REGIONAL INITIATIVES – ASIA-PACIFIC

Best Practices for IMPLEMENTING NEXT GENERATION NETWORKS (NGN) IN THE ASIA AND PACIFIC REGION

CASE STUDY
INDIA, PHILIPPINES AND SRI LANKA

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Telecommunication Development Sector

Best Practices for Implementing Next Generation Networks (NGN) in the Asia and Pacific Region

Case Study: India, Philippines and Sri Lanka

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1 Executive Summary

1.1 Objectives

This project will assist the developing countries in Asia-Pacific region to assess technical and regulatory aspects of NGN migration with specific country experiences. This would also help build human capacity and skill development in dealing with issues of migration from legacy networks to NGN environment through national workshops and trainings on relevant NGN issues in the Asia-Pacific region as well as disseminate NGN related case studies by promoting a cooperation mechanism.

1.2 Background

Telecommunications and information and communication technologies (ICTs) have been widely recognized as a driver of economic and social development, poverty reduction and wealth creation. Telecommunications/ICTs provide an opportunity for developing countries to facilitate trade and economic development in general, as well as business development and job creation, especially for poor and marginalized populations, including women, indigenous peoples and persons with disabilities. However; developing countries often face challenges of rapid pace of change of technologies and convergence, financial resources, lack of suitable technical experience in planning and deploying advanced technologies and networks.

Infrastructure is central to achieving the goal of digital inclusion, enabling universal, sustainable, ubiquitous and affordable access to ICTs and services for all. The ICT sector is characterized by rapid technological change, and by convergence of technological platforms for telecommunications, information delivery, broadcasting and computing. The deployment of common network infrastructures for multiple telecommunication services and applications and the evolution to all IP-based wireless and wired next-generation networks (NGNs) open up opportunities but also imply significant challenges for developing countries

The provision of access to ICTs in rural and remote areas remains a particular challenge confronting governments, regulators and operators in developing countries. The World Summit on Information Society (WSIS), 2003, Declaration of Principles (Paragraph 22), highlights the existence of coherent telecommunication networks and services at the national, regional, interregional and global levels, for the development of national economies as an important element in the improvement of the socio-economic status of countries – especially of developing countries.

Establishing telecommunication infrastructure, countries have already invested heavily in the traditional public switched telephone network (PSTN) and public land mobile network (PLMN) networks and are now facing challenges in migration from existing networks in urban areas to advanced networks such as NGNs. To meet this challenge, they need the financial resources and technical skill sets to prepare for a smooth migration to NGN and introduction of new content rich multimedia services.

Migration from conventional networks to a NGN platform requires techno-economic considerations both at the core and access network levels. The access network is one of the key components in providing broadband services, which has the potential of becoming a serious bottleneck for the delivery of multimedia applications. It is recognized that the access network is one of the most expensive components of telecommunication infrastructure compared to other parts of the network, for both developing and developed countries. The access network, therefore, needs to be accorded due consideration when looking into the readiness of a telecommunication network infrastructure for migration toward NGN. In the absence of proper access network planning, it would be challenging for a NGN migration strategy to succeed. Consequently, the access network is one of the main focus areas in migration to NGN.

NGN is considered an affordable solution for the development of rural communications, and bridging the digital divide. The need for development of telecommunication infrastructure in rural areas is obvious, as

a large proportion of the population, especially in most developing countries, reside in rural areas which have special requirements for reliable and affordable telecommunication infrastructure due to remoteness, difficult terrain, and scattered population. In addition, the majority of the population living in rural areas, having low literacy levels, need multimedia services to facilitate easy access to relevant information and services.

Today, NGN is considered a social infrastructure on which broadband services can be provided, opening new opportunities in the telecommunication industry. Countries can benefit from NGN deployment with a wide range of advanced ICT-based services and applications in building the information society; implementing systems for public protection and disaster relief during emergency communication, especially early warning systems for dissemination of emergency information; and, improving access to information and knowledge in the rural areas and empowering marginalized communities for digital inclusion.

Adopted at the World Telecommunication Development Conference (WTDC, Doha, 2006), the Doha Action Plan (DAP) includes a regional initiative on "*NGN planning*" in the Asia-Pacific region aiming to assist developing countries of the region in the smooth migration from existing networks to NGN, considering NGN as a potential tool for rural communications. It was also requested that ITU play an important role by using the study group process, a collection of best practices and through practical advice and assistance from the ITU Regional Office for Asia and Pacific.

The World Telecommunication Development Conference (WTDC, Hyderabad, 2010) adopted the Hyderabad Action Plan (HAP) which includes five regional initiatives for the Asia-Pacific region. Regional Initiative 4 seeks ITU assistance to developing countries in the region for broadband adoption and the use of broadband technologies to propel innovation and new services. However, the challenge of bridging the digital divide is compounded by disparities in broadband access and infrastructure between and within countries especially between urban and rural areas. It envisages broadband access and uptake in both urban and rural areas taking into consideration the need for development of ICT infrastructure based on which governments are better able to provide e-government services to their citizens, which improve transparency, accountability, utilization of resources and access to governmental services, including health and education. The scope of this regional initiative covers migration from legacy circuit switched networks to NGN, and fulfils the mandate of the ITU Asia-Pacific Regional Initiative on Broadband Access and Uptake in Urban and Rural Areas.

1.3 Project strategies

The aim of this project, in collaboration with ITU APT Foundation of India[1], Telecom Regulatory Authority of India[2], Telecom Regulatory Commission of Sri Lanka, the Philippines Commission on ICT together with the National Telecommunication Commission[3], is to publish a report on NGN migration through

[1] ITU APT Foundation of India submitted its contribution to ITU Asia Pacific Regional Preparatory Meeting 2009 to bring out best practices from relevant practical experience as a case study and to prepare a manual consisting of various implementable action points for licensing, regulation, planning, standardization, and operation for facilitating smooth transition towards NGN. It further suggested enhancing awareness as well as knowledge exchange regarding best way forward towards NGN migration and carry out interactive workshop for the stake holders through use of guidebook of best practices.

[2] TRAI decided to establish committee named NGN-eCO which would undertake to create a NGN awareness building programme by closely interacting with international bodies like ITU, ETSI, 3GPP2, regulators abroad etc. for obtaining latest information and knowledge related to NGN and to prepare a detailed timetable for NGN migration in the country for implementable, phased and business-driven roadmap/ action-plan for achieving this objective. URL: www.trai.gov.in/NGN.asp

[3] The Commission on Information, Communication and Technology together with National Telecommunication Commission (NTC) also confirmed their interest to participate in this regional study on NGN regulation and migration strategies being carried out by ITU Regional Office for Asia and Pacific.

assessment of country specific case studies along with knowledge sharing through workshops and trainings on related NGN issues in the Asia-Pacific region. It includes the publication of this report to share NGN-related case studies to Member States and Sector Members in the Asia-Pacific region. In addition, the project plan included organization of three workshops, one each in the Philippines, India and Sri Lanka[4] for capacity building as well as knowledge sharing amongst the stakeholders.

Three successive field missions to Philippines, India and Sri Lanka involving detailed interactions with stakeholders have resulted in qualitative as well as quantitative data based on the detailed questionnaires submitted by ITU as well as interviews with the stakeholders.

The ITU ICT Development Index (IDI) rank for the Philippines, India and Sri Lanka is indicated in Table 1 (which are comparable to other developing countries) and reflect the current status of NGN deployment and strategies for migration including the regulatory regime. Through this project, ITU plans to develop a migration strategy for these three countries which could be considered as a reference resource for other countries in the Asia-Pacific region.

Having a good blend of national and international expertise, ITU engaged national experts in each country who were assigned to jointly co-author the report, especially the local technological as well as regulatory context while the ITU expert contributed and led to other international best practices and suggested strategy for migration.

Table 1: IDI Asia and Pacific

Economy	Regional rank 2008	Rank 2008	IDI 2008	Rank 2007	IDI 2007	Rank 2002	IDI 2002	Rank change 2007-2008
Korea (Rep.)	1	3	7.68	2	7.23	2	5.84	-1
Japan	2	8	7.12	7	6.89	17	4.79	-1
Hong Kong, China	3	11	7.04	10	6.78	12	4.98	-1
Singapore	4	14	6.95	15	6.47	16	4.79	1
Australia	5	15	6.90	14	6.51	14	4.97	-1
New Zealand	6	16	6.81	16	6.38	18	4.72	0
Macao, China	7	24	6.29	28	5.73	23	4.33	4
Brunei Darussalam	8	42	5.07	42	4.77	39	3.25	0
Malaysia	9	56	3.96	55	3.66	50	2.71	-1
Maldives	10	68	3.54	72	3.11	87	1.97	4
Thailand	11	76	3.27	75	3.03	74	2.13	-1
China	12	79	3.23	77	3.03	90	1.96	-2
Iran (I.R.)	13	84	3.08	86	2.73	92	1.94	2
Viet Nam	14	86	3.05	93	2.61	106	1.59	7
Philippines	15	90	2.87	95	2.61	81	2.02	5
Fiji	16	91	2.81	88	2.69	85	2.00	-3
Mongolia	17	95	2.71	94	2.61	86	1.98	-1
Sri Lanka	18	105	2.51	104	2.32	99	1.74	-1
Indonesia	19	107	2.46	108	2.15	109	1.57	1
India	20	117	1.75	116	1.62	116	1.21	-1
Lao P.D.R.	21	118	1.74	117	1.60	123	1.09	-1
Myanmar	22	119	1.71	118	1.60	104	1.66	-1
Cambodia	23	120	1.70	120	1.53	122	1.10	0
Bhutan	24	123	1.62	124	1.48	117	1.15	1
Pakistan	25	128	1.54	127	1.45	144	0.92	-1
Bangladesh	26	137	1.41	137	1.34	128	1.05	0
Nepal	27	142	1.34	141	1.27	131	1.04	-1
Papua New Guinea	28	151	1.08	150	1.06	137	0.99	-1

Source: ITU.

Source: ITU

[4] TRCSL, Sri Lanka submitted its proposal to ITU ASP RPM 2009 to cover overall NGN issues, including architecture and design principles, timescales for notification of network change, service withdrawal, migration including proposal for information sharing through symposia, workshops, publications, studies etc.

Three national workshops one each in Manila, New Delhi and Colombo were organized in 2010 involving local experts and ITU experts to share experiences on technical, regulatory and best practice on NGN regulatory and migration strategies.

Philippines, India and Sri Lanka provided a pool of experts to help write the report.

1.4 End project situation

The outcome is in the form of a report on migration to NGN environment through real life assessment of case studies along with knowledge sharing through organization of workshops and trainings on related NGN issues in the Asia and Pacific region. The final goal is to publish, present and disseminate NGN-related case studies to ITU Member States.

1.5 Key findings and conclusions for NGN regulation and migration

A good level of insight was reached within the project for auditing current country status on regulation, network and services through collaboration with the local experts during the site visits and the development of national workshops.

