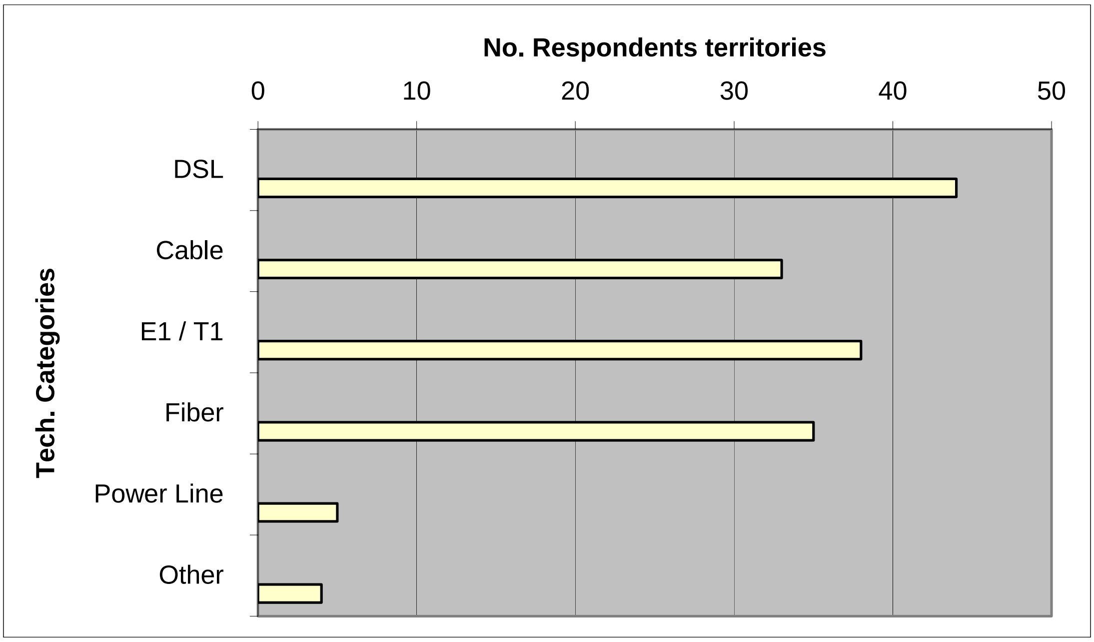
This report follows the overall structure of the questionnaire and summarises the findings as reported by questionnaire respondents. For the purpose of this report where more than one response for a member state was received, the data was merged during data analysis for the given territory where appropriate or in the case of conflicting information, data supplied with verifiable cited data sources, was selected. As a result, for the purpose of this report, the term respondent is used to indicate the information provided by a responding territory, rather than the individual responding organization.

Where provided data seemingly in response to ambiguity or misinterpretation of a given question is noted in the report text in order to facilitate discussion during the relevant Study Group meeting.

Technology

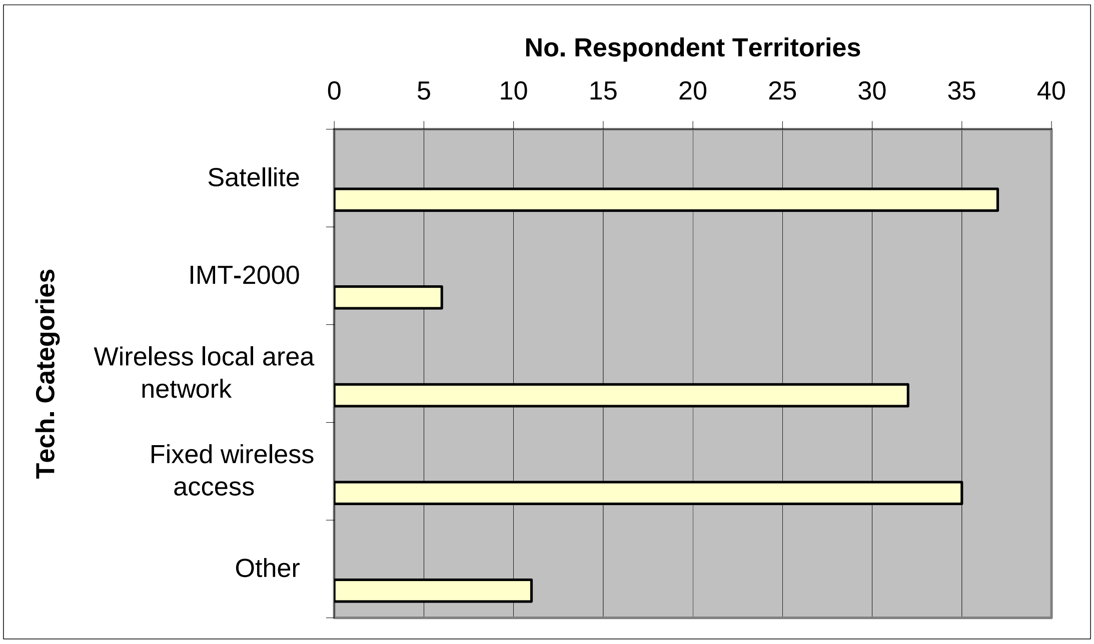
The technology section of the questionnaire aimed to discover which broadband technologies are in use to deliver broadband-based services. As can be clearly seen from Figure 1 below, the current dominant technology for delivering broadband services over wire line networks is DSL, closely followed by more traditional E1/T1 (E1 interface provides a 2 048 kbit/s access rate, T1 interface provides a 1 544 kbit/s access rate, see also ITU-T Recommendations G.703 and G.704 Interface for WAN analysis), fibre and cable connections.

Figure 1 – Wireline Technologies utilized to provide broadband services



Wireless technologies are widely used to deliver broadband services in developing countries with satellite, fixed wireless and wireless local area networks are used to overcome barriers where wireline solutions are inappropriate, as indicated in Figure 2 below:

Figure 2 – Wireless technologies utilized to provide broadband services



A number of countries employed technology solutions other than DSL, Cable, E1/T1, fibre and power line for wireline based solutions to deliver broadband services. Other technologies used in delivering wireline solutions included ISDN, ATM.

For alternates to the main wireless technologies of satellite, IMT-2000 or wireless LAN some respondents were using developments such as laser free space optics used in both South Africa and Canada, general packet radio service (GPRS) in Estonia and spread spectrum solutions in Ecuador. Table 2, provides a summary of the other technologies reported by questionnaire respondents:

Table 2 – Other technologies employed by respondent countries to deliver broadband service

Country	WIRELESS_OTHER_DESC
Armenia	802.11b Radio Ethernet
Belarus	GPRS, IMT-MC-450
Bolivia	MMDS (Multipoint multi-channel distribution systems), LMDS (local multipoint distribution systems)
Brazil	Multipoint multi-channel distribution systems (MMDS) are currently used and local multipoint distribution systems are in network roll out focused on the delivery of broadband services.
Canada	Optional Free Space (Laser), used by companies in some urban centres.
Ecuador	Spread Spectrum (A communication technique that spreads a signal bandwidth over a wide range of frequencies for transmission and then de-spreads it to the original data bandwidth at the receiver.)
Estonia	GPRS
Ethiopia	Fibre based access in Addis Ababa and major Cities
Korea (Rep.)	CDMA 1X (according to our, Korean, definition, it belongs to 2.5G and not to 3G IMT-2000)
South Africa	Free Space Optics (Laser)
Sri Lanka	Point to point Microware

Competition

The competition section of the questionnaire aimed to assess the degree of competition for Internet services, in local loop provision, among different broadband technologies and how many operators offer high speed internet, DSL, cable, wireless, etc.

Of the respondent countries only four countries did not permit competition in Internet services, namely:

Ethiopia, Costa Rica, the Philippines and the United Arab Emirates.

As shown in Table 3, twenty-eight of the respondent countries have competition in the local loop.

Table 3 – Respondent countries with competition in local loop

• Chad	• Japan
• Nigeria	• Korea (Rep.)
• South Africa	• Myanmar
• Uganda	• Sri Lanka
• Bolivia	• Thailand
• Brazil	• Tonga
• Canada	• Belgium
• Chile	• Bulgaria
• Dominican Rep.	• Denmark
• Ecuador	• Malta
• Guyana	• Norway
• Mexico	• Portugal
• China	• Spain
• India	• Switzerland

While as shown in Table 4, the following twenty one countries do not:

Table 4 – Respondent countries without competition in the local loop

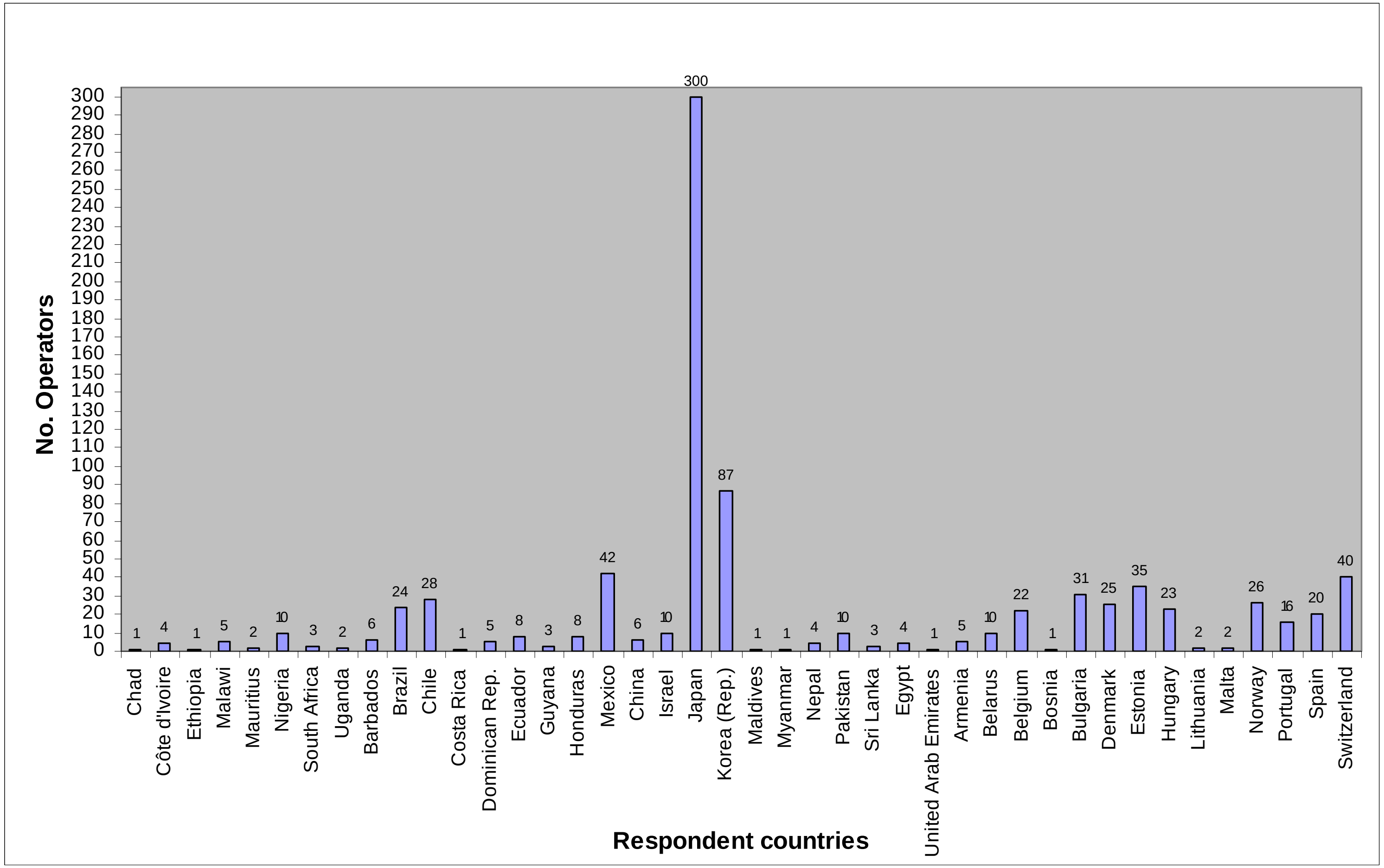
• Côte d'Ivoire	• Philippines
• Ethiopia	• Egypt
• Malawi	• United Arab Emirates
• Mauritius	• Armenia
• Barbados	• Belarus
• Costa Rica	• Bosnia
• Honduras	• Estonia
• Israel	• Hungary
• Maldives	• Lithuania
• Nepal	• Poland
• Pakistan	

