ICT REGULATION TOOLKIT

MODULE 7: NEW TECHNOLOGIES AND THEIR IMPACTS ON REGULATION

EXECUTIVE SUMMARY

TECHNICAL UNIVERSITY OF DENMARK

March 2007

ABBREVIATIONS AND ACRONYMS

1G	First Generation Mobile Phone Technology
2G	Second Generation Mobile Phone Technology
2.5	Second and a Half Generation Mobile Phone Technology
3G	Third Generation Mobile Phone Technology
ADSL	Asymmetric Digital Subscriber Line
ATM	Asynchronous Transfer Mode
BWA	Broadband Wireless Access
CA	Conditional Access
CERT	Computer Emergency Response Team
DOCSIS	Data-Over-Cable Service Interface Specification
DSL	Digital Subscriber Line
DVB	Digital Video Broadcasting
E.164	ITU-T recommendation which defines the international public telecommunication numbering plan used in the PSTN and some other data networks.
EDGE	Enhanced Data for GSM Evolution
ENUM	Electronic Numbering
EPG	Electronic Programming Guide
FEC	Forward Error Correction
FMC	Fixed Mobile Convergence
FMI	Fixed Mobile Integration
FTTx	Fiber to the X
FWA	Fixed Wireless Access
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
HSCSD	High Speed Circuit Switched Data
IC	Interconnection
ICT	Information and Communication Technologies
IP	Internet Protocol
IPv4	Internet Protocol Version 4
IPv6	Internet Protocol Version 6
IPTV	Internet Protocol Television
ISDN	Integrated Services Digital Network
ISM	Industrial, Science and Medical
ISP	Internet Service Provider
ITU	International Telecommunication Union
ITU-T	International Telecommunication Union-Telecommunication
kbps	kilobits per second
km	kilometer
LAN	Local Access Network
MAN	Multi-access Network
mbps	megabits per second
MOS	Mean Opinion Score
MPEG	Moving Pictures Experts Group
MSP	Multi-stakeholder Partnership
NGAN	Next Generation Access Network
NGCN	Next Generation Core Network
NGN	Next Generation Network
PCMIA	Personal Computer Manufacturer Interface Adaptor
PDA	Personal Digital Assistant
PLC	Power Line Cable
POTS	Plain Old Telephony Service
PSTN	Public Switched Telephone Network
PPP	Public-Private Partnership
QoS	Quality of Service
RFID	Radio Frequency Identification
RPP	Receiving Party Pays
SDR	Software Defined Radio
SLA	Service Level Agreement
SMS	Short Message Service
VANS	Value-Added Network Service
VoIP	Voice over Internet Protocol
VSAT	Very Small Aperture Terminal
Wi-Fi	Wireless Fidelity
WiMAX	Worldwide Interoperability for Microwave Access, Inc.
xDSL	x Digital Subscriber Line (of any type)

Table of Contents

I. Introduction

The goal of this paper is to inform and assist telecommunications (telecom) regulators, policy makers, and others involved in the telecom reform process about new information and communications technology (ICT) trends and their implications for telecom regulation, with particular emphasis on developing countries. During the initial phase of telecom reform, incumbent national telecom operators were commercialized, and, in most countries, partially or fully privatized. Additional operators were licensed, especially in mobile services, and limited competition was permitted or encouraged. National policies and supporting legislation were developed, and national regulatory authorities were established to implement government policies and monitor sector developments. These reforms have been implemented with varying degrees of success, but in general, they have had a significant positive impact on the development of networks and services.

Meanwhile, there have been continuing dramatic improvements in ICTs that are fundamentally changing the telecom sector, and creating significant new opportunities for further development. Policies and regulations that were appropriate in the first phase of telecom reform far too often become major barriers to achieving further development of networks and services. Today, regulators and policy makers examining the diffusion of new technologies and services are encountering major new challenges in the design and implementation of an appropriate set of regulatory standards, models, and tools to guide the next phase of telecom reform and regulation.

In response to these challenges, the Center for ICT, Technical University of Denmark has prepared a set of materials as a multi-purpose *Module on the Impact of New Technologies on Regulation.* The module consists of three parts:

1. A report on *The Impact of New Technologies on Regulation,* that provides a comprehensive overview and analysis of the issues. This paper is the Executive Summary of that report.
2. A *Web-based electronic "Toolkit" on New Technologies and Their Impact on Regulation*. This facilitates access to specific issues covered in the report, provides selected additional information, and provides hyperlinks to related content in the other modules of the *info*Dev/ITU ICT Regulation Toolkit (www.ictregulationtoolkit.org).
3. *Training Material.* This consists of summaries of the key issues. It is presented in Microsoft Power Point format to facilitate presentations and discussions.

This material is presented in a modular structure. It focuses:

- first, on the underlying key technologies and technology trends;
- second, on market and regulatory implications; and
- third, on the characteristics of a new regulatory paradigm appropriate to the new technological environment.

The modular structure enables readers to go directly to their issues of concern, guided by the detailed table of contents.

II. Technologies, Markets, Policies & Regulations

The analysis in the report recognizes the interrelationships and interdependencies among technologies, markets, and regulation. These are illustrated in Figure II.1.

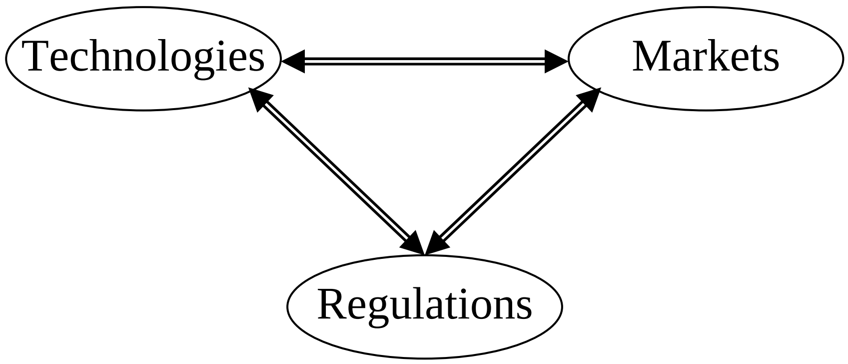


Figure II.1: Forces Shaping Telecom/ICT Sector Development

Technological change facilitates new technical opportunities, but these will only be realized if they are associated with market opportunities in a favorable economic climate. The policy and regulatory environment has a heavy influence on both the technical and the economic opportunities. That environment can foster new opportunities or restrict, delay, and sometimes even prevent them from being realized. Policy and regulation often follow technological developments. Policy makers and regulators often make modifications to accommodate new technologies only under pressure, after those changes have already been implemented elsewhere. However, proactive regulation can foster the development and application of new technologies in ways that will better serve network development and other policy objectives. In fact, both the telecom reform and Internet development processes began with policy and regulatory changes that made reform possible.

Some new technologies are more significant than others for network development and for regulation. By focusing first on the underlying key technologies and technology trends, this report enables regulators to better understand the direction and significance of technological changes. This will place them in a better position to make informed decisions on technology-related issues.

Selection and Classification of Specific Technologies

As a first step in the selection and prioritization of the specific technologies to be examined, the technologies were mapped and assessed in terms of their significance with respect to a number of important criteria. The following are the criteria that this study used to identify and classify the specific technologies that are considered essential in shaping and driving the future market structure and its corresponding regulatory regime:

- **Capacity –** To what extent will the new technology increase the speed of transport and delivery and thereby enhance the potential for new services?
- **Costs** - How will the technology influence the level and structure of costs for infrastructure and service provision?
- **Scalability –** To what extent are the solutions offered by the technology scalable, i.e., possible for general application as opposed to only local solutions?
- **Flexibility –** How can the solutions offered by the technology adapt to change?
- **Mobility –** To what extent is mobility offered?
- **Platform for innovation –** To what extent does the technology enhance convergence and development of new services?

The significance and impact of new technologies for the future will be even greater than they have been in the past, and the pace even faster. The impacts on markets and regulation will be both major and diverse. This dynamic technology environment can create vibrant and flexible markets, but dynamic and flexible regulation will also be required if the opportunities are to be realized.

The aim of this study is not only to examine the implications of technological developments on traditional core areas of telecommunications regulation, but also to extend the presentation of the impacts of technology change to a wider range of policy and regulatory issues related to the regulation of the telecommunications markets.

III. Three Waves of ICT Technological Development

This mapping of technologies helped to identify and classify three waves of ICT technological development leading to fundamental changes in network and industry development. Those three waves can be categorized in the following manner:

1. **Digital Technologies**;
2. **Mobility and Internet Technologies**; and
3. **Application Technologies to Restructure Organizations and Activities**.

Telecom reform so far has been primarily associated with or in response to the technological changes of the first wave of technological development. The key features of the second and third waves challenge the established regulatory paradigm in a number of ways. Telecom networks are becoming more multifaceted and complex. The end-to-end design of Internet Protocol (IP) networks gives rise to a range of new issues, e.g., VoIP competition, network security, interconnection, and quality of service (QoS). The moving of network intelligence from the central core of networks to the edges allows many new kinds of ICT service and application providers to become significant market players. It also poses new security risks. End-to-end design means that a whole new range of players can be active in markets, and nevertheless remain outside traditional regulatory oversight and control.

The implementation of second and third wave technologies gives rise to the further advanced development of infrastructure networks, including ubiquitous networks, the portable Internet, and the automated Internet of communicating objects. Many new technologies are expected to be on a smaller scale and less expensive to deploy. This will change investment cycles and patterns, speed up the introduction of new products and services, and enhance possibilities for competition. Smaller players will be able to enter markets and fuel network expansion with relatively small-scale investments, if the policies and regulations are not obstructive.

The policies and regulations established in this more multifaceted and complex environment will influence technological trends, affecting the speed, direction, and extent of development in different countries. Compared to the relatively simple success criteria of fostering network development through competition and universal access rules that characterized the first wave, regulators will need to establish multidimensional success criteria. The second and third waves introduce major new challenges for policy makers and regulators.

Table III.1 illustrates the essential intersections among the major technological developments, and the traditional areas of regulation that must be reexamined in the new environment. For example, traditional price regulation must be reexamined not only regarding the implications of new mobile technologies, such as 3G, but also regarding the combined effects of mobility with the Internet, NGNs, and other dimensions of convergence.

Table III.1: Technological Challenges of Regulation

	Pricing	Interconnection	Licensing	Universal Service	Spectrum Mgmt	Numbering
Mobile						
NGNs						
Internet						
Convergence						

The sooner regulators are able to address these challenges, the greater the influence they will have over the development path of the telecom and ICT sectors, and of the information society that emerges in their respective countries.

III.1 The First Wave: Digital Technologies

The first wave consists of the technologies associated with the conversion of telecom networks from analog to digital communication. It includes the three interrelated technologies of Network Digitalization, Computerization, and Packet-based Switching. This wave provided the technological foundation associated with the first wave of regulatory reform, as well as the building blocks for a second wave of technological change. These technologies are now well-established and widely implemented globally. There will be continuing improvements in these technologies that will enable further reductions in the costs of equipment and services. Regulatory issues are seldom raised anymore with respect to these technologies, because this technology trajectory is now mature. It is understood that their continued development is beneficial, and any remaining regulatory barriers to their full implementation should be removed.

Digitalization, Computerization, and Packet-based Switching have greatly improved resource utilization and increased bandwidth capacity in communications networks. They have enabled possibilities for the creation of new services and created conditions for gaining synergy in technological development.

These changes have directly influenced the communications markets and the regulation framework, as they are the basis for the IP revolution, the convergence process and the emergence of Next Generation Network (NGN) technologies, which in turn have reshaped and restructured different communications sectors.

III.1.1 Digitalization

Digitalization is the technological foundation for the modern convergence process. Three main technologies have been essential in making ICT digitalization become a reality:

1. **Compression**;
2. **Modulation**; and
3. **Forward Error Correction**.

Compression

There is normally a considerable amount of redundant information in the analog audio and video signals. Compression techniques reduce the bandwidth necessary for transmission of a given signal. Compression standards have been a vital factor for enabling the distribution of audio/video services on the IP networks. Moving Pictures Expert Group (MPEG) has developed three audio/video compression standards that are widely deployed in the development of audio/video services.