A set of assessments and recommendations (about 40) are provided in chapter 4 derived from the analysis of current status in chapter 2 and the benchmarking with best practices covered in chapter 3. A summary of most salient and generic recommendations is described here as follows:

R1) *Currently, the analyzed countries have fragmented and partial policies for the network modernization and for the promotion of development level on ICT.*

→ Define an overall coordinated strategy for ICT, e-services and broadband development in coordination with relevant ministries (ICT, Science and Technology, education, health, finance, agriculture tourism, etc.), stakeholders, service providers and related sectors.

R2) *Today available broadband offers have low speeds and medium speeds cost more than developed countries which seriously limits the deployment of many services.*

→ It is recommended to extend the offer of higher speeds and reduce pricing through economies of scale as indicated in chapter 4. This implies corresponding actions on network provisioning and commercial plans.

R3) *Licensing procedures are well defined in the countries with some flexible, India is a good example of a suitable unified licensing regime.*

→ It is recommended to have sufficient availability of spectrum for provision of 3G/4G services to allow faster adoption of new broadband services in urban areas and for considering technologies such as WiMAX in low density areas.

R4) *Level of competition in mobile services is good but relatively much lower in fixed broadband services with similar pricing strategies between service providers in each country.*

→ Promote competition in fixed broadband services removing barriers for network access and facilitating cost savings by infrastructure sharing, especially for access to physical networks, ducts, poles, including local loop unbundling, avoiding an oligopoly situation that does not facilitate innovation or time to market.

R5) *Specific studies are being carried out currently in all countries in relation to NGN development with a fragmented vision.*

→ Perform a national study of each service provider for medium term (i.e.: five years) to evaluate technical and economic consequences of network modernization and introduction of new services with the corresponding what-if analysis of different migration rates, services introduction, package offers, pricing strategies and related business results including net present value, internal rate of return and payback period.

R6) *A major technological change for migration to NGN implies to resolve many new issues due to the technical functionalities, interfaces, operation, etc. that are not widely known.*
→ Identify convenient strategic technology partners for collaboration at the initial phases of the migration in order to solve the inherent operational issues with any new technology and avoid unnecessary delays and bottlenecks.

R7) *Network migration and services introduction today is taking place by partial sub-network evolution at core, access and edge segments based on MetroEthernet, xDSL, WiMAX and Mobile 3G with limited overall coordination.*
→ Develop at each service provider a specific NGN migration operations group to coordinate all implementation for network elements: terminals, access, edge, core, services and operation support systems and business support systems and assure correct service handling during the transition phases. Accelerate the initiated deployment of ADSL2+ for 8 to 10 Mbps for higher speeds.

R8) *Regulatory frameworks are relatively well developed for PSTN solutions but NGN related regulations are in initial phases of development.*
→ Anticipate a simplified high level "macroscopic" regulation to include solutions to encourage competition and introduction of new broadband services taking into account end-to-end provision of quality of service, and the utilization of an Internet exchange ensuring cybersecurity.

R9) *Most operational employees have a good background on classical technologies but very few are familiar with the IP based technologies.*
→ Develop comprehensive training programmes for operational staff on the NGN and IP mode techniques, protocols, engineering and capacities starting at the metropolitan areas and to be extended to all regions to avoid operational issues and service deployment delays.

R10) *Quality of IP services is today not guaranteed in many cases due to the lack of traffic flow monitoring and the lack of application of robust engineering rules at different network segments and elements, frequently resulting in lower broadband speed and quality at busy hours.*
→ Develop at each service provider a team with capability and specialization on IP traffic measurement, processing, projection, dimensioning and planning in relation to new operation support systems applications, as illustrated in section 3.3.7, in order to assure required QoS specified by the regulator and ensure efficient utilization of resources.

2 Telecommunications Context

2.1 Philippines

Information and data summarized in sections below were obtained during the site visit to the countries as planned in the project with additional post processing and input by stakeholders in the Philippines[5].

[5] Philippines country information by CICT, NTC and Service providers: Templates on data for General Telecom, Regulation and Networks. June 2010

2.1.0 General context

2.1.0.1 Socio-economic context: Role of broadband in the economy

With an estimated population of 97,976,603 (as of year 2009) and with a growth rate of 1.96 per cent[6], the Philippines is the world's twelfth most populous country. With the pressing problems on poverty, the Philippines would like to embrace ICT as one of the strategic solutions to address this.

For the Philippines, embracing broadband development will help drive growth and deliver benefits such as but not limited to higher productivity, better governance, and efficient and effective conduct of business transactions right across society and will be an important factor in addressing the digital divide. As stated in the CICT's ICT Roadmap of 2006 – 2010[7], the emergence of the Internet has also seen the emergence of new, high bandwidth networks and new network paradigms that are rapidly displacing the traditional, narrowband PSTN model.

Filipino children enter public school (nursery) at about age four. At about seven, children enter Elementary School (six years).This is followed by High School (four years). Students normally need to apply and pass College Entrance Examinations (CEE) to enter University.

As per available data, for the year 2004 – 2005, there were about 2,402,315 college enrolees (male: 1,100,199; female: 1,302,116). For the year 2008-2009, however, there were about 6,763,858 secondary education enrolees (public: 5,421,562; private: 1,342,296) and the number of elementary enrolees reached about 14,862,142 (pre-school: 1,175,499; elementary: 13,686,643)[8]

The Philippines with a total population of 97,976,603 and land area of 300,076 square km has a population density of 326.506 inhabitants/square km with the following distribution per area type:

- Metro: ~ 16M (18 per cent)
- Urban: ~ 18M (21 per cent)
- Sub-urban: ~ 31M (35 per cent)
- Rural: ~ 23M (26 per cent)

Concerning the country positioning on the telecommunication sector and related services, the Republic Act[9] states the following:

1) Article II (Policy and Objectives) Section 4a states that the fundamental objective of government is to develop and maintain a viable, efficient, reliable and universal telecommunication infrastructure using the best available and affordable technologies, as a vital tool to nation building and development.
2) Section 4f states that a healthy competitive environment shall be fostered, one in which telecommunication carriers are free to make business decisions and to interact with one another in providing telecommunication services, with the end in view of encouraging their financial viability while maintaining affordable rates.
3) Section 4l states that the development of a domestic telecommunication manufacturing industry to meet the needs of the Philippines and to take advantage of export opportunities shall be promoted without preventing, deterring or hampering the goal of full universal service.

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6 National Statistics Office (NSO)

7 Commission on Information and Communications Technology: www.cict.gov.ph/

8 Reference Department of Education (DepEd) www.deped.gov.ph: facts figures and Commission on Higher Education (CHEd) www.ched.gov.ph:

9 Republic Act 7925

4) Article III (Administration) Section 5c mandates a fair and reasonable interconnection of facilities of authorized public network operators and other providers of telecommunication services through appropriate modalities of interconnection and at a reasonable and fair level of charges which make provision for the cross subsidy to unprofitable local exchange service areas so as to promote telephone density and provide the most extensive access to basic telecommunication services available at affordable rates to the public.

5) Section 5e promotes consumer welfare by facilitating access to telecommunication services whose infrastructure and network must be geared towards the needs of individual and business users.

6) Section 5f protects consumers against misuse of telecommunication entity's monopoly or quasi-monopolistic powers by, but not limited to, the investigation of complaints and exacting compliance with service standards from such entity.

According to CICT's Roadmap 2006 – 2010[10], "All citizens should therefore have access to basic government services, information, and quality education through the use of appropriate and affordable ICT Technologies". The government's primary concern is to ensure appropriate connectivity to be available in all local government units and public schools. Broadband services enable high capacity communications services characterized by both high data transmission speeds and high volumes of data. With the growth of high-speed broadband infrastructure, either wired or wireless, coupled with technological advancement on equipment, and the global proliferation of small mobile devices and other intelligent terminals that can be used to communicate and gather converged data, voice and video information and services anywhere, anytime will make the lives of people more efficient, effective, and convenient.

2.1.0.2 Overall characterization

As presented by the National Telecommunications Commission (NTC)[11], there are 77,043,460 subscribers for mobile service as of 2009 and about 3,850,000 subscribers for fixed service for the same year. The Philippines has a liberalized market and has encouraged competition in the telecommunication market. Traditionally, it has separate networks for voice and data. However, networks are starting to converge and next generation networks are being introduced and encouraged.

Universal service obligation (USO) is being imposed on the international carriers and on the radio mobile network operators to provide local exchange service. As a result of this regulatory structure, rapid expansion on mobile, on national, and on international networks was established.

The biggest fixed network operators are as follows: 1) PLDT 2) Innove/Globe 3) BayanTel and, 4) Digitel (7.9 per cent market share). The main mobile service operators are: 1) Smart, 2) Globe and, 3) Sun Cellular.

Based on current market analysis, the Philippines dominant speeds of broadband are 512 Kbps (with a price range of P895 – P999) and 1Mbps (with a price range PHP 1,299 – PHP 1,500).

The most common services provided by different players are as follows (not necessarily in order of ranking):

1) VPN-IP (Virtual Private Network-Internet protocol);

2) VPN-MPLS (Virtual Private Network-Multiprotocol Label Switching);

3) VoIP (Voice over Internet Protocol);

4) other new services planned to be added in the next two years.

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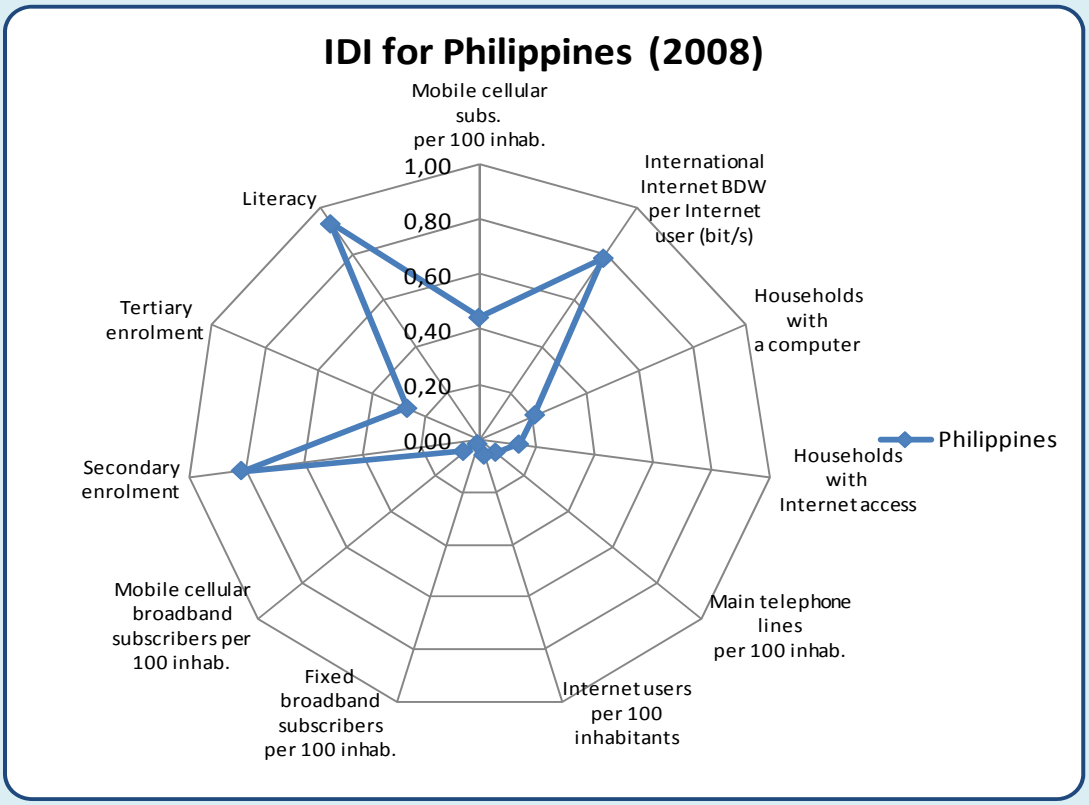
[10] CICT's ICT Roadmap 2006 – 2010

[11] NTC: http://portal.ntc.gov.ph/wps/portal

2.1.0.3 ICT index per dimension: IDI

In 2008, the Philippines was 90 out of 159 countries in terms of ICT development index (IDI) with a value of 2,87 and gained five places from the previous year[12]. Observing the spike diagram for the 11 parameters that characterize the IDI indicator in Figure 1, it becomes clear that maturity level is high in literacy, secondary enrolment and available bandwidth per Internet user while indicators for Internet penetration and broadband access both on fixed network and mobile are significantly low.

