4.8 Technologies for Universal Access and Service

Developments in technology affect the cost, acceptability and feasibility of services and have a direct impact on universal access and service (UAS). Because technological developments influence regulators' expectations and users' technology preferences, minimum requirements for and expectations of UAS increase over time.UAS policy needs to be resilient and forward looking as it takes emerging technologies into account, but it should aim to be technologically neutral. Regulators should be informed observers regarding technologies, but they need to allow UAS providers to choose which technologies are cost effective. As an overall principle, it is important to note that technologies are neither isolated from market, nor solely the determining factor in successful service provision. Country by country, whether a particular technology is an appropriate solution for UAS and rural areas, and for low income people, depends strongly on these market factors:

- Competition (the market position of the providers, their service packages and pricing strategy);
- Demand and affordability;
- Customer density; and
- End user terminal distribution and availability.

Such factors should not be overridden by governmental preferences; technological choice should be left to service providers and the regulator should focus on providing equal opportunity for participants.

This Chapter provides an overview of relevant trends and issues for UAS.

Module 7 - New Technologies and impacts on Regulation provides a more comprehensive coverage of trends, with references where applicable. Module 7 describes in detail the four main streams of technology development - Internet and Internet Protocol (IP), Mobile Communications, Next Generation Network (NGN) infrastructures, and Convergence. These trends create a new ICT network paradigm for the Information Society and imply that there is a need for UAS policy interventions to encourage network and service build-out in directions that are regionally balanced and ubiquitous. However, just as the mobile revolution has driven progress in achieving UAS for telephony, it would be advisable for regulators to give high regard to fundamental market developments taking place in the broadband field also.

In summary, policy makers and regulators need to recognize the following:

- The requirement for UAS has moved from pure telephony to include broadband [1] (thereby allowing access to different types of content and ICT applications);
- The trends in Internet and IP development, NGNs and Convergence are giving impetus to the emergence of a "broadband revolution." Commercial and market forces in this development promise to be just as dynamic as those which drove the mobile revolution;
- UAS policy needs to harness the principles of competitive market regulation and technological openness/neutrality to encourage the most economic and sustainable deployment from among the plethora of technologies available for ICT.

Reference Documents

- Universal Access & Service (UAS) and Broadband Development

4.8.1 TECHNOLOGY AND SERVICE NEUTRALITY

Historically, services were often regulated according to the different types of technologies; for example, wireless fixed telephony has had different licence obligations from wire line fixed telephony. Resources like phone numbers, radio frequencies and rights of way have often been regulated in ways that restrict the services using them; for instance, certain radio frequencies are historically reserved for fixed wireless (e.g., CDMA) or mobile (e.g., GSM) telephony. Regulators now aim for technology neutrality within service definitions, as explained in **Module 6 Section 4.3.1** and outlined in the Practice Note Service neutrality in the allocation of scarce resources. Neutrality helps service providers react quickly to technological changes, whereas tying phone numbers, radio frequencies, operating licences or universal service/access obligations to the use of particular technologies (such as PSTN, GSM or CDMA) could impede progress. In the field of Universal Access and Service Funds (UASFs), subsidies have traditionally been allocated in service-specific ways (e.g., for fixed telephony payphone services). This has been changing recently, with more and more countries allowing service-neutral competition (e.g., fixed or mobile) as well as technology-neutral competition (e.g., between GSM, CDMA, WiFi, WiMAX and VSAT) for UASFs.Universal access and service (UAS) policies and funding strategies that are technology-neutral should be based on service targets and quality of service (QoS) standards, within which UAS providers are free to choose the most cost effective technologies. The targets and standards should reflect user demand and preferences, preferably based on results of a consumer/user survey, as described in Section 5.3 of this module. ICT Quality of Service Regulation: Practices and Proposals discusses how these standards should be selected and defined. Regulators might need quality of service standards for UAS that differ slightly from those for the national service (as well as from those for UAS in other countries), depending on cost, feasibility and how uniform the service is intended to be across the country.In practice, technology neutrality has limits and issues that need to be taken into consideration. Different technologies may offer similar services, but customer demand and quality standards, and required service growth, need to be well defined at the outset. Without clear specifications, less than optimal results can arise. These might include:

- National service compatibility – Internationally, open competition is best practice for UAS tendering. However, even though the most economic choice is made, competition for telephony to rural areas between fixed and mobile, established and new entrant providers, each with alternative technologies, could give a sub-optimal outcome for customers. For example, service from a dominant mobile operator with a national network might offer the preferred outcome for users who want to use their handset and service wherever they travel in the country, but if the UAS tender was won by a new entrant with an alternative technology and little national presence, and with uncertain (though competitively determined) future build-out, customers may end up with inferior service.
- Service quality and scope – UAS competitions that allow satellite VSAT operators to compete with mobile operators for public access services are limiting the potential for market expansion as well as access to affordable private service for customers. If mandatory private service provision is also included as a required scope of service, VSAT operators will not be able to comply and thus be discouraged from bidding. Such a requirement (as included by the Ugandan regulator in its Rural Communications Development Fund (RCDF) universal access tenders) may effectively limit competition to mobile or fixed wireless services, but is more effective at using funds to help promote market growth and service sustainability in rural areas and thus foster universal service.
- Data speeds can dictate technology choice – Broadband service with as high a bandwidth as feasible is the ultimate target for UAS to the Internet in rural districts. The market currently offers a wide range of possible access network technologies (e.g., EDGE, WCDMA, CDMA2000 1xRTT, CDMA2000 1xEVDO, HSPA, WiFi and WiMAX) [*]. Some are currently only available in urban areas and are unlikely to migrate out to rural areas until the demand is perceived to be significant. Universal Access and Service Fund (UASF) strategists could dictate the highest speed available, though in doing so they may actually be limiting the number of bidders as well as long term service sustainability. Setting the requirement to meet standards commonly available today from the network operators most capable of providing commercially sustainable service could be the most practical strategy for ultimate growth of the broadband market. Very often, the most practical bandwidths will have a huge impact in terms of service and application availability in any case. Once advanced services are established through the initial competition, bandwidths will subsequently increase further, in stepped fashion, as the technology trends and market sustainability dictate.
- Backbone selection – Some governments want network build-out into rural areas using fibre backbones and are considering the subsidization of investments from UASFs or government sources. On the other hand, as noted in **Section 8.2.3**, terrestrial radio may have sufficient capacity for all realistic levels of broadband demand into many areas, as well as offer economic synergies for operators wishing to expand mobile coverage. Generally, the market should decide on backbone selection, but in some cases mandating the use of a particular technology (e.g., fibre) might be justified. The decision as to whether this is economically and strategically justified should be based on a feasibility study, as well as on industry consultation. Chile has used UASF funds to finance fibre infrastructure [*] and India's USOF is also expected to offer subsidies for fibre build-out. In the meantime, the USOF is also funding passive terrestrial infrastructure (towers) in remote rural areas, which will doubtless be linked together mostly by microwave systems (see **Section 3.4.6**).

Regulators should maintain technological neutrality as much as possible; market players should determine the viability of technology choices. It is not necessarily possible for UASFs to influence technological choice if the long term business case dictates otherwise and is not able to demonstrate sufficient demand. Newer technology is only better than older if it improves UAS goals. This point is stressed in Information and Communication Technologies, Poverty and Development: Learning from Experience.

Practice Notes

- Service neutrality in the allocation of scarce resources

Reference Documents

- ICT quality of service regulation
- Information and Communication Technologies, Poverty and Development

4.8.2 TECHNOLOGY CHOICES

The main network technologies, and their economic characteristics, are described in **Module 7 Section 2.2.2** on networks innovations, are:

- Copper based access networks
- Cable TV
- Optical fibre
- Power line communications
- Mobile Networks
- Wireless networks (other than mobile)
- Satellite
- Key point and recommendations

This section describes the network technologies that are most suitable for underserved and rural areas, following the same typology as in **Module 7 section 2.2.2**. Some of these technologies are appropriate for last mile telephony or Internet access, while others might be suitable for backhaul from rural and remote areas.

4.8.2.1 OPTICAL FIBRE

Optical fibre, with its unsurpassed capacity, is particularly suitable for backbone networks and plays a key role in migration to broadband services. Optical fibre is also used for access networks to major business customers in city or town centres, and increasingly in developed countries, for residential access, with the fibre reaching to:

- Street cabinets (Fibre to the Cabinet – FTTC);
- Curb / Kerb (FTTC / FTTK);
- Buildings (FTTB – largely businesses and residential apartment blocks); and
- Home (FTTH).

The cost of fibre is becoming competitive with copper wire, but installation is expensive. The considerable costs of labour for fibre installation makes it as expensive as copper in the local loop. Fibre may therefore not be economically justifiable over existing copper plant except for advanced broadband applications in new greenfield situations, or as replacement for obsolete cable at the end of its useful life.Fibre is appropriate for trunk and long distance inter-city transmission. It is favoured over terrestrial radio (microwave) transmission systems when the usage level is high enough to justify fibre's higher capital and operating costs. Some countries are considering the deployment of fibre backbone transmission systems under UASF funding. The Indian USOF is considering the subsidization of fibre networks into rural areas that are likely to have the greatest demand for broadband Internet service provision. In 2007, Chile's Telecommunications Development Fund (TDF) subsidized the implementation of two fibre-optic transmission networks in southern regions of the country, that lacked mobile coverage or Internet service. The first project, the Fibra Óptica Austral Project, extended the national network to 31 localities in Chile's Tenth and Eleventh Regions (Los Lagos and Aisén). The network cost 4.6 million USD in private and government investment with a subsidy of 2.5 million USD. The second project involved network extensions from the Eleventh Region into the Twelfth Region (Magallanes), which is the most southerly.Fibre is particularly important in Next Generation Networks (NGNs), which are inherently broadband. They are discussed in **Section 8.4.1**.