Modulation Technologies

Modulation technology is used to encode information, including audio and video signals prior to transmission. The information transmitted is modulated on the carrier wave and demodulated at the reception point. In principle, the technology is used for both analog and digital transmission, though the techniques used in digital modulation – where a stream of binary numbers is sent – are different from analog modulation.

Forward Error Correction (FEC)

The signals that are received at the end-user's site are often erroneous, especially in the wireless environment, due to noise and multi-path interference in the transmission medium, among other things. In two-way communications networks, the problem of errors is often solved by retransmission of the signal. When there is no return path to send commands upstream and request the transmission source to retransmit the signal, or alter the timing requirements if the signal does not permit retransmission, another technology that can be used is Forward Error Correction (FEC).

III.1.2 Computerization

The development of computers has had a vital influence on the effective organization and operation of network infrastructure.

The processing power of computers and the new applications have had a radical impact on the ICT sector. On the one hand, the expensive and complex functions in the network, such as switching and Intelligent Network services, are done to a large extent by computers. On the other hand, computers have been diffused in practically every function necessary for the operation of an ICT network, such as billing and human resource management.

III.1.3 Packet-switching

The development from a circuit-switched to a packet-switched paradigm is an important technological development. In a circuit-switched network, a dedicated connection (circuit or channel) is set up between two parties for the duration of the communication. The connection, i.e., the network resources, is occupied during the whole session. A good example of this is a POTS (Plain Old Telephony Services) network. The problem with circuit-switched networks is that the network resources are occupied even when they are not in use.

Packet-switched technologies are designed to use the network resources only when meaningful data are subject to transport. Hence, packet-switched networks utilize network resources more efficiently through bandwidth sharing. Another aspect of packet-switched networks is their capabilities for carrying different types of services. Many modern packet-based technologies like ATM and IP are designed to be able to carry different types of services. However, specific technologies/protocols must be implemented for different services. The most important packet technology with the widest spread and use in the ICT platforms is the Internet Protocol (IP).

III.2 The Second Wave: Mobility and Internet Technologies

The second wave of technological changes builds upon the digital networks established during the first wave. It includes the following:

1. **The Internet (including Internet Protocol)**;
2. **Mobile Communication**;
3. **Next Generation Access Networks (NGANs)**; and
4. **Convergence**.

These are technologies that allow new network services to be developed, network capacity to be expanded, and the convergence of services to take place. These technologies are now at different stages of development and implementation and are raising a number of important issues for regulators. National regulatory authorities are already playing a significant role in influencing the conditions under which these new technologies are being implemented or restricted. In most countries, some changes in regulations are necessary to enable the full benefits of these technologies to be realized.

III.2.1 The Internet

The emergence of the Internet, which interconnects billions of IP-based devices such as computers to each other, is one of the most important changes in the ICT sector in recent times. While a number of issues related to the organization of the general Internet are in place,[1] there are a number of unsolved problems and challenges related to the "Internet of things",[2] which will be on the political agenda in the coming years.

Even though the Internet itself has not been regulated directly in many countries, it has had massive implications for the regulatory framework, because the Internet at different levels of development has been able to facilitate the provision of regulated services such as voice telephony and TV/radio. Issues such as IP interconnection are becoming more important as Internet development expands in developing countries.

Some fundamental technological issues related to the Internet are described in the sections below.

[1] The current organization is subject to discussion; one of the main issues is the dominance of the US in the governance of the Internet and the skewed allocation of number resources. For more discussions on this, see the section on IPv6 later in this chapter.

[2] The increasing trend of embedding small mobile transceivers (electronic tags, e.g., RFID) in a variety of technology tools and everyday items enabling new forms of communication between people and things, and things themselves, through connectivity for anything at anytime and anyplace for anyone. See http://www.itu.int/osg/spu/publications/internetofthings/.

Internet Protocol (IP)

The way in which Internet protocol (IP) technology is designed enables a radically new environment for service development, innovation, and competition in regard to infrastructure platforms and service development platforms. Some of the important characteristics of the IP platforms are:

- separation between network technology and services;
- end-to-end architecture and extension of intelligence from the core to the edge of a network;
- scalability; and
- distributed design and decentralized control.

The separation between the underlying network technology and the services themselves removes entry barriers for the service providers. The only precondition for service provision is access to the network. This has created a huge change in service development within the Internet, but it has also created a revenue-sharing problem between the owners of the network infrastructure and the service/content provider. This is more obvious in the broadband IP infrastructure that is mainly provided by the telecom operators. Here flat-rate billing for connectivity has become the dominant business model, implying that the development of value proposition is mainly concentrated in service provision.

End-to-end architecture and the extension of intelligence from the core to the edge of a network is another factor that moves the development and innovation activities to the edge of the network.

Scalability is another main feature of the IP design. One of the barriers to further scalability is the shortage of address capacity or room in the current IP version 4 (IPv4) systems. As discussed below in the section on IP version 6 (IPv6), the shortage of address room is a considerable problem for developing countries, mainly due to uneven allocation of the IPv4 address room.

Distributed design and decentralized control have improved conditions for the development of services and innovations and the creation of new businesses. This is because various types of networks can easily connect to other IP networks, including the Internet, and obtain value added from network effects, etc.

Quality of Service (QoS)

QoS denotes the capability of network infrastructure, client applications, and end-user terminals to deliver a service that meets certain quality levels. QoS requirements vary from service to service and are linked directly to the specific services. In POTS, for example, there are detailed recommendations on QoS from ITU on maximum delay, blocking rate, MOS (Mean Opinion Score), etc.

QoS on the Internet is affected by a number of factors, including:

- delay;
- bit error and packet loss;
- speech compression;
- echo; and
- firewalls.

In the Internet domain, QoS comes about largely with the use of IPv6 (IP version 6, the advanced version of the current IP technology).

Security

In regular telephony services, security and consumer protection standards have been defined and have generally been found to be adequate. In the IP services, there is no one-to-one relation between the service and the physical infrastructure. Anyone with access to the network can intercept the signal and actively damage the integrity of the message and the signal.

It is also increasingly recognized that modern, industrialized societies are dependent on a wide variety of national and international information structures. The functionality of these networks has to be secured through a combination of policy and regulatory measures and technical tools. Some countries are quite advanced in this regard, whereas others do almost nothing. However, solving the problem will require both national and international initiatives.[3]

Mobility and Nomadicity

Generally speaking, there are two types of mobility in relation to ICT:

- **Terminal mobility**: A mobile terminal can move around the network without disrupting the service;
- **Personal mobility (nomadicity)**: A user can move to different terminals and networks and remain connected.

Terminal mobility requires a wireless connection. Personal mobility can be implemented without necessarily having wireless access. What is available now on the Internet could be called personal mobility or portability, i.e., one can move to different places and connect to the Internet and check e-mails, etc. Mobile operators are attempting to provide terminal mobility through their advanced services.

Mobility can be implemented at the following levels:

- the link layer;
- the application layer; and

[3] See http://www.itu.int/cybersecurity/index.html.

- the IP layer.

For the e-mail application, mobility (nomadic use) is implemented at the application level.

IP version 6 (IPv6)

The current Internet Protocol, which is primarily based on IPv4 (IP version 4), has experienced exponential growth regarding: (i) the number of IP-enabled devices; and (ii) applications and services. IPv4 suffers from major weaknesses in coping with these developments. This has resulted in the standardization of a new version of Internet Protocol, IPv6 (IP version 6) to overcome the shortcomings of IPv4.

One of the main weaknesses of IPv4 is the amount of IP addresses available globally. The IPv4 address consists of 32 bits, meaning that there are about four billion addresses available. Obviously, four billion addresses are not enough in a world in which more and more devices and terminals are becoming IP-enabled. Furthermore, even the current addresses available are allocated so unevenly that many developing countries lack the IP addresses needed to build their ICT infrastructure.

According to a Consultation Paper issued by the Telecommunications Regulatory Authority of India (TRAI): "India has merely 2.8 million IPv4 addresses compared to 40 million acquired by China".[4] It is important to note that any United States university has more IP addresses than the total of India, and that a US ISP, Level-3, alone has more IP addresses than China. The distribution is worse when it comes to the least developed countries, such as Bangladesh, which has only 150,000 IP addresses.

IPv6 extends the address room to128 bits. That means that the number of IP addresses would not present a problem for the foreseeable future. This provides the possibility of allocating more addresses to different countries and regions. With IPv6, addresses can be allocated more evenly, because IPv6 does not suffer from the legacy effects created by the allocation of the IPv4 address room. In the future, if the "Internet of Things"[5] is to be realized, there will be an even greater need for IP addresses.

The other issues that IPv6 deals with are QoS and security.

[4] TRAI: Consultation paper no. – 8/2005, TRAI, "Issues Relating to Transition from IPv4 to IPv6 in India," August 26, 2005, available online at http://www.trai.gov.in/trai/upload/ConsultationPapers/6/conspaper26aug05.pdf.
[5] See the 2005 ITU Internet report, *The Internet of Things*, *supra* note 2.

Peer2Peer

Traditionally, the Internet has been based on a client-server approach – there are a number of servers in the networks performing specific tasks, such as an e-mail server and web server. The end-users install clients on their IP terminal – computers, mobile phones, and PDAs – and connect to the servers for specific services. However, there is another approach that is being used more and more, in which the end-user's IP terminals act both as a client and a server. This approach is called Peer2Peer to indicate that peers communicate directly with each other. In Peer2Peer, the IP terminals connect directly to each other and share information, files, etc.

III.2.2 Mobile Communication

Mobile technologies have primarily been driven by voice telephony, but they embrace the whole portfolio of converged services in their development, particularly when it comes to wireless standards and the new generation mobile technologies. The emergence of mobile communication has influenced telecom regulation at all levels, particularly licensing and frequency management. Furthermore, the regulatory design related to interconnection and tariff regulation, pricing, numbering, etc., has been important for the development of a competitive and innovative mobile market. Mobile communication has been especially valuable in offering telephony to developing countries, because of its "time to market" and flexibility.

First Generation (1G) and Second Generation (2G)

The first generation mobile standards were based on analog technology. The mobile market in this era was fragmented, with a variety of standards developed and used in different countries. The second generation standards are based on digital technology. Digital technology utilizes the transmission resources in an efficient way, due to advances in both audio compression standards and digital modulation technologies. Another important characteristic of the 2G is that it leads to a less fragmented mobile market. This is especially due to Europe's decision to use a common standard and the subsequent creation of a single mobile market. Furthermore, the European standard, GSM, has had enormous success beyond Europe and has been used in a number of other countries.

Evolution of 2G towards 2.5G

In the 2G and 2.5G mobile platforms, several technological developments have been introduced to increase the capacity bandwidth of the networks and to enable the provision of new services. Two approaches are used to increase the available capacity at the end-user's site in GSM networks:

- deployment of several time slots - this is called HSCSD (High Speed Circuit Switched Data);
- deployment of packet-oriented IP-based technologies such as GPRS and EDGE.

When using HSCSD technology, a maximum capacity of 38.4 kbps will be achieved if 9.6 kbps per time slot is used. **GPRS**, on the other hand, is packet based and is optimized for IP traffic. In GPRS, the capacity per time slot depends on the deployed technology. **EDGE** can be seen as a technology with the same characteristics as GPRS, but with more efficient modulation techniques and consequently higher capacities per time slot.

Although GPRS and EDGE are capable of offering high bandwidth connectivity to end-users, the quantity of frequency resources in the GSM network is far below the amount necessary to cope with the ever-increasing demand of end-users for data services.

The technological evolution path towards 3G networks and the standards that will be deployed in different markets, depend primarily on the current 2G markets.

Third Generation: 3G

The main development in the mobile networks has been the transition from 2G to 3G and beyond. This has been primarily driven by the fact that there were insufficient frequency resources in 2G to cope with the rapid development and penetration of mobile services. This meant that there was a compelling need for new mobile services with varying demand on bandwidth. The 3G platforms include new frequency bands for the provision of mobile services, and they deploy more efficient technologies than 2G. This results in substantially increased spectral efficiency. Furthermore, the 3G technologies have greater potential in respect to meeting the goal of universal access. This has been one of the strongest arguments at ITU for backing the development of 3G standards.