Figure 1: ICT Development Index for the Philippines, 2008



Source: ITU

2.1.1 Policy and regulation

2.1.1.1 Licensing regime

As the State recognizes the vital role of communication and information in nation-building (Philippines Constitution, Article 2, Sec. 24), the Philippines has created two licensing regimes: 1) The Commission on Information and Communications and Technology (CICT) as the main ministry, created under executive order[13] signed by President Gloria Macapagal Arroyo is mandated to be the primary policy, planning, coordinating, implementing, regulating, and administrative entity of the executive branch of government that will promote, develop, and regulate integrated and strategic ICT systems and reliable and cost-efficient communication facilities and services; 2) The National Telecommunications Commission (NTC) as

[12] Measuring the Information Society, ICT Development Index (IDI). 2010 ITU International Telecommunication Union. CH-1211 Geneva Switzerland

[13] Executive Order (EO) 269 series of 2004

the regulatory agency[14], with regulatory and quasi-judicial functions taken over from the Board of Communications and the Telecommunications Control Bureau which were abolished in the same order, is the sole body that exercises jurisdiction over the supervision, adjudication and control over all telecommunication services throughout the Philippines. For the effective enforcement of this responsibility, it adopts and promulgates such guidelines, rules, and regulations relative to the establishment, operation and maintenance of various telecommunication facilities and services nationwide.

In the Philippines, there are several operators/players for fixed services such as PLDT[15], Globe[16], Digitel[17], BayanTel[18], Eastern Telecom, and others. Presently, the latest National Telecommunication Commission statistics indicate that there are about 3.8 million or more fixed-line subscribers which is approximately 3.92 per cent of the population. However, the number of Philippine mobile telephony subscribers has risen to 77.04 million which is approximately 79.38 per cent of the population. Mobile operators are as follows: Globe, PLDT, Smart Communications, Talk and Text, Digitel/SunCellular, Bell Tell, and others. Although there has been no appreciable increase in wireless service, the Philippines maintains forward momentum and expect mobile subscriber numbers to increase considerably every year. In addition, broadband subscribers (both fixed and wireless) has increased market share significantly especially in mobile broadband, which attracted a great deal of interest. Market leaders PLDT (along with its Smart Communications subsidiary) and Globe Telecom reported rapid subscriber growth for 3G/3.5G-based wireless broadband offerings throughout 2009.

Executive Order (EO 546 series of 1979) mandates NTC to manage the radio frequency spectrum. Moreover, provided in the Republic Act No. 7925 (An Act To Promote And Govern The Development Of Philippine Telecommunications And The Delivery Of Public Telecommunications Services) Article II (Policy and Objectives) Section 4 (Declaration of National Policy) letter C states that: The radio frequency spectrum is a scarce public resource that shall be administered in the public interest and in accordance with international agreements and conventions to which the Philippines is a party and granted to the best qualified. The government shall allocate the spectrum to service providers who will use it efficiently and effectively to meet public demand for telecommunication service and may avail of new and cost effective technologies in the use of methods for its utilization. In addition, Article V (Other Services and Facilities) Section 15 states: The radio frequency spectrum allocation and assignment shall be subject to periodic review. The use thereof shall be subject to reasonable spectrum user fees. Where demand for specific frequencies exceeds availability, the Commission shall hold open tenders for the same and ensure wider access to this limited resource.

2.1.1.2 Interconnection

Republic Act 7925[19] states that: A fair and reasonable interconnection of facilities of authorized public network operators and other providers of telecommunication services is necessary in order to achieve a viable, efficient, reliable and universal telecommunication services; and the government shall give all the assistance and encouragement to Philippine international carriers in order to establish interconnection with other countries so as to provide access to international communications highways on a competitive basis respectively. Moreover, Article III (Administration) Sec. 5 letter C mandates a fair and reasonable interconnection of facilities of authorized public network operators and other providers of

[14] National Telecommunications Commission (NTC) Executive Order No. 546 promulgated on July 23, 1979

[15] Philippines Long Distance Telephone Company: www.pldt.com.ph/Pages/Home.aspx

[16] Globe: http://site.globe.com.ph/personal?sid=TUAeWcuxpRYAACipgpQAAABae

[17] Digital Telecommunications Phils., Inc.: www.digitel.ph/

[18] Bayan Telecommunications: www.bayan.com.ph/

[19] Republic Act. (Article II. Policy and Objectives) Section 4 letters G and F

telecommunication services through appropriate modalities of interconnection and at a reasonable and fair level of charges which make provision for the cross subsidy to unprofitable local exchange service areas so as to promote telephone density and provide the most extensive access to basic telecommunication services available at affordable rates to the public.

The RAO (Reference Access Offer) of 2009[20] provides the conditions, prices and terms a telecommunication company offers in exchange for access to its network, facilities, systems or customer base by another player or by value-added service providers which includes Memorandum Order No. 02-04-2009, which is the implementing guidelines on developing RAO. The operators that received the order include Philippine Long Distance Telephone Co., Smart Communications Inc., Globe Telecom, Eastern Telecommunications Inc., Digital Telecommunications Phils. and Bayan Telecommunications Inc. Moreover, NTC MC 09-07-2007[21] states that no interconnection and access charges between interconnected local exchange carriers (LECs) within a local calling area, among others, can be added as reference on this matter. Interconnection revenue sharing was set at 30-40-30 for national long distance telephone service revenue and 9 per cent of the collection rates for international long distance telephone service revenue.

2.1.1.3 Cost allocation, charging and billing

Today, there are no defined specific cost allocation principles and type and there are no defined rules for PSTN and IP mode charging and billing.

2.1.1.4 Infrastructure sharing

NTC Memorandum Circular (MC) 07-08-05[22] states: Qualified applicants must submit a written undertaking that shall allow the sharing of its network and facilities with other 3G players in areas where demand does not allow more than one 3G network; Must submit written undertaking that it shall negotiate roaming agreements with other 3G networks or existing duly authorized CMTS service providers; Must submit a written undertaking that it shall abide by the terms and conditions set by the Commission in cases where its negotiations for interconnection, sharing of networks and facilities and/or roaming fail to reach agreements within ninety (90) days from date of the start of negotiations for the same respectively is being encouraged. Moreover, Section 7[23] states that:

- Assignees shall Interconnect with all 3G networks, cellular mobile telephone networks, local exchange networks and all other public networks pursuant to existing laws, rules and regulations on mandatory interconnection;
- Share its 3G network and facilities with other 3G players in areas where demand does not allow more than one 3G network at mutually agreed prices or at prices set by the Commission. Only 3G operators that have complied with their approved roll-out plans can share their networks and facilities subject to mutually agreed commercial terms and conditions;
- Negotiate roaming agreements with other 3G networks and existing duly authorized CMTS service providers. Only 3G operators that have complied with their approved roll- out plans can negotiate roaming agreements among themselves and with existing duly authorized CMTS service providers respectively.

Concerning unbundling for the fixed access networks and other active equipment sharing within the national network segments, there is no specific mandate or regulation.

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[20] NTC Memorandum Order No. 02-04-2009: Implementing Guidelines on Developing Reference Access Offers

[21] NTC MC 09-07-2007: Rules on Interconnection of Local Exchange Carriers in Local Calling Areas

[22] NTC Memorandum Circular (MC) 07-08-05. *Section 3.6 letters C to E*

[23] NTC Memorandum Circular (MC) 07-08-05. Section 7 (Obligations of Assignees) letters H to J

2.1.1.5 Quality of service

Quality of service (QoS) is referenced to ITU recommendations and more specifically the requirements for Internet access services and wired telecommunication services are defined in the MC 19-12-2004[24] which specifies parameters and values for: network availability, system accessibility, service activation time, bandwidth throughput, QoS at interconnection points, service reliability and response to billing enquires within five working days.

Complaints against service providers can be filed in whatever form and manner and should be addressed and resolved within 15 days. The complaint is presumed to be valid unless proven otherwise by the service provider. Before any regulation is promulgated, public consultation and formal public hearings are conducted. For complex issues, public consultation and hearings may take one year to complete. Notice of public hearings is published in newspapers of general circulation. Any interested party can submit comments and position papers.

2.1.1.6 Security, privacy, lawful interception

Republic Act No. 4200[25] Section 1 states that it shall be unlawful for any person, not authorized by all parties to any private communication or spoken word, to tap or wire or cable, or by using any other device or arrangement, to secretly overhear, intercept, or record such communication or spoken word by using a device commonly known as a Dictaphone, or dictograph or detectaphone or walkie-talkie or tape recorder, or however otherwise detected. Only those authorized (with written order of the court) shall execute the acts declared to be unlawful in the two preceding Sections in cases involving the crimes of treason, espionage, provoking war and disloyalty in case of war, piracy, mutiny on the high seas, rebellion, conspiracy and proposal to commit rebellion, inciting to rebellion, sedition, conspiracy to commit sedition, inciting to sedition, kidnapping as defined by the Revised Penal Code[26], and violations of Commonwealth Act No. 616, punishing espionage and other offenses against national security.

Memorandum Circular MC 05-06-2007 Section 2.2[27] states that any data supplied by the consumer shall be treated as confidential by the entity or service provider and shall not be used for purposes not authorized by the consumer. Upon subscription, the consumer shall be informed of the right to privacy and the manner by which data would be protected. Section 5 (Administrative and Penal Sanctions) of this MC states, non-compliance with and/or violation shall be dealt with appropriate administrative and penal sanctions provided by law. Moreover, MC 04-06-2007 (Data Log Retention of Telecommunications Traffic) Section 1 states that: PTEs (Public Telecommunications Enterprises) shall retain the call data records on voice calls and similar records for non-voice traffic. Non-voice traffic includes SMS, MMS and other similar telecommunication services.