4.8.2.2 WIRELINE NETWORKS

Copper access networks

Copper has no application beyond local access. In the context of developing countries, copper is increasingly used solely for urban applications. Copper access, extensive in developed countries, has significantly contributed to universal service. Several countries where network penetration is high have designated incumbent network operators as their universal service providers; this has happened in much of the EU, and is described in **Section 3.1.2**. Some other countries, such as South Africa, have included such obligations in the licences of incumbent network operators. However, this practice is declining as market liberalization proceeds and customers are demonstrating that their preferences do not necessarily involve copper-based service. In many developing countries where fixed networks are no longer expanding, wireless technologies are likely to be preferred. Although copper access can achieve high data rates, wireless alternatives are increasingly able to compete.

Coaxial cable

The high capacity of coaxial cable has led it to be used for television transmission in many countries. In India, the density of cable television connections is very high, and there are many local cable operators in cities and towns who use coaxial cable. In principle, these cable networks could be used for distribution of broadband Internet and telephony together with television channels (Triple Play). In practice, many are inhibited from doing so by the nature of the network architecture (tree and branch) and the cost of upgrade. In cities and towns, most modern cable TV companies now use fibre at least to street cabinet level, and have architectures that allow easier migration to telecommunications service provision. While this can play a role in progress towards urban and semi-rural universal service, its potential role in providing universal access to less developed areas is generally very limited.

4.8.2.3 TERRESTRIAL RADIO

Terrestrial radio systems – ranging from VHF and UHF frequencies below 1 GHz to microwave systems up to 30 GHz – are central to universal access and service (UAS), supporting long distance backhaul, local point-to-point and point-to-multipoint connections and last mile access. Technologies such as GSM, CDMA, WiFi and WiMAX that play the largest role in the provision of universal access and service (UAS) to telecommunications and ICTs are discussed in **Sections 8.2.4** and **8.2.5**.Point-to-point microwave links, typically with hop distances between repeater terminals ranging from 10 Km up to 30 Km or more (depending on frequency, topographic and atmospheric conditions, as well as required service reliability) can adequately supply backbone services for both PSTN and mobile telephony or IP enabled links for hundreds of kilometres. Bandwidth or communications channel capacity may range from less than four E1's (8 Mbps or 120 voice channels) to STM1 (155 Mbps or 63 distinct E1's) and STM4 (622 Mbps or 252 distinct E1's). Currently, there are fewer microwave systems providing the sole means of backbone at the higher level of capacity as fibre is becoming favoured for high capacity routes. The bandwidth of fibre systems is virtually unlimited for many practical purposes. Microwave has the advantage of having repeater towers that can be shared by mobile or WiMAX base stations along major transmission routes. These routes often overlap with transportation routes that provide revenues for the mobile companies. However, the cost of operation and maintenance, including power supply and fuel to remote sites lacking commercial power supply, can be prohibitive in developing countries. This contributes to the economic justification for fibre systems on the heavier capacity routes, and often even on relatively light routes.

4.8.2.4 MOBILE NETWORKS

Mobile networks, together with fixed and other non-mobile wireless access networks (see **Section 8.2.5**), have become favoured for universal access and service (UAS) applications for the following reasons:

- Mobile networks are generally less expensive and quicker to deploy than conventional wireline solutions (lower civil engineering costs), and are readily deployed and maintained over many terrains;
- Mobile second generation (2G) experience has demonstrated that service can spread rapidly due to high user demand and also contributes to economic development;
- Mobile networks can resist damage and theft better than wireline networks;
- Mobile networks are more able to provide both public and private access, and share capacity between many users in an area;
- Both mobile and non-mobile networks can easily exploit resources (i.e., radio frequencies) that are often underused in rural and remote areas; and
- Considerable development effort is going into reducing costs, which will enable mobile operators to expand economically into sparsely populated rural areas.

Mobile operators have an increasingly recognized role in providing UAS and are being allowed to participate in UAS funding competitions. The role of 2G services – both GSM and CDMA - in voice telephony is clear and has been well documented. The role of 2G/2.5G and 3G will be less clear in the provision of universal access to Internet services, since more choices are emerging from WiFi and WiMAX networks in particular. The choice depends on the economy of scale most appropriate to the situation. This section provides information on the following mobile technologies and adaptive measures that relate to UAS:

- 2G and 2.5G Networks
- 3G Networks
- CDMA450 Networks
- Cost reduction trends for rural areas

2G and 2.5G Networks

2G and 2.5G based services are well suited to national UAS deployments, since the cost is mitigated by the pre-existence or deployment of a main network. Thus the required investments are for incremental extension only. Most mobile networks support text messages, typically through the Short Message Service (SMS), as well as voice calls. Many applications have been designed to use text messages; for example, to contact people who do not read well, the senders of messages can create voice messages and simply send short text messages to alert the recipients of the voice messages, as used in Bangladesh. There are also systems that convert between SMS messages and voice messages (and systems that convert between SMS messages and email), for transmission to users on other networks. Such systems could do much to improve the accessibility of communications to people who have impaired hearing, speech or vision, as illustrated in the Practice Note *Communication possibilities for people with impairments in the UK*.GSM also offers the Unstructured Supplementary Service Data (USSD), which differs from SMS by using immediate communications (instead of store-and-forward communications rather like email) and having its special own addressing (instead of conventional phone numbering); because of the differences from SMS, USSD is sometimes preferred for banking applications. SMS and USSD are often regarded as data services (at least in the accounts of mobile network operators), though they do not use IP. In some countries, text messages are as popular as voice calls, if not more so. Network operators in the Philippines, offer schemes for prepayments that are small enough to pay for several messages but which are not enough for a single call. This has created revenues for text messages equal to those of voice calls, and is examined in What works: Smart Communications – expanding networks, expanding profits. Text messages are also important in the development of financial services for the poor, as discussed in **Section 1.6.4**. Universal access obligations might mandate that text messages be supported and that local public phone operators offer them.In developing countries, data and multimedia services using 2G technologies are less widely provided though there might be a business case for wider use, as explained for GPRS in Internet for Everyone in African GSM Networks. It is important however, to take into consideration that the pace of later developments such as EDGE (Enhanced Data rate for GSM evolution) will soon leave GPRS well behind. Purely 2G data technologies such as GPRS can only offer transmission rates comparable with those of dial-up access, suitable for many text applications, email, financial transactions, and some audio applications such as music downloading and voice mail; their data rates are typically not high enough for good quality VoIP or web browsing. Also, price of data services on mobile can make VoIP and other applications expensive, especially for low-volume users. Mobile network operators often prefer applications that increase voice revenues above what normal VoIP does; possibilities include voice mail and push-to-talk [*]. Internet access technologies can now readily be offered by UAS providers that are mobile network operators and in many countries they are becoming available. 2G technologies such as EDGE and CDMA2000 1xRTT (which are sometimes called "2.5G" or even "2.75G" technologies) offer higher speed Internet access and are derived from the widespread 2G technologies. They are often simple enhancements of existing 2G networks for telephony which already require much of the same network infrastructure. Since 2002, many new networks and phones have been able to use these technologies. They could be important for universal Internet access.For the ITU, EDGE and CDMA2000 1xRTT formally qualify as 3G technologies under the umbrella of International Mobile Telecommunications (IMT), but they are often regarded as 2G technologies. This can raise a regulatory issue, since occasionally services based on EDGE have been prohibited on the grounds that 3G licences would be needed; this happened in Egypt [*].

3G Networks

3G technologies such as WCDMA, HSPA and CDMA2000 1xEVDO are evolutions of 2G and 2.5G technologies intended for mobile broadband Internet access. 3G networks can use many parts of 2G networks; also, WCDMA can be replaced by HSPA (in the forms of HSDPA and HSUPA) largely through software upgrades. Regulators need to consider whether universal Internet access might evolve similarly through step-by-step upgrades and geographic expansion of existing network capabilities. For broadband Internet access, multiple choices are emerging. In developing countries, 3G networks may exist in urban areas but often do not extend to rural or remote areas where the business cases for them are not proven. 3G may require heavy investment or subsidies to extend service from urban cores to nationwide coverage, since the networks require major bandwidth enhancements to the 2G/2.5G infrastructure. However, there are signs that 3G networks can be rolled out more rapidly than 2G networks, since they can exploit the existing infrastructure and experience. Japan took eight years to achieve 100 per cent coverage with 2G mobile networks, but 3G coverage was accomplished in just four years, as noted in ITU World Information Society Report 2006.Countries in which extensive 2G/2.5G networks are not available may find difficulties in attracting investors for greenfield 3G development, though these cases are reducing with time. 3G may participate in universal broadband and Internet access in the following ways:

- 3G network operators could contribute to UAS funding through the sales receipts for governments of radio frequencies (or possibly operating licenses) or paying levies on 3G revenues as per the standard practice in relation to Universal Access and Service Funds (UASF).
- 3G network licenses could include modest build-out obligations into less-urbanized and regional areas in exchange for lower license fees. The objective would be to test how well 3G can meet the demand for competitive service from rural based fixed and semi-fixed customers such as vanguard institutions, e.g., schools, government, NGOs and leading businesses. Many governments have included coverage requirements in the license obligations of 3G mobile operators. In Sweden, the telecom regulator reports that the country's high 3G population coverage is due to regulatory obligations, with roll-out faster than purely commercial conditions would have dictated: the regulator allowed 3G network sharing but required services to be offered to 7 million people (out of a population of 9 million) by the end of 2004, 8 million by the end of 2005 and 8.5 million by the end of 2006.
- 3G network operators could offer their IP backbone networks on fair commercial terms for other uses such as competitive ISPs and VoIP operators using the public Internet. This might be opposed by the operators on the grounds that it weakens network security, because 3G services have walled gardens (controlled network environments) that deliberately exclude the public Internet. However, some 3G network operators are coming to terms with the Internet by demolishing walled gardens and providing public Internet access with simple pricing models, just like conventional ISPs.