Mobile Services

Mobile services in the 1G and 2G platforms are dominated by regular voice services, offered primarily in circuit-switched network architecture. In 2G, however, the SMS service has also been important. Furthermore, IP connectivity and Internet access have been the drivers of the development towards 2.5G and 3G. It is generally accepted that data and Internet services will be particularly dominant in 3G markets. In addition, voice services will be further differentiated and will not remain as a unique and coherent set of services.

Future Technologies
Software Defined Radio and Cognitive Radio

Software Defined Radio (SDR) and Cognitive Radio are new technologies that provide a more flexible design for the wireless and mobile industry. These technologies also enable alternate utilization of frequency resources. However, correct deployment of these technologies requires radical changes in the regulatory framework of frequency management.

SDR is a flexible radio architecture programmed through software, which is reconfigured depending on the usage scenario. SDR consists of a programmable hardware base that is controlled through software, in which different parameters, such as power level, frequency band, and modulation are changed/configured, depending on the environment in which users move.

SDR creates a number of regulatory challenges, especially when it comes to frequency allocation and management. For regulators, SDR has the potential to bring radical changes to how spectrum is used, and the regulations that apply to radio communications systems would have to be changed accordingly.

Cognitive Radio was created as a means to make efficient use of unused spectrum. It has the potential to free up large amounts of spectrum for future high bandwidth applications. Most of today's radio systems are unaware of their spectrum environment, because they are designed to operate in a specific frequency band. A Cognitive Radio system senses and understands its local radio environment. It identifies temporarily vacant spectrum that is available for use by a secondary user for a limited period of time. Cognitive Radio senses when the primary user[6] of that frequency band needs to use it again, and transmits the temporary user to other spectrum that has temporarily become vacant.[7]

III.2.3 Next Generation Networks (NGNs)

ITU defines Next Generation Networks (NGNs) as, "a packet-based network able to provide telecommunications services and able to make use of multiple broadband, QoS-enabled transport technologies and in which service-related functions are independent from underlying transport related technologies. It enables unfettered access for users to networks and to competing service providers and/or services of their choice. It supports generalized mobility which will allow consistent and ubiquitous provision of services to users".[8]

The concept NGN is used in two distinct ways:

1. A broad concept encompassing the whole development of new network technologies, new access infrastructures, and even new services; and
2. A focused concept of specific network architecture and related equipment, with one common IP core network deployed for the entire legacy, current, and future access networks.

In this paper, the concept "NGN" denotes the second definition. A distinction needs to be made between the Next Generation Core Network (NGCN) and Next Generation Access Network (NGAN). The NGCN refers to the new switching, gateways, and transmission equipments in the core network, which enables several access networks to use the same

[6] For example, a license holder to that part of spectrum.
[7] See Ofcom Technology Research Program 2005, available online at http://www.ictregulationtoolkit.org/en/Publication.1792.html
[8] ITU-T Recommendation Y.2001, available online at http://www.itu.int/itudoc/itu-t/aap/sg13aap/history/y2001/y2001.html.

core network. The NGAN refers to new *access* networks, such as the deployment of optical fibers, and the particular challenges that they pose.

NGN refers to the transition of current dedicated voice (and radio/TV) networks to the IP-based networks. From a technology efficiency point of view, this is a natural development of all network technologies. However, there are a number of problems related to the overall organization of NGN platforms, which are among the most contentious issues before regulators at present. One of the main issues is determining which interconnection model should be used. Will it be dominated by the IP interconnection models such as peering and transit, or will it be dominated by a modified PSTN interconnection and tariff regime? The telecom incumbents tend to see NGNs as a means of significantly reducing their network operating costs and complexity, while the market players from the IT world see NGNs as an opportunity for changing and revolutionizing the organization model of the entire future network.

NGNs cover different network technologies with different technical parameters. With respect to NGCNs, the important parameters are the high level of flexibility and scalability. The NGCN bandwidth levels and innovation possibilities are also quite high. With respect to NGANs, the characteristics are very different. The cost of establishing fiber networks is very high, and the scalability is low, due to the high cost of extending the network. However, the scalability depends on geographical conditions. In wireless networks, the level of mobility can be high, the cost of establishing networks is quite low, and the level of scalability is high. The level of bandwidth in wireless networks depends on the chosen technology. However, the bandwidth levels of all modern wireless networks are comparatively high.

Next Generation Core Networks (NGCNs)

Figure III.1 illustrates the difference between today’s telecom networks and tomorrow’s NGN platforms. Today, the PSTN, mobile networks, Cable TV networks, and wireless networks use several dedicated metro and core networks.

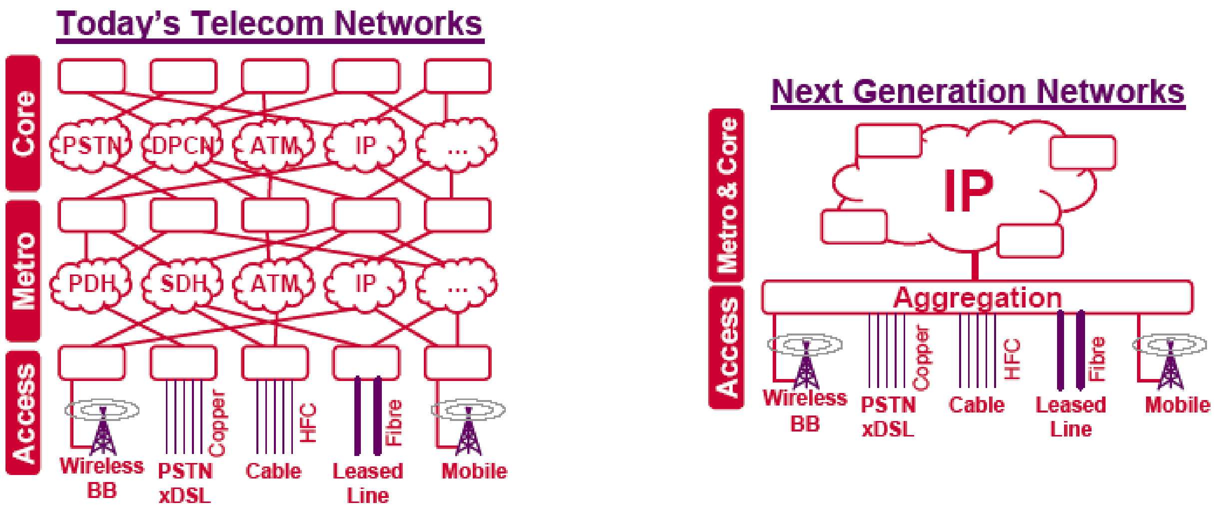


Figure III.1 *NGN*[9]

In the NGN platform, all of these different access technologies share the same IP core network. Some of the main arguments for transition to the NGN architecture are as follows:

- It is not efficient to maintain several core networks for different access networks. The economy of scope inherent in a single converged network can lead to substantial cost savings.
- NGNs enable improved time to market for new services and improve customer experience.
- NGNs enable continuation in offering services in the legacy access networks.
- NGNs enable provision of value-added innovative services, presenting the possibility that one core network can connect to and manage different access networks. For example, an SMS can be sent to a mobile subscriber to inform the users if there are problems with the operation of DSL.

The paragraphs above make it clear that the implementation of NGNs is a radical change in the network architecture of incumbent telecom operators. This raises the following question: should regulators intervene in the practical implementation of NGNs, and if so in what way? The role of regulation is, on the one hand, to make sure that effective competition can take place in the NGN era, and, on the other hand, to make sure that consumers, and the level of services they receive, are not affected in a negative way during this transition.

[9] Ofcom: Next Generation Networks: Further Consultation, Issued: 30 June 2005, Closing date for responses: 12 August 2005, available online at http://www.ictregulationtoolkit.org/en/Publication.1795.html.

Next Generation Access Networks (NGANs)

One of the main challenges of network infrastructure development is the efficient deployment of broadband technologies. In Europe, DSL technology has dominated thus far, but other broadband technologies, such as cable, fiber optic lines, wireless, and satellite count for a substantial part of broadband households and growth rates. In other countries and regions, the broadband technologies other than DSL dominate growth. In the developing world, it is likely that traditional broadband such as DSL will play a minor role and that the development of broadband will be determined primarily by the development of new wireless technologies.

Thus far, the development of broadband has generally been dependent on the ability of regulation to open up the legacy telecom networks for the provision of DSL services, via unbundling and bitstream access.[10] The issue of cable TV networks as a provider of broadband is now part of the open access discussion. This issue is mainly important in the United States, where the number of cable broadband subscribers is many times that of DSL broadband. In Europe, cable broadband is becoming an attractive competitor, especially in the era of triple/multi-play.[11] Here open access can spur variety in ISPs and may reduce prices for services.[12]

Mobile and wireless technologies use the radio spectrum resources to offer new narrowband and broadband access technologies. The scarcity of frequency resources puts high requirements on the efficient utilization of radio spectrum resources, which is partly achieved by developing new technologies and partly by combining various technologies.

The following section discusses the potential of technologies other than mobile to provide access infrastructure in the framework of NGANs.

xDSL

Due to the pervasive installed base of the PSTN physical infrastructure, PSTN has been the basis for fast and efficient development and penetration of the Internet. In the pre-broadband phase, this was implemented by the modulation of data signals in the same frequency spectrum as regular voice in the copper access lines. The data capacity in this frequency bandwidth is small. The next phase was the introduction of ISDN, which essentially doubled the capacity. This was followed by the emergence of technologies with real broadband potentials, primarily different variants of xDSL technologies. The advantage of xDSL is the availability of the physical infrastructure, and therefore the low

[10] This applies where competitive operators are trying to enter the broadband provisioning market through unbundling or bitstream access. However, it is not an issue if there is no legacy infrastructure to upgrade. In developing countries, the new broadband deployments, such as 3G and WiMAX, are more important.
[11] The provision of three main services, Internet, VoIP and IPTV, in broadband networks is denoted as triple play. The term multi-play refers to broadband networks which offer additional services to the triple play.
[12] See Bittlingmayer G. and Hazlett T.W., " 'Open access:' the ideal and the real", in Telecommunications Policy, June 2002, Vol. 26, No. 5, pp. 295-310.

deployment cost. However, it has limitations when it comes to coverage and capacity. The first generation ADSL can theoretically deliver 8 mbps, but only on high quality lines close to the central network. New xDSL technologies and standards address this problem, but again only within a limited distance (1 to 2.5 km).

Cable TV

Cable TV has an infrastructure with a huge installed base and with great potentials for the delivery of broadband connections. One of the reasons why Cable TV systems have a huge capacity is because they use coaxial cable, rather than the twisted copper of xDSL.[13] However, the total capacity utilized depends on how modern the system is, and consequently on how much of the frequency bandwidth is utilized.

Cable TV infrastructure is very well positioned for the future broadband market, due to its capabilities in offering triple/multi-play services. This is because the network is optimized for TV distribution, and is capable of delivering broadband. Many other broadband infrastructures face a huge challenge in delivering broadcast TV.

One of the weaknesses of the Cable TV network in relation to broadband is that it is a shared medium, i.e., a number of users share the capacity in a network segment. Another problem is that it would be extremely difficult to open the cable networks to a third party operator and establish competition, because Cable TV networks are not standardized.

An important element in the utilization of the Cable TV structure for broadband is the introduction of VoIP with QoS support. There are specific procedures for establishing prioritization to minimize delay and jitter, particularly in DOCSIS 1.1, which are highly necessary for VoIP. However, because it would be such a complex task to open the network to third-part operators, the general “best effort” VoIP operators cannot take advantage of these QoS-improving measures.

Power Line Cable (PLC)

Policy makers, particularly those in Europe, have for many years proposed delivering broadband via power lines as an obvious way to establish a new communication access infrastructure to promote competition.

PLC utilizes the high frequency part of the spectrum in existing power line infrastructure. With regard to the capacity, PLC has been able to match DSL technologies in recent years. One of the strongest arguments for utilizing PLC as IP infrastructure has been the ubiquity of the physical infrastructure.