MC 05-06-2007 Section 2.1 and 2.2 states that a subscriber of any of the entities mentioned in Section 1.1 shall have a right to be treated equally as other similarly situated consumers; and any data supplied by the consumer shall be treated as confidential by the entity or service provider mentioned under Section 1.1 and shall not be used for purposes not authorized by the consumer. Upon subscription, the consumershall be informed of the right to privacy and the manner by which data would be protected. In cases where a public directory listing of subscribers is regularly published by the service provider, the consumer shall be given the option not to be listed in succeeding publications.

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[24] NTC Memorandum Circular No. 19-12-2004: Service performance standards for Internet access services and wired telecommunication services

[25] Republic Act No. 4200: An Act to Prohibit and Penalize Wire Tapping and Other Related Violations of the Privacy of Communication, and for Other Purposes

[26] www.chanrobles.com/revisedpenalcodeofthephilippines.htm

[27] NTC. Memorandum Circular MC 05-06-2007 Section 2.2: Consumer Rights

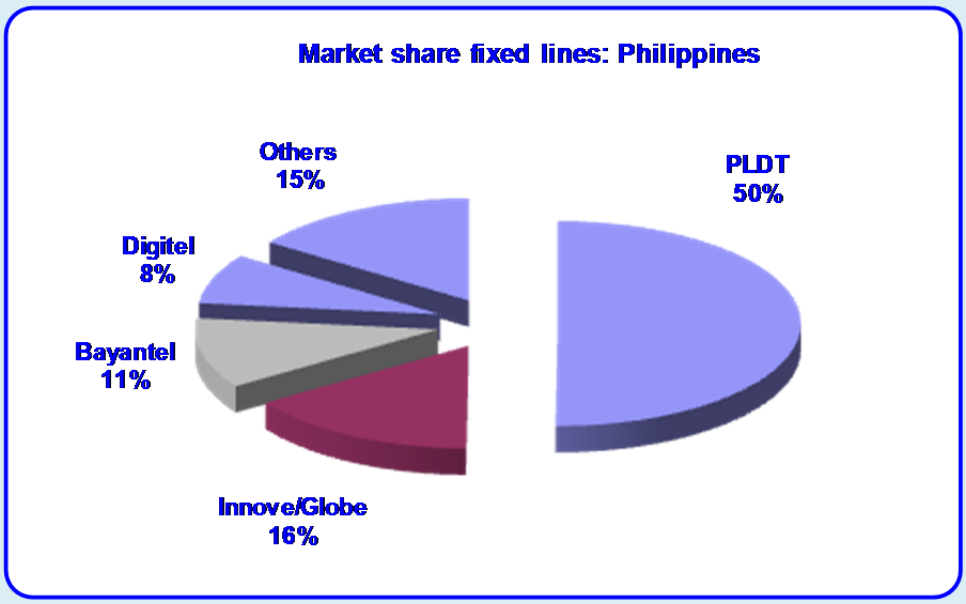
Moreover, MC 04-06-2007 Section 3 states that PTEs shall allow the NTC and the complaining subscriber access to these records upon a formal written request and only in connection with a complaint filed and pending with the NTC. The records shall not be made available to any other person or party without a court order or a written consent from the subscriber concerned. The PTEs shall furnish the NTC with the hard copies of these records within three days from the date of request.

2.1.2 Players

2.1.2.1 Main national players

The dominant players for fixed line telecommunications are as indicated in Figure 2 with Philippine Long Distance Telephone (PLDT) as a leader with market share close to 50 per cent followed by Innove/Globe Telecommunications, Bayan Telecommunication (BayanTel), Digital Telecommunication (Digitel).

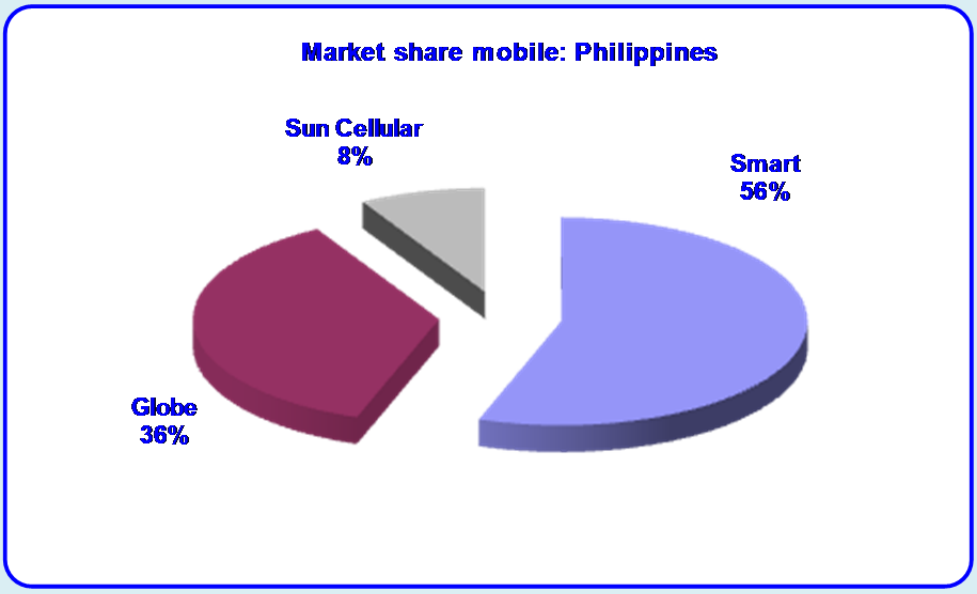
Figure 2: Market share in the Philippines for fixed lines



Source: Working Team: Philippines

Dominant players for mobile are indicated in Figure 3 with Smart Telecommunications having a 55.42 per cent market share followed by Globe Telecommunications and Sun Cellular.

Figure 3: Market share in the Philippines for mobile lines



Source: Working Team: Philippines

2.1.3 Infrastructure and NGN status

2.1.3.1 Services demand and broadband penetration

Majority of service providers/operators primarily depend on the network coverage of four major telecommunication networks in offering broadband services in the country. The existence of major telecommunication companies means the presence of service providers in the area. According to the National Telecommunications Commission (NTC), the total number of broadband subscribers as of end December 2009 reached about 3.6 Million. These figures included both prepaid and post broadband users. However, it can be noted that a wide range of broadband services/applications are being offered/concentrated in major cities and urban areas. Fixed line penetration rate averaged 3.7 per cent by 2009 but in Metro Manila alone, fixed line penetration rate reached 18.3 per cent in 2007.

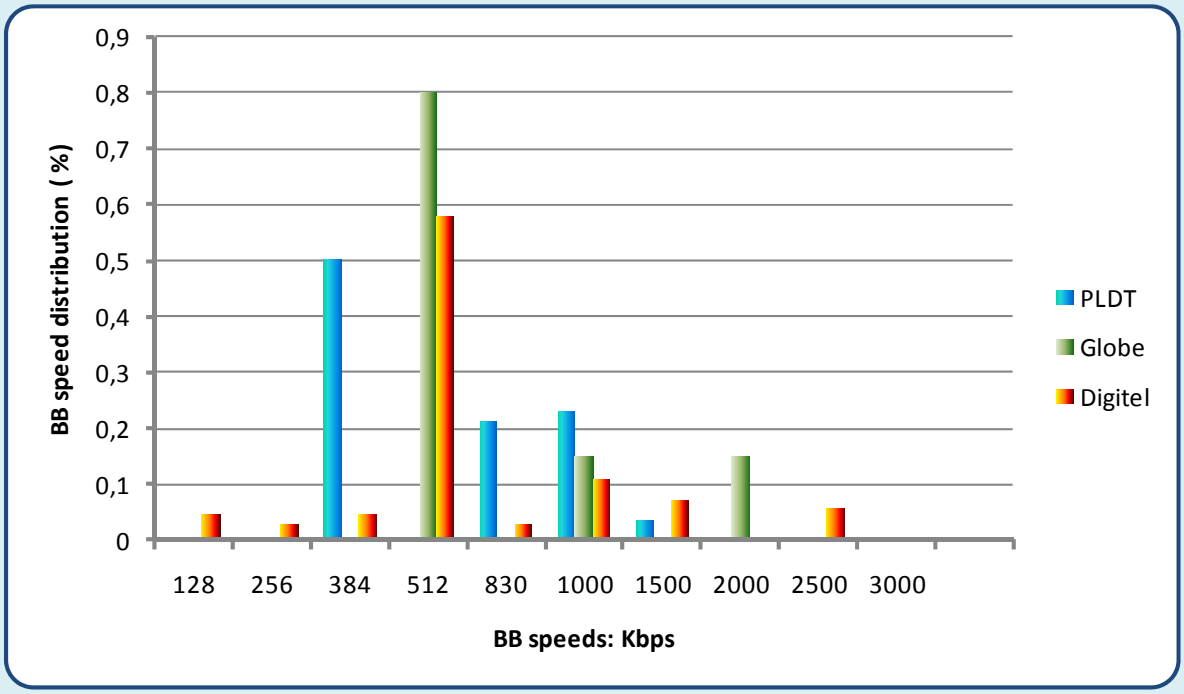
For mobile, the current penetration rate and growth was about 84 per cent with notable increases of about 40 per cent in 2009. Despite this mobile presence nationwide, subscribers particularly in rural areas have contented themselves as Internet users enjoying mostly Internet surfing, online games and research. Among the top data services and penetration are Virtual private Network – Internet Protocol (VPN-IP), Virtual Private Network – Multiprotocol Label Switching (VPN-MPLS) and Voice over Internet Protocol (VoIP).

The Philippine Long Distance Telephone Company (PLDT)/Smart Communications offers the minimum speed of 384 Kbps for its subscribers followed at the speed of 767 Kbps, 1.5 Mbps and 3 Mbps. On the other hand, Globe Telecom offers only three speed mixes starting at 512 Kbps then 1 Mbps and 2 Mbps. Around 80 per cent of Globe subscribers are at 512 Kbps, 15 per cent and 5 per cent are subscribed at the speed of 1 Mbps and 3 Mbps respectively. Digitel Telecommunications offers wide range of broadband speed selection starting at 128 Kbps, 256 Kbps, 384 Kbps, 512 Kbps, 830 Kbps, 1 Mbps, 1.5 Mbps, 2 Mbps, 2.5 Mbps and 4.5 Mbps. Among these speeds offered by Digitel, 512 Kbps covered around 58 per cent of its subscribers with the lowest subscribers on 4.5 Mbps. Meanwhile Bayan Communications (Bayantel) offers five ranges of broadband speeds starting at 768 Kbps, 1 Mbps, 1.5 Mbps, 2 Mbps and 2.5 Mbps.

Particularly for Metro Manila, Metro Cebu and Metro Davao, broadband speed may go up to 2 Mbps as advertised but commonly with no guaranteed minimum speed. Rates range from PHP 777 (around USD 17) up to PHP 3000 (around USD 64) with the initial speed offering at 128 Kbps to 4.5 Mbps.