3G technologies can have data rates comparable with those of DSL. Besides offering major speed improvements over 2G and 2.5G technologies for applications such as file downloading and web applications, 3G technologies can support further audio applications such as VoIP and some video applications.

CDMA450 Networks

By using the lower 450 MHz frequency range, CDMA technology allows larger cell sizes, which are appropriate for rural areas. In turn, this means reductions in installation costs, as fewer base stations are required. CDMA also supports high-speed transmission of data, so the advanced 2.5G and 3G CDMA Internet capabilities can be deployed. A number of countries have already deployed CDMA450 networks both commercially and as part of their UAS programmes. A total of forty-five countries have CDMA450 commercial networks. In addition, smaller regional operators in Russia have made use of CDMA450 [*]. However, the single largest hurdle to the development of the CDMA450 market is commercial. The low number of handset options available, their higher price and the fact that even fewer available handsets offer multi-band capability, prove to be an impediment to growth of the technology. At the same time, the development of innovative approaches to rural network design and marketing by the GSM operators limits the market for CDMA450. The International 450 Association [*] and a number of mobile operators have created an alliance to aggregate purchases in a bid to drive down costs via volumes and to nurture a market for entry-level devices.

Measures to reduce mobile network costs for rural areas

The greatest challenge operators face is the cost of network expansion and operation in low population density areas with poor electricity and transport infrastructure and challenging topography. While operators may increase revenues through deeper coverage, average marginal revenues may decrease with geographic expansion.Operators have to identify every component of cost – capital expenditure (Capex) and operating expenditure (Opex) – and minimise the total cost of ownership (TCO) of the network through addressing each significant component. Whereas minimising Capex is important, Opex is increasingly dominant in areas of rural expansion, for at least three reasons:

- Where Capex per customer is high due to low population density, ongoing Opex is driven higher because of its direct relationship with Capex (typically a reasonably fixed percentage of Capex);
- Some Opex may be higher in rural areas because operation and maintenance requires longer journeys and higher transportation costs; and
- Some specific Opex (e.g., diesel fuel) is higher because a larger proportion of sites in expansion areas may be without commercial power supply.

Operators' cost structures include business operating and network costs. Business operating cost reductions apply across the entire operation and are typically applied in both urban and rural areas to increase or maintain financial margins in the face of competition and the transition to lower average revenue conditions.

Network costs

Network operations

- Operation & Maintenance
- Spares
- Power supply (incl. fuel)
- Transmission backhaul Opex
- Site rental
- Support & training
- Network performance efficiency technology (AMR, SAIC, etc.)

Capex / Depreciation

- BTS Equipment
- Transmission Equipment
- Other site Equipment – Power Gen
- Civil Works – Towers, Shelters, A/C
- Licences

Table: Cost reduction measures in mobile networks for rural areas

Measure	Impact	Benefit	Capex	Opex
Improved ventilation, cooling and/or heat tolerance of BTS electronics	Eliminate or reduce air conditioning requirement, with consequent lower power requirement	Reduce external electric power supply, or Eliminate or reduce requirement for diesel generator and fuel supply, or Enable more economic use of solar panels	 ✓ ✓	✓ ✓
Improved ventilation, cooling and/or heat tolerance of BTS electronics, *as well as* smaller size for outside installation	As above	As above	✓	✓
Enhanced radio transmission performance	Improved and balanced "link budget" and longer signal range for "strong" signal coverage	Fewer BTS sites, resulting in lower Capex and Opex costs	✓	✓
Enhanced network voice and data carrying technology, e.g., AMR [6])	Improved quality and capacity on existing networks and maximum growth efficiency	Fewer BTS sites, and improved revenue versus cost relationship on existing and expansion networks	✓	✓
Enhanced radio & antenna technology to achieve extended range	Larger cell size applicable to and tailored to low density areas	Fewer BTS sites in very high cost and low density areas	✓	✓
Enhanced transmission technology to achieve lower interference, e.g., SAIC [7]	Optimum signal processing performance & user capacity with lower transmitter output power	Lower power consumption for equivalent network performance		✓
Smaller BTS equipment cabinet size	More portable and easier to install, easier site acquisition	Smaller shelters, more rapid deployment	✓	
Shared antenna configuration	Base stations expanded without the need for additional antennas	Reduced tower space	✓	
Mobile "softswitch" in appropriate regional location	Enables traffic to be switched locally or within a region	Minimising the need for backhaul transmission of all traffic to a central MSU		✓
Advanced pre-paid platform architecture update	More service features, automated support, etc.	Enables wider range of segments to be supported economically		✓
Market responsive site placement	Strong local community relationships	Reduced need for security guards and more rapid deployment		✓
Common backbone and tower infrastructure	Shared sites with common infrastructure has the potential to reduce build-out costs	Reduces the cost of transmission and some BTS costs	✓	✓

◂ Cost Reduction Measuresin Mobile Networks in Rural Areas

Clearly, no single or set of measures is superior or appropriate in all situations but there are certain strategies and technologies that reduce the costs on all networks while others are specific to costly rural environments. Operators are guided by the market, by geographical and population density, by local requirements, and sometimes by the need to standardize system-wide on a limited number of technical solutions to minimise organization and methods operations and maintenance costs.Governments and regulators can also play a critical role in promoting cost reduction and commercial network expansion through regulatory and fiscal / tax regimes that encourage operators to employ cost minimization and increase efficiencies.

Reference Documents

- **Internet for Everyone in African GSM Networks**
- **What works: Smart Communications – expanding networks, expanding profits, (WRI, September 2004),**
- **World Information Society Report 2007**

4.8.2.5 FIXED AND OTHER NON-MOBILE WIRELESS ACCESS

For Internet as well as developing VoIP services, newly emerging non-mobile networks may have niches in various situations, competing with 2G and 3G mobile. Their position could strengthen. The choice depends on the economy of scale most appropriate to the situation. Non-mobile technologies such as WiFi and wireless mesh networks built from WiFi are more suited to local initiatives for which large and expensive centralized organisation are unnecessary. Typically, non-mobile technologies can support VoIP alternatives to 2G telephony if regulation allows and if user terminals are sufficiently inexpensive.Four forms of non-mobile wireless that may be considered for universal access and service (UAS) are:

- Wireless local loop (WLL)
- WiFi
- WiMAX
- Wireless Mesh Networks

Wireless Local Loop (WLL)WLL is a fixed wireless service used for telephony and broadband applications, in which copper-based local loop is replaced by a wireless connection. This is described in **Module 7 Section 2.2.2**. When first introduced WLL had great promise, especially in developing countries, as an economic solution to reach areas beyond the reach of the copper-based network. In a few cases, such as Ghana Capital Telecom's use of WLL, these hopes have been partially realized.Generally, WLL for telephony was eclipsed by the success of 2G Mobile networks. WLL did not achieve the same economies of scale. Furthermore, even though it was initially believed that most users in developing countries did not need mobility, the lack of ability to roam from urban to rural areas with the same handset have proven to be a serious shortcoming for WLL operators. Many of these were using CDMA technology that is capable of full mobility operation, but regulations governing fixed and mobile licensing created the restriction. In the case of CDMA, the growth in mobile networks has been accompanied by reductions in the cost of wireless access generally. Nevertheless, other factors which have limited the success of WLL are developments in regulation such as roll-out obligations on mobile network operators and their inclusion in competitive tendering for Universal Access and Service Funds (UASFs). Together these changes have stimulated the use of mobile services even in areas where WLL would have otherwise been a natural solution. In South Africa, mobile network operators were obliged to provide fixed public payphones. In other countries, such as Uganda and Ecuador, mobile network operators have installed public payphones without being obliged to do so, because the incremental costs are small where base stations already exist. In contrast, India's two large CDMA network operators received subsidies from the universal service fund to provide WLL service. One network operator has provided service to 600'000 users and 40'000 villages in two years through these subsidies [*]. However, pressure grew for the CMDA networks to be cut free from their fixed status, first to limited mobility (single cell or single area) status, and then to enable them to provide mobility throughout the network. The pressure to cut WLLs free from fixed points is one reason why unified licences, as described in **Module 6 Section 4.3.1**, were introduced in India, as well as in Nigeria and elsewhere. Increasingly around the world WLL providers, those using CDMA at least, are likely to use these licences to make their services fully mobile, with the result that conventional WLL will continue to decline as a provider of telephony service.WiFiWiFi (Wireless Fidelity) is a popular name for implementations of the IEEE 802.11 standards. **Module 7 Section 4.2** provides a brief account of WiFi; this section considers WiFi more specifically as a technology that is relevant to UAS because it has been chosen in several projects to provide Internet points of presence in rural and remote areas.The advantages of WiFi for developing countries include:

- High data rates (compared with many 3G technologies).
- Flexibility for small networks to develop outside of large centralised organisations.

- Use of radio frequencies that are exempt from licensing in many countries (because the ITU radio regulations intend those frequencies to be used by equipment with very limited range and indoors operation, for which interference does not need control through licensing).
- Use of cheap standard equipment that is readily available and has type approval for many countries.