Historically, PLC has suffered from a number of problems with noise and interference. Today, those problems have been solved to a certain extent in the low-voltage part of the power line infrastructure. Despite these improvements, there are few market players that

---

[13] A coaxial cable consists of a round conducting wire, surrounded by an insulating spacer, surrounded by a cylindrical conducting sheath. This construction provides a high transport capacity.

see any real future for this technology as a means to deliver IP/broadband services.[14] PLC is mainly deployed in a niche market requiring low capacity compared to the potentials of FTTx solutions.

Optical Fiber Technology and FTTx

Optical fibers are broadband infrastructures with huge potentials. However, these capacities have rarely been implemented at the end user's site, due mainly to the costs of termination equipment and the costs on the service provider side.

The deployment of optical infrastructures is more expensive than other broadband technologies, but the broadband product that can be offered in these infrastructures is far superior to the traditional broadband product. In the last few years, the implementation of fiber infrastructures has become more and more viable. This is mainly due to: (i) the decreasing cost of fiber; (ii) the decreasing cost of termination equipment; (iii) the continuing liberalization of the sector; and (iv) the opening up of the market to new actors, and the possibilities that presents for offering triple/multi-play.

Broadband Wireless Access (BWA)

The two best known broadband wireless access networks are Wi-Fi (Wireless Fidelity) and WiMAX. Wi-Fi uses the unlicensed Industrial, Science and Medical (ISM) band. In the absence of licensing barriers, and because of the simplicity of the technology and its cost-effectiveness, Wi-Fi networks have developed rapidly in both industrialized and developing countries. WiMAX is, like Wi-Fi, becoming a standard that is supported by several market actors. WiMAX is forecast to be a simple and inexpensive technology,[15] with long coverage and high capacity. However, the capacity offered over long distances is only a fraction of the maximum capacity. WiMAX, as access technology, is offered in distances of 5 to 10 km. WiMAX will therefore be a good complementary/competitive infrastructure to traditional broadband.

WiMAX may become the international BWA standard, because other BWA and FWA standards have proven not to be competitive in the access networks. (The former general wireless access standard was Fixed Wireless Access (FWA). With the advent of mobile, the name was changed to BWA. In other words, BWA encompasses both FWA and mobile wireless access.) The lack of success of FWA and BWA in the access networks has, among other factors, been due to the lack of open standards and the requirement for line of sight in the installations.

Another advantage of Wi-Fi and WiMAX technologies is that they are highly relevant for rural areas.

---

[14] Data communication over PLC can be relevant when it comes to operation and maintenance and monitoring of the power line infrastructures.
[15] The real cost of the technology depends on a variety of factors.

Digital Broadcast Infrastructures

One of the main advantages of digital over analog broadcasting is more efficient use of frequencies. In analog transmission, each TV program requires its own set of frequencies, whereas in digital transmission several programs/services can share a frequency due to coding and multiplexing. The digital signal at the end user's site can be fed directly into the integrated digital receivers, or in a transition period into a set-top-box, by feeding a regular analog TV receiver.

In digital broadcasting, there are three basic modes of distribution. They are:

1. Satellite;
2. Cable; and
3. Terrestrial.

The transition to digital is not straightforward, because it introduces a range of interrelated political, economic, and technical challenges. Some of these challenges are specific to the mode of distribution. Terrestrial, in particular, presents special problems and potentials.

Furthermore, digital broadcast denotes a set of standards that aim both to distribute broadcast signals and to transmit data services. Different standards apply to different infrastructures, because each infrastructure has a unique set of characteristics. DVB standards are widely used all over the world, in all three modes of distribution. In the European DVB system, a unique set of standards has been devised for each of the three modes. In some markets, combinations of different standards are used.

Because the basic technologies are now ready, solutions to two sets of regulatory issues are pertinent for the development and diffusion of terrestrial DVB. One set is related to the concept of Public Service Broadcasters. There is general acceptance of the need for the continued existence of Public Service Broadcasters, but there is disagreement over how prominent of a role they should play in the context of new services.

The other set of issues is related to new facilities, such as multiplexing (management of frequency sharing), Electronic Programming Guide (EPG), and Conditional Access (CA). The organization of the multiplexing function will be crucial, as digital broadcasting allows a number of content providers to share frequencies traditionally allocated to one channel. The EPG represents users' entrance to digital services. The strong presence of national programs makes cultural policy and regulation a high priority in relation to these functions. This is especially true in small language areas. Conditional Access regulates entry to services. Typically, this is done via an entrance code on a PCMIA-card. From a user's perspective, it is essential that entry control is standardized and does not require different hardware for each content provider.

III.2.4 Convergence

The traditional broadcasting and telecommunications industries have co-evolved with the developing Internet, but technological development is making this current sectoral distinction unsustainable. Content and service provision has already been taking place across the traditional sectoral boundaries for some time. Technological advances are making it possible for more and more services to be carried on different infrastructures. Furthermore, the end users' access equipment will be designed to communicate with a whole range of services.

Mobile / Broadcast Convergence

One of the main challenges the mobile industry faces is the demand for increased broadband capacity necessary to distribute video, music, games, and other digital content optimally to many mobile users at the same time. Parallel to this, the broadcast industry faces a decisive challenge in personalizing content and segmenting channels toward an increasingly fragmented market. In addition to digital TV and radio, that market includes the Internet, which must be accessed through mobile terminals.

The following are conditions that are conducive to the convergence of the broadcast and mobile industries: (i) the ability to distribute a large number of programs and other digital content to many mobile users at the same time; and (ii) the possibilities that lie in the mobile network for new interactive services and business models.

Convergence between digital broadcast and mobile services can be viewed as a paradigm shift that will change radio and TV from being a broad "push" media, to being largely a "pull service" oriented media. In the future, radio and TV will be delivering a large amount of segmented channels, with targeted "pull" services customized to mobile users' constantly changing demands and uses. Mobile and nomadic application will result in decisive new behavior patterns that carry great potential for research and innovation.

Fixed / Mobile Convergence

Fixed Mobile Convergence (FMC) or Integration (FMI) is a broad concept that covers various ways of integrating mobile and fixed technologies and services. Several FMC services have been on the market for the last five to seven years, but new technological and market developments have created new incentives for the further development of existing FMC services and the creation of new types of FMC services. The following are among the reasons for the emergence of these services:

- A high proportion of mobile calls are made from the home and office environment.[16]
- Fixed operators are losing voice minutes, and want to reallocate some of their traffic from mobile to fixed.

[16] The Yankee Group estimates this to be 30% of calls.

- Mobile networks can currently offer far less data capacity than fixed networks. Therefore, it is much more efficient to connect to the fixed network whenever possible.
- VoIP is gaining momentum, and many broadband operators now offer VoIP services. Integration of mobile telephony and VoIP opens up new possibilities for competition in the voice telephony market.

As a result of all these factors, FMC is foreseen to be massively developed in the near future. However, the efficient provision of FMC is dependent on the maturing of technologies deployed in the backbone network, and is closely related to the development of NGNs.

VoIP

In the new regulatory paradigm, it is generally accepted that networks must be opened up for competition through unbundling and interconnection regulation. However, within the traditional telecom paradigm, competition would have at best existed between a few actors in an oligopolistic market.

VoIP has gradually changed this situation, and the convergence process has opened up new conditions for service development. Using VoIP technology and the general Internet as backbone, new providers can offer competitive prices, particularly for long distance and international calls. The transmission of the service over long distances within the Internet is much less expensive than keeping the service within POTS with its distance-related cost structure and interconnection pricing schemes. The entry barriers for these service providers are lower and the number of them is increasing, contributing to the overall competition in the public voice market.

III.3 The Third Wave: Application Technologies

The third wave of technological changes builds on the second wave. It applies various elements of the second wave, so as to change the fundamental way in which organizations function (e.g., e-commerce). It applies **ICT Network Services** and **ICT Network Equipment** as valuable resources and it applies second wave **Generic Technology** (i.e., a technology whose impacts are so wide-ranging that it has the potential to distribute its benefits throughout an economy and/or society, thus transforming it). The third wave makes it possible to redesign and rationalize production, administration, and transaction processes of all kinds, and to create new products and processes commonly associated with visions of future information societies.

The third wave is at an early stage of development and implementation, and is therefore subject to significant influence by policy and regulation. However, most of the potential regulatory issues associated with third wave changes will not become significant until the regulatory issues associated with the second wave have been resolved. The opportunities and effectiveness of third wave policy and regulation will depend heavily on the foundational developments with the second wave technologies.

New organizational forms developed in interaction with ICTs are generally seen as carrying the real socioeconomic benefits of these technologies. It relates clearly to the discussions during the World Summit on the Information Society (WSIS) on providing a roadmap to bring the benefits of ICTs to underserved economies.[17] The WSIS activities aim to bring the benefits of information and communications technologies to everyone. They cover a very broad area, including almost all socioeconomic activities.[18] Major categories of the project are as follows:

- national e-strategies;
- multi-stakeholder projects involving the private sector in partnership with public bodies;
- infrastructure projects;
- broadening access to ICTs;
- international and regional cooperation;
- access to information - create online libraries and provide open access to public and research data;
- policy and regulation;
- capacity-building;
- online education, medicine, business, government;
- security; and
- cultural issues.

This very broad approach to promoting the benefits of ICTs can be seen as an illustration of the idea behind the concept of the "Third Wave": that ICTs basically have qualities as one of the emerging generic technologies – the others being biotechnology and nano-technology. There are two main dimensions in the generic aspect of ICTs: one is related to the effects on the potential commercialization of services, and the other to the effects on the internal structures of companies and associated transaction costs often discussed as "virtual organizations."

IV. Market and Regulatory Implications

In the historic model of telephone service, supply, services, and facilities were integrated by technical design, as both were supplied by telephone monopolies. Internet technologies, and particularly Internet protocol (IP), have permitted a clear separation between network facilities and services. This separation was achieved: first, for data; second, for pictures, audio, video, and private voice networks; and third, for public voice networks, due to the emergence of VoIP. This completes a technical unbundling process

[17] Proposed at the World Summit on the Information Society, Phase I, Geneva, December 2003 and confirmed at Phase II, Tunis, November 2005.
[18] http://www.itu.int/wsis/tunis/newsroom/background/wsis-stocktaking.html.

that allows for the separation of network facility capacity from the services supplied over these facilities. The technologies of the second wave are facilitating the final steps of the convergence of telecom services, and the new regulatory paradigm must reflect that fact.

The second wave has made it necessary for telephone operators, service providers, policy makers, regulators, and users to make a number of important adjustments to the new technological environment. Any major technological improvement that dramatically reduces unit costs and expands service capabilities offers the potential of enormous benefits in terms of network and market expansion, cost and price reductions, and the development of new services. However, it brings the threat of significant losses to those who want to hold on to the traditional ways of doing things.

Policy makers and regulators must reassess the extent to which, in the new environment, their established structures of policy and regulation:

1. create artificial barriers to the achievement of full converged service benefits;
2. create unjustified biases that favor or retard one segment of the industry in relation to the others;
3. adequately address new public service and public interest opportunities and requirements; and
4. adequately facilitate the application of the new technological and service possibilities toward extending network and service development to unserved and underserved regions and persons.

Most developing countries started the telecom reform process much later than developed countries, and have not yet fully completed the transition to an effective structure of liberalized market participation and independent regulation. Therefore, the issues of structural adjustment raised by the new technologies are particularly difficult and acute for developing countries. Virtually all of these countries face the daunting task of extending the national telecom network by several orders of magnitude to unserved rural areas and widespread pockets of the population that have limited or no access to telecom services, in addition to upgrading the national network for broadband access to Internet services. On the other hand, these technologies offer outstanding potentials for developing countries to overcome inherited problems and take advantage of the participation of many players, old and new, to truly transform their telecom infrastructure and service networks.