Major offered stable speeds (not including transitory marketing offers) are illustrated in the diagram below for those operators where speed distribution is available that show a dominant frequency of 512 Kbps followed by 384 Kbps and 1 Mbps.

Figure 4: Distribution for major broadband speeds of stable offers by main operators



Source: Working Team: Philippines

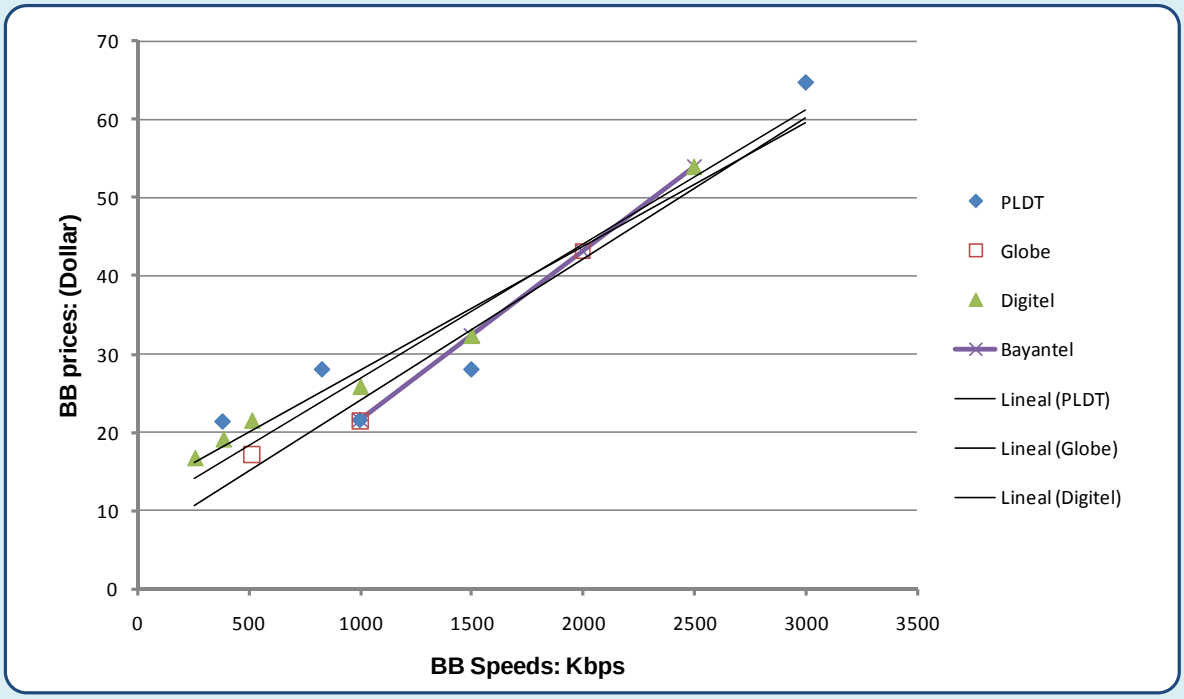
With the same concept of stable offers Figure 5 illustrates the relations between speeds and prices that are close between operators and show a significant linear increase with speeds. It is derived that economies of scale inherent to the technologies are not applied in order to reduce prices at higher speeds and competition level is low as similar behaviour is present in all offers.

2.1.3.2 Transit network segment

According to the Philippine Chamber of Telecommunications Operators (PCTO), about six telecommunication operators have already started deploying NGN in their network. These include PLDT/Smart, BAYAN (Bayantel), Globe Telecom, Eastern Telecom, Cruztelco and Digitel. Cruztelco on the other hand has no International Gateway Facility (IGF), however its TDM (Time Division Multiplexing) switches have already been upgraded into NGN soft switches.

The Philippines is connected to several high capacity submarine fibre optic systems in the Asia-Pacific region linking it to North America as well as connection to Southeast Asia, Middle East and Western Europe regions. PLDT/Smart has two international transit exchanges including cable stations in Nasugbu, Batangas Cable Station where the Asia Pacific Cable Network (APCN), APCN2, Southeast Asia Middle East and Western Europe (SEA-ME-WE 3) and Guam – Phil (G-P) and Domestic Fiber Optic Network terminate. Currently, PLDT has a total of twenty-two NGN core nodes. Globe Telecom has one NGN soft switch and has cable stations in Nasugbu, Batangas where City to City (C2C) and Domestic Fiber Optic Network terminate. Globe has its existing two international legacy switches in Ermita and Mandaluyong and around 78 PE/core routers installed for its NGN core nodes. Meanwhile, Digitel has a cable station in Naic, Cavite where the East Asia Crossing (EAC) terminates. Digitel also has its C4 facilities to NGN international switches.

Figure 5: Relations between broadband speeds and prices for the main stable market offers in the Philippines



Source: Working Team: Philippines

Further, the Philippines have access to several satellite systems both in the Pacific and Indian Ocean regions. For the international satellite system, Philcomsat who is the official signatory to Intelsat operates the Earth Stations facing the Pacific and Indian Ocean Satellite in Pinugay, Rizal while the Mabuhay Satellite Corp., the operator of Agila II has a separate Earth Station in the former US Subic Navy Base.

In addition, PLDT/Smart has around 100 transit national exchanges. Digitel has around 23 while Globe Telecom has five transit national exchanges.

2.1.3.3 Local/edge network segment

There are three inter-exchange service providers that operate a nation-wide fibre optic system covering most of the regional centres. PLDT/Smart operates a nationwide self-healing Digital Fibre Optic Network (DFON) with capacity ranging from 2.5 to 55 Gbps. Prior to the completion of DFON project, the company and its subsidiary Smart Telecom operates two nationwide microwave networks. Telecphil, a consortium of telecommunication service providers led by Bayantel operates a nationwide digital fibre optic system with a capacity of 10 Gbps. Radio Communications of the Philippines Inc. (RCPI), a sister company of Bayantel also operates a nationwide microwave network. On the other hand, Globe Telecom constructed in the last few years, a nationwide digital fibre optic system with capacity of 10 Gbps in addition to their nationwide microwave radio network.

Digitel has C4 facilities (partial) migrated to NGN switches in line with utilizing the NGN switch as second tandem (redundancy). It also operates around five NGN edge nodes (four TDM and one IP). Currently, Digitel has three soft switches (IGF3-Huawei, NGN-ZTE, IGF4-Huawei). On the other hand, Globe has around 660 NGN edge nodes (Aggregations/MetroE) and is operating two national soft switches and seven Media Gateways (MGWs). Meanwhile, PLDT has five soft switches in operation.

2.1.3.4 Access network segment

The Philippine Long Distance Telephone Company (PLDT)/Smart having 130 local exchanges has a total number of 1.8 million installed lines and has around 23 co-located TDM access units nationwide averaging around 300 subscribers. PLDT also has a number of co-located DSLAMS and cable cabinets. Both co-located and remote DSLAMS has around 720 ports while the cable cabinets are up to around a 400 subscriber capacity. Its cable distribution point (DP) averages about 10 subscribers each.

Digital Telecommunications (Digitel) has around 55 local exchanges in its franchise areas, has installed about 586 481 lines (around 259 849 switching operational) with available cable pairs of around 563 500 nationwide. It has also around 495 remote TDM units. Digitel has 137 788 xDSL lines with around 1 594 co-located DSLAMS nationwide with the average size of 96 and 100. Further, Digitel operates around 1 496 remote DSLAMS with an average size of 96 and 160. Its cable cabinets are around 2 257 at an average size of 250 to 300. Digitel also has 44 761 DPs averaging around 20 pairs with a local loop distribution per distance of more than five kilometers. Its local loop facility average is less than 20 years (15 years).

Globe Telecommunications (Innove) with 24 local exchanges has installed around 165 000 lines for its data, 395 000 for its MSAN ports and has around 395 000 lines for its legacy facilities. With this, a total of 520 000 lines are operational (switching). Globe has a total number of 695 000 available cable pairs and around 65 000 reserved cable pairs installed nationwide. It has about 120 co-located TDM access units with an average size of 2 800 while its remote TDM units totaled 1 127 with an average size of about 350. Globe also has its co-located and remote DSLAMS of around 2 144 with an average size 192 each. Its xDSL lines are about 165000 lines. Concerning its cable cabinets, Globe has an average size (per CC) of 25 pairs while its distribution point averages around 10 or 20 each. Globe's local loop distribution measures less than five kilometers and its estimated life span is less than fifteen years.

2.1.3.5 Interconnection

In the Philippines, interconnection was mandated to all telecommunication operators through executive order[28]. The existing interconnection as regards to voice and data services (among these telecommunication operators) depends on the actual demand and forecast (subscribers) of each other. The interconnection is mostly at E1 level and toll interconnection is commonly located in major national/tandem switches but not necessarily at international switch locations. The Telecommunications Office (TELOF) of CICT, for instance, has its point of interconnection (POI) with Bayantel, PLDT and Digitel in many different major cities such as Cebu, Davao, Cagayan de Oro and Manila. Depending on agreements, backhauling is being handled but with corresponding charges (including termination– access charges). The National Telecommunications Commission (NTC) may intervene in the case where both parties fail to reach an agreement.

It is the common practice that the cost of equipment such as cables; routers, etc are being shared equally by both parties in accordance with the mandated interconnection among the operators. There is no specific requirement as to what systems will be used to interconnect but there is existing interconnection which utilizes microwave radios, fibre optic and line drivers (modems). Depending on the actual demand, both parties are guided by Executive Order 59 for its expansion for seamless interconnection.

2.1.3.6 Operation/business support systems and network management

Currently there a number of specific platforms for the operation support system (OSS) associated to each technology and equipment provider in fixed, mobile and data networks (>10). The number of functionalities for new services is growing and there are processes being implemented to reduce and integrate those platforms for a more efficient operation.

[28] Executive Order (EO) 59

2.1.3.7 Quality of service and security

Each telecommunication operator has its own way of measuring/monitoring its quality of service (QoS) and network security with reference to ITU standards and specific requirements defined by NTC. It can be noted that due to tight/fair competition, issues on quality of service and security are immediately addressed once reported. NTC has its feedback and complaint centre visibly seen in its websites[29] to ensure that quality of service are being maintained and achieved.

2.2 India

Information and data summarized in the sections below were obtained during the site visit in New Delhi as planned in the project with additional post-processing and input by stakeholders in India.[30]

2.2.0 General context

2.2.0.1 Socio-economic context: role of broadband in the economy

It is a recognized fact that Information and Communication Technologies (ICTs) play a significant role in bridging the divide between the poor and the non-poor. Experts are of the view that the impact of broadband on GDP is much higher than any other ICT. According to World Bank a 10 per cent increase in broadband penetration increases GDP of a developing country by 1.38 per cent. The inclusive potential of ICT is evident at two levels: the benefits that it brings to poorer communities and the capacity of individuals within these communities to participate in new economic opportunities. ICT, particularly broadband, is therefore, seen as a powerful tool for inclusive socio-economic growth.