Thirty-nine of the respondent territories have competition between different broadband technologies with only the following ten respondent countries having no competition:

• Ethiopia	• Maldives
• Malawi	• Nepal
• Barbados	• Philippines
• Costa Rica	• United Arab Emirates
• India	• Bosnia

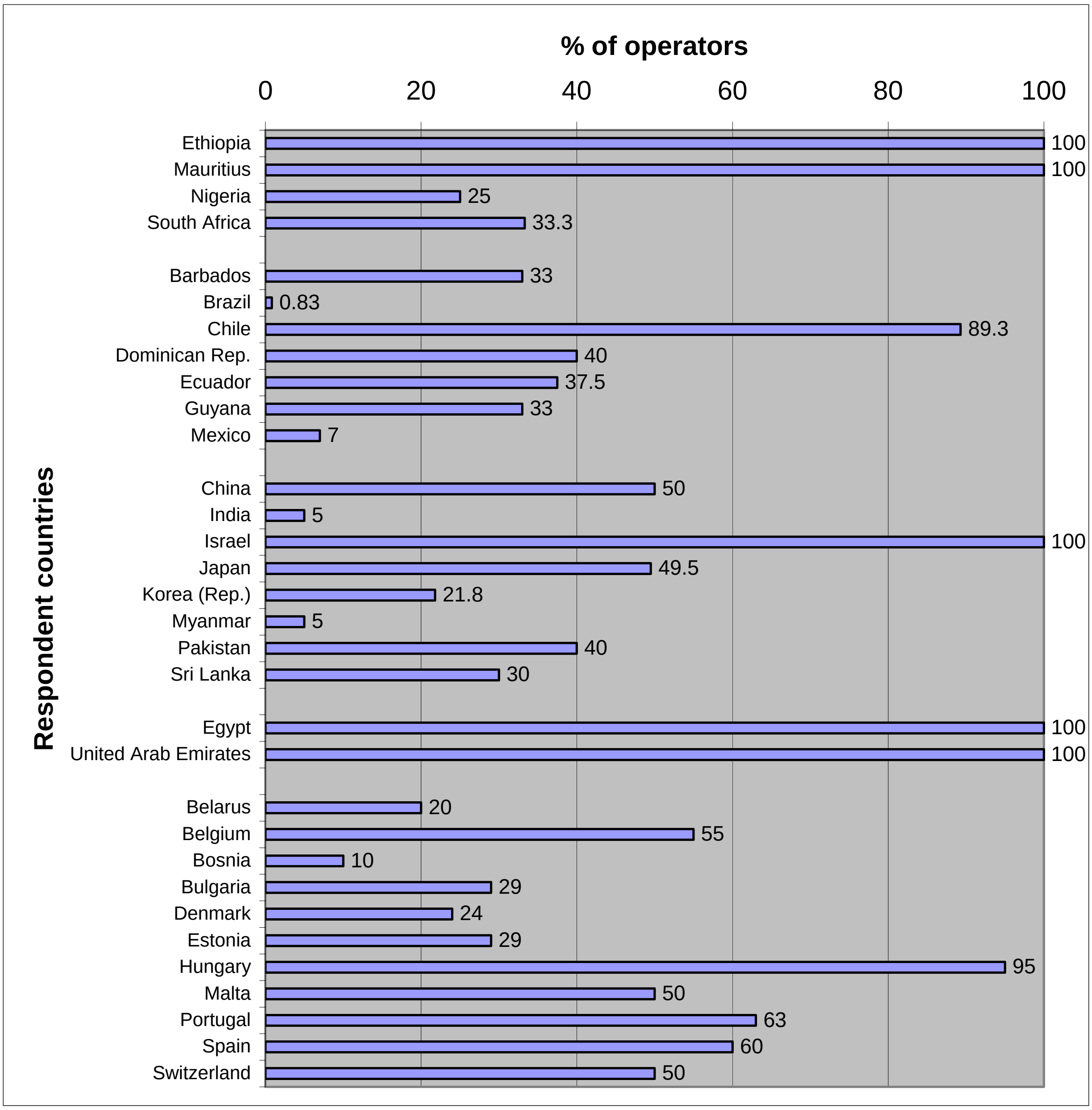
The following (Figure. 3) graph shows the number of operators offering high speed Internet:

Figure 3 – No. Operators offering high speed internet services



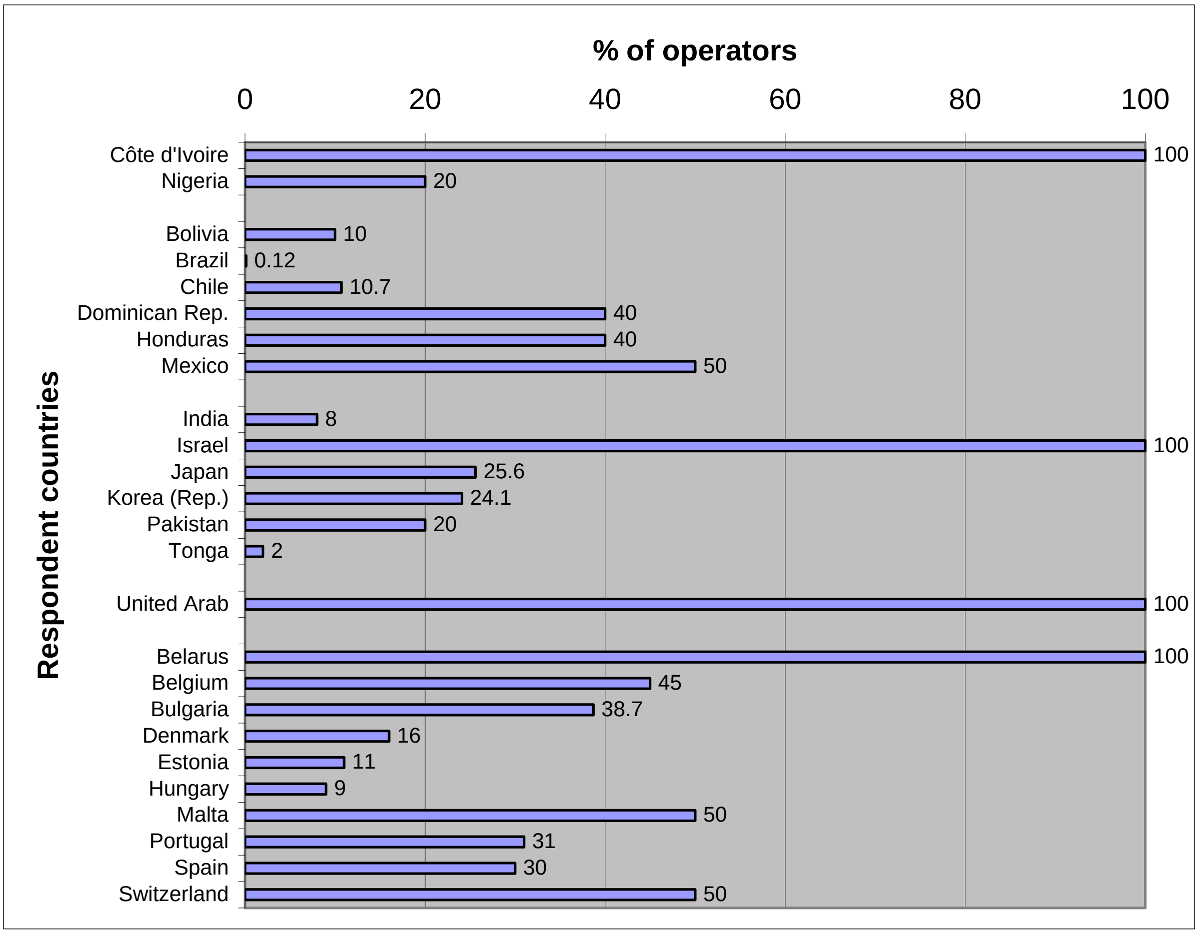
The following set of graphs shows the percentage of operators offering DSL, cable modem and wireless broadband-based services.

Figure 4 – Percentage of Operators offering DSL connections[92]



92 In the case of Ethiopia – there is only one ISP – ETC. there is no competition in the provision of Internet services and since ETC offers DSL and HDSL, the resultant percentage of operators offering DSL is 100%. It should be noted that this figure does not imply coverage or 100% of access to DSL based services.

Figure 5 – Percentage of operators offering cable connections

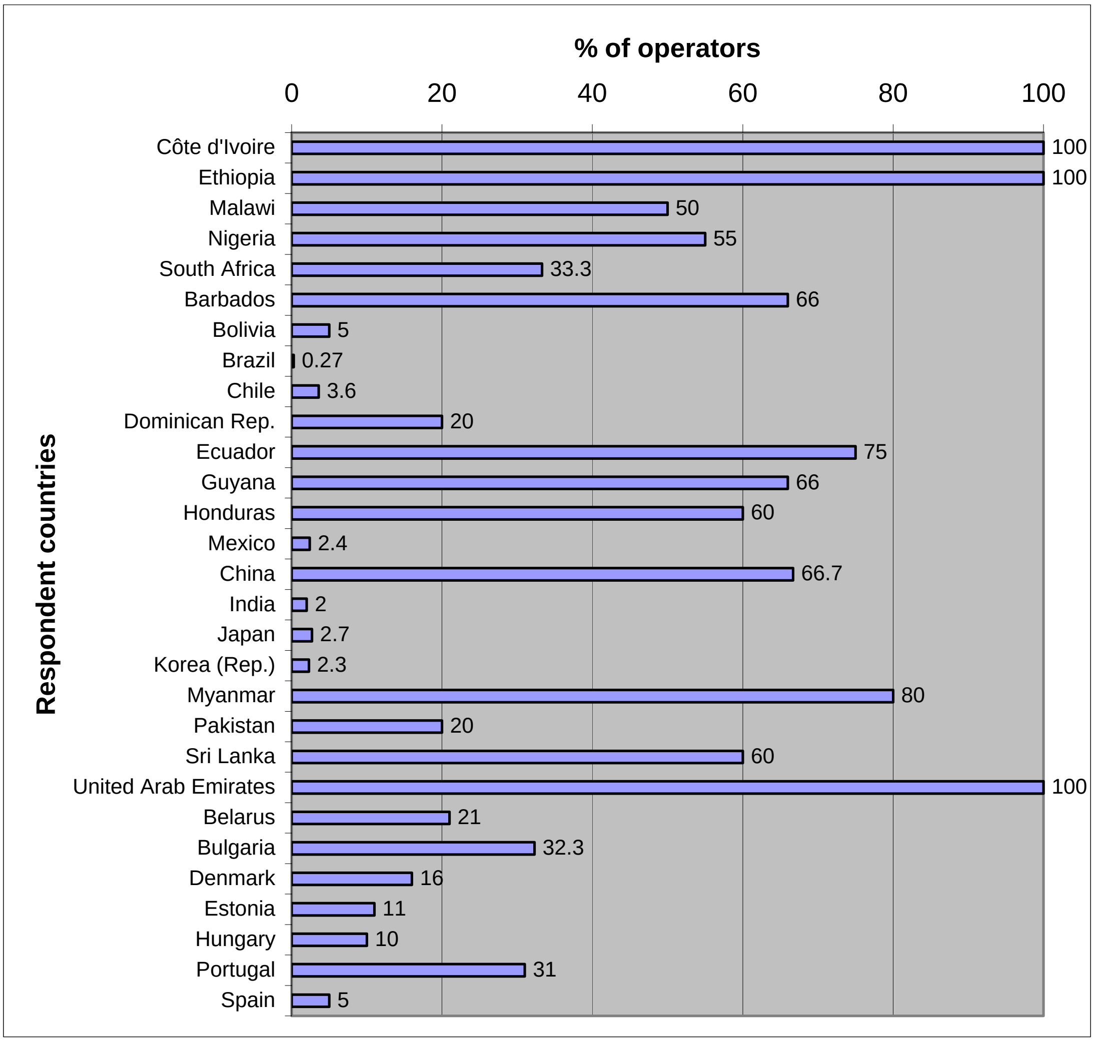


NOTE – Brazil's response of 0.12% does not show on the scale used for this document.