IV.1 Market implications

In the past two decades, the structure of telecom markets has been transformed, due to the interrelated effects of changes in technologies, industry economics, and policies and regulations. The following are four different types of structural changes in markets that have been part of that transformation:

- **Service innovations;**

- **Network innovations;**
- **Vertical structure separation (unbundling);** and
- **Horizontal structure integration.**

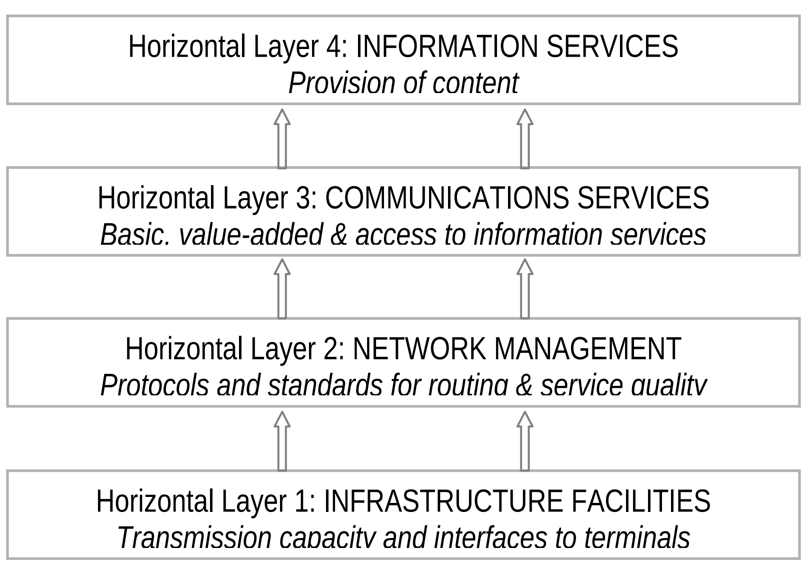
The restructuring of markets along these four dimensions is diminishing the relevance of traditional regulatory models to telecom markets, and introducing a range of new issues requiring regulatory attention.

Telecom markets have developed from an oligarchic, homogeneous, single-service market - public voice telephony - to an increasingly diversified multi-service market that includes voice, data, fixed, and mobile services and provides an increasing variety of information content. Mobile services are now more widespread than fixed services. The Internet provides a common platform for an expanding set of services, ranging from the World Wide Web and e-mail, to e-commerce and voice telephone. These services are widely used by almost all types of businesses and individuals. Therefore, ensuring the availability of wide access to these services is becoming increasingly important.

Continuous network innovation is not only making substantial cost savings possible, but is also making it feasible to establish effective competition in more and more segments of the telecom market. This has created a need to ensure that inherited regulations do not provide unjustified biases favoring particular technologies, services, or competitors.

It has become easier to separate infrastructure network and service provision. This has enabled the development of a market structure with a vertical separation between network operators and service providers, as is seen in the Internet market. The development of these vertical separations within the Internet market implies the need for a new model. The new model consists of four layers of horizontal markets vertically separated from one another. This is illustrated in Figure IV.1.

Figure IV.1: Horizontal Layers of the Internet Market



The following is an explanation of each of the horizontal layers, and of the pairs of arrows, that appear in Figure IV.1:

- **Horizontal Layer 1** represents the **Network Infrastructure Facilities** that provide the raw capacity that enables telecom connections. This includes cables, wires, microwave towers, mobile cells, and satellites.
- **Horizontal Layer 2** represents **Network Management –** the standards and protocols that permit the routing and determine the technical quality of network services. IP has permitted the gradual unbundling of network services from infrastructure facilities.
- **Horizontal Layer 3** represents the provision of **Communications Services** using IP. Until VoIP was introduced, Layer 3 was typically referred to as Value-added services, because it did not include the basic public voice service. With VoIP, it includes all types of communications services.
- **Horizontal Layer 4** is the **Information Services**, such as websites, that are accessible on a network using IP.
- **The pair of arrows** between each of the horizontal layers represents the **vertical separations**.

With Internet technologies now applied to all network services, the structure of the overall market for communications services has changed radically. In the former vertically integrated structure, most services and facilities were licensed and provided together. In the Internet-based infrastructure, there are four separate horizontal markets for: (i) network infrastructure capacity; (ii) network management; (iii) communications services; and (iv) information services. This reduces the technical barriers to entering these markets. It provides new opportunities for increased participation by new players that provide a wide variety of different service packages. It requires incumbent operators to reassess their business models and their strategies as they face increasing competition at different layers within the market structure. At the same time, they are also presented with opportunities to develop new services, such as VoIP, which is reducing costs significantly, and is placing market pressure on international telephone charges. VoIP can also be provided by companies that are outside the remit of the national regulator.

Both service and network innovations have caused a blurring of the boundaries of the telecom sector. There are a wide range of new telecom service products. Some of these products incorporate service elements from other sectors, such as IT or broadcasting. At the same time, digitalization and the expansion of network capacities enables network convergence, i.e., the transmission of IT, telecom, and broadcasting services on the same network.

Although IP was developed for and initially applied to the Internet, the largest users of IP are the incumbent telephone operators around the world. These operators are in the process of converting their entire telecom systems to IP, because of the enormous cost reductions and the potential for providing new converged services in the future information economy. Among those new services are e-commerce, e-government, and other e-application services. At the same time, the extended application of IP by Internet Service Providers to include public voice services has opened a major new service opportunity for them, and introduced a significant new element of participation and competition in the supply of both public voice services and new converged services.

The convergence of services requires regulatory attention in areas where different regulations for different services are creating an uneven playing field. Regulatory obligations, such as open access requirements or universal service taxes that are applied to one among a group of converged services, can place that particular service at an unfair disadvantage. For instance, it is becoming more and more difficult to distinguish between different types of Internet-based voice services such as VoIP and voice mail and telephone services. The same holds true for mobile phones and video services provided via the Internet vs. broadcasting services. Network convergence may require the harmonization of network infrastructure regulation.

IV.2 Regulatory Implications

In regard to regulatory areas that influence market structure and network development, this study focuses on the following six:

1. **Price regulation;**
2. **Interconnection;**
3. **Licensing;**
4. **Universal Service;**
5. **Spectrum management;** and
6. **Numbering.**

This study analyzes how each of those six regulatory areas is affected by the following four broad technology trends:

1. **Mobile communication;**
2. **Next generation networks;**
3. **Internet;** and
4. **Convergence.**

These four technology trends are discussed in greater detail in Chapter III.2.

IV.2.1 Price Regulation

Price regulation is becoming more complex as more and more service offerings are provided. Some of these services are close substitutes, although the underlying cost structures may be very different. In some markets, competition is sufficient to permit the relaxation of price regulation. In others, market developments suggest that it is appropriate to shift from retail to wholesale market price regulation. But even in competitive markets, there may be important elements of monopoly power requiring regulatory attention. For example, new, imaginative pricing schemes in competitive mobile markets in many countries have required the regulation of termination and roaming charges. In those particular elements of the market, competition has not been effective, and consequently, consumer protection has become a more complex task for regulators.

Pricing schemes are constructed to achieve technical, allocative, and dynamic efficiency. True cost-based prices may imply a substantial barrier of entry for new customers, as high entry fees and subscription charges may drive away customers. Pricing schemes must provide the right incentives toward potential customers, and should be transparent so customers are able to foresee total usage costs. Users must to be able to determine pricing comparisons without great effort and cost.

Mobile markets are generally more competitive and less regulated than fixed service markets. The former have been very imaginative with regard to the creation of new pricing schemes. Variations in pricing schemes can be an advantage to consumers and may stimulate growth in penetration. However, they also make markets less transparent. Regulators can play an active role in providing comparable pricing information on different pricing schemes.

Handset subsidies are another innovation within mobile pricing schemes. Mobile phones are sold at subsidized prices if bundled with a subscription. This innovation is rooted in the fact that the handset terminal constitutes the major part of the investment needed for adding a new customer. Operators and manufacturers have a common interest in paying terminal subsidies. Manufacturers can sell more and more expensive terminals. Operators can attract more customers. More advanced mobile terminals tend to generate more traffic, and hence more revenue, than ordinary mobile phones.

Fixed calls terminated in a mobile network are often charged differently than ordinary fixed calls. This premium can either be paid by the receiving party, or, more commonly by the calling party. The receiving party does not initiate the call, and may have no interest in a particular call. Therefore, subscribers may turn off their phone most of the time, if they have to pay for incoming calls. This impedes the value of the total service market and may restrict penetration. If the calling party pays, it must be clear to the calling party that the call terminates in a mobile network. This may prevent the implementation of full number portability.

Convergence of services and networks necessitates convergence of pricing schemes. As long as telecom service products are clearly distinguishable and serve different purposes, different pricing schemes can easily co-exist. The problems arise when new service applications such as VoIP and IPTV become more widespread. Regulation of prices for traditional telecom products such as POTS will be complicated by the fact that substitutes for this service are using very different and usually unregulated pricing schemes. This threatens the whole underlying business model for the provision of fixed voice telephony. Therefore operators may need to redesign their pricing schemes by the introduction of a flat rate or substantial reductions in usage charges. This may lead to substantial losses in revenues coming from POTS. The only way that these losses can be recuperated is through higher subscription charges, if that is permitted by current price regulation. It should be noted that losses in POTS revenues are likely to be compensated by increased revenues from the provision of Internet access. But some of these revenues may go to other infrastructure providers, e.g., cable operators, electricity companies, or providers of wireless access.

Technology implications on price regulation are summarized in Table IV.1, pp. 34-35.

IV.2.2 Interconnection

The development of new types of service networks and network infrastructures has created many new interconnection arrangements, including new definitions of capacity and traffic drawn from the Internet rather than traditional telephone usage.

In general, mobile markets are more competitive than fixed telecom markets, and the need for regulation is not as great. Nevertheless, markets for mobile termination have created particular problems. Each mobile operator enjoys a monopoly on termination in its own network, and prices are substantially higher than can be justified by the underlying costs.

National roaming is of particular importance in regard to operators that lack full national coverage of their own network. In this situation, national roaming can be used to extend geographical coverage of their services. This will be particularly helpful to new entrants, and thereby facilitate more competition. On the other hand, it may delay the expansion of network facilities. Regulators may compensate for the latter problem by including specific demands on network coverage in licensing conditions.

In general, rates for international mobile communication are substantially higher than national rates, and for the most part the price gap goes far beyond what can be justified by the underlying costs. The regulation of international roaming requires international cooperation.

The development of new types of infrastructure has created a wide range of new interconnection products. Regulators may consider extending the obligation for unbundling posed upon operators of copper-based telecom networks to include these new network infrastructures. Is it fair that operators of broadcast networks are allowed to refuse other operators access to their facilities, if they want to provide Internet access by use of cable modem for example? Why should optical fibers not be subject to the same type of regulation as copper lines? If the philosophy of technology neutrality is applied, the same rules should be applied for all network technologies. On the other hand, these networks are often established under very different market conditions. If heavy regulatory measures are used to promote service development in the short term, this may hamper long-term investments in network facilities. In the least developed countries in particular, it is important that investors have a reasonable chance of recovering their costs –

otherwise, there will be little or no incentive for foreign investments. Therefore, it may be necessary to apply generous access rules for new entrants.

The use of forward looking cost-accounting models will become even more resource demanding than it is today. The use of new types of infrastructure demands that new cost models must be constructed, and these models must be revised every time it becomes possible to implement new technologies affecting costs. If the cost models are to be forward looking and based on the most efficient operator principles, new technologies must be taken into account even they if are not yet implemented in the domestic network infrastructure.

The creation of next generation access networks and IP as a common platform implies that circuit-switched interconnections are becoming less important, while the interconnection of packet-switched networks and services is becoming even more important. The setup for the interconnection of packet-switched networks is very different from that of circuit interconnection. With many new small market players, interconnection negotiations are often asymmetrical and require regulatory oversight. Many developing countries are net recipients of payments from international revenue settlements. But this source of revenue is being undermined by: (i) drastic reductions in tariffs for international calls; and (ii) increasing use of VoIP. Developing countries also face substantial expenditures for international Internet interconnection transit services, which at present can only be ameliorated by the expansion of the local Internet market and increased peering among local ISPs.

VoIP enables provision of voice telephony in settings outside the purview of current regulation for voice telephony. Therefore, VoIP operators may have difficulties in demanding the right to interconnect with PSTN networks. The development of new innovative business models for providing VoIP or similar services should not be hampered unintentionally via regulation.

Due to the lack of facility-based competition in certain areas, regulation of the interconnection of network facilities may be necessary. Competition at the service level is much more likely to occur when operators can provide services without a local physical presence. However, there may still be a need for the regulation of the interconnection of services such as VoIP. It has been said that “if anyone possesses a termination monopoly, it is the VoIP service provider, not the provider of the broadband pipe.” The need for regulation of services relates to the fact that communications services inhibit substantial network economies. Those economies can only be realized if various service providers are interconnected. Therefore, access to essential facilities such as directory databases must be ensured.