WiFi, with potential data rates of 11 Mbps and 54 Mbps, was originally intended to link computers over Local Area Networks (LANs) in homes and offices. It was then used to make LANs publicly accessible at indoor and outdoor hot spots and then to make long distance point-to-point connections. To reduce interference in licence-exempt WiFi use, power emissions are restricted so signals do not go far; WiFi in a typical home or office might have a range of 100 m. With directional antennas and higher power emissions, WiFi can have a range of 8 km. Some networks (e.g., in Indonesia and Peru) sometimes use a range of 50 km, and experimental demonstrations have reached several times that far [*]. Longer ranges make deployment more difficult and expensive. However, there is WiFi standard equipment that now offers five times the data rates and twice the ranges over the original intentions for LANs.The use of WiFi hot spots with connections to the Internet led to the development of municipal networks offering wireless broadband public access throughout large parts of cities and towns. Two of these networks are described in the Practice Note *The municipal wireless broadband networks in Knysna and Tshwanein in South Africa*. Because municipal networks may compete with, or reduce investment in, commercial networks, they are often obliged to offer open access to all service providers. This is discussed in Study On Local Open Access Networks for Communities and Municipalities.In Singapore, the Infocomm Development Authority of Singapore (IDA), has initiated a programme known as "Wireless@SG", in which Singaporeans have access to free wireless connectivity at speeds up to 512 kbit/s, in almost every part of the country. The programme is run by three private local operators who are investing approximately 65 million USD; IDA is defraying around 19 million USD of the total cost. The programme aims to increase the number of public WiFi hotspots in the country and by March 2008, more than 6,900 places offer the service in cafés, libraries and fast-food restaurant. Wireless@SG's basic tier is free until December 2009, but there are premium features such as higher connection speeds, that people can subscribe to for a small monthly fee [*]. WiFi enables community networks in rural and remote areas to develop without large centralised organisations, even though the administration responsible may find rapid or widespread growth difficult to manage. Two well-established examples of WiFi community networks are described in the Practice Notes *The rural wireless broadband network in Myagdi District in Nepal* and *The rural wireless broadband network in Chancay-Huaral Valley District in Peru*. An example of a guide to planning and building these types of networks is Wireless Networking in the Developing World. When networks grow they need to be scale-able and to cover long distances and offer enough resilience without making their operations disproportionately complex. In this scenario, WiFi can be used with WiMAX or even mesh networks. It could then play a major role in providing universal Internet access through centrally organised networks, as well as through community networks. Though WiFi is intended for licence-exempt use, some countries require licences where deployment is outdoors and there is an extended range. This was the case in Indonesia for many years where, as discussed in WiFi “Innovation” in Indonesia: Working around Hostile Market and Regulatory Conditions, the use of WiFi by Internet service providers was widespread but illegal. There are still legal obstacles to the use of WiFi and related technologies in some countries [*]. In particular, licences may be needed for operating an Internet service provider that offers VoIP, using frequency bands that elsewhere are licence-exempt, or that deploys equipment (even after stringent type approval testing elsewhere). Obtaining such licences can be expensive and slow, especially for community networks. Often these licensing requirements are becoming obsolete and could be easily abolished.

WiMAX

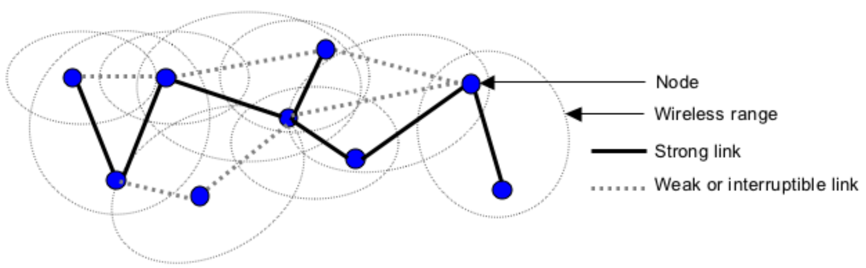
WiMAX, (Worldwide Interoperability for Microwave Access) is a popular name for implementations of the IEEE 802.16 standards. **Module 7 Section 4.3** provides a brief account of WiMAX. This section discusses WiMAX in relation to UAS because it has been marketed widely as a technology for providing broadband in fixed and mobile networks, especially in rural and remote areas. For the ITU, WiMAX formally qualifies as a 3G technology under the IMT umbrella, but is usually regarded as separate from the 2G and 3G technologies widely used by mobile network operators. WiMAX is intended for fixed networks as well as mobile networks, but unlike many fixed wireless technologies, it may benefit from economies due to its standardisation. In fact, WiMAX shares many of the advantages for developing countries that are listed for WiFi. WiMAX was originally envisaged for links from base stations to homes, offices and vehicles. Its role in providing UAS needs scrutiny because expectations about its performance have often been unrealistic. WiMAX might have data rates of up to 40 Mbps and a range of 8 km for fixed networks, and data rates of up to 15 Mbps and a range of 3 km for mobile networks, however data rates can fall to 2 Mb/s because of restrictions on the frequency bands and base station locations. With directional antennas and line-of-sight links, WiMAX can have a data rate of 2 Mbps and a range of 50 km, so it is suitable for backhaul. Eventually, WiMAX might take over the role of WiFi as computers will have both WiFi and WiMAX interfaces. Because of its mobility and VoIP provision capabilities, WiMAX can serve as a last mile application. As the potential for economic WiMAX deployment grows, policy makers and regulators will be faced with difficult decisions about whether to allow WiMAX for last mile access. Whereas 2G and 3G technologies might be better suited to the available infrastructure and levels of demand, regulators ultimately must take a technology and service neutral approach and allow operators to decide which technology is the best competitively.WiMAX is being licensed in many countries. However, working examples of commercial networks are few and far between to date; the most notable ones are the following in Pakistan and Spain:

- Wateen Telecom, Pakistan (**www.wateen.com**) has implemented a service that offers Internet speeds ranging from 128 Kbps to 2Mbps and uses the 802.16e standard. The company says it signed up over 10,000 customers in the first 20 days of service. Service launched on December, 2007 in 22 cities.
- Iberbanda, Spain (**www.iberbanda.es**) is a broadband communications provider that offers high speed Internet, telephony, data transmission and value added services. Iberbanda has the most significant WiMAX network in operation in Europe and covers nearly 30 per cent of Spain.

While there is a broad interest and enthusiasm for WiMAX technology and its potential, the business case for WiMAX and its ultimate success is determined, as with other technologies, through the market relevant factors. These are competition, demand, affordability of services, customer density and price points and availability of end-user terminals. Some market observers and potential operators claim that the economics do not look as promising as the technology itself. Service providers are likely to make different choices in different countries, appropriate to local market conditions and potential. WiMAX faces fierce competition from 3G technologies and the cost of WiMAX end-user terminals compared to mobile phones can be a potential hurdle. For licence-exempt use, WiMAX power emissions need to be limited which results in limited range and mobility. License-exempt use could therefore lead to licensed use: companies would first validate their business cases using license-exempt frequency bands and then provide their services widely using licensed frequency bands. “Balancing the Use of Licensed and Licence-exempt Spectrum” is identified as one of the three *Regulatory Principles Applied in Ireland to Successfully Promote Wireless Broadband*.WiMAX has to co-exist with other wireless technologies in both licence-exempt and licensed frequency bands, however using WiMAX and WiFi in the same frequency bands can reduce WiFi performance. WiMAX nodes transmit without checking whether doing so interferes with WiFi and other wireless nodes. While network operators should be free to select the wireless technology they want, their choice should not interfere with the choices made by others. Where congestion might occur, licence-exempt use might require consideration (politeness) of other service providers and their technologies. The relation between licence-exempt use and congestion is discussed in **Module 5 Section 1.5.3**. As in other cases, frequency harmonization can help reduce costs by creating economies of scale and reducing end-user terminal complexities. This in turn improves the feasibility of serving rural areas and low-income customers. Coverage could also be increased by using frequencies below 1 GHz. *

Wireless Mesh Networks

Mesh networking is a way to route data and voice between multiple nodes. It allows for continuous connections and reconfiguration around paths that may be permanently or temporarily blocked by topographic or other obstacles, by hopping from node to node until the destination is reached. IP networks can do this anyway, but mesh networks can do it more rapidly, by using the ability of nodes to sense how good transmission are on particular links. An illustration of a wireless mesh network is provided in the figure below. The diagram illustrates that each node has a radio transmission capability, which differs in strength of reception due to topographic conditions. Solid lines represent strong signals, whereas dotted lines represent weak signals that may be blocked at certain times due to weather or other atmospheric conditions. Under all scenarios, the link from one edge of the network to the other is possible through one route or another. Line-of-sight is not necessarily required.



◂ Figure: Mesh Network Architecture

Mesh networks can adapt themselves to exploit all possible links between nodes that are not blocked. Because of this, mesh networks are highly resilient and can be given higher collective data rates just through connecting extra nodes, without much network planning. This is particularly useful in situations needing rapid actions, such as disaster recovery. Even nodes that are user terminals can relay signals rapidly. Generally, mesh networks can cover large distances easily. Mesh networks may use wireline or wireless links, and may have fixed or mobile nodes. The most important cases of mesh networking have wireless nodes, and, often, mobile nodes. They are especially challenging, as the links can appear and disappear as the nodes move [*]. A potential use might include communication with nomadic people and keeping track of livestock. An experiment that may exploit mesh networks as a method for developing UAS is described in the Practice Note *Nomadic deployments in Norrbotten County in Sweden* .Some wireless technologies (such as CDMA or GSM) are not well suited to mesh networks because interference between nodes is difficult to control. By contrast, WiFi is often well suited to mesh networks. Many municipal WiFi networks have been structured as mesh networks.WiFi mesh networks, usually in urban settings, typically have many relatively inexpensive nodes close together, instead of few widely separated nodes with high performance antennas, radios and masts. They can work well in towns if equipment can be attached to buildings or lampposts and if damage and theft are unlikely. As they can adapt to use any available links, they might also be suitable in informal settlements or rural areas (where vegetation may grow to weaken the signals) if the nodes can be close enough together or very well sited. Still, their role in providing UAS is likely to be small compared with the roles of other technologies.