On analysis of the responses received it became apparent that there might have been some confusion on in the responses for the number of operators offering cable-based services. A number of respondents reported that cable technologies were not used in their countries to deliver broadband services but did indicate that a percentage of operators offered cable based services. As a result of this seeming contradiction those companies that indicated that cable technologies were not used, have not been included in the above (Figure 5) graph.[93]

[93] This is the case for Ethiopia and Egypt. In the case Cote d'Ivoire it is not apparent if all operators offer cable services; Africa Online offer cable services to businesses while AfNet offer fixed line services – the figure for Cote d'Ivoire awaits further confirmation.

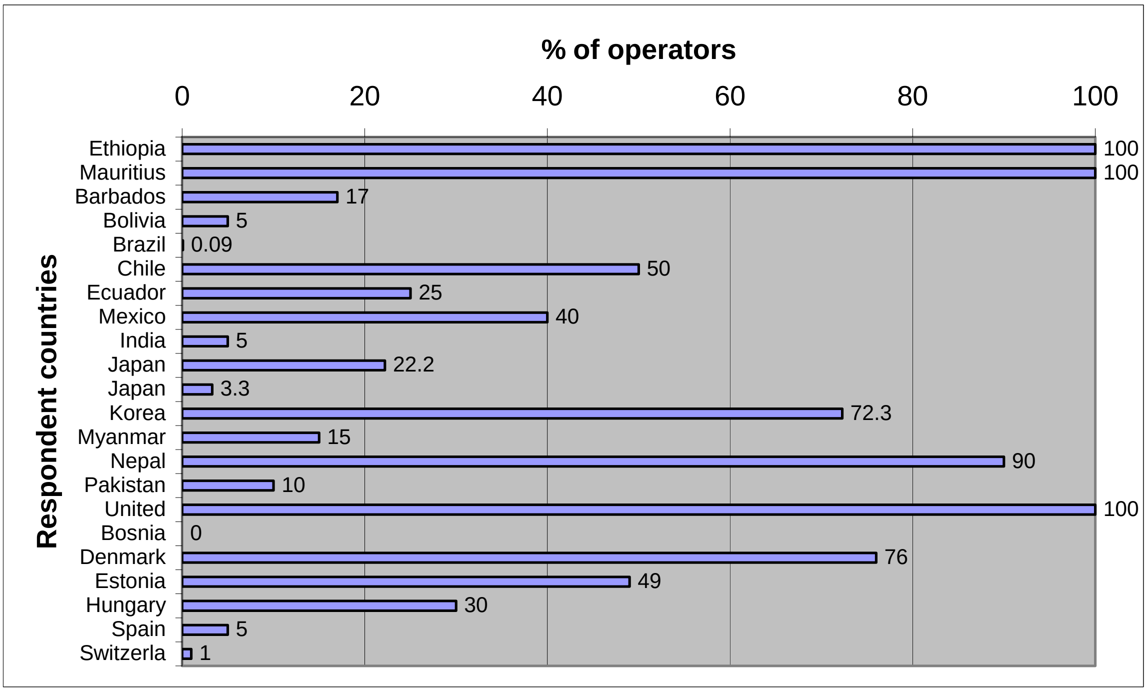
Figure 6a – Percentage of operators offering wireless connections



The percentage of operators offering other broadband access technologies such satellite, GPSR and optic fibre based networks, is shown in the following graph.[94]

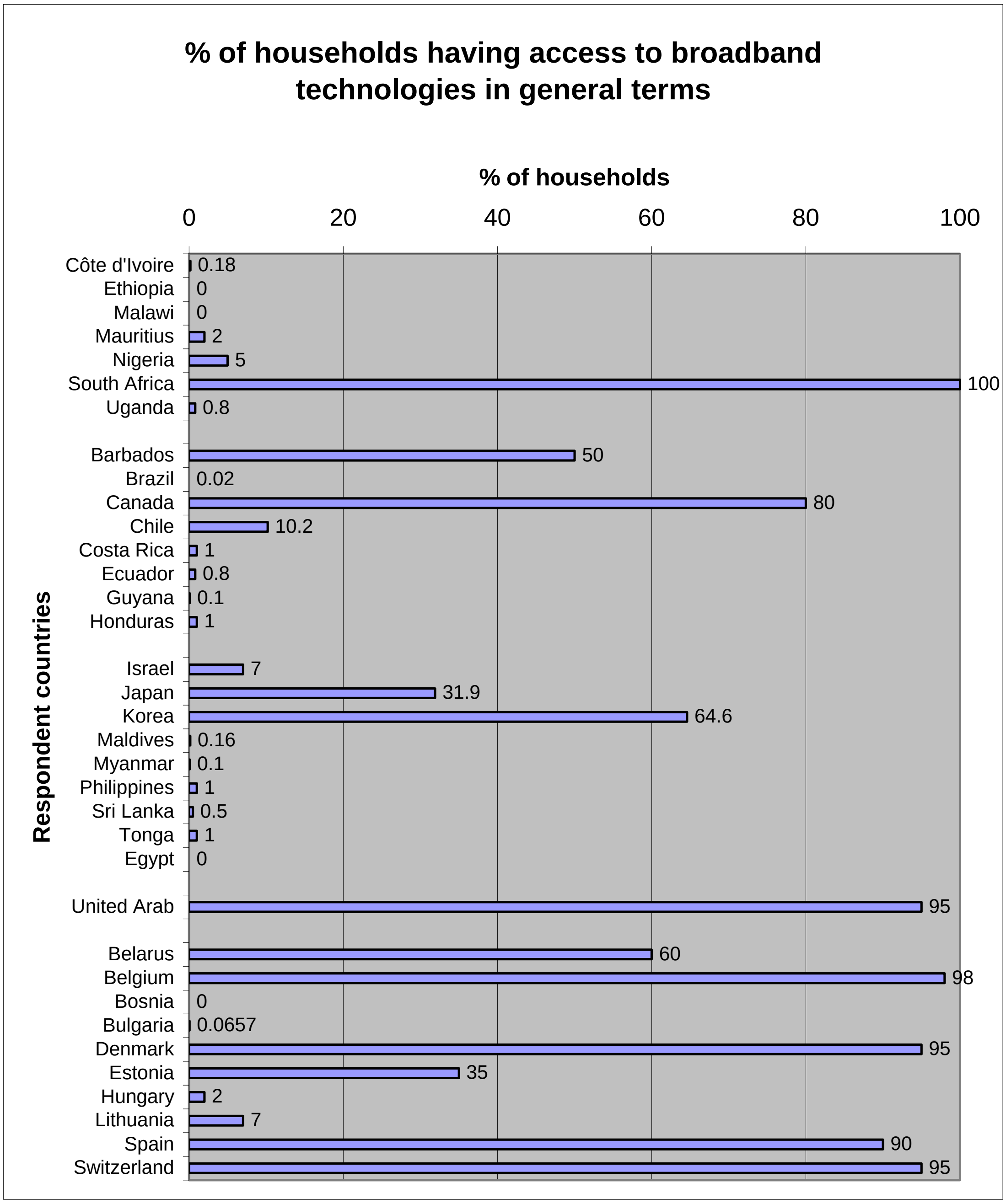
94 In the case of Ethiopia – there is only one ISP – ETC. there is no competition in the provision of Internet services and since ETC offers DSL and HDSL, the resultant percentage of operators offering DSL is 100%. It should be noted that this figure does not imply coverage or 100% of access to DSL based services.

Figure 6b – Percentage of operators offering other broadband connection technologies



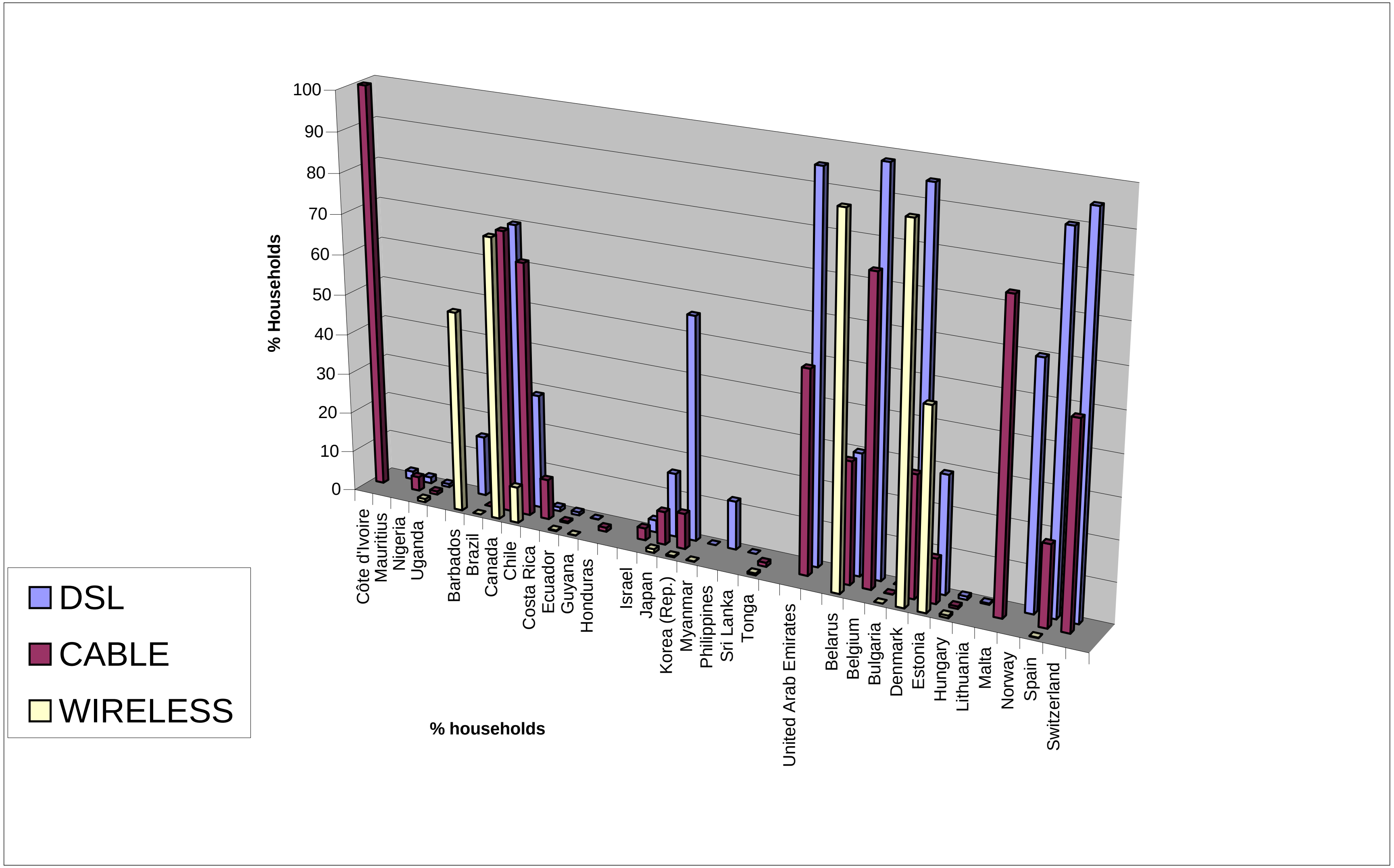
Access

The Access section of the questionnaire sought data on the percentage of access to broadband technologies by households and businesses and rural telephone subscribers and whether or not gender barriers existed to accessing services delivered with these technologies. The situation in regard to accessing broadband technologies was well illustrated by respondents when considering the overall percentage of households that have general access. The following graph shows highlights the differences in access that exists between countries.