In the Government of India Broadband Policy of 2004, broadband has been defined as an "always on" connection with downloads speeds of 256 kbps or more. There were 0.18 million broadband connections at the end of March 2005. These broadband connections grew to 10.30 million by the end of September 2010. Also, the national regulator, the Telecom Regulatory Authority of India (TRAI), has recommended the upward revision in the definition of broadband with a minimum download speed of 512kbps in December 2010.

Total telecommunication contribution to GDP and service Revenue: During the financial year 2008-09, the telecommunication service industry contributed about 3 per cent to the national GDP and it expected that the same trend has continued in the FY2009-10 also. Telecom service sector revenue is growing by about 20 per cent per annum. At the end of financial year 2008-09, total revenue of the telecommunication service sector was about INR 155 000 Crore and it is expected that at the end of 2009-10 financial year it would be about 160 000 Crore. (I crore = 10 million INR, 1 USD = INR. 45).

Access services are contributing about 80 per cent to the total revenue of the telecommunication service sector. During the 2007-08 financial year, the revenue share of the wireless segment to the total revenue was about 62 per cent.

It may be mentioned that the revenue of telecommunication service sector is not growing at the same pace as growth of the subscriber base. During the last five years, industry has shown an average growth in its revenue at the rate of about 20 per cent whereas average growth in the subscriber base was 41 per cent.

Investment and Profitability: As per financial statement of the service providers, during the financial year 2008-09, telecommunication operators invested about 60 000 Crore in their access and long distance

[29] Complaint center reference (www.ntc.gov.ph)

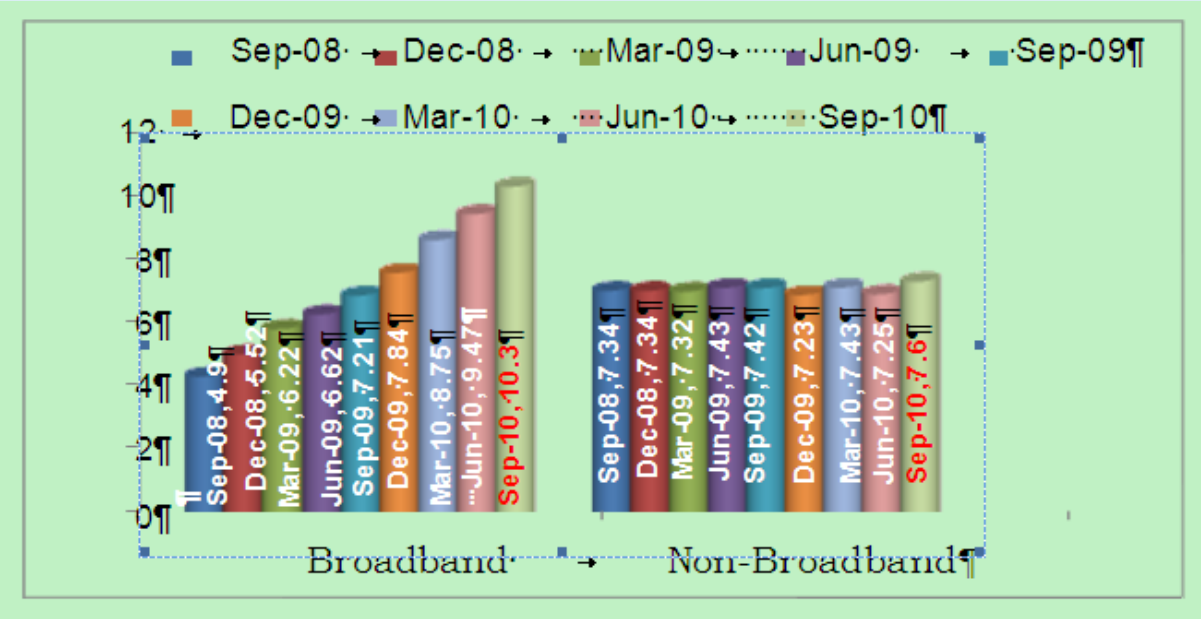
[30] India country information by TRAI and Service providers: Templates on data for General Telecom, Regulation and Networks. September 2010

networks. At the end of the financial year 2008-09, the cumulative investment in the gross block (gross book value of fixed assets) was about 338 000 Crore.

During the 2008-09 financial year, EBITDA margin of the industry was about 30 per cent, whereas during same period wireless and long distance segments have registered EBITDA margins in the range of 35 to 40 per cent. Two leading listed telecommunication companies have shown their EBITDA margin in the range 40 to 42 per cent. During the financial year 2008-09, the India telecommunication service sector reported Return on Capital Employed (RoCE) of about 7 per cent, however listed telecom companies have reported RoCE in the range of 15 per cent to 30 per cent.

During the last five-year period (from 1 April 2005 to 31 March 2010), the Cumulative Annual Growth Rate (CAGR) of this segment was about 117 per cent. A comparison of quarterly growth for the last two years is given in Figure 6. In the quarter ending September 2010, broadband registered a quarterly growth of 8.8 per cent and year-on-year growth of about 43 per cent.

Figure 6: Internet and broadband connections in millions



Source: Telecom Regulatory Authority of India (TRAI)

2.2.0.2 Overall characterization

Most recent data characterizing the telecommunication market by main parameters is provided in Figure 7 corresponding to third quarter of 2010[31].

[31] TRAI report: The Indian Telecom Services Performance Indicators, 2010. www.trai.gov.in

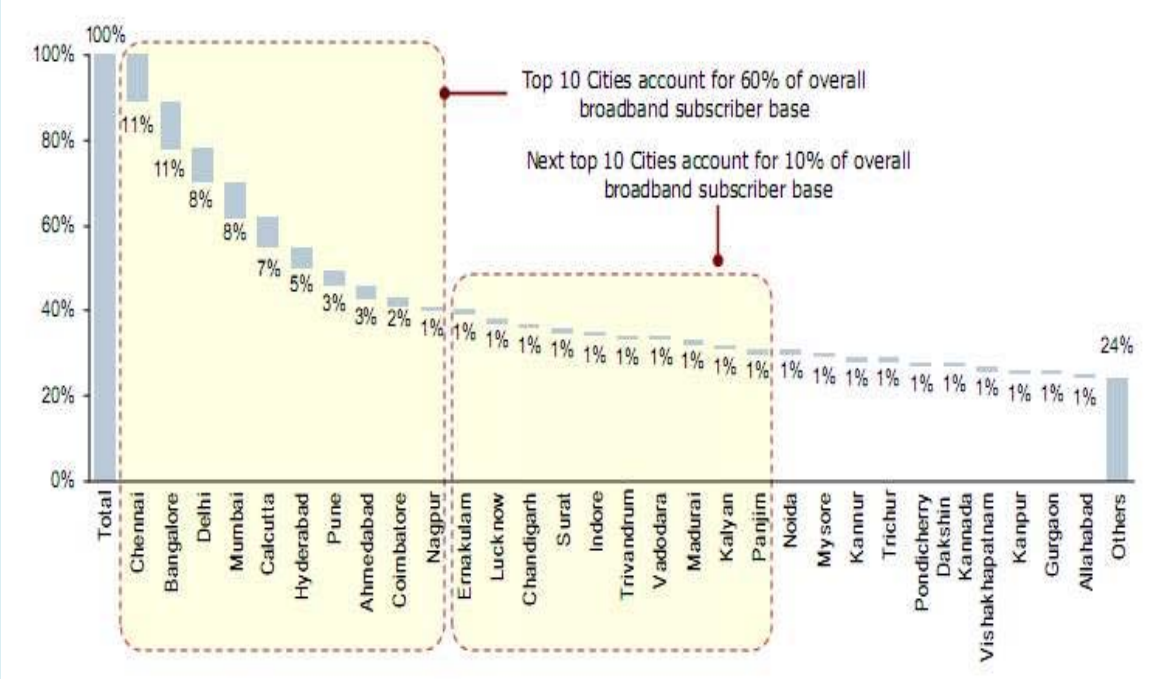
Figure 7: Telecommunications characterization by main sector data as on 30 September 2010

General data for telecommunication sector characterization	
Telecommunications Subscribers (Wireless + Wireline)	
Total Subscribers	723.28 Million
Urban Subscribers	487.07 Million (67.34%)
Rural Subscribers	236.21 Million (32.66%)
Teledensity	60.99
Urban Teledensity	137.25
Rural Teledensity	28.42
Wireless Subscribers	
Total Wireless Subscribers	687.71 Million
Urban Subscribers	460.63 Million (66.98%)
Rural Subscribers	227.08 Million (33.02%)
GSM Subscribers	578.49 Million (84.12%)
CDMA Subscribers	109.22 Million (15.88%)
Teledensity	57.99
Urban Teledensity	129.80
Rural Teledensity	27.32
Wireline Subscribers	
Total Wireline Subscribers	35.57 Million
Urban Subscribers	26.44 Million (74.34%)
Rural Subscribers	9.13 Million (25.66%)
Teledensity	3.00
Urban Teledensity	7.45
Rural Teledensity	1.10
Village Public Telephones (VPT)	0.57 Million
Public Call Office (PCO)	3.52 Million
Internet and Broadband Subscribers	
Total Internet Subscribers	17.90 Million
% change over the previous quarter	7.02%
Broadband Subscribers	10.31 Million
Broadcasting and Cable Services	
Total Number of Registered Channels with I&B Ministry	526
Number of Pay Channels	154
Number of private FM Radio Stations	248
DTH Subscribers registered with Pvt. SPs	26.44 Million
Number of Set Top Boxes in CAS areas	775,876
Revenue and Usage Parameters per month (for the QE Sep-10)	
Average Revenue Per User (ARPU) GSM	Rs` 110
Average Revenue Per User (ARPU) CDMA	Rs` 73
Minutes of Usage (MOU) GSM	368 Minutes
Minutes of Usage (MOU) CDMA	283 Minutes
Minutes of Usage for Internet Telephony	159.12 Million

Source: Telecom Regulatory Authority of India (TRAI)

The broadband growth in India has not only been slow but also has more focus towards profitable urban areas. Presently, more than 60 per cent broadband subscribers are in the top ten metros and tier-I cities and more than 75 per cent connections are in top 30 cities. Just 5 per cent of the broadband connections are in rural areas which are meager compared to about 31 per cent of total mobile telephone connections in rural areas. Figure 8 below gives the broadband penetration for the top 32 cities.