Technology implications on interconnection regulation are summarized in Table IV.1, pp. 34-35.

IV.2.3 Licensing

The development of the market for mobile communication will depend on how regulators manage the issuing of licenses. Licenses will be necessary, because mobile operators need the allocation of radio spectrum, which is a scarce resource. Licenses may include obligations regarding the following: (i) geographical coverage; (ii) capacity; (iii) level of service; and (iv) pricing. Rules for rights-of-way and infrastructure sharing must also be specified. It is important to carefully assess the market potential before demands in these areas are detailed. Demands for extensive geographical coverage may be an important contribution to ensuring universal access. On the other hand, too ambitious requirements may be so costly for operators that the economic viability of providing the service will be threatened. This would hamper network development, as well as universal access, in the long run.

The development of new types of infrastructure enables more facility-based competition, where different network structures compete for the provision of the same or similar services. It is necessary to ensure that regulation is technology-neutral, in order to avoid favoring one particular infrastructure. If different licenses are required for the provision of different types of network structures, regulation can easily unintentionally favor a particular technology. In this respect, licensing is one of the regulation areas that may impact the future direction of technology development – either stimulate it, slant it unfairly, or stunt it.

The increasing convergence of service capabilities on common technical platforms makes it more difficult to define licenses according to specific technologies or types of service provided. A transition to harmonized licensing is necessary to prevent inherited licensing restrictions from creating arbitrary, inefficient, and unjustifiable regulations for the new environment.

By contrast, structural separation among the different layers of network functionality implies that licenses can be defined according to the layers within the communications network. For example, Malaysia has adopted a four-layered licensing structure. This type of licensing structure can be used to facilitate greater opportunities for competition both within and across network layers.

VoIP is an important example of a new service that has challenged the current framework for licensing. The demand for licensing will often depend on the technical solution applied for provision of the service. The current practice varies between countries. Licensing can help provide regulatory certainty, as in Peru where 28 licenses were issued to VoIP operators by 2000. However, demand for licenses can also work as a barrier of entry for new operators, if the licensing scheme is obstructive.

Broadcasting is another area where convergence affects licensing. Broadcasters are able to provide their services on multiple platforms such as Web-TV and mobile phones. Telecom operators are able to develop content services, which are difficult to distinguish from broadcasting services. Consequently, there is a need to coordinate licensing for telecom content providers and broadcasters.

Telecom markets are becoming more and more international. This complicates national regulation in all areas. Licensing is one of the areas most affected, because restricting market access is becoming more difficult.

Apart from satellite, all other network infrastructures demand some kind of physical presence on the national market. Service and content provision can be provided from any location. Trends in cost structures and separation of network functions from service functions facilitate the development of internal markets for the provision of services and applications. In these markets, national licensing requirements are easily circumvented. It is becoming virtually impossible to restrict market access at the national level - general requirements to providers can only be imposed through the development of a common international framework.

Technology implications on licensing are summarized in Table IV.1, pp.34-35.

IV.2.4 Universal Access/Service

New wireless services, including WiMAX, Wi-Fi, and 3G, offer new opportunities for improving universal access. However, these new technologies are also challenging current schemes for funding universal access by industry cross-subsidies. In many countries, those schemes are still focused entirely on fixed network service provision by incumbent operators. New technologies, competition, and the shift of voice traffic away from the traditional fixed network public service are all signaling that this traditional mechanism for funding universal access network development has become obsolete, unfair, and ineffective. Policy makers need to develop alternative approaches relevant to the new environment.

Licensing conditions may be instrumental in ensuring a positive contribution to universal access by mobile services. Mobile licenses may include obligations to cover less populated, and hence, less profitable areas. If, however, these obligations are too strict, they will threaten the economic viability of mobile services and have a negative impact on network expansion.

It is necessary to allow operators other than the incumbents to participate in the task of providing universal access. Regulators can accomplish this by appointing different providers in different regions. However, this solution may hamper the use of different network technologies within the same region. A more flexible solution is to let a subsidy follow the subscribers. In this scheme, operators receive subsidies according to the number of subscribers they connect in each area.

Today, universal access deals mainly with the provision of voice telephony, although provision of Internet services, e.g., from telecenters, may be included as well. Voice communication is only one out of a host of different telecom services. Policy makers need to conceptualize universal access in a much more expansive manner, so that it encompasses such services such as Internet access. There can be significant economies in providing combined voice and Internet access to rural and underserved areas.

With the introduction of packet-switching network structures, it becomes more reasonable to focus regulation on network access rather than access to services. The provision of network infrastructures will maintain those techno-economic characteristics that make real competition in low-density areas unlikely, while the markets for service provision will become more competitive.

A definition of universal access based on access to network infrastructures rather than on access to a particular service will contribute to an unbundling of networks and services. This will make it more difficult for a universal access provider to achieve a monopoly position in both markets.

An important question is whether broadband should be included in the definition of universal access. The following factors are relevant for considering the inclusion of a specific service in the universal access obligation:

- Is the service available to a majority of the population?
- Does a majority of the population subscribe to the service?
- Is the service essential for education, public health, or safety? Does non-use lead to social exclusion?
- Does widespread use contribute to the benefit of current subscribers?

These and similar parameters are applied for the review of universal access/service obligations in the United States and the European Union.

However, even if broadband is included conceptually as a part of universal access/service obligations, it still must be decided on a case-by-case basis whether a broadband obligation would be the best way to stimulate penetration. If not properly designed, a universal access obligation may distort the market and delay network investments. A more light-handed approach may be preferable.

Technology implications on universal access/service are summarized in Table IV.1, pp. 34-35.

IV.2.5 Spectrum Management

With the development of more wireless technologies, services and applications, spectrum management is becoming a crucial issue for future regulation. It is of the utmost importance that the regulation of the spectrum facilitates the development of new applications, instead of being a barrier to market participation as it has become in some countries.

The combination of new wireless technologies and the liberalization of telecom markets has created an environment in which a wide range of different types of actors are applying for frequency resources. Spectrum management has developed from being primarily a technical discipline, to becoming an area in which economic and policy considerations play an increasing role for both the allocation and the assignment of frequency resources. Allocation is the distribution of frequencies to particular radio *services*, and assignment is the distribution of frequencies to specific radio *stations*. The implications of technology trends must be seen in the context of the ongoing liberalization and market orientation of frequency management.

New applications create new spectrum needs, but new technologies, e.g., digitalization, also enable more efficient use of existing spectrum resources and the productive use of even higher frequency bands.

Use of similar standards for the transmission of different applications implies that the reservation of particular frequency bands for particular applications will become less important for the technical optimization of spectrum use. Therefore, many of the current restrictions in the use of spectrum can be relaxed without affecting technical efficiency. Spectrum management will become simpler and more flexible. It will be easier to introduce new applications, because there will be far less occasion to issue separate licenses.

Spectrum reallocation or refarming will become a more prominent element of spectrum management in the future - regulators must examine the possibilities for incorporating beneficial spectrum trading into their schemes. The development of new wireless service applications may create a need for freeing spectrum resources in a particular band in order to be compliant with international market standards and enable the use of mass produced wireless equipment. Regulators may need therefore to refarm current use of spectrum resources.

Technology implications on spectrum management are summarized in Table IV.1, pp. 34-35.

IV.2.6 Numbering

Geographical numbering plans were once a necessity, but today a growing number of countries have stopped demanding a relation between numbers and geographical location. This enables a more efficient use of an increasingly scarce resource and facilitates number portability for subscribers moving to a new location. Moreover, convergence between local and long distance calls makes it less necessary to provide information about the geographical location of subscribers.

The growing penetration of mobile subscribers has encouraged this development in the following ways: (i) first, the growth in the number of mobile phones has increased the total demand for numbers, which potentially can lead to number scarcity in some regions;

(ii) second, mobile phones are used from many different locations - and numbering and tariff schemes for mobile phones are most often national and not regional.

This enables national (or even international) numbering plans. If different charges are applied for calling different types of subscribers, some users may desire clearly distinguishable numbers for PSTN, mobile and VoIP services. However, such a numbering plan would create a barrier to cross-service portability, and might hamper some convergence possibilities and some types of competition.

At present, it is not possible to trace an emergency call from a VoIP phone. Therefore, the call may be routed to an incorrect location – sometimes even in the wrong country. It is possible to assign a physical address to a VoIP number, but the same VoIP number may be used from many different locations just like mobile phones.

Translation between IP numbers and the E.164 numbering plan used for telephone services can now be provided by a technology called ENUM. This enables Internet-based users to communicate with telephone subscribers and vice versa, and is being implemented in a number of countries. The implementation of changes in national numbering schemes is a very expensive process for operators, service providers, and users. Regulators will need to pay special attention to transitions in numbering plans to accommodate new technologies.

However, recent experiences have revealed a number of critical issues related to the use of ENUM. All of these issues are related to the fact that ENUM was developed outside the formal regulatory framework. ENUM may be adopted through agreement among major Internet service providers without any governmental involvement. On the other hand, the E.164 numbering plan is administered by the national regulatory agencies. Therefore, regulators will have to reconcile the differences between these procedures of administering numbers, in order to make it viable to utilize this technology across the board.

Technology implications on numbering are summarized in Table IV.1, pp. 34-35.

IV.3 Conclusion

In each of the six key areas reviewed, it is evident that the traditional regulations established during the initial phase of telecom reform are no longer appropriate. In some cases, the continuation of their use will even cause major inefficiencies and restrict further network development. In general, the innovations studied in this report will lead to more opportunities for competition and less need for direct regulatory intervention in telecom markets. However, the new technologies also create new regulatory issues and challenges that must be met in order to ensure continuing innovation and network development.

Table IV.1: Technology Implications on Six Regulatory Areas

	Price Regulation	Interconnection Regulation	Licensing	Universal Access/Service	Frequency Management	Numbering
Mobile Communication	- Regulation of new pricing schemes such as prepaid and RPP. - Rules for handset subsidies and binding periods. - Pricing of mobile termination.	- IC between mobile operators and mobile and fixed operators. - National and International roaming. - IC of SMS and other mobile data services.	- Specification of licensing conditions for mobile operators.	- Defining the role of mobile services in obtaining universal access/service. - Demands for geographical coverage to mobile operators.	- More pressure on spectrum resources. - Harmonization of spectrum use in order to facilitate international roaming.	- Wireless infrastructures providing opportunities for roaming challenges geographical numbering plans. - Strong growth in the number of mobile phones has increased the demand for numbers. - Special number series for mobile services. - Number portability between fixed and mobile services. - Need for transparency in infrastructure use if this affects tariffs.
Next Generation Network Infrastructures	- The same or very similar services are being provided via infrastructures with different cost characteristics. This complicates cost-based pricing.	- The trend from single platform to multi-platform service provision implies a need for new types of interconnection products. These include interconnection between different types of networks and new types of unbundled network components.	- Fair competition between different network infrastructures requires a technology-neutral licensing regime. Unified licensing will stimulate optimal use of technology options by operators.	- Universal access can be obtained by use of a combination of many different network technologies. - Demand for a definition of universal service obligation, which is independent of network technology. It must be clearly defined how different types of networks should contribute to funding of a universal service obligation.	- New wireless networks increase demand for network resources. - Need for refarming of spectrum resources. - Modulation and compression techniques, smart antennas, and widening of spectrum range increase capacity. - Intelligent radio terminals enable more flexible spectrum allocation.	-Wireless infrastructures providing opportunities for roaming challenges geographical numbering plans. - Strong growth in the number of mobile phones has increased the demand for numbers. - Need for transparency in infrastructure use if this affects tariffs.
Internet	- Enables the separation of pricing of infrastructure and pricing of services.	- The trend from voice-centric to multiservice-centric networks challenges the interconnection of both voice and data services. The interconnection of IP networks becomes a crucial issue for network development and competition.	- A separation of networks and services enables licenses to be specified to particular layers.	- It becomes more relevant to define universal access/service as network access instead of service access. Obligation to provide universal access/service should in this case be imposed on network providers rather than service providers.	- Radio technical considerations become less important for allocation of frequencies. - Restrictions on use become less relevant when different applications use the same protocols.	- Nomadic use and separation of networks and services challenges geographic numbering plans. - Tracing of geographical origination, e.g., emergency calls becomes more complicated.