However, the graph itself maybe misleading since the original question was possibly misinterpreted by some respondents. The question was interpreted by some respondents as meaning the percentage of households having general access to broadband i.e. via home, public access point (school, post office etc) or commercial point (cyber-café or telecentres) leading to figures such as 100% for South Africa or 95% for Switzerland. Other respondents interpreted the question as the number of individual households that have access (i.e. in the home) to broadband technologies. This was echoed in the figure of 10% for Switzerland supplied by the respondent from OFCOM. For the purpose of this document, the wider interpretation of the question was used (and hence in the case of Switzerland, the data supplied by SwissCom was used rather than that supplied by OFCOM), with this caveat attached that original question may have been misinterpreted by respondents and the data may not best represent the access situation in some countries

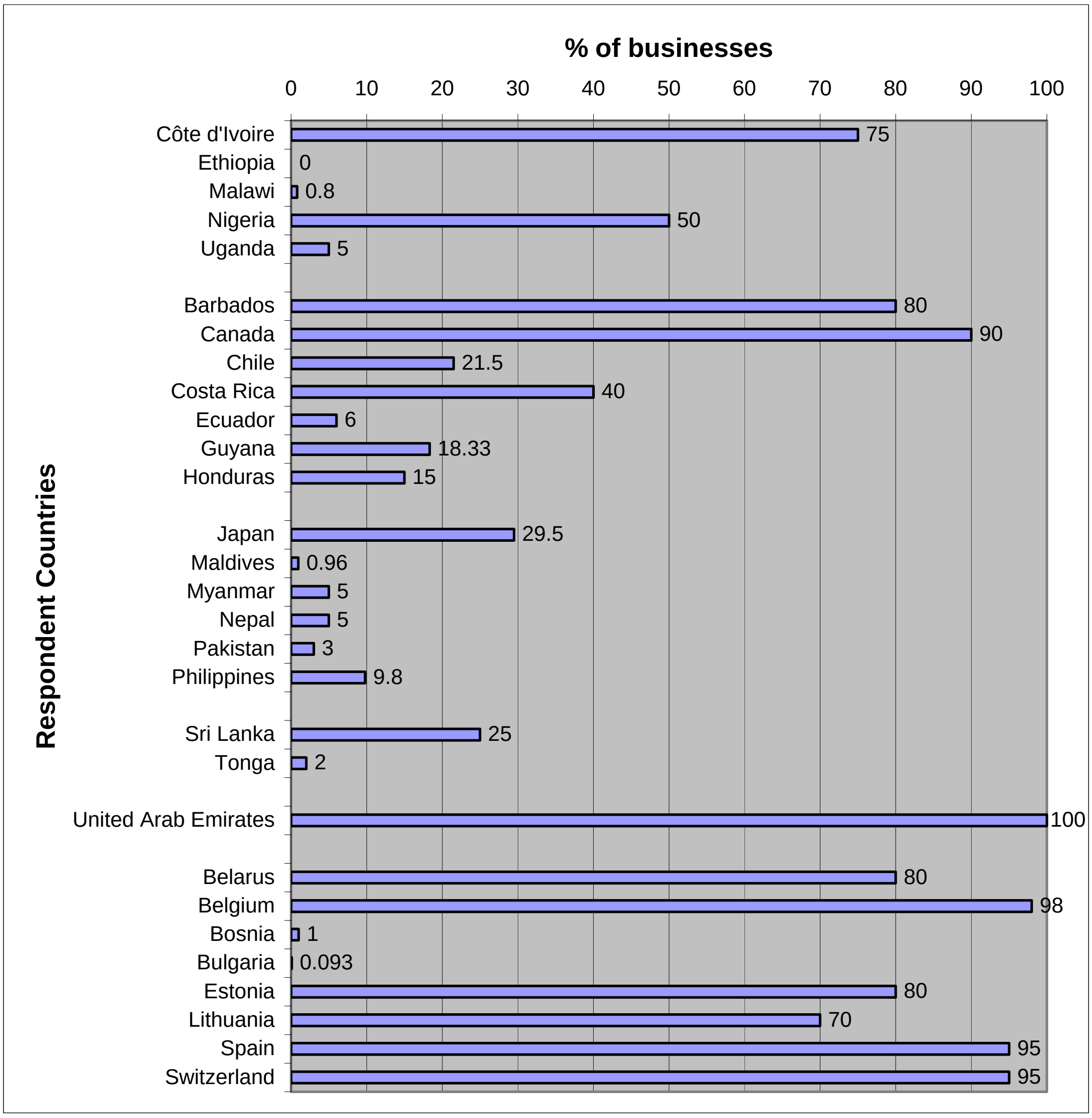
Figure 7 – Percentage of households with access to DSL, Cable and Wireless



The situation shown in the previous graph depicting the percentage of households with access to DSL, cable or wireless technologies reinforces the access situation to broadband-based services. Many of the countries shown have only a fraction of 1 per cent of the households in the country with access to one or another of the three main broadband technologies. Some other countries – primarily developed ones, are well served with access via DSL, cable or wireless – or in some cases where local technology competition exists, the option to select between which technology best meets current need.

Business applications are one of the main drivers of adoption of broadband services. The following graph (figure 8) indicates the percentage of businesses in respondent countries that have access to some form of broadband technology.

Figure 8 – Percentage of businesses with access to broadband technologies



Business access to individual broadband technologies, illustrated by the following graph, echoes this structure and illustrates the larger role of wireless access for businesses in comparison with the household based access. Meanwhile the rural telephone subscribers access to broadband-based services graph, illustrates the differential in access problems facing developing and developed countries. As the graph clearly shows, in countries such as Chile, Ecuador, Myanmar, Sri Lanka and Tonga only a minute fraction of the rural population has access to broadband technologies. A number of countries including Côte d'Ivoire, Malawi, Nigeria, South Africa, Honduras, Bosnia and Hungary stated that **no** rural telephone subscribers had access to broadband technologies.

Figure 9 – Percentage of businesses with access to DSL, Cable or Wireless technologies

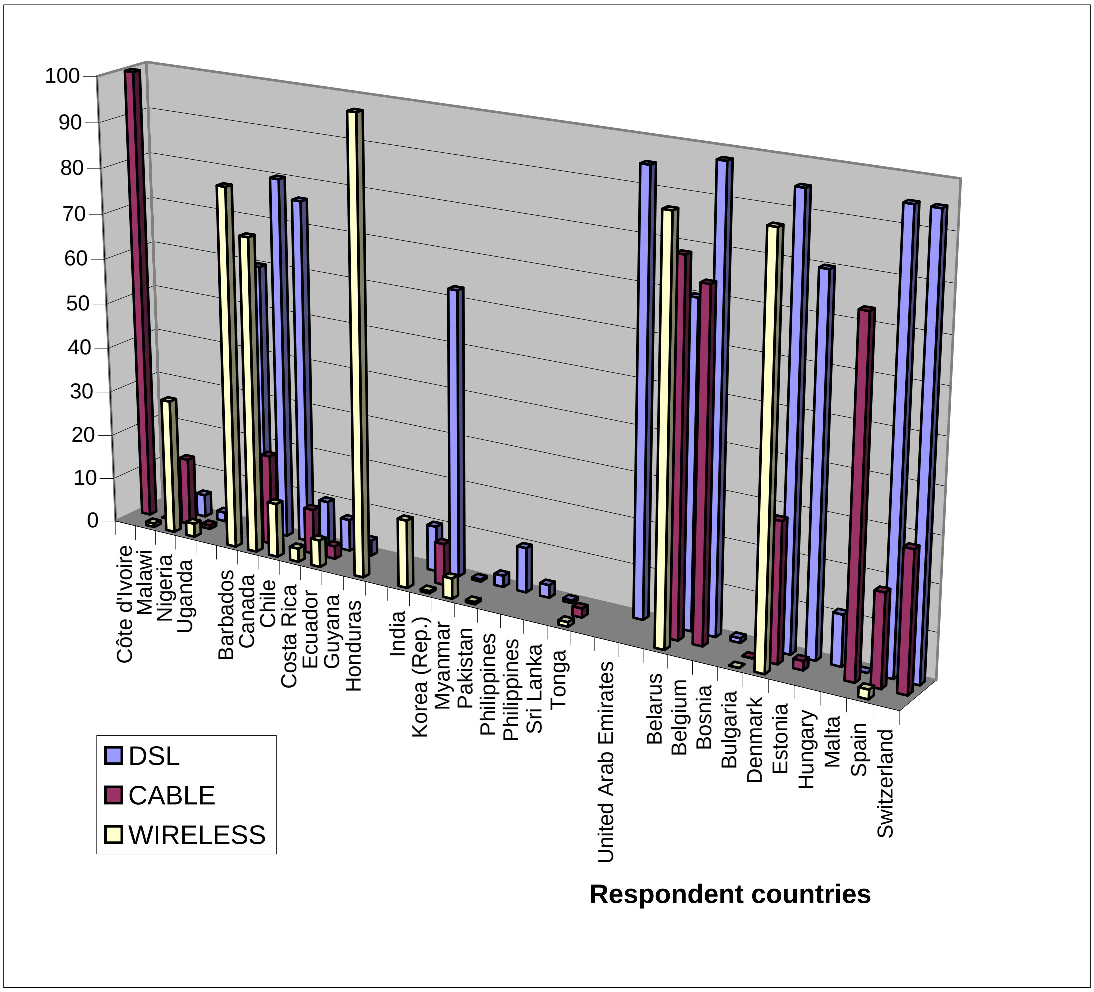
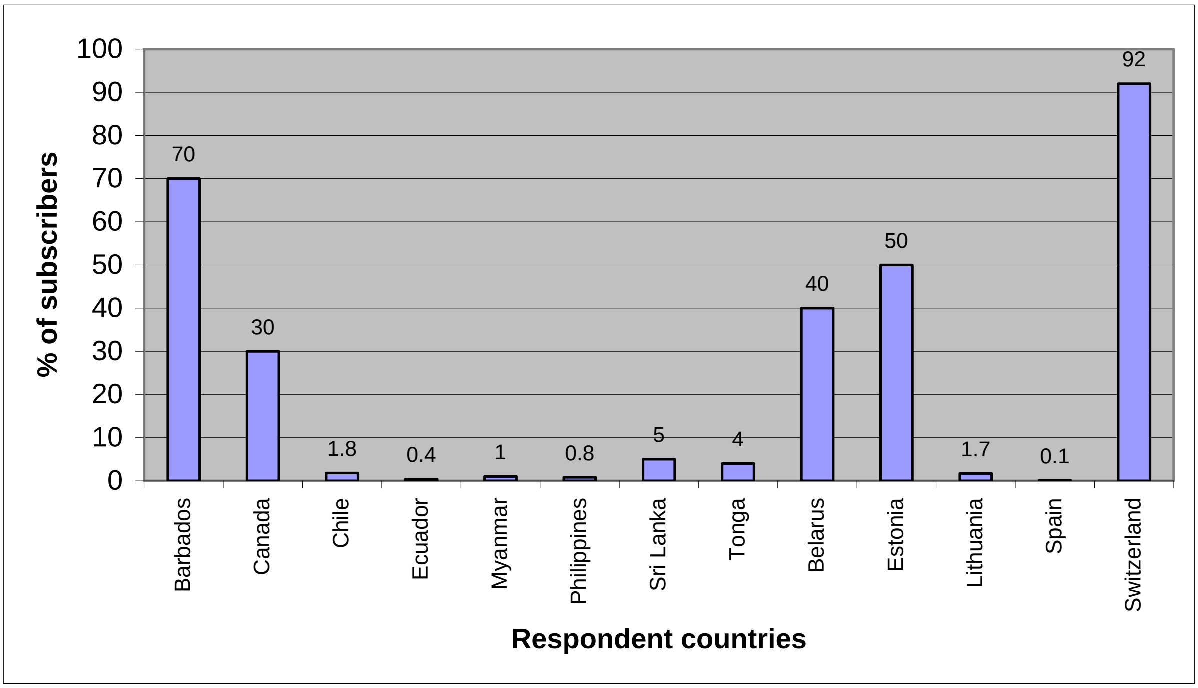