Practice Notes

- **Nomadic deployments in Norrbotten County in Sweden**
- **The municipal wireless broadband networks in Knysna and Tshwane in South Africa**
- **The rural wireless broadband network in Chancay-Huaral Valley District in Peru**
- **The rural wireless broadband network in Myagdi District in Nepal**

Reference Documents

- **Regulatory Principles Applied in Ireland to Successfully Promote Wireless Broadband Access (Comreg, November 2005):**
- **Study On Local Open Access Networks For Communities and Municipalities**
- **WiFi "Innovation" in Indonesia: Working around Hostile Market and Regulatory Conditions**
- **Wireless Networking in the Developing World**

4.8.2.6 SATELLITE

In addition to their use in broadcasting, satellites can be appropriate for universal access (public access points) to telecommunications and the Internet. However, their use is usually confined to Very Small Aperture Terminals (VSATs). The costs compared to alternatives such as terrestrial radio and wireless access networks limit VSAT applications to relatively remote areas. VSAT has a successful record for providing fixed public access telephony in many remote areas worldwide, including Chile, Peru, Colombia, South Africa, Nepal and Mongolia (consider Output-Based Aid in Mongolia: Expanding telecommunications services to rural areas). Associated with VSAT technology, satellites are also used as long distance trunking to a minority of remote rural exchanges and mobile base stations in a large and diverse number of countries. VSATs are also well suited for the provision of distance learning and tele-health applications in very remote or distant areas. The Practice Note *Distance learning using VSATs in the Solomon Islands* describes this type of scenario.

Practice Notes

- **Distance learning using VSATs in the Solomon Islands**

Reference Documents

- **Output-Based Aid in Mongolia**

4.8.3 BROADBAND AND THE IMPLICATIONS OF USING IP

There is currently a strong emphasis on using IP in the access and backbone networks to support all ICT services. This must be understood in the context of general trends towards deploying broadband networks. As noted in the introduction to this module, the deployment of IP and broadband networks is inevitable and commercially driven. The main reasons for the move to IP are:

- The Internet has demonstrated that IP networks can grow large, be used enthusiastically by the public and are capable of triggering the development of many new applications;
- Applications can exploit IP networks much more readily than they can exploit traditional telephone networks;

- Voice Over IP (VoIP), often in the form of voice over the Internet, is bypassing traditional telephone networks and has increasingly acceptable voice quality as well as low cost.
- IP Television (IPTV) and related applications can resemble existing conventional broadcasting but also offer extra capabilities through the use of software on personal computers instead of special-purpose equipment. The end user can pick and choose and not have to rely on the broadcaster to decide when and where broadcasts may be viewed. IPTV also leads to the concept of the end user becoming a content provider / broadcaster;
- Traffic for users of different services, and with different and changing capacity requirements, can be carried efficiently over IP networks; and
- The drift towards IP is making traditional telephone network equipment more expensive, and even impossible to buy, as equipment vendors are encouraging customers to invest in new networks.

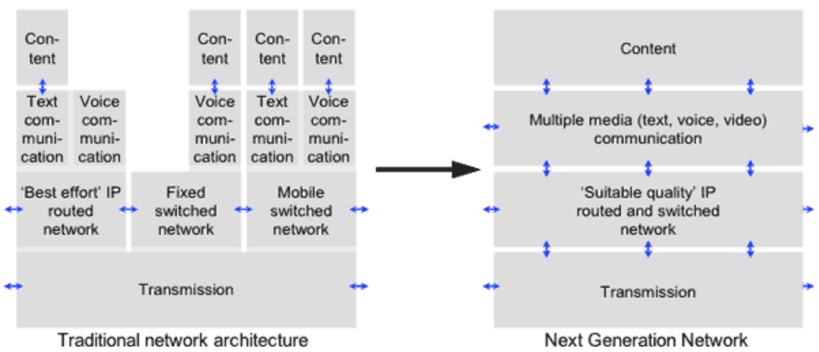
The overall implication of the above is that universal access and service (UAS) policies need to take into account the potential of the Internet and IP networks for much broader use than delivery of conventional telecommunications and Internet services. This points to the inclusion of broadcasting within a multi-sector, multi-media UAS policy (as well as within regulatory authority generally). Service providers recognise that future networks will be largely based on IP and that they will be required to support an increasing range of services of ever increasing bandwidth. This is central to service providers' interest in Next Generation Networks (NGNs). The migration to NGNs affects UAS policies in ways that are discussed in **Section 8.3.1**. For a deeper discussion of regulatory issues related to NGNs, see **Section 2.5** of this module.The Internet can affect telephony policy, described in **Section 8.3.3**, as well as broadcasting, as described in **Section 8.3.4**. Universal Internet access itself – at least in the form of Internet Points of Presence throughout the country - must be included in the scope of UAS policies, at least for main population centres (e.g., district centres) and educational institutions. The implications of this for content provision are outlined in **Section 8.3.5**.

Reference Documents

- **Universal Access & Service (UAS) and Broadband Development**

4.8.3.1 NEXT GENERATION NETWORKS

In **Module 7 Section 1.4**, the term Next Generation Network (NGN) is used both broadly, to cover new technologies and services, and narrowly, to refer to a network using IP to deliver multiple services with quality of service guarantees. This section uses the term narrowly in looking at the effects of Next Generation Networks (NGNs) on universal access and service (UAS); the effects of new technologies such as WiFi and WiMAX are described in **Section 8.2.5** and new services such as VOIP in **Section 8.3.3**. In the past, different services have been supported by different networks: specific transmission and switching networks have carried specific services. By contrast, NGNs support different services independent of the transmission network: they separate the services from the transmission network by using the transmission network to carry IP and the IP network to carry the services. Changing networks into NGNs gives them separate layers for transmission, IP, services and content. The figure below illustrates what happens when networks are migrated to NGNs.



◂ **Figure: The separation of network layers in NGNs**

Source: **ICT quality of service regulation: practices and proposals**, Robert Milne, ITU, August 2006.

NGNs' relevance to UAS is discussed extensively in What Rules for Universal Service in an IP-Enabled NGN Environment? and NGN and Universal Access. Issues with NGNs that may offer opportunities and changes are:

- Separation of services from networks. NGNs allow services to be independent of networks. This can separate the role of service provider from the role of network operator. In this environment, service providers are best able to determine rural revenues and business opportunities, but network operators make the main investments in NGNs.This can lead to a situation where one or several service providers might be willing to provide services but no network operator is willing to build a rural network. In these circumstances, policy-makers might consider distributing Universal Access and Service Fund (UASF) finance to either network operators to build networks or service providers to provide services; the latter then could in turn entice network operators to invest. Migration to NGNs will likely lead to additional hurdles to overcome and challenges for coordination between potential operators in rural areas and this may call for regulatory intervention.The degree of separation between service providers and network operators will vary between countries depending on the case and how NGNs actually evolve. UAS policies for use of funds need to be decided on a country-by-country basis.Service providers (fixed and mobile) in developing countries are aware of cost saving efficiencies associated with NGNs in core networks. In Brazil, India, Mongolia, Kazakhstan and Vietnam, providers have already announced plans to migrate to NGNs for their core networks. Also, in Argentina, Bangladesh, Brazil, Bulgaria, Pakistan, Venezuela and Vietnam providers have initiated fibre to-the-x (FTTx) projects. At this stage, however, the high costs and uncertain returns limit such projects to high population, high-income areas.

- Deepening of the digital divide. NGNs are expensive to build, even in urban areas. In fact, some network operators (e.g., in the United States) plan to sell rural assets to finance building NGNs elsewhere. Business cases for NGNs that depend on increasing revenues (not just on decreasing costs) are likely to assume that new services are provided only in selected urban areas. Other areas will not benefit from the NGNs unless their access networks can also support the new services. In particular, the data rates available in urban areas may need to guide the design of wireless networks for rural areas to avoid deepening the digital divide between urban and rural areas
- Requirement for broadband. Universal access to NGNs requires universal access to broadband. Though the impetus to increase the ubiquity of broadband networks has its own origins and does not depend on NGNs, many UAS policies have concenrated on increasing last mile access to telephony at low data rates. This is changing, but if rural areas are to benefit from NGNs, the NGNs are likely to require broadband backhaul, at least from district centres, public access points and educational institutions. The backhaul could terminate at Internet eXchange Points (IXPs) that themselves might depend on UASF finance.
- Need for suitable content. Introducing NGNs raises the importance of telecentres and other forms of public access to the Internet relative to payphones, provided that they make suitable audio and video content available (e.g., in relevant languages). If NGNs are to offer more than what is already available through telephony and broadcasting, the IP applications should fulfil the user requirements outlined in **Section 8.3.5**.
- Elaborate implementation. The standards for NGNs are complicated because they cater to fixed and mobile networks and for old and new services with good security and quality of service. Expertise in this area could take years to develop. Developing countries with very limited and old networks could find it difficult to leapfrog and implement these standards. On the other hand, precisely because many developing countries do not have extensive circuit-switched networks, they could possibly leapfrog to implement directly a fully IP-enabled NGN from the outset, as opposed to making a slow migration as in the case of more advanced countries. Irrespective of this, of course the complexity of technically implementing NGN standards as well as concerns regarding the level of investment needed remain.
- New interconnection arrangements. The introduction of NGNs typically changes the locations and functions of points of interconnection and requires interworking with legacy networks. Points of interconnection move from expensive town centres to less expensive business parks, and include equipment to convert between data recognised by IP networks and data recognised by other networks. The costs of these changes need to be shared equitably. Ultimately, both parties to the interconnection agreement are likely to benefit.Introducing NGNs also opens up the possibility of changing the pricing of interconnection to arrangements such as sender keeps all (as adopted in Internet peering). These arrangements are usually unsuitable for rural network operators, especially if they have historically enjoyed asymmetric interconnection pricing. Interconnection arrangements are examined in Interconnection Challenges in a Converging Environment: Policy Implications for African Telecommunications Regulators and NGN Interconnection and Access.
- Requirements to reduce regulation or to introduce regulatory forbearance. In some countries incumbent service providers have requested that regulators encourage investment in NGNs by reducing the effects of regulation. In Hong Kong, China, there have been suggestions that the cost of UAS provision should be calculated by combining the cost of the existing network and the cost of the NGN. The regulator has rejected these suggestions and will consider the cost of the NGN only where the change to the NGN stops the existing network from providing UAS [*]. Generally, investments in NGNs are motivated by the benefits derived from the convergences of dedicated networks such as the PSTN, broadcast networks and the Internet onto a single network. This convergence saves