Convergence	- Many different products offering similar facilities become available. These products may use different pricing schemes and be subject to different types of regulation.	- A need for interconnection between new services such as VoIP and instant messaging.	- More difficult to control provision of a particular service through licensing. - Service specific licenses will become a barrier to development of new services. Convergence leads to a demand for service neutral licensing. - Coordination between regulation of content services and broadcasting licensing.	- A definition of an obligation to provide universal access/service which only includes voice becomes less relevant as voice is delivered in combination with a host of other services.	- Restrictions on use become more complex and hamper development of new applications	- Need for coherence between different numbering plans facilitating communication across platforms.
Implications Resulting from Changes in Market Structure	- More competition reduces the need for price regulation.	- Dominance by a few international carriers. New imbalances in payments of international settlements.	- Providers may easily circumvent licensing barriers, especially in the content and application markets.	- Provision in rural areas becomes cheaper and more economically viable. Role of micro-entrepreneurs and public sector players to provide access can be augmented.	- Many different types of actors providing different types of applications compete for the same limited resources	- More competition implies need for more focus on fair allocation of numbers. - More competition implies greater need for portability of numbers.

V. Cross-cutting Issues

In addition to the traditional issues regarding regulation, there are six general and transversal regulatory issues that are significantly affected by the technology developments described in this report. Those issues are:

1. **Sector-specific vs. general competition regulation**;
2. **Technology neutrality**;
3. **Infrastructure vs. service competition**;
4. **Cost-based regulation**;
5. **Regulatory set-up and business models**; and
6. **Quality of service**.

V.1 Sector-Specific vs. General Competition Regulation

With respect to sector-specific vs. general competition regulation, the aim since the beginning of telecom sector liberalization has been to introduce competition wherever possible. Sector-specific regulation has been implemented with the purpose of eventually expanding competition to the point where that regulation can be reduced significantly, i.e., the regulation is designed to ultimately make itself obsolete to the greatest extent possible. However, an open question remains as to how far it will be possible to substitute competition for regulation. Nevertheless, the aim is to move continuously in the direction of creating fair competition on the telecom markets, and to lift sector-specific regulation whenever possible.

There are three market-oriented reasons for public intervention in markets: (i) market failures; (ii) social concerns; and (iii) industrial policy. All three reasons have played a role in telecom and have contributed to its sector-specific regulation. The present discourse on sector-specific vs. general competition regulation is centered on the level of competition reached in the different telecom market segments.

It does not necessarily have to be an either/or proposition. The use of sector-specific regulation does not inherently preclude the use of general competition regulation, or vice versa. There should and will be a combination of general competition rules and sector specific regulations, according to the different situations in the given market segments.

V.2 Technology Neutrality

The aim of technology neutrality is to ensure that applications of different technologies compete fairly on the basis of their comparative advantages. The idea is to create an environment in which the choice of technology solutions is left to the companies themselves. Technology convergence will facilitate more competition in the telecom markets, because new network and service providers can enter markets that previously were served by specific technology solutions. This will increase the possibilities for: (i) transitioning from sector-specific to general competition regulation; and (ii) transitioning from technology specific regulation to technology-neutral regulation. This applies to:

- universal service/access, where unified licensing procedures as opposed to technology specific licensing can be implemented to a higher degree;
- competition regulation, where different technology solutions can be used to service the same communications needs; and
- radio frequency regulation, where the choice of technology solutions can be left to market players to a greater extent.

The concept of technology neutrality means that different technologies offering essentially similar services should be regulated in a *similar* manner. However, *identical* regulations of substitutable technology solutions may result in the advantage of one technology over another in the market. In that event, technology-neutral regulation should include *slightly differing* regulations for different technology solutions in the same market segment.

Technology neutrality is based on technology convergence. The fact that similar services can be supplied on different technology platforms means that there is an issue regarding how regulators should treat these similar services. Advocates of technology neutrality are putting forward the concept that regulations should seek to promote competition between different technology solutions, instead of “picking a winner.” However, the implications of technology neutrality go beyond technology convergence. The concept is based on the more profound philosophical stance of limiting public intervention in regard to the direction that technology development will happen to take.

The technology neutrality concept has implications for most telecom regulatory issues, including universal service/access, frequency management, and competition. In a number of developing countries where narrow technology licenses have traditionally been granted, the technology neutrality concept should be used to promote a greater degree of harmonized licensing.

V.3 Infrastructure vs. Service Competition

Since the beginning of the liberalization of the telecom sector, infrastructure competition has been seen as a more sustainable form of competition than service competition. In most national contexts, in which there is one dominant incumbent operator, service competition implies that the alternative operators are dependent on the incumbent. Unfortunately, infrastructure competition has been difficult to obtain in fixed line areas, because the required investments have been prohibitive. Therefore, service competition has been used as a substitute or complement to infrastructure competition. The emergence of technology convergence, which enables the use of alternate infrastructure for a number of different services, makes infrastructure competition more realistic.

A related issue concerns infrastructure sharing. There are strong arguments to be made for allowing infrastructure sharing, especially in developing countries. One drawback is that this may lead to less infrastructure competition. On the other hand, it has the advantage of fostering infrastructure construction and increased access.

Service-based competition is considered to be less sustainable than infrastructure-based competition, because the alternative operators have to rely on the infrastructure elements provided by incumbents with whom they happen to be competing. In developing countries with little developed access infrastructure, new operators will often be inclined or forced to build their own access loops. This puts a great premium on network interconnection rules. It also brings the issue of network sharing to the forefront, because network sharing can hasten infrastructure construction.

The best policy is to support a whole range of competitive strategies and network expansion strategies. Instead of viewing service- and infrastructure-based competition as alternative policy options, an optimal policy is to consider them as complementary.

V.4 Cost-based Regulation

To the extent that regulation of end-user and interconnection prices is considered necessary, two important issues should be considered. The first concerns the development towards basing interconnection prices and end-user prices on costs. This has been an important aim since the beginning of liberalization, and a large number of countries have implemented it. However, many developing countries still need to apply more streamlined methods and procedures in their cost calculations. The second issue deals with the broader question of using cost calculations as a basis for technology choices. In the cases where new technologies are less expensive than existing technologies or other technological options, costs should be an important parameter in technology choice and substitution.

In the wake of telecom sector liberalization, regulators implemented cost-based end-user and interconnection pricing. Regulators often preferred the costing method, which is based on forward-looking costs. The advantages of this method are: (i) that it rewards the efficient operators; and (ii) that it sends price signals that will induce a forward-looking decision-making process by alternative operators, regarding whether to use the network resources of the incumbent or invest in their own network resources. However, there may be sound reasons for choosing another method. Calculating and negotiating the LRIC-based prices can be a very lengthy and resource consuming exercise. This can be an especially compelling reason in a developing country, where regulatory resources can be scarce. There are clearly circumstances in which it makes a whole lot of sense to apply simpler costing and pricing methods, such as benchmark cost and price comparisons within and between similar countries. It is important to establish the basic principle of cost-based regulation, while allowing for the possibility that prohibitive implementation costs or some other impediment will make a different choice more sensible under some circumstances. Cost-based regulation will facilitate the development of fairer retail as well as wholesale prices. Furthermore, it can also be used as a tool for promoting technology changes. Knowledge of the costs of different technology solutions can be used to shape regulations so that market players have incentives to take up new technology solutions.

V.5 Alternative Business Models

There is presently an emphasis on exploring all kinds of organizational models in order to expand connectivity. In the first period of telecom liberalization, the focus was mostly on establishing competition and on expanding telecom infrastructure by means of the activities of alternative, but traditionally structured, telecom operators. It has turned out that there are limits to this strategy. Competition in important market segments is still not significant, and it has been difficult for developing countries to attract new operators, especially in the wake of the telecom crisis of the first few years of the new century. This is one of the reasons why there is an increasing emphasis on promoting alternative demand-led and cooperative telecom networks.

The overall purpose of the new regulatory paradigm must be to open as many paths to network development as possible and refrain from controlling and restraining these developments. This implies promoting a wide range of business models and organizational forms. Telecoms have traditionally been dominated by large companies that have benefited from economies of scale and scope. These kinds of players will continue to play important roles, but regulators should increasingly seek creative ways to promote other organizational forms, including alternative operators and more demand-led initiatives, such as end-user organized networks.

V.6 Quality of Service

Quality of Service (QoS) is an area that has been part of telecom regulation from the very beginning. On the national level, for many years the issue revolved around the service quality that end-users could obtain. On the international level, there was also the question of service quality regarding interconnections between foreign operators during international communication. With the liberalization of the sector, the quality of wholesale services has also become an important issue on the national level. The main concern is whether the problems related to QoS have changed fundamentally with the transition from a circuit-switched to a packet-switched environment, and whether, or to what extent, regulatory policy has kept pace.

Among the biggest telecom problems for developing countries, are those that relate to QoS. Often quality is poor on all indicators. This applies to PSTN technology and to Internet technology.

Internet is presently a “best effort” network, which is not a big problem for most data communications, because smaller delays are unimportant for the transmission of data files, and packets can be re-transmitted. However, it does constitute a serious problem for real-time communication, such as telephony.

The technical parameters for QoS are different when comparing circuit switching and the Internet. However, the real differences in terms of regulatory implications are related to the multi-service and multi-operator environment of the Internet, and to the fundamentally global character of the Internet.

QoS regulation is especially relevant regarding service level agreements (SLAs) included in the interconnection agreements between dominant market players and competitors. In these circumstances the competitors are dependent on the quality of the interconnection services delivered by the dominant operators. Furthermore, QoS for end-users can be secured by way of regulatory provisions. Users will often experience that the QoS delivered regarding transmission speed or the quality of VoIP services does not correspond to the promises made.

However, there are good reasons to hesitate with respect to strict regulatory interventions in the field of QoS on the Internet. One is the extremely dynamic character of the Internet and the continuously changing technology solutions used. Another is that the Internet environment is mostly competitive, and regulatory intervention should, accordingly, be light-handed.

VI. Policy Integration

Regulation is concerned with the implementation of policy decisions in both a proactive and reactive sense. Therefore, regulation should be seen in the wider policy context. The following are five areas in which regulation is involved in policy issues, or there is a close affinity between regulatory actions and policy measures:

1. **Policy and Regulation in General**;
2. **Innovation**;
3. **Standardization**;
4. **Public-private Partnerships**; and
5. **Network and Information Security**.

VI.1 Policy and Regulation in General

Regulation is one of several different modes of public policy intervention in the construction of markets. Therefore, it is important to view communications regulation in the context of the broader array of different ICT policy areas, in order to construct a coherent public communications policy. This means that the specific regulatory goals and activities should be guided by the general policy visions and decisions in the ICT field, in order to prioritize regulatory activities. At the same time, it is essential that regulatory independence in the implementation of those goals be defended. There is no contradiction in this, as independent regulation is guided by the overall policy goals set at the policy level. Such a division of powers is in accordance with the general principles of divisions of powers in the sphere of public institutions.

Most regulatory provisions will be similar in the vast majority of countries. There will be differences with respect to the emphasis placed on various areas of regulation. The mix of policy initiatives, and the more specific features of those policy initiatives, will also vary.

VI.2 Innovation

During the telecom sector liberalization of the 1980s and 1990s, the primary emphasis in telecom policy and regulation in most developed nations was on establishing competition and lowering prices. In developing nations, the focus was, first and foremost, on increasing penetration on the basis of well-established technology solutions (PSTN), and also, and more significantly, by means of mobile communications. During the past few years, there has been an increasing awareness of the importance of promoting innovation in the sector. This is very strongly linked to the emergence of new access technologies in the wireless area, such as wireless LAN and MAN (e.g., Wi-Fi and WiMAX), as well as wire-based solutions, such as cable modems, fibers, and power lines. However, innovation in new applications, services, and content is equally important, and plays a major role in user demand and the demand for new access facilities. Regulation should contribute toward opening the sector for innovations. It should be seen as part of a broader national strategy for innovation of the communications area.