Figure 10 – Percentage of rural telephone subscribers with access to broadband technologies



Only six countries reported that there were gender barriers to broadband access, though the barriers they describe (given in table 5 below) are also general barriers to the adoption of broad band.

Table 5 – Gender barriers to adoption of broadband

Country	Are there gender barriers to broadband access?	Description of barrier
Chad	YES	Lack of awareness and the cost of computer training
Guyana	YES	The issue of affordability arises. Due to Guyana's economic situation, residential customers in particular would have no choice but to utilize their resources on immediate essentials rather than access to luxuries such as broadband
Philippines	YES	Economical. The economic condition leads to market being price sensitive hence, DSL affordability becoming a barrier to broadband access. In the provincial areas market is very price sensitive
Sri Lanka	YES	Infrastructure facilities
Thailand	YES	
Bosnia	YES	Economical

Service pricing and usage

The service and pricing section of the questionnaire sought to establish average price for Internet dial up, average monthly price for broadband service (including Internet access) and whether or not operators offer unlimited usage plans as well as the most common usage/pricing plan for broadband services. Table 6 below, indicates the average prices for both dial up and broadband services on an ITU regional basis. As can be seen despite the variance in size and nature of the economies of those countries which respondent to the question there is a general convergence on the average price for Internet dial up accounts across ITU regions, however broadband prices show a marked variation between regions especially in terms of large bandwidth capacity based services.

Table 6 – Average prices for both dial up and broadband services on an ITU regional basis

Region	Average Price for Internet Dial Up access (USD per minute)	Average Price for Internet Dial Up access (USD per month)	Broadband average price (USD) per month	
			Between	In Excess and depending on the bit rate
Africa	0.03	24.08	1 011.17	19 731.96
Americas	0.02	19.69	177.36	496.28
Asia-Pacific	0.38	13.50	130.46	299.51
Arab States**	0.005	NA	64.52	189.76
Europe	0.02		227.21	364.78

** It should be noted that only two countries for the Arab States region, Eqypt and the United Arab Emirates provided pricing data and no data was provided for monthly dial up costs.

Intra-regional variations in pricing models are also common. In the case of Europe the high estimated average monthly costs of broadband access in Armenia (1 000)*[95] and Belarus (1 200) raised the average broadband price dramatically, without their inclusion the average service price in Europe for broadband services was just USD 146.98. This figure is in stark contrast to Africa's average pricing of USD 1011.17 that is also driven to a higher overall average rate as a result of Ethiopia's higher than average broadband access cost of USD 3 780 per month.

Given that only two Arab State countries answered the question, the figures are possibly misleading for the region as a whole and should certainly not be taken as illustrative of the broadband situation in the Arab States overall.

Further while dial up access is standardized means of Internet access –broadband access includes a variety of technologies ranging from ISDN through to ADSL and dedicated fibre, with ISDN and ADSL or cable typically forming the lower average cost of broadband access and dedicated fibre the basis for high end service pricing.

[95] Armenia's figure for excess cost of USD 20 000 was left from the table and is due for verification. If the figure was included then excess costs for Europe would be USD 2 419.80 per month.

Unlimited usage plans offered by operators did not show a marked regional bias but rather were governed by the domestic situation facing individual operators. Of the 49 countries that responded to the question, only nine countries did not offer some form of unlimited usage plan, these are:

Chad, Ethiopia, Costa Rica, Dominican Rep., Israel, Maldives, Philippines, Egypt, Bosnia.

Table 7 below describes the most common usage-pricing plans for broadband on an ITU regional basis:

Table 7 – Common Usage pricing models

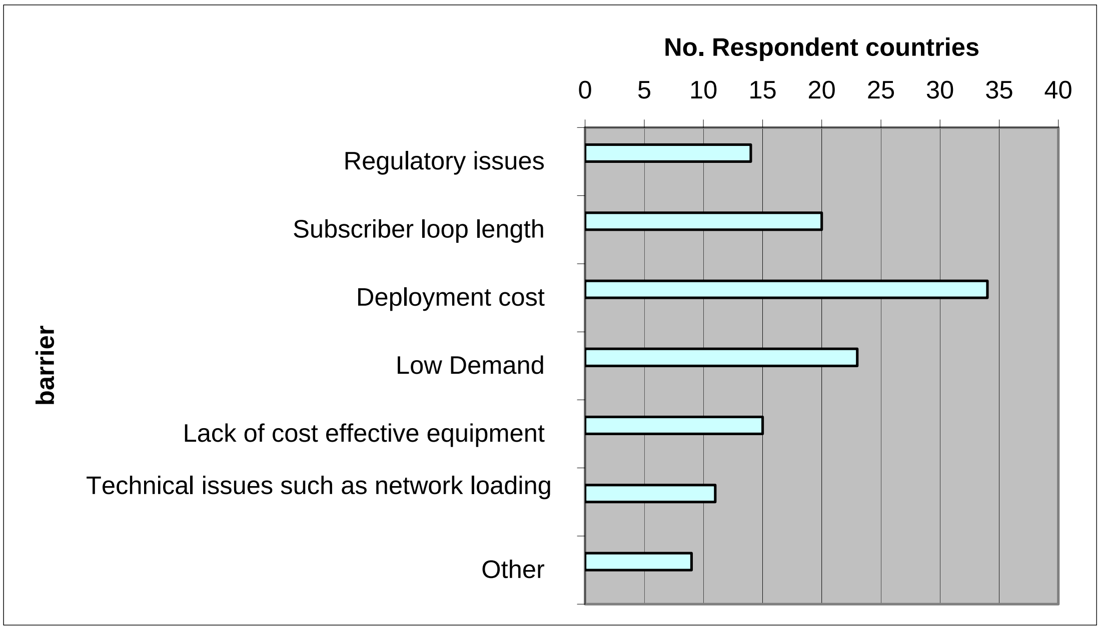
Région	Common Usage pricing plan
Africa	Common usage-pricing plans reported by the African respondents included: 1. Time, bandwidth and distance consideration 2. Flat rate, monthly rental, for given bandwidth 3. Per data unit (price per gigabit of transfer capacity).
Americas	In the America's region most models were based on the concept of unlimited access at a fixed rate such as 64 or 128 kbit/s for a fixed monthly fee. Where available ASDL is also offered on this model for a fixed monthly fee. In some countries a fixed monthly price plan is established with bandwidth usage limited to a set transfer threshold, for instance data transfer up to 10/15 Gigabytes, if data transfer exceeds this agreed limit then excess charges are then applied.
Arab States	In the case of Egypt, a fixed fee per minute is charged for access. In the case of the United Arab Emirates a fixed fee per month was charged and differed if the charge was for residential or business connection
Asia	Pricing plans varied including: Fixed dial up access costs based price per minute but packaged and presented as a combination of paid hours and with X number of additional bonus free hours. Other models include monthly fixed fees linked with specified data transfer limits (e.g. 1 GB per month). If the data transfer rate is exceeded than an excess charge is applied. Another model (where available) employs a monthly fixed fee for unlimited access e.g. ADSL based access. Where this model was operational but customer bandwidth requirements exceeded those offered via ADSL, the speed and nature of service requirement (e.g. E1/T1) would dictate the price of the agreement.
Europe	In Europe the most common usage plan is unlimited usage time with a flat fixed monthly payment This is used widely for DSL based connections. Following this are models for a monthly price plan with limited usage to a set threshold, for instance data transfer up to 10/15 Gigabytes with excess charges then being applied of traffic exceeding this threshold.

Barriers to Broadband Access Deployment

This section of the questionnaire sought to identify what are the major barriers to the deployment of broadband services, as well as thee the major cost issues limiting the spread of broadband, the financial (if any) assistance and the difficulties in raising finances for broadband build out facing operators.

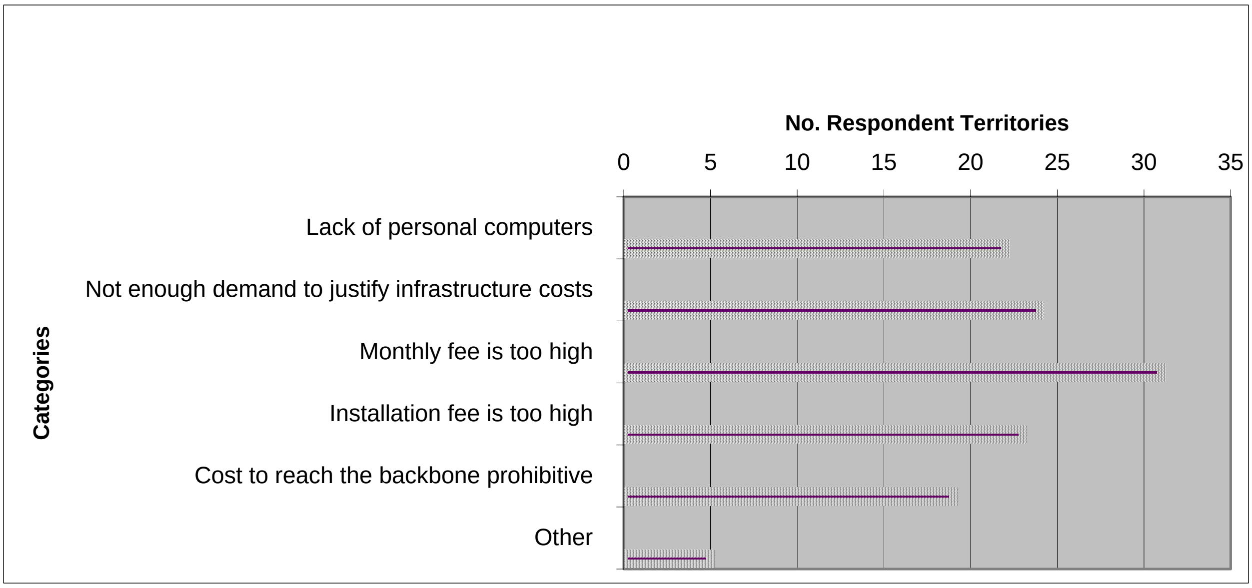
Figure 11, below, shows the major barrier to widely deploying broadband services, is the deployment cost of technologies.