Figure 8: Broadband DSL connections by city



Source: Telecom Regulatory Authority of India (TRAI)

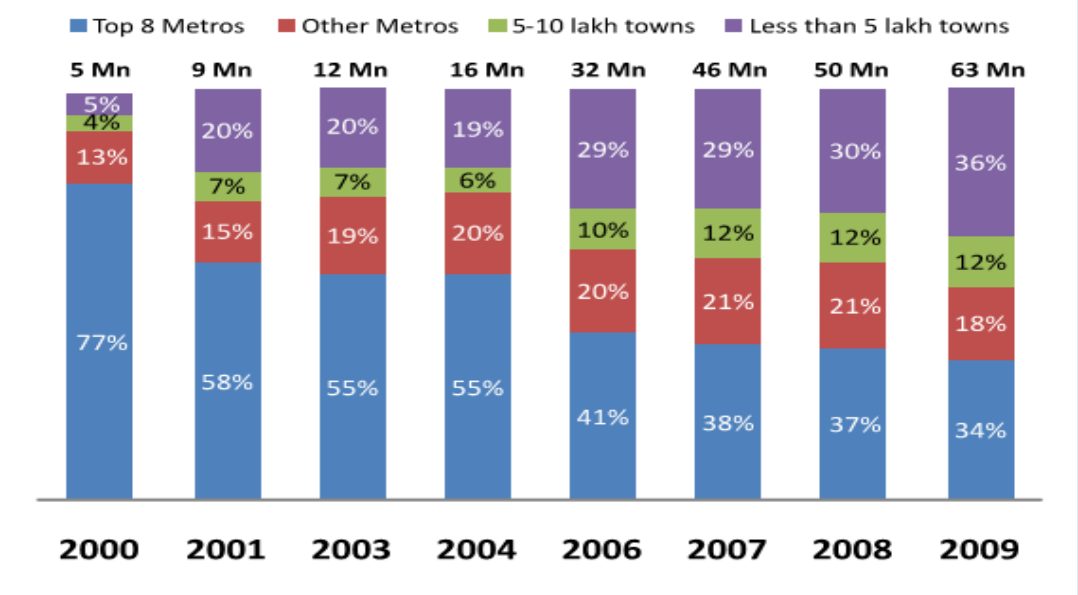
It has been noted that Internet services through non-broadband connections have penetrated well in smaller cities and towns (with populations less than 0.5 million). In these cities, Internet usage has grown from 5 per cent in year 2000 to 36 per cent in 2009[21]. Smaller towns have overtaken top 8 metros in terms of Internet usage. Figure 9 below gives the spread of the Internet across different category of cities and towns.

2.2.0.3 ICT Development Index (IDI) per dimension

In 2008, India was 117 out of 159 countries in terms of ICT Development Index (IDI) with a global value of 1, 51[32]. Observing the spike diagram for the 11 parameters that characterize the IDI indicator in Figure 10, it is evident that maturity level is high in the literacy, second enrollment and available bandwidth per Internet user while indicators for the specific Internet penetration and broadband access both on fixed network and mobile are significantly low.

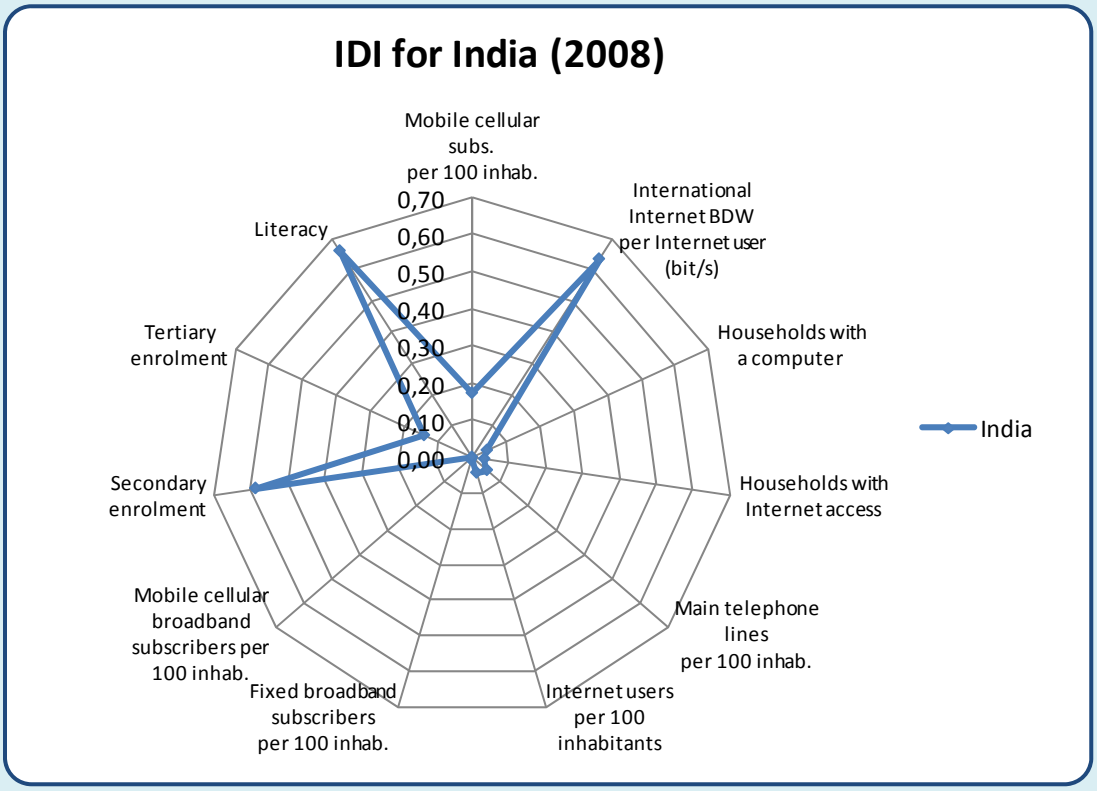
[32] Measuring the Information Society, ICT Development Index (IDI). 2010 ITU International Telecommunication Union. CH-1211 Geneva Switzerland

Figure 9: Internet spread across city types



Source: Telecom Regulatory Authority of India (TRAI)

Figure 10: ICT Development Index components for India in 2008



Source: ITU

2.2.1 Policy and regulation

2.2.1.1 Licensing regime

As per Section 4 of the Indian Telegraph Act, 1885, the Central Government may grant a licence, on such conditions and in consideration of such payments as it thinks fit, to any person to establish, maintain or work a telegraph within any part of the country.

Telecommunications services in India are provided through various licences issued by the Licensor, the DoT, in line with the above provision. The initial licences for basic services and mobile services (CMTS), granted through the bidding process with an annual fixed licence fee, were allowed to migrate to the revenue sharing regime in 1999. Subsequently, the long distance services were also opened to private sector participation. Since then various telecommunication services are being provided under multiple licences and registrations.

The licences include Unified Access Services (UAS), Cellular Mobile Telephone Service (CMTS), National Long Distance (NLD), International Long Distance (ILD), Internet Service Provider (ISP), Very Small Aperture Terminal (VSAT), Public Mobile Radio Trunk Service (PMRTS) etc. Infrastructure Provider Category – I (IP- I) who are allowed to provide passive infrastructure to licensed telecommunication operators requires only registration with the government.

Access services in India are divided into 22 service areas (metropolitan service areas and telecommunication circles). An operator wishing to operate in a particular service area is required to have a licence specific to that service area. Based on their characteristics and commercial attractiveness, the service areas are categorized into four groups: Metro, category A, category B and category C.

Presently, there are about 281 access service providers, 29 NLD operators, 24 ILD operators18, 219 IP-I, 376 ISPs, 11 commercial VSAT services providers, 55 PMRTS and 20 VMS/AUDIOTEX/UMS service licensees.

Regulatory Evolution in India: The Indian telecommunication industry was state-owned until 1991, when the DoT began the process of introducing private participation in the sector by inviting bids for non-exclusive licences to provide cellular services in the four metropolitan service areas (Delhi, Mumbai, Kolkata and the Chennai service area). The bidders were required to be Indian companies with up to 49 per cent foreign ownership. Any foreign partner of the bidding company had to be an entity with experience in the telecommunication sector. In 1995, two licences were issued for each of the four metropolitan service areas.

In 1994, the government announced the National Telecom Policy which defined certain important objectives, including availability of telephone on demand, provision of world class services at reasonable prices, improving India's competitiveness in global markets and promoting exports, attracting FDI and stimulating domestic investment, ensuring India's emergence as a major manufacturing/ export base of telecommunication equipment and ensuring universal availability of basic telecommunication services to all villages.

In 1995, the government (DoT) invited bids for two cellular services licences each in 18 more circles. The government issued 34 licences covering 18 service areas to 14 companies from 1995 through 1998. No bids were received for the Jammu and Kashmir circle. The terms of the licences required mobile operators to interconnect through the fixed-line networks of BSNL and MTNL.

Another round of reforms in the telecommunication sector was initiated through the introduction of the New Telecom Policy 1999 (NTP-99). NTP-99 was approved on 26 March 1999, to become effective from 1 April 1999. NTP-99 laid down a clear roadmap for future reforms, contemplating the opening up of all the segments of the telecommunication sector for private sector participation. It clearly recognized the need for strengthening the regulatory regime in telecoms and for restructuring the Department of Telecommunication Services into a corporate organization, in order to separate the licensing and policy-making functions of the government from that of being an operator. It also recognized the need for resolving the prevailing problems faced by the operators so as to restore their confidence and improve the investment climate by strengthening the regulatory framework for the sector.

In January 2001, the government published guidelines concerning the fourth licence to be awarded for each service area. Also, during same month, based on the recommendations of the Telecom Regulatory Authority of India (TRAI), the government issued guidelines to permit fixed-line telecommunication service providers to provide limited mobility services using wireless in local loop (WLL (M)) technology, within specified short distance calling areas in which the relevant subscriber was registered. In October 2003, TRAI recommended to the government that fixed-line telecommunication service providers intending to provide limited mobility services based on WLL (M) technology pay a specified amount as an additional entry fee.

In November 2003, NTP-99 was amended to include a UAS licence, permitting a licensee to provide fixed-line and/ or mobile services using any technology in a defined licence area upon conversion to a UAS licence. The government issued guidelines relating to UAS licences in November 2003. There is no limitation on the number of UAS licences that can be granted in any given licence area.

The year 2003 also saw a transition to a Calling Party Pays (CPP) regime. The termination charges were also made cost based and has been regulated by the TRAI.

In November 2005, the government, through Press Note 5 of 2005, raised the foreign direct investment limit applicable to the telecommunication sector from 49 per cent to 74 per cent (held directly or indirectly) subject to compliance with certain conditions, including that the majority of the directors and selective key senior management personnel of a company operating in the telecommunication sector be resident Indian citizens, the shareholder agreements and the memorandum and articles of association of the company be amended to ensure compliance with the conditions of the relevant licence agreement, and a resident Indian promoter hold at least 10 per cent equity of the company.