costs through network consolidation and elimination of local exchanges, which means customer premises can be connected with higher-level data switching capabilities. NGNs also allow operators to increase revenues by making it possible to offer multiple services (e.g., voice, video, data) and innovative new services, over a unified network. Investments in NGNs should not affect UAS requirements (except, perhaps, by lowering cost). Regulators need to determine where the issues lie in each case.

- Scale, scope and monopoly. The EU regulators views expressed on these issues for access networks are provided in the ERG Opinion on Regulatory Principles of Next Generation Access. The ERG identifies as a significant issue for regulators the fact that economies of scale and scope are reinforced by NGNs. The report indicates that in some locations, there could be natural monopolies "in certain areas of the electronic communications value chain"; for example, one fibre, cable or duct, controlled by one service provider, might be enough for fibre to the curb. Since the effects of scale and scope will vary from country to country and even within countries, the ERG concludes that it is unlikely that a common regulatory approach would work for all countries – or even for all regions within a country. The impact of scale effects in different parts of a country could make the market structure more heterogeneous since NGNs would not be rolled-out everywhere simultaneously.
- Compliance with normal regulatory requirements for services: The transition to NGNs will be accompanied by increased use of VoIP whether a fixed line network or a mobile network is used. In the context of UAS, the migration to VoIP raises a number of issues that revolve around quality of service (QoS) and access to emergency services. Currently, VoIP calls differ in terms of quality and reliability from voice over the PSTN; VoIP is more susceptible to Internet-related technical problems and, in the case of fixed line VoIP, reliant on electrical power supply for calls. VoIP services normally do not include free calls to emergency numbers, the automatic rerouting of emergency calls to the nearest emergency call centres, or caller identification (see also **Section 8.3.3**).The shortcomings of VoIP in comparison to voice over the PSTN have led regulators to introduce a variety of different measures regulating the provision of VoIP [*]. But mandating VoIP to have the same QoS and emergency related features as voice over the PSTN increases the cost of providing the service. Given that the affordability of VoIP's makes it very attractive, light-handed regulatory measures may be more suitable to strike a balance between meeting consumer expectations and lowering costs.
- Enhanced competition. The expected advantages of NGNs are that users will have access to an increasing variety of service providers, assuming the number of viable service providers increases when they do not have to provide their own networks. This should stimulate price competition and incentives to provide new services.
- Fixed-mobile convergence: NGNs will also tend to increase the availability of multiple services through any kind of device, assuming the basic infrastructure becomes common to all. The Telecommunications Regulatory Authority of India [*], for example, estimated that 70 per cent of mobile calls are originated and terminated inside fixed locations. If NGN is implemented in end-to-end networks, such in-building or fixed-location mobile calls could possibly be completed on fixed networks, resulting in cost savings and more efficient utilization of scarce resources like spectrum. Of course, such concepts assume that users would be interested in switching from fixed to mobile on a price-basis [*].

Reference Documents

- **Challenges in a Converging Environment: Policy Implications for African Telecommunications Regulators**
- **ERG Opinion on Regulatory Principles of Next Generation Access**
- **Next Generation Networks and Universal Access: The Challenges Ahead**
- **NGN Interconnection and Access: Interconnection on an IP-based NGN Environment NGN Interconnection and Access: Interconnection on an IP-based NGN Environment**
- **What Rules for Universal Service in an IP-Enabled NGN Environment?**

4.8.3.2 CONTRIBUTION TO UNIVERSAL ACCESS FUNDS

Traditionally, the contributors to Universal Access and Service Funds (UASF) were the providers of voice telephony services, though both fixed and mobile operators have become much more than voice service providers. However, with the trend to use of VoIP, data and multimedia services, existing methods of funding universal access and service (UAS) may become unsuitable. The general trend for UASFs in developing countries is that levies should be made on all communications service providers, with the only exceptions being exemptions for companies below a certain level of revenue. Examples of issues that have arisen, even in relatively advanced countries, which are in fact exceptions to the general rule, are:

- In Hong Kong, China UAS is financed by a levy on the revenues from international gateway switches. Because international VoIP traffic does not use these switches (and because tariffs have been falling), revenues have been declining. As explained in Review of the Regulatory Framework for Universal Service Arrangements, the regulator has now decided that UASF finance will be provided by a levy on the quantity of telephone numbers (whether fixed or mobile) allocated to service providers. The decision treats VoIP providers in the same manner as conventional fixed and mobile operators, however, the regulator ignores peer-to-peer calls between computers, which do not access the public telephone network and which therefore do not use telephone numbers.
- In Canada, UAS finance were provided by a levy on the revenues from calls other than VoIP calls. As explained in Regulatory framework for voice communication services using Internet Protocol, the regulator adjusted the regulations to make them technology-neutral by introducing suitable obligations and rights for VoIP providers. In particular, the levy providing UAS finance is based on revenues from all calls except peer-to-peer calls, but is paid only by service providers that have revenues of at least 10 million USD.

Generally, UASFs can be compatible with the development of VoIP if contributions to them are calculated in technology-neutral ways. However, further revisions would be substantial if peer-to-peer calls between computers, which are typically made without charges to callers, were included. Thus they should probably not even be counted, let alone assessed for revenues.

Reference Documents

- **Regulatory framework for voice communication services using Internet Protocol**
- **Review of the Regulatory Framework for Universal Service Arrangements**

4.8.3.3 SUBSTITUTION FOR TELEPHONY

Voice calls and text messages alone do not need IP, but when other interactive applications are used, the case for using IP is clear. Even then, VoIP is likely to be the most popular broadband application for many beneficiaries of universal access and service (UAS). Surveys in The Economic Impact of Telecommunications on Rural Livelihoods and Poverty Reduction show how important voice calls and text messages are in poorer countries, compared with other uses of ICTs. However, providing VoIP in public access points (e.g., cyber cafés) might encourage people in these communities to try out other IP applications.Voice over the Internet (VoIP) takes various forms. One widespread distinction is between VoIP that uses managed IP networks (such as corporate networks and NGNs) and VoIP that uses the Internet (which is sometimes termed "voice over the Internet"). VoIP that uses the Internet does not have quality of service guarantees: calls may fail to be set up, become unusable or be dropped. Service quality guarantees are particularly significant when traffic is growing more rapidly than network capacity.VoIP is cheap, so it is popular despite limitations in the UAS obligations that it can satisfy. These limitations typically relate to emergencies: as outlined in **Module 7 Section 4.4**, many VoIP implementations do not work when the main electricity supply fails, do not connect emergency calls or do not automatically pass location information to emergency services. From the perspective of general quality of service as well as UAS, these limitations are serious in areas where users have expectations formed by fixed wireline networks. They are less serious, however, where users have expectations formed by mobile networks which often have similar limitations, or where emergency services are unable to respond rapidly for other reasons. Regulators need to protect users by ensuring that any serious limitations have sound economic or technical justifications and are explained carefully to users. VoIP for peer-to-peer calls between computers is likely to spread without any intervention by regulators beyond making it legal. Calls based on IP that access the public telephone network can be encouraged by making phone number allocations technology-neutral and service-neutral and by giving VoIP providers the right to negotiate interconnection agreements with other telephone network operators. There is a discussion of VoIP regulation in **Module 2 Section 4.4**.Regulators can support the use of VoIP in UAS in other ways provided they are convinced that the promotion of VoIP actually contributes to the policy objectives. In particular, they could allocate UASF finance to enhanced network capabilities including VoIP exchange points, which move VoIP traffic between networks, and ENUM (Electronic Numbering Mapping) systems (which map phone numbers into information for use in VoIP routing). VoIP exchange points and ENUM systems are best supported by regulators in ways like those described for Internet eXchange Points (IXPs) in **Module 2 Section 4.8**. Regulators should encourage VoIP providers to co-operate in developing such network capabilities. However, they should not impose particular implementations and might not need to provide funds. For instance, they should not require the use of ENUM systems as these are not necessarily the best way of mapping phone numbers into routing information.