Figure 11 – Major barriers to broadband access deployment



In addition to deployment costs, lack of demand for broadband services seemingly undermines any business case for investigating means to reduce deployments costs and overcome problems such as the subscriber loop length – which is a technical hurdle for the introduction of technologies such as DSL. Of the issues limiting the spread of broadband identified by respondents, the most common was that the monthly associated fee was too high as indicated in Figure 12.

Figure 12 – Major cost issues limiting the spread of broadband



High monthly fees, high installation costs and lack of access to personal computers when combined can result in insufficient demand to justify infrastructure costs and make the business case for deploying broadband services more difficult. Other reasons identified include relatively low levels of education and computer literacy and the respondent from Malta identified the cost of acquiring content in local languages.

Some thirty one countries did not have any form of loans or other financial assistance available to enable operators to provide broad band to the last mile and these are listed in Table 8:

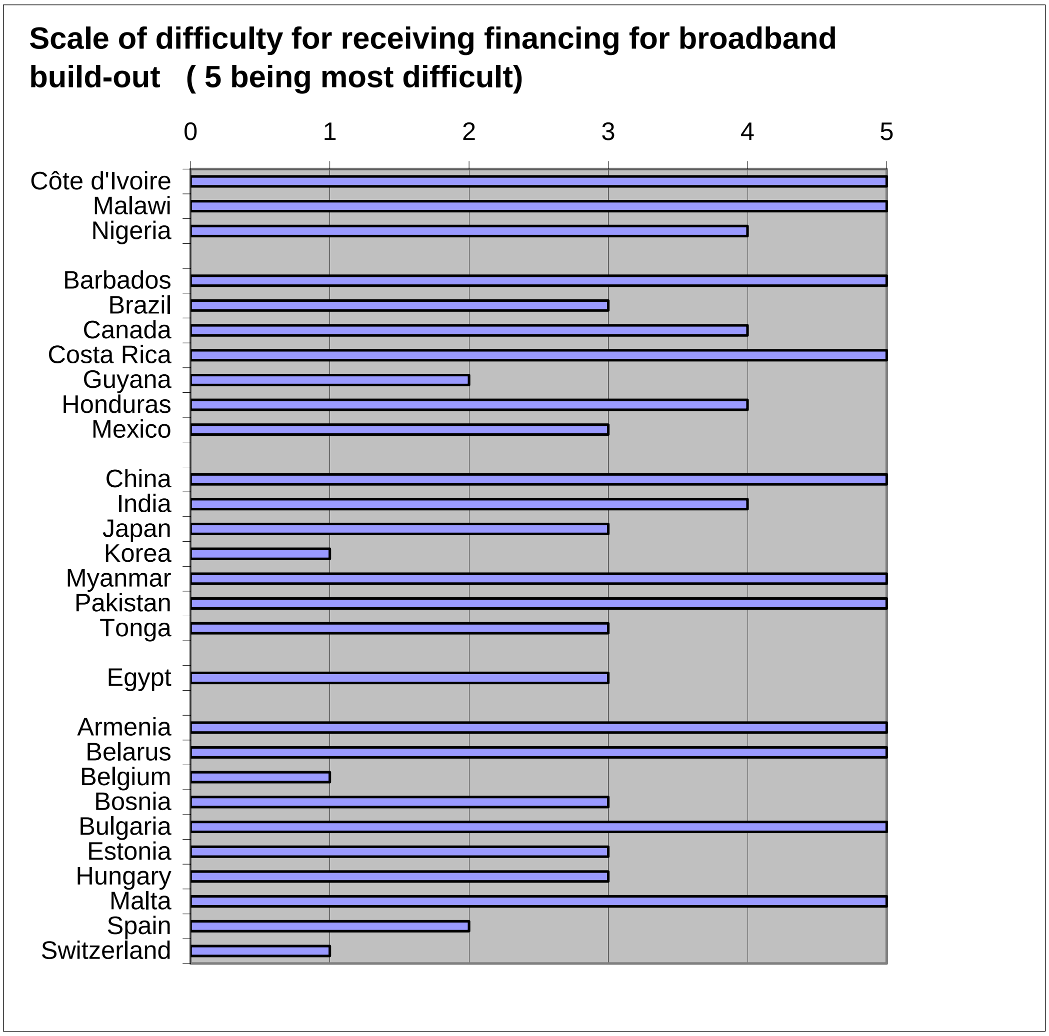
Table 8 – Countries without loans or financial assistance for the deployment of broadband services

Africa	Americas	Arab States	Asia	Europe
Chad	Barbados		China	Armenia
Côte d’Ivoire	Brazil		Israel	Belarus
Ethiopia	Chile		Korea (Rep.)	Belgium
Malawi	Costa Rica		Maldives	Bulgaria
Mauritius	Ecuador		Myanmar	Estonia
South Africa	Guyana		Nepal	Lithuania
	Honduras		Pakistan	Norway
			Sri Lanka	Poland
				Spain
				Switzerland

While 12 countries offered loans and other forms of financial assistance to encourage the expansion of broadband services including: Nigeria, Uganda, Canada, Dominican Rep., Mexico, India, Japan, Tonga, Egypt, Bosnia, Denmark, Hungary; how these loans are facilitated differs widely from country to country. Canada and Mexico, Japan and Egypt all offer government based loans for broadband development schemes. In Uganda offers only private loans are available to operators, where as in Nigeria loans for operators are available as a result of UNDP and WorldBank programmes in addition to private lenders. In Denmark incentives take the form of tax exemptions for data communication related developments and in Hungary corporate tax reductions and direct state subsidies are available for developing broadband-based services. Some developing countries also qualify for international aid – such as loans and grants from USAID.

The difficulties facing operators in raising financing for broadband build-out is illustrated in the following graph – where questionnaire respondents rated the difficulties in raising finance on a scale of one to five with five being the most difficult. Unsurprisingly those countries with large rural areas, and dispersed rural populations are among those that face the greatest difficulties in raising finances for broadband build-out.

Figure 13 – Scale of difficulty for financing broadband services



Quality of Service

In the questionnaire the quality of service section sought to establish the average speeds of downstream data for DSL, cable, wireless and other technologies employed to deliver broadband services. In most cases responses gave a range of speeds e.g. DSL may vary from 384 kbit/s downstream for residential and 512 for business. In some cases the reasons for the different capacities stated were not provided or were not clear given the mixed usage-pricing models that are used in differing countries. As a result the lowest average speed indicated was used for the graphs and purposes of comparisons. This means that in the case of some countries such as Japan the average downstream speed is shown as 2 Mbit/s rather than the 10 to 1 000 Mbit/s that is available over specialist fibre networks available to businesses. For the purposes of the graphs, the respondent countries are alphabetically grouped in terms of their ITU regional groupings of Africa, Americas, Arab States, Asia-Pacific and Europe.

In addition to DSL, cable and wireless a number of other technologies are used to deliver downstream broadband services. In Ethiopia the school-net, health-net, gov-net services and a DDN service that supports dedicated, and frame relay service connection for Internet access and enterprise wide LAN, etc offers speed up to 45 Mbit/s. In Barbados fixed wireless connections are used to deliver speeds of 128 kbit/s and a number of countries use satellite-based services – in Canada these offer access speeds of 500 kbit/s, while in Myanmar broadband satellite (IPSTAR) offers connection speeds up to 1 218 kbit/s. In Estonia general packet radio services (GPRS) are used to deliver connection speeds of the 30 kbit/s. Finally fibre is used in a Japan (up to 100 Mbit/s for FFTH), 10 Mbit/s in Norway and 2 Mbit/s in Egypt. The following graphs illustrate the average downstream data for DSL, Cable and wireless based broadband services at an average distance of two to four kilometers.