The issue of innovation implies a number of two-way relationships. These include:

- the relationship between **technology change** and **regulation**. Not only will regulation be adapted to technology changes; technology and organizational innovations will be actuated by regulatory changes.

- the relationship between **competition** and **innovation**. Not only will competition enhance innovative market offerings; innovations will increase competition.

- the relationship between **network developments**, and **application, service, and content developments**. Not only will network developments lead to the implementation of new applications, services, and content; the demand for applications, services, and content will actuate network capacity-expanding initiatives.

VI.3 Standardization

Standardization is essential in a network context, because compatibility standards are the technical prerequisites for interconnection and interoperability. Often a differentiation is made between de facto and de jure standardization. Since liberalization in the telecom sector began, de facto standardization has gained strength at the expense of de jure standardization. This is as much related to the internationalization of communications as it is to the liberalization and privatization of the sector on the national level. Before telecom liberalization, communications systems were, to a large extent, national systems and met at the borders where standardization of interfaces was necessary. Today, communication systems are mostly international, and standards are negotiated between international manufacturers and operators, rather than between national public authorities.

The two most outstanding features of the new standardization environment are:

- the establishment of Internet-specific organizations with responsibility for the development of the Internet, including standards; and

- the establishment of a wide range of specialized fora for specific technologies, with standardization as one of their major tasks.

Among the consequences of the latter development are: (i) that the influence of smaller and economically weaker nation-states has been diminished; and (ii) that national public authorities in many countries have very limited influence on standards for telecom networks. This does not mean that standardization activities are no longer relevant for national regulatory authorities. Instead, it means that the focus and direct influence of national authorities has shifted from the network aspects towards the application and service aspects.

Among the most important public policy issues regarding standardization are:

- the use of standards, and specifically open standards within and between public institutions. Promoting these will influence the use of standards not only between public institutions and citizens and private enterprises, but also among citizens and private enterprises.

- the choice between intra-standard and inter-standard competition. This choice is very complex and there is no one right answer – it depends on the specific technology area and the specific situation. However, there is currently a preference for allowing or promoting more inter-standard competition, e.g., in relation to the use of unlicensed radio frequencies and in relation to the trading of radio frequency licenses.

- the national character of type approval processes. This often creates very lengthy type approvals. One of the ways to speed up type approval is to implement a system of mutual recognition.

VI.4 Public-Private Partnerships

Public-private partnerships (PPPs) involve the cooperation of two parties: the public sector and the private sector. It refers to either of the following activities: (i) private sector entities carrying out assignments on behalf of public sector entities, or to fulfill public policy goals; or (ii) public sector activities aiding private sector entities. Most often, the term is used to indicate that private sector entities, at different levels and scales, are taking care of activities traditionally performed by public sector entities. PPPs are thus situated somewhere in the middle of the spectrum between direct provision by government departments and privatization.

PPPs are often part of the discourse on privatization. However, they can easily be disentangled from that discourse, and viewed instead as a key element in the public-private cooperation in implementing infrastructure and delivering services. A variety of public-private partnership arrangements can make distinctive contributions to both infrastructure and service development.

The fact that communications services are increasingly subject to market forces makes it more relevant to examine the ways in which public sector initiatives can help to build infrastructure. This is particularly true of areas in which private operators are not providing service, as is often the case in geographically peripheral and low-income areas.

These partnership arrangements should not be limited to those between the public sector and private companies. There should be room for other individual and collective actors, such as civil society organizations and non-governmental organizations, which will result in Multi-Stakeholder Partnerships (MSPs). The test of participation should only be whether a contribution can be made to infrastructure or service development.

VI.5 Network and Information Security

Network and information security is one of the very important issues in the regulation of communications in the years to come. Security in relation to technology-mediated communications is a multidimensional term which encompasses a multitude of different issues. It reaches into the areas of privacy protection on the Internet and consumer protection in connection with e-commerce. It also reaches into the area of cyber-crime, including protection against illegal and harmful content. Furthermore, it is connected with the protection of state institutions against information breaches, which conversely can be in conflict with privacy protection, etc. However, only the issue of network and information security, i.e., the technical aspects and their regulatory implications, is touched upon here. Even this is an issue with many different dimensions.

- Societies today are far more dependent on technology-mediated communications than before. Furthermore, the security issues related to the present communications systems including the Internet are more far-reaching than security issues in the period where telephony was by far the most dominant service. This combination poses a significant challenge, where regulation has a role to play.

- The important issue to be dealt with in connection with network and information security is to construct the appropriate combination of technology and legal measures taking the broader market and norms environment into consideration.

- Regulators are increasingly approached in security issues, but there are other organizations looking into these matters, for instance the national Computer Emergency Response Teams (CERTs). There can be many models for the organization of security work, partly or to a larger extent involving communication regulators.

VII. Conclusions: A New Regulatory Paradigm

The technology trends identified in this report and their market and regulatory implications point to the conclusion that a new regulatory paradigm will be needed for the future. The main pillars on which such a new regulatory paradigm should rest are as follows:

1. A communications sector that is open to as many different and diversified initiatives as possible in order to maximize the contributions of new technologies, services, ideas, and organizational arrangements.
2. A clear and comprehensive national ICT policy and a strong, credible regulator to ensure its full implementation.
3. Regulation that takes the dynamic character of technology and market convergence into consideration in all areas.
4. Recognition of the wider international context of ICT technologies, markets, and regulations.
5. An organizational structure of regulatory institutions that is adapted to the changing technology and market developments in terms of the scope of regulation and regulatory practices.

The following sections present a summary of key findings presented in this report and how they relate to creating a new regulatory paradigm.

VII.1. Increasing Diversification in Network and Service Development

The overall purpose of the new regulatory paradigm must be to open as many paths to network and service development as possible and to resist attempts to control or restrain participation, unless there is clear evidence of harm to the public interest. Among the different areas of regulation, universal service/access remains the most central in developing countries. The prospects for technology leapfrogging in the ICT area seem relatively good in relation to backbone infrastructure, access infrastructure, and services delivered. However, success will require an open technology environment, open markets, and credible regulation. Without the related institutional changes there can be little progress on the possibilities of technological leapfrogging.

The most significant immediate issue for regulators is changing the licensing regime for operators and service providers. At present, most licenses in most countries are technology-specific (e.g., VSAT, 2G mobile, cable), or service-specific (e.g., public voice, data, VANS, TV transmission). The convergence technologies have made these distinctions largely obsolete. For the most part, they are significant barriers to the next stage of market development. All too often, they prevent technologies from being used efficiently in the supply of different combinations of services. All too often, they prevent valuable services from being provided to the public. In most countries, realigning license conditions and licensing practices to reflect the opportunities in the new convergence environment must be a priority.

In many developed countries, a debate is underway over whether infrastructure competition or service competition is most appropriate. Developing countries do not need to wrestle with this issue. All opportunities for both kinds of competition must be captured. Experience suggests that the best policy is to support a wide range of strategies to participate in the market, as both infrastructure and service competition will stimulate network development through both wholesale and retail markets. It is important for developing countries to embrace the basic principle of cost-based regulation without adopting the complex and costly methods, such as LRIC, that have been used in some large developed countries. Cost benchmarks are often more effective. Knowledge of the cost characteristics of different technologies can be used to shape regulations so that market players have incentives to adopt the most efficient new technology solutions.

In developing countries, the problems of quality of service (QoS) remain important issues for regulation, both for PSTN and Internet services. The primary areas where regulation can have a role to play are in service level agreements (SLAs) in relation to interconnection among operators, and if necessary, agreements with users. There is, however, good reason to hesitate with respect to strict regulatory interventions in QoS on the Internet, due to the extremely dynamic character of Internet technologies and services and the relatively early stage of its development.

VII.2 Policy Integration

Communications regulation must be seen in the broader context of policy measures related to the development of ICT infrastructure and services. However, the principle of independent regulation must be upheld, in order to secure credible, stable, and accountable regulation for the implementation of policy. Telecom regulation should contribute to opening the sector for innovation and be seen as part of a broader national strategy for innovation in the communications sector. Innovation will enhance competition, which will in turn stimulate innovation. Similarly, new network developments will open opportunities for new services, content, and applications, which in turn will act as drivers for network expansion.

There are important public tasks in: (i) promoting the use of standards, and specifically open standards within and between public institutions; and (ii) establishing provisions that will enable experimentation with standards in new areas, e.g., unlicensed frequencies. For most equipment, a system of mutual national recognition of type approvals should be adopted.

It is becoming increasingly more relevant to examine the ways in which public sector initiatives can help build infrastructure, particularly in geographically peripheral and poor areas where private sector investment is unlikely. Public-private partnerships (PPP) should be viewed as a key element in the public-private cooperation in implementing infrastructure and delivering services. There should be room in the formation of PPPs for individual and collective actors, including local and regional government agencies, businesses, civil society organizations, and non-governmental organizations in Multi-Stakeholder Partnerships (MSPs). The limited experience so far suggests that these new organizational structures have much to contribute to network and service development.

The challenge for policy makers and regulators regarding network and information security is to construct the appropriate combination of technology and legal measures, taking the broader market and norms environment into consideration. Regulators need to be involved in fashioning solutions to security issues, even if they do not have primary responsibility. Liaison with other organizations such as national Computer Emergency Response Teams (CERTs) is important in regard to security issues of a broader scope.

VII.3 Maintaining Competitive Opportunities in Converged Markets

Developed countries have emphasized the competition-enhancing aspects of technology convergence. By contrast, developing countries have emphasized network development and new access possibilities. Regulators should take advantage of the new access and competition potentials created by new technologies. In the new market environment, horizontal markets are now technically efficient, and effective competition can drive services and network development. For the future, regulators will need to examine both horizontal and vertical markets to ensure that proposed mergers and integration will promote market development and not create monopolistic barriers to market participation.

The concept of technology neutrality should be interpreted as meaning that regulation should not establish preferences for any particular technology. Different technologies offering essentially similar services should be regulated in a *similar*, but *not identical* manner. All technologies should be not only allowed but encouraged to maximize their potential contributions to network and service development.

VII.4 International Outlook

Most ICT equipment markets have become global, and many services and content markets are becoming more international. These developments affect more and more national regulations, and the interrelationships between national, regional, and international regulations. The processes of liberalization and internationalization of communications have increased the importance of informed participation in international organizations and forums. Developing countries should consider strengthening their influence in ICT international organizations through greater regional and global cooperation among telecom regulators.

VII.5 Structuring Regulatory Organizations

The convergence of telecommunications, IT, broadcasting, and other media has led to many initiatives around the world to establish ICT convergence regulators. There are also initiatives to establish multi-utility regulators covering a range of infrastructure provision, e.g., telecom, energy, transport, and water. In addition, there is a concerted effort to establish closer working relations between sector-specific regulation and general competition regulation. The best organizational design of regulatory institutions in any country depends on the specific national circumstances, i.e., stage of development in the different sectors, resources to be applied to regulation, available skills, and national priorities.

The regulatory organizations in developing countries are typically at an early formative stage. This means that these organizations are often relatively weak, but it also means that they can more easily be shaped to the new convergence developments if there is the necessary political will and regulatory commitment. There is, in other words, the possibility to leapfrog some of the institutional evolution that regulatory organizations have gone through in developed countries, particularly with respect to establishing effective convergence regulation.

Telecom regulators must play an important role in facilitating and in some cases leading the transition process to the new converged technological, market, and regulatory environment. Success will require a major effort to educate the key players who will collectively influence the transition to convergence policies and a new regulatory paradigm. This will require a strategy for managing the transition that means that the regulatory issues must be prioritized in light of the specific circumstances in each country. This report provides a reference source to facilitate the development of such strategies.

VII.6 Closing Remarks

New ICT technologies are having a revolutionary impact on the ICT sector, requiring that all players – equipment manufacturers, operators, service providers, policy makers, and regulators – reassess their traditional knowledge and decision-making models. Telecom regulators must respond to the changes being thrust upon them in this dynamic environment. They can be a major barrier to change, or they can play a significant role in shaping how the new ICT sector develops in their countries. Many existing regulations, established for older technologies and a very different environment, are obsolete; many constitute major barriers to progress. New regulations, implemented by informed regulators, can facilitate the application of these new technologies so as to achieve their full benefits in providing universal access to a wide variety of traditional and new services.