Reference Documents

- **The Economic Impact of Telecommunications on Rural Livelihoods and Poverty Reduction**

4.8.3.4 SUBSTITUTION FOR BROADCASTING

Broadcasting is popular and widely available, often more than telephony. Radio and television can be powerful educational tools. Many countries recognise this by having universal access and service (UAS) policies for broadcast content, having public service broadcasting arrangements and obliging commercial broadcasting service providers to carry certain content. UAS policies should note that expanding telephony and broadcasting may, in some cases and during certain early phases of development, be more effective and less expensive than providing IP networks unless there are needs or demands for interactive applications and Internet access.However, the use of Broadband IP networks for television programme distribution is a development that telecom operators are seeing as an opportunity that enables them to offset revenue declines from traditional services as well as to "hit back" competitively, through telecom/media convergence, especially in broadcasting markets previously dominated by cable TV operators [*]. IPTV involves transmitting television programmes over IP networks [*]. As with VoIP, discussed in **Section 8.3.3**, there is a distinction between IPTV that uses managed IP networks and IPTV that uses the public Internet (which is sometimes termed Internet television or web television). IPTV that uses the Internet is likely to have no quality of service guarantees. In fact, in standards it is not regarded as IPTV at all, as mentioned in **Module 7 Section 4.5**.In their digital forms, radio and television can offer on-demand programmes and interaction with the user. In contrast, broadcasting does not offer the same variety or creativity as the Internet. Also, it usually confines users to walled gardens that allow access only to information chosen by the service providers. By contrast, providing IPTV might encourage users to experiment with other IP applications. In some countries, IPTV might be more beneficial for national development through UAS than digital television.

4.8.3.5 PROVISION OF CONTENT

IP supports many new communications applications, however several types of applications that are used extensively in urban centres may not be first choice in rural and remote areas of countries where people have little formal education and low literacy rates. Sometimes, radio and television, along with voice communications, are more effective in spreading information to these populations than email or web pages. In general, to have the greatest effect, content and applications specifically developed for rural areas need to consider the following requirements:

- Tolerance of inadequate links in networks. In some locations or at some times, applications might need to use narrowband networks instead of broadband networks. The narrowband networks might have poor quality phone lines, or short wave radio transmissions that support email but not web access, as described in the Practice Note Short wave radio in the Solomon Islands.Applications that can be used in these situations should minimize the data that is transferred across the Internet, by following guidance to make web pages compact [*]. Failing that, web pages can be read after removing graphics as demonstrated in the Practice Note The Loband web interface.
- Distinctiveness from existing alternatives. Applications should offer more than what radio and television offers. Unless applications are informational alone, involving searching for and displaying information, they should be interactive; applications might allow users to play educational games, undergo health checks, complete forms or take part in tutorials and on-line tests. However, as stressed in Section 1.6.2 in the case of government applications, there needs to be careful planning and designing of these types of applications if they are to be widely used.
- Acceptance of low levels of literacy. Applications should exploit the capabilities of ICT to avoid requiring high levels of literacy or knowledge of foreign languages. Typically, except where applications are designed for classroom use, they should provide spoken help messages and encourage spoken contributions to on-line forums. In fact, applications might be convergent; by exploiting multiple network technologies they could provide co-ordinated release and exchange of information in radio programmes and on-line forums.
- Robustness. In many places, applications and other programs will have unskilled users or inexperienced system managers who must maintain the stability of the terminals from as far as possible. When problems occur (because of viruses, for example) or software is to be upgraded, local people must be able to maintain terminals through simple operations (e.g., typically just by restarting them).
- Security. Security problems with applications on the Internet are so notorious that many people are willing to use more time-consuming and labour-intensive ways of doing business. These problems are discussed in the Information Technology Security Handbook and Cybersecurity Guide for Developing Countries.
- Assistive design. The content should also be planned to eventually incorporate features that are appropriate for use by people with disabilities.

Practice Notes

- Short wave radio in the Solomon Islands
- The Loband web interface

Reference Documents

- Cybersecurity Guide for Developing Countries
- Information Technology Security Handbook

4.8.4 TERMINALS

Advances in technologies as well as economies of scale are lowering the costs of user terminals or information appliances such as phones and computers. With the trend to convergence, technological advances are also blurring the distinctions between types of terminals. There are a range of different devices:

- handheld computers known as personal digital assistant (PDA);
- phones combined with video cameras and music players;
- mobile phones that are also Internet-enabled mini-computers (e.g. the Blackberry and other equivalent devices which enable e-mail and web-browsing among other wireless services); and
- powerful handheld 3G end-user terminals that provide “triple-play” services – telephony, Internet and IPTV and mobile TV.

For the purpose of universal access and service (UAS), this section focuses mainly on phones and computers.

4.8.4.1 HANDSETS: PHONES AND PDAS

With strong encouragement from service providers, equipment vendors have been developing low-cost mobile phones. In 2007, 2G phones were available for as little as 30 USD, and 3G phones were available for 130 USD. The 30 USD price for an individual mobile phone is still too much for at least 1 billion people, so some mobile phones are now being designed for sharing. In fact, entire systems for shared access have been designed [*]. These systems include not just the phones, but also power generators, marketing material, directional antennas, user guides and training. A power generator can be a solar panel or a human power generator (wind-up or step-on) as phones consume at most 5 W. Programs for sharing phones and the Subscriber Identity Module (SIM) that store tariffs and calculate the charge for each call make phone sharing easy, affordable and viable.Trials of systems for shared phone access indicate that typically 30 people share one phone. Some case studies of shared access are described in Development Fund Annual Report 2006. These systems illustrate one way in which countries can move gradually from universal access to universal service. As service becomes more affordable and people’s perceived or real need of a personal phone increases, the number of people sharing a phone can fall. Of course, even without specially designed phones, several people can use one phone on a commercial basis. This is common in several village phone programs around the world (see **Section 3.3.1**). Some regulators discourage the reuse of second-hand phones from other countries for various reasons (e.g., how to set (or lift) import duties for low priced, second hand phones raises issues which are not necessarily easily resolved; and some believe that the second-hand market increases the possibility of theft). However, the reuse of existing phones has helped to increase demand in various countries. In Burkina Faso, phones provided for reuse through an NGO in Switzerland sell for prices between 7500 CFA (15 USD) and 45000 CFA (90 USD), depending on the phone features [*]. The market grows faster when there are no unnecessary barriers to the use of phones. Common barriers include high import duties and laborious approval procedures. Type approval regulations are best designed to avoid inessential country-specific requirements and to allow mutual recognition of the testing and certification processes of different countries. As observed in **Section 8.2.5**, widespread type approval is one reason why WiFi is so popular.Personal digital assistants (PDAs) of various kinds have been successfully used as an inexpensive and, due to portability, more practical alternative to computers and conventional Internet connections in health applications. They are especially useful for data collection (such as on vaccination and on disease management) as well as for information dissemination (e.g. on disease treatment or prevention). Also, mobile phones, if equipped with a camera and able to send photos, can be used for applications such as remote diagnosis.

Reference Documents

- Development Fund Annual Report 2006 (GSMA, 2007)

4.8.4.2 COMPUTERS

Many projects have tried to develop and provide inexpensive computers using advances in display and storage technologies (e.g., flash memories) *. These computers are also designed to have low power consumption and thereby reduce the cost of power generation. One of the more prominent initiatives to provide low-cost computers is the One Lap-Top per Child (OLPC) initiative. Started in 2005 by faculty and researchers of the MIT's Media Lab, this initiative aims to provide children worldwide with new opportunities to explore, experiment and express themselves. The XO was designed to be flexible, low-cost, power-efficient and durable. It uses free and open-source software. The XO, originally intended to cost 100 USD, ended up costing 188 USD, mainly because little or no large quality purchases were forthcoming from governments as expected. The first production units were delivered in December 2007. Other small, inexpensive computers such as Intel's Classmate PC and the Asus Eee PC were also released in 2007 to address the demand for low-cost computers.Though computers can cost less than 200 USD, this is still too high for many educational institutions. Because of high costs for individual computers, there are projects for sharing computers just as there are projects for sharing phones. In these projects a single server computer, with a 2G or 3G modem, runs open source programs and stores data for multiple client computers connected over a LAN. This form of shared access should save costs by sharing the use of 2G or 3G links, open source programs and storage. Eventually, these savings (except those due to shared 2G or 3G links) might shrink as computer costs continue to fall. An example is the Jhai PC/ Jhai Network, which is currently field-tested. It is a thin client/ server technology based on the netPC system, providing a simplified desk-top for the end-user, while the operating system and applications are stored and accessed through the server. Advantages are that end-user terminals are cheap and consume little power, and that they are easy to manage and upgrade (as it can be controlled centrally by skilled staff). The disadvantage is that it requires a constant and fast connection to the server and that might not be available in some rural areas. It also requires a sufficiently sized server for the number of end-users. An alternative to the use of new computers is the reuse of used computers from other countries. However, these sometimes consume too much power (perhaps 120 W for a desktop computer and 80 W for an old display, or 40 W for a laptop computer), or are too fragile especially for rural and remote areas.Another consideration is that the cost of applications can exceed the cost of computers. Having said this, many applications and other programmes are available as open source software or even free software. Open source software is free for alteration, in that users can tailor it for their own purposes and is often also free of charge, though there may be (generally modest) charges for maintained and documented versions. Free software is not necessarily open source software; for instance, several web browsers, document readers, VoIP phones and other programs for client computers are free but not open source software.Open Source Software Perspectives for Development and Free/open source software (FOSS) policy in Africa: A toolkit for policy-makers and practitioners set the context for the use of open source software in developing countries. The Practice Note Examples of open source software lists some open source (and free) programs. These are only examples: they are not necessarily endorsed in this toolkit, and there are many other options.The cost of computers is not the only obstacle to their effective use. Often most of the equipment cost is due to the power generators, not the computers. The total cost of ownership must factor in not just equipment cost but also operating costs. Other considerations besides cost, are that there must be suitable applications, trained supervisors and motivated users *. An introduction to some of these issues is provided by Making the Connection: Scaling Telecentres for Development.