Figure 14 – Average speed of downstream data for DSL

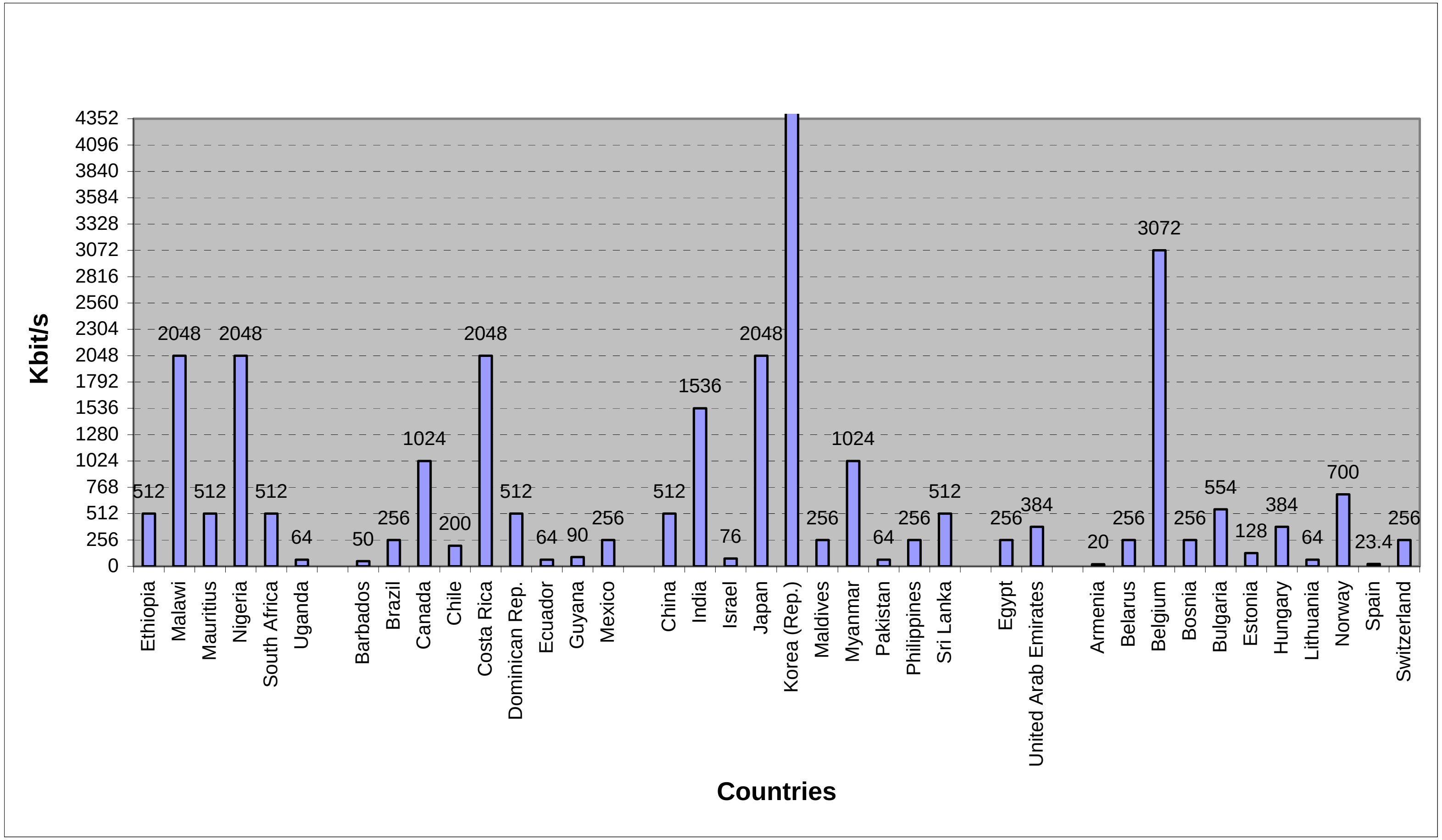


Figure 15 – Average speed of downstream data for Cable

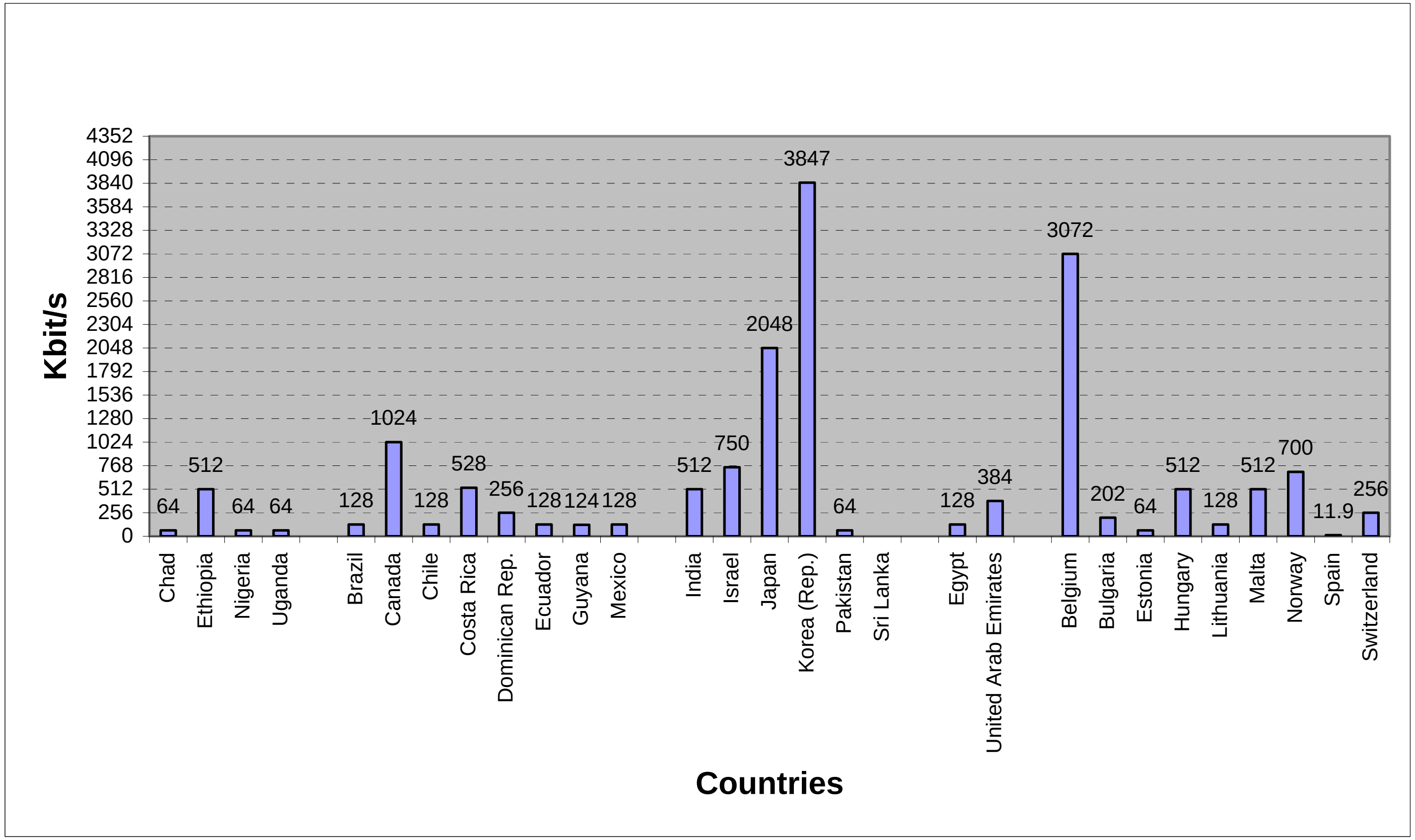
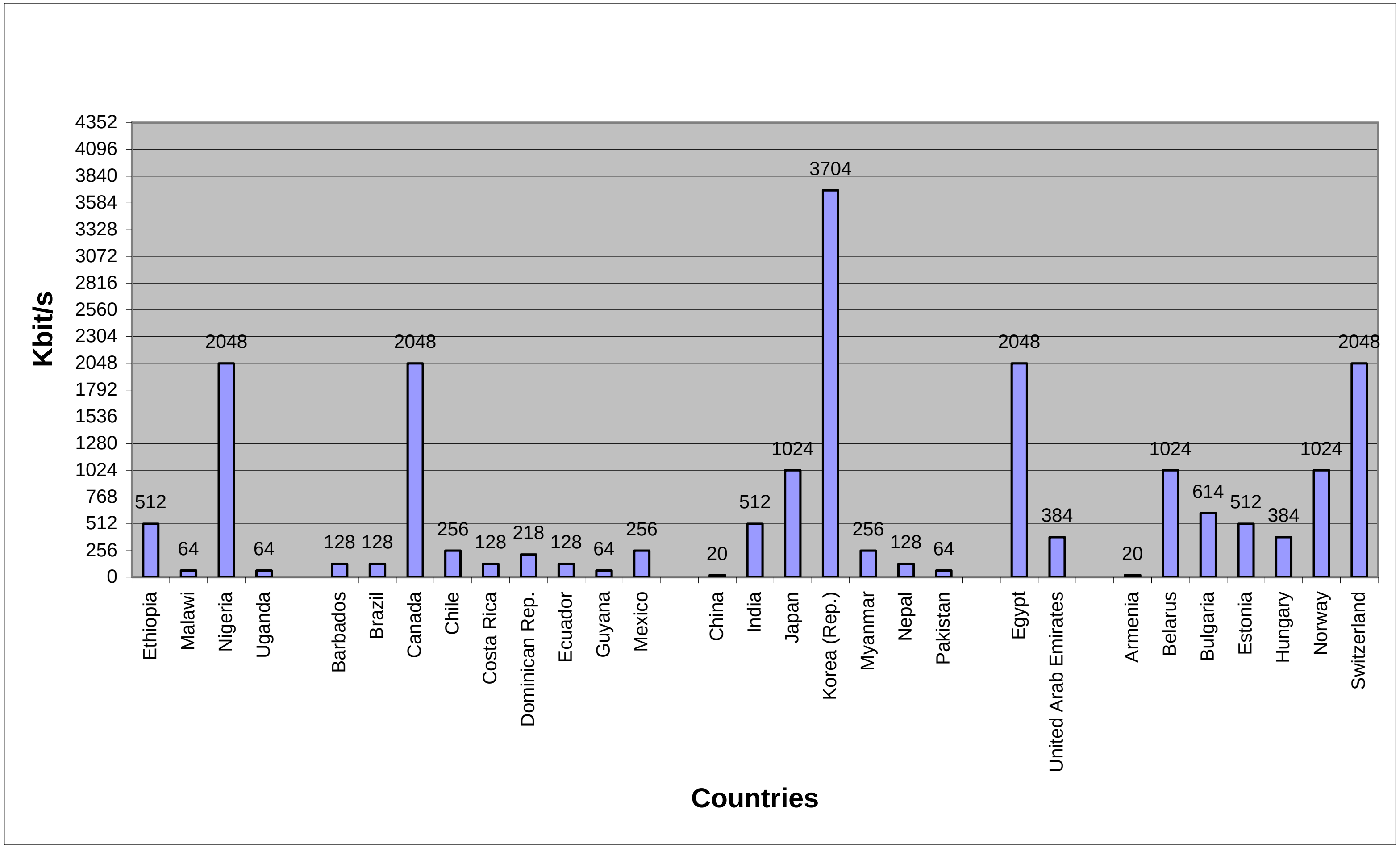


Figure 16 – Average speed of downstream data for wireless based services



Miscellaneous

The miscellaneous section of the questionnaire sought information on public access points to broadband services, fastest growing broadband technologies and those applications areas that broadband services are being used for. Seventeen respondent countries offered free access to broadband services through public centres such schools, libraries, hospitals, government office buildings and telecentres etc. These countries are:

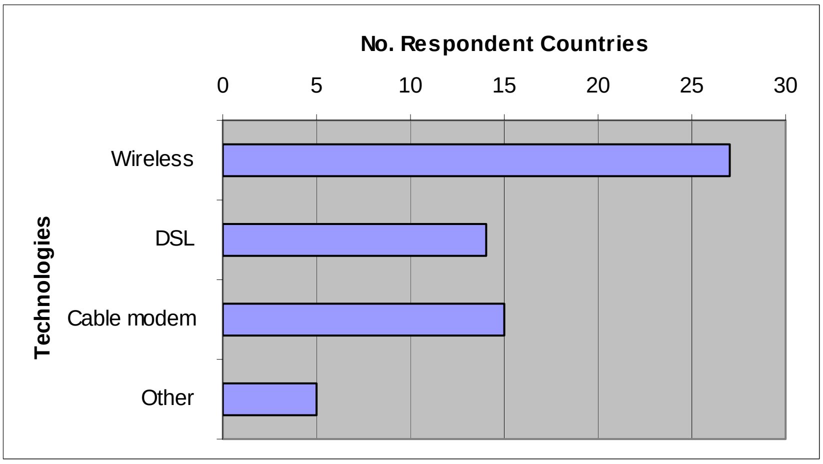
- Côte d'Ivoire
- Canada
- Chile
- Dominican Rep.
- Israel
- Japan
- Korea (Rep.)
- Myanmar
- Belgium
- Denmark
- Hungary
- Lithuania
- Malta
- Norway
- Poland
- Spain
- Switzerland

A further seven countries offered access to broadband services through public centres via a special pricing agreement, these were:

- Nigeria
- Uganda
- China
- Maldives
- Thailand
- Tonga
- Belarus

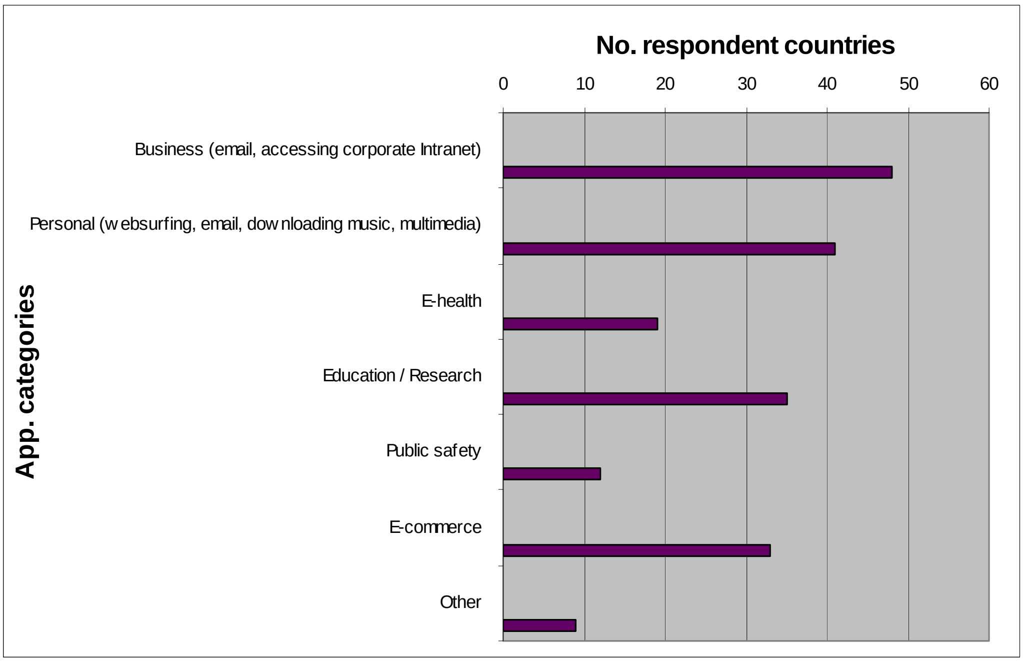
Finally Guyana, Sri Lanka, Armenia and Estonia offered access to broadband services through public centres but at standard market prices. The fastest growing broadband technology identified by respondents (as shown in the following graph) was wireless. A number of countries such as Belarus, Estonia, Ethiopia and the Philippines selected more than technology and reflects their current marketplace, in that no one technology has reached a dominant market position or serves diverse needs.

Figure 17 – Fastest growing broadband technologies



Broadband-based services are used in a number of application areas, with the main drivers being business (for accessing email, corporate intranets etc) and personal information access (web browsing, downloading music and multimedia etc). When examining the regional basis for these applications – the proportions are roughly the same business use is the primary driver in both developed and developing countries, while personal use is also a major driver for broadband services in both developed and developing countries. The respondent countries that were exceptions to this were Malawi, Guyana, Honduras, Nepal, Thailand, Armenia, Bosnia where business applications were the sole main application driver.

Figure 18 – Application categories that broadband is used for



In Nigeria, Canada, and Demark E- government services were identified as other application areas for broadband services; Whilst Japan and Korea both mentioned IP telephony applications being used and Korea also identified both games and video on demand as the basis for entertainment applications.

Appendix

Broadband Questionnaire

DEADLINE FOR THE REPLIES: **30 May 2003**

Given Name

Family Name

Your Title

Organization / Main activity

Telephone/Fax (with area code)

Country

City

Business Address

E-Mail

Any queries or requests for further information regarding this questionnaire should be addressed to:

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Fax: +41 22 730 5484
Mob.: +41 79 239 2739
www.itu.int/ITU-D/e-strategy/internet/iptelephony/

INTRODUCTION

Purpose

1) To assess the current status of broadband access technologies.

2) To analyse broadband access technologies including the following dimensions: demographics, gender, geographic, technical and economic factors; market structures for delivery of broadband access service.

Output expected from the replies

The central output will consist of conclusions drawn from the data collected to include in the final report to assist ITU-D Members with the development of broadband access technologies. This research will generate information on the technical, economic and development factors having an impact on the deployment of broadband access technologies in developing countries. At the end of the study period, a final and complete report will be created on *Broadband Access Technologies*. The present questionnaire is designed to provide extensive, consistent background data for the overall study, to be complemented, as necessary, in the yearly work plans.

Technology

What wireline technologies are utilized to provide broadband services:

____ DSL

____ Cable

____ E1/T1

____ Fibre

____ Power Line

____ Other (please describe)

What wireless technologies are utilized to provide broadband services?

____ Satellite

____ IMT-2000

____ Wireless local area network

____ Fixed wireless access

____ Other (please describe)

Competition

Is competition permitted in Internet services? (YES/ NO)

Is there competition in the local loop? (YES/ NO)

Is there competition among differing broadband technologies? (ex. DSL, cable, broadband wireless)

(YES / NO)

How many operators offer high-speed Internet service? ____________

Percentage of operators offering DSL broadband service ____________

Percentage of operators offering cable modem broadband service ____________

Percentage of operators offering wireless broadband service ____________

Percentage of operators offering other broadband service ____________

Access

Approximately what percentage of households have access to broadband access technologies in general? ____________

Percentage of households with access to DSL broadband service ____________

Percentage of households with access to cable modem broadband service ____________

Percentage of households with access to wireless broadband services ____________

Approximately what percentage of businesses have access to broadband access technologies in general? ____________

Percentage of businesses with access to DSL broadband service____________

Percentage of businesses with access to cable modem broadband service____________

Percentage of businesses with access to wireless broadband services ____________

What percentage of rural telephone subscribers have access to broadband technologies? ____________

Are there any gender barriers to broadband access (i.e. political, economic, social, etc.)? (YES/NO)

If so, please describe.

Pricing and Usage

What is the average price[96] for Internet dial up access (please specify per time unit or data unit)? ________________________________

What is the average monthly price for broadband service (including Internet access)?

between 64-500 kbit/s ________________________________

in excess of 500 kbit/s ________________________________

Do operators offer unlimited usage plans? (YES/NO)?

Describe the most common usage/pricing plan for broadband. (Please specify per time unit or data unit)

---

96 Preferably in US.

Barriers to Broadband Access Deployment

What are the major barriers to the deployment of broadband service? (mark all that apply)

____Regulatory issues

____Subscriber loop length

____Deployment cost

____Low demand

____Lack of cost-effective equipment

____Technical issues such as network loading

____Other (please describe)

What are the major cost issues limiting the spread of broadband? (mark all that apply)

____Lack of personal computers

____Not enough demand to justify infrastructure costs

____Monthly fee is too high

____Installation fee is too high

____Cost to reach the backbone prohibitive

____Other (please describe)

Are there affordable loans/other financial assistance for operators to provide broadband to last-mile customers? (YES/NO)

If yes, please describe (government, private, other organizations).

How difficult (scale of 1-5; 5 being the most difficult) is it to receive financing for broadband buildout?

Quality of Service

What are the average speeds of downstream data for DSL? __________________________

What are the average speeds of downstream data for cable broadband? ________________

What are the average speeds of downstream data for wireless broadband service? ________

What are the average speeds of downstream data for other broadband services? (Please describe which service)? _________________________________

Miscellaneous

1) Do public centres (schools, libraries, hospitals, government office building complexes, telecentres, etc) offer broadband service? (YES/NO)

   If yes, are the services generally free of charge? (YES/NO)

   If services are not free, is there a special price? (YES/NO)

2) Which broadband technology is growing the most quickly? (wireless, DSL, cable modem or other)

   For which applications is broadband service used? (mark all that apply)

   _____ Business (email, accessing corporate Intranet)

   _____ Personal (websurfing, email, downloading music, multimedia)

   _____ e-health

   _____ Education/research

   _____ Public safety

   _____ e-commerce

   _____ Other (please describe)

ANNEX III

Other ITU Sector Relevant Study Groups, Questions and Recommendations

Listing of appropriate Questions and relevant Recommendations to be studied in other ITU sectors.

In ITU-T Study Group 9, which deals with integrated broadband cable networks and television and sound transmission. The following Questions and their relevant recommendations are to be followed:

Question 6/9 – Conditional access methods and practices for digital cable distribution to the home

Question 12/9 – Cable Television delivery of advanced multimedia digital services and applications that use Internet Protocols (IP) and/or packet-based data

Question 13/9 – Voice and Video IP Applications over cable television networks

In ITU-T Study Group 15 which covers optical and other transport networks, the following Questions and relevant associated Recommendations will be covered:

Question 1/15 – Access network transport

This question maintains a comprehensive standards overview that is updated on a regular basis and can be found at the following website address: www.itu.int/ITU-T/studygroups/com15/lead.html

Question 2/15 – Optical systems for access networks

In ITU-T Study Group 16, which is the lead group on multimedia services, systems and terminals, the following Questions and relevant associated Recommendations will be covered:

Question C/16 – Multimedia applications and services

Question 2/16 – Multimedia over packet networks using H.323 Systems

In ITU-R Study Groups 4, 6, 8 and 9, relevant questions and associated recommendations will be followed. Additional information on ITU-R terrestrial fixed and mobile wireless access information can be found at the following website: www.itu.int/ITU-R/study-groups/was/itu/index.html.

ANNEX IV

Best Practice Guidelines for the Promotion of Low-Cost Broadband and Internet Connectivity

We, the regulators participating in the 2004 Global Symposium for Regulators, have identified and proposed best practice guidelines to achieve low-cost broadband and Internet connectivity. Our goal is the creation of national regulatory frameworks that are flexible and enable competition between various service providers using multiple transport and technology options. We believe the best practices outlined below will help bring social and economic benefits to the world's citizens.

An enabling regulatory regime that encourages broadband deployment and Internet connectivity

1) We encourage political support at the highest government levels with such support expressed in national or regional policy goals. These include an effective, separate regulator insulated from political interference, a transparent regulatory process, and adoption and enforcement of clear rules.

2) We believe that competition in as many areas of the value chain as possible provides the strongest basis for ensuring maximum innovation in products and prices and for driving efficiency.

3) We encourage regulators to set policies to stimulate competition among various technologies and industry segments that will lead to the development and deployment of broadband capacity. This includes addressing barriers or bottlenecks that may exist with regard to access to essential facilities on a non-discriminatory basis.

4) We believe that the primary objective of regulation should be to secure fair and reasonable access for competitive broadband services, including Internet connectivity.

5) We encourage the maintenance of transparent, non-discriminatory market policies in order to attract investment.

6) We encourage regulators to adopt policies that are technology neutral and do not favor one technology over another.

7) We encourage regulators to take into consideration the convergence of platforms and services and that they regularly reassess regulatory regimes to ensure consistency and to eliminate unfair market advantages or unnecessary regulatory burdens.

8) We encourage regulators to allocate adequate spectrum to facilitate the use of modern, cost effective broadband radiocommunications technologies. We further encourage innovative approaches to managing the spectrum resource such as the ability to share spectrum or allocating on a license-exempt non-interference basis.

9) We urge regulators to conduct periodic public consultations with stakeholders to inform the regulatory decision-making process.

10) We recommend that regulators carefully consider how to minimize licensing hurdles.

11) We encourage the development of a regulatory framework that permits ISPs and broadband providers to set up their own last mile.

12) We encourage regulators to provide a clear regulatory strategy for the private sector in order to reduce uncertainty and risk, and remove any disincentives to investment.

Innovative Regulatory Policies Must Be Developed To Promote Universal Access

1) We recommend that the promotion of access to low cost broadband interconnectivity should be integrated from "grass-roots" efforts to identify local needs all the way through the "tree-tops" of international law. Governments, business and non-governmental organizations should be involved.

2) We recommend that regulators adopt regulatory frameworks that support applications such as e-education and e-government.

3) We encourage each country to adopt policies to increase access to the Internet and broadband services based on their own market structure and that such policies reflect diversity in culture, language and social interests.

4) We encourage regulators to work with stakeholders to expand coverage and use of broadband through multi-stakeholder partnerships. In addition, complementary government initiatives that promote financially sustainable programs may also be appropriate, especially in filling in the market gap that may exist in some countries.

5) We encourage regulators to adopt regulatory regimes that facilitate the use of all transport mechanisms, whether wireline, power line, cable, wireless, including wi-fi, or satellite.

6) We encourage regulators to explore programs that encourage public access to broadband and Internet services to schools, libraries and other community centres.

7) We encourage regulators to implement harmonized spectrum allocations consistent with the outcome of ITU Radiocommunication Conference process and each country's national interest. Participation in this well-established framework will facilitate low-cost deployment of equipment internationally and promote low-cost broadband and Internet connectivity through economies of scale and competition among broadband vendors and service providers.

Broadband is an Enabler

1) Regulation should be directed at improving the long term interests of citizens. Broadband can contribute to this by improving and enabling education, information, and increased efficiency. It can reduce costs, overcome distance, open up markets, enhance understanding and create employment.

2) We encourage regulators to educate and inform consumers about the services that are available to them and how to utilize them so that the entire population benefits.

3) We urge regulators to work with other government entities, industry, consumer groups, and other stakeholders to ensure consumers have access to the information they need about broadband and Internet services.

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