Practice Notes

- Examples of open source software

Reference Documents

- End-user sharing
- Free/open source software (FOSS) policy in Africa
- Making the Connection: Scaling Telecenters for Development
- Open Source Software Perspectives for Development

4.8.5 RELATIONSHIP WITH THE ENVIRONMENT

ICTs have a complicated relationship with the environment, having the potential for good or harm. This section considers that relationship of ICTs with the environment in terms of various specific topics. For all these topics there are implications for ICT policy and regulations, which may work with or against the achievement of universal access and service (UAS). This issue is included in the technology section since environmental requirements are typically applied at the equipment level, even though the impetus might come from policy.The effects of ICTs on the environment are often not reflected in immediate costs. In these circumstances, policies and regulations might need to depart from being technology-neutral, as explained in Section 8.1.

4.8.5.1 REUSE OF EQUIPMENT

Organising the reuse of existing equipment such as phones can be an effective way of making ICTs available to people who otherwise would not have them. Reputable organisations in developed countries make phones and computers available for re-use in developing countries. However, some schemes use these programs to simply dump largely worthless equipment. For example, between 25 per cent and 75 per cent of the equipment arriving for re-use in Nigeria is reported to be incinerated or dumped. Regulators in developing countries can help this situation by issuing lists of reputable organisations that distribute equipment that adheres to performance standards and limits on hazardous content. Sales and marketing practices can make equipment valueless or obsolete in a short time and potentially turn it into waste. For example, sometimes music (MP3) players are promoted as fashion items, or phones are subsidised by subscriptions or call charges as well as being replaced by new competitive offers on a periodic basis. Regulators could discourage or even in prohibit such practices, though it is not easy or advisable to interfere with competitive practices. Some market regulations can create beneficial results from cutting across common sales and marketing practices. For example, Finland in 2003, in contrast with many countries, did not have phone subsidies because there was a prohibition on locking phones to particular service providers. This probably contributed to the success of mobile number portability; once introduced there was an immediate impact in terms of subscribers changing provider, and resulting reduction in call charges. However, it is impossible to make a direct link between this and favourable environmental impact. Since the environmental impact interplay is often complex, it is not possible to generalize on the benefits of policy, though it would appear that this case might have had benefits to both market competition and the environment.

4.8.5.2 RECYCLING OF EQUIPMENT

Ultimately, all equipment fails or becomes obsolete and its components need to be recycled. Laws about unauthorised dumping of equipment are difficult to enforce. In some countries, users are likely to send equipment for recycling only if there is an incentive or obligation to do so. This is typically provided through regulations.The EU policy encourages users to recycle and places obligations on manufacturers, importers and distributors of electrical and electronic equipment (according to the producer pays principle). Manufacturers and importers must finance the collection, treatment, and recycling of waste equipment, and distributors must let users return waste equipment free of charge. To make recycling less hazardous, manufacturers and importers must limit the proportions of certain substances in equipment. Similar regulations apply to batteries and accumulators, with extra restrictions (e.g., untreated industrial and automotive batteries and accumulators must not be incinerated or dumped in landfill). The Practice Note Rules for the recycling and disposal of electrical and electronic equipment in the EU outlines regulations implementing the EU policy. The equipment itself should be designed to adhere to standards for environmental performance such as those summarised in the Practice Note The IEEE 1680 standard for the environmental performance of electronic equipment. In the EU, there is a systematic attempt to embed requirements for improvement of environmental effects in the very early stage of equipment design (e.g., there are codes of conduct to cut the power consumed during stand-by operation of equipment such as DSL modems, power supplies and televisions).

Practice Notes

- **Rules for the recycling and disposal of electrical and electronic equipment in the EU**
- **The IEEE 1680 standard for the environmental performance of electronic equipment**

4.8.5.3 ALTERNATIVE POWER SOURCES

Supplying power to remote ICT network sites is a significant cost element in any network serving rural regions. When network reach rural and remote areas ahead of the main electricity supply, alternative power sources are necessary. Diesel power generation is common, but technological developments have made it increasingly possible to consider renewable power sources that do not increase net greenhouse gas emissions. These energy technologies are becoming progressively less expensive and more practical. Solar, wind and water (micro hydro plants) generation is feasible in many places as are combinations of alternative energy sources (e.g., joint solar and window power generation in Namibia). For individual terminals, human power generation is sometimes used as in pedalling, where a human can generate 20 W or even 40 W fairly easily. A basic overview of the main alternative power sources, as well as network technologies, is provided in New Technologies for Rural Applications. However the following two web-based toolkits provide the most up-to-date and useful guidance on this subject:

- **www.eurorex.com/ugtoges/intro.htm** Users Guide to Off-Grid Energy Solutions by EuroREX is designed to help those who require energy-consuming equipment in off-grid (mainly rural) areas. A guide to multiple options are considered, including those appropriate for infrastructure systems as well as “audio-visual”, office and telecom equipment used at the user level, including telecentres. In each case, typical levels of power consumption are provided and the comparative suitability and cost of power sources, such as Photovoltaic (PV) systems, diesel generator, wind-turbine and micro hydroelectric plants considered. Particular attention is given to the costs and suitability of PV as an appropriate powers source. EuroREX is a network of European companies and trade associations focused on renewable energy solutions. It is partially supported by the European Commission.

- www.dot-com-alliance.org/POWERING_ICT/ Powering ICT: An Energy Solutions Toolkit for ICT Projects is a resource developed by the DOT-COM Alliance (sponsored by USAID). The toolkit is designed to help users determine a cost-effective combination of ICTs and energy systems. This toolkit provides equally useful information on Photovoltaic (PV) systems, diesel generator, wind-turbine and micro hydroelectric plants. The toolkit focuses exclusively on the power needs of ICT equipment, mainly computers, local area network and ancillary equipment used for telecentres. It is therefore also an invaluable guide to provide both an understanding of the power options available a step-by-step cost comparison and decision guide. It includes a planning and costing guide for telecentres.

Biofuel power generation is also being tested for network equipment. This could conceivably cut out the costs of transport, storage and consumption of diesel in conventional generator plants. Well publicised trials in Nigeria and India are using oils from groundnuts and jatropha as fuel stocks for powering GSM base stations which might have power requirements of 1 kW each. However, this is controversial because using biofuels might destroy forests, reduce water supplies, raise local food prices and introduce genetically modified organisms. Using biofuels might even worsen climate change; palm oil is said to produce 10 times the greenhouse gas emissions of petroleum. Biofuel obtained from agriculture and forestry waste such as straw and woodchips raises fewer objections but is harder to exploit.Currently, research and development of battery technology aims to improve the lifetimes of batteries and reduce the dependence on heavy metals, however, progress is slow. Fuel cells based on converting biomass (including dead flies, in one case) are highly experimental and generate insufficient power for phones, let alone computers. Larger fuel cells, typically based on hydrogen or alcohol, might become suitable as back-up power sources for network equipment.

Reference Documents

- New Technologies for Rural Applications (ITU-D Focus Group 7, ITU, September 2000)

4.8.5.4 CONTRIBUTIONS OF INFORMATION AND COMMUNICATION TECHNOLOGIES

ICTs can have positive and negative effects on the environment, although the identifiable impacts tend to be positive or neutral, unless contribution to economic growth is considered to be negative. On the matter of recycling and waste, ICTs may improve waste collection by contributing to better management, but they also produce waste equipment. ICTs may often reduce the need for travel (e.g., a simple phone call may often replace the need to deliver a message personally). As well, ICTs can make it easier to travel (e.g., users are able to find out bus schedules more easily, or to better coordinate meetings and other travel related events). The balance between the good and the bad depends on policies in ways that are not yet fully understood, though a useful attempt to examine the balance for the EU is reported in The Future Impact of ICTs on Environmental Sustainability. There are some specific suggestions for positive programmes in a developing country in Using ICTs for Poverty Reduction and Environmental Protection in Kenya. More generally, even in developing countries, regulators, service providers and equipment vendors can take the steps listed in the Practice Note Simple actions for improving the environmental effects of ICTs.For regulators the principal actions involve:

- Ensuring that their own operations set good examples, especially in their use of buildings and travel;
- Encouraging the provision of services (including e-government, etc.) that use telecommunications to reduce travel, thus reducing polluting emissions (CO_2, etc.);
- Requiring that equipment adheres to standards that limit environmental effects, through type approval or otherwise [*];
- Educating users about the strengths and weaknesses of applications that support secure on-line transactions and thereby reduce the use of paper; and
- Contributing to national environmental protection strategies, to ensure that sector strategies include the use of ICTs to reduce greenhouse gas emissions.

For service providers and equipment vendors, ICTs can affect the environment in ways besides those considered here. For instance, network construction and operation can degrade natural habitats by being noisy and ugly. The relevant authorities, who are not usually the ICT regulators, are likely to require an environmental impact assessment for any major project, using guidelines on mitigating impacts such as those in Environmental, Health, and Safety Guidelines for Telecommunications.Many regulators, service providers and equipment vendors record their plans for environmental protection and periodically report on their actions. An example of an annual report, from the regulator in Hong Kong, China, is provided by Environmental Report 2006/07.

Practice Notes

- Simple actions for improving the environmental effects of ICTs

Reference Documents

- Environmental Report 2006/07 (OFTA, 2007)
- Environmental, Health, and Safety Guidelines for Telecommunications (IFC, April 2007)
- The Future Impact of ICTs on Environmental Sustainability (Lorenz Erdmann and others, IPTS, August 2004)
- Using ICTs for poverty reduction and environmental protection in Kenya

Next: 5 Radio Spectrum Management ➡