In 2008, the government awarded new licences to several operators in various service areas. Additionally, under the “crossover spectrum” policy, CDMA and GSM operators were made eligible to use both technologies under the same licence. In 2010, the government awarded 3G and broadband wireless access spectrum to several operators in various service areas through open e-bidding

2.2.1.2 Interconnection

Types of interconnection and Points of Interconnection (POI): Presently, in India, interconnection of PSTN/PLMN is not permitted with ISP networks as the ISPs are not treated as an interconnection entity. The permissible types of interconnection among various operators are described below:

i. Multiplicity of networks and service providers

   In the current scenario of liberalization service providers are operating different types of networks and offering differentiated products and services to subscribers and to other service providers. There are access – fixed and mobile and long distance – national and international and Internet services. Access service providers and national long distance operators cooperate to give national long distance service to the end user. A fixed access service provider will compete with other fixed access service providers, and to the extent fixed service is substitutable by mobile service, with mobile access providers in the same service area. Interconnection is required between both cooperating and competing networks. There would be a large number of permutations and combinations making the interconnection scenario fairly complex. Various types of interconnections are listed below:

   - fixed with fixed,
   - fixed with cellular,
   - fixed with national long distance,
   - fixed with international long distance,
   - mobile with mobile,
   - mobile with national long distance,

- mobile with international long distance,
- national long distance with international long distance.

This situation is further complicated by the number of licensees for each service within a service area. According to information on DOT web-site as of 11.05.2010 there are 2 basic, 38 Cellular Mobile Telecommunication Service (CMTS) and 240 Unified Access Service Licensee (UASL) in the country. In the long distance segment there are 29 National Long distance (NLD) and 24 International Long Distance (ILD) operators.

ii. Geographical subdivision

Besides different networks, services and products, another element complicating the interplay of interconnecting operators is the size of the country. For proper administration and technical compulsions the country has been divided into telecommunication circles, which are mostly co-terminus with state boundaries with exceptions having more or less than one state in a circle. Access licences are issued circle-wise/service area wise, thus these licensees have to negotiate interconnection with service providers within and outside each service area. The circles are further divided into Long Distance Charging Areas (LDCAs) also known as Secondary Switching Areas (SSAs) each roughly corresponding to a district. Each LDCA has a Long Distance Charging Centre (LDCC), which is a Trunk Automatic Exchange in the important town or in the headquarters of the district. The LDCAs are sub-divided into Short Distance Charging Area (SDCAs), which approximately correspond to tehsils. An important town in the SDCA is defined as the Short Distance Charging Centre (SDCC). There are 322 SSAs or LDCAs and 2645 SDCAs in the country. The geographical area co-terminus with Short Distance Charging Area (SDCA) and served by an exchange or an exchange system is defined as "Local Area". There may also be the case when the licensor has declared any area served by an exchange system to be the local area for the purpose of telephone connections.

iii. Traffic flows

Calls are designated according to where they originate and terminate in relation to the divisions of area described above. Fixed and WLL (M) calls originating and terminating within the same local area are treated as local calls. For fixed and mobile access provider, a call terminating in a local area other than in which it is originated is defined as a long distance call. The intra circle traffic including the Long distance calls originating and terminating within boundaries of the licensed service area can be carried by access providers themselves. The intra circle traffic may also be carried by National Long Distance Operators (NLDOs) with mutual agreement with originating service provider. For carriage of inter circle traffic i.e. long distance traffic originating in one telecommunication service area and terminating in another telecommunication service area, the call has to be routed through licensed NLDOs. Calls from one circle to another would again be carried by national long distance service providers. International Long Distance (ILD) traffic from fixed and mobile network is routed through network of NLD service providers to the ILD service providers' gateways for onward transmission to international networks. However, in situations where Point of Presence (POP) of ILD service licensee and switch of access provider's (GMSC/ Transit Switch) are located at the same station of Level -I TAX the access provider switch can interconnect with the ILDO directly.

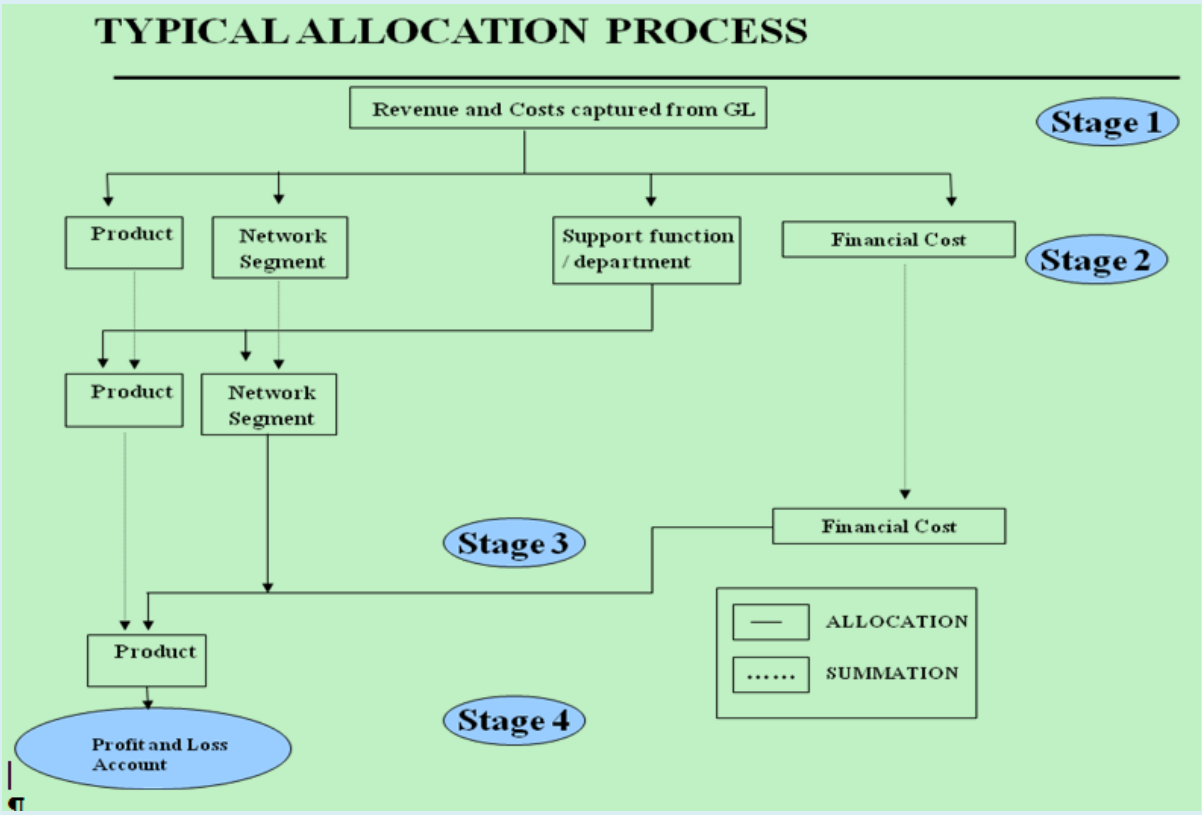
2.2.1.3 Cost allocation, charging and billing

In line with the generic causation principle for cost allocation (see Figure 11), costs are broadly divided into four categories:

1. *Direct costs*, which are solely generated by a particular service or product or network element and are recorded in the accounts against the relevant product, service, asset or function.
2. *Directly attributable costs*, which are solely generated by a particular service or product but are not recorded in the accounts against the relevant product/ service.

3. *Indirectly attributable costs*, which are part of a pool of common cost but which can be attributed to a particular service or product or network element through a non-arbitrary and verifiable cause and effect relationship. There is no requirement for this to be a one-to-one relationship and it may be multi-step.
4. *Unattributable costs*, which are part of a pool of common cost and cannot be identified to a particular service, product, asset or function through a non-arbitrary and verifiable cause and effect relationship.

Figure 11: Typical process for cost allocation based on causation principle



Source: Telecom Regulatory Authority of India (TRAI)

Steps involved in the allocation process:

Step 1 – Allocate cost captured from the General Ledger to the relevant Revenue / Service Centres, Network Elements (both dedicated and common) and Support Cost Centre.

Step 2 – Attribute the costs of support functions to Revenue / Service Centres and other cost centres, which will depend upon whether such costs are directly attributable, indirectly attributable or un-attributable.

Step 3 – Apportion the network element cost and financial cost to various products (the cost is inclusive of allocations from support functions) on basis of relevant cost drivers.

Step 4 – Aggregate costs of various services / products thus providing the product wise profit and loss.

2.2.1.4 Infrastructure sharing

Active Infrastructure sharing amongst service providers was allowed by the government from April 2008 onwards for sharing of antenna, feeder cable, Node B, Radio Access Network (RAN) and transmission system only. Passive infrastructure sharing was allowed much earlier for sharing of physical sites, buildings, shelters, towers, masts, power supply and battery back-up.

Under the scheme launched by the universal service obligations (USO) fund subsidy, support was provided for setting up and managing 7436 infrastructure sites (towers) in 500 districts spread over 27 states for provision of mobile services in the specified rural and remote areas, where there is no existing fixed wireless or mobile coverage. The infrastructure so created with the help of the USO fund shall be shared by three service providers for provision of mobile services. The agreements effective from 1 July 2007 were signed with the successful bidders in May 2007. Sharing of the allocated spectrum is not available today but it is recommended by TRAI to be permitted in the future.

2.2.1.5 Quality of service

Relevant regulation in this regard is available by TRAI on the following areas:

- Regulation on Quality of Service of Dial-Up and Leased Line Internet Access Service, defined in 2001
- Regulation on Quality of Service for VoIP based International Long Distance Service defined in 2002

Quality of service (QoS) parameters and benchmarks for broadband service are given in the TRAI's notification dated 2006 on quality of service standards for broadband service.[33]

2.2.1.6 Security, privacy, lawful interception

Clauses pertaining to security and privacy are mentioned in the licence condition. Analysis of call/subscription/traffic data of various licensees, technical arrangement for the lawful interception / monitoring of all communications passing through the licensee's network are monitored by Term Cell under the Department of Telecommunication (DOT).

2.2.2 Players

2.2.2.1 Main national players

The dominant players for fixed lines are as indicated in Figure 12, with Bharat Sanchar Nigam Ltd (BSNL)[34] as a clear leader with a market share of around 77 per cent followed by Mahanagar Telephone Nigar Limited (MTNL)[35], Bharti Airtel[36] and Tata Tele Services Limited (TATA)[37] as of the end of 2009.

Market players for mobile are indicated in Figure 13 with a widely distributed market share starting with a 27 per cent of Bharti, 22 per cent by Reliance Tele Services Limited (Reliance)[38], 22 per cent by Vodafone India (Vodafone)[39], 15 per cent by TATA, and 14 per cent by BSNL, by the end of 2009.

Concerning the broadband market, Internet Service Providers (ISPs), Unified Access Service Licensees (UASLs), Cellular Mobile Service Providers (CMSPs) and Basic Service Operators (BSOs) are permitted to provide broadband access under the existing licensing framework. There are 105 service providers who are currently providing broadband services.

However, the top ten service providers have captured more than 95 per cent of market and top five service providers have about a 90 per cent share. State owned companies BSNL and MTNL together

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33 TRAI: www.trai.gov.in/WriteReadData/trai/upload/Regulations/57/regulation6oct06.pdf

34 Bharat Sanchar Nigam Ltd: www.bsnl.co.in/

35 MTNL: www.mtnl.net.in/

36 Bharti: www.airtel.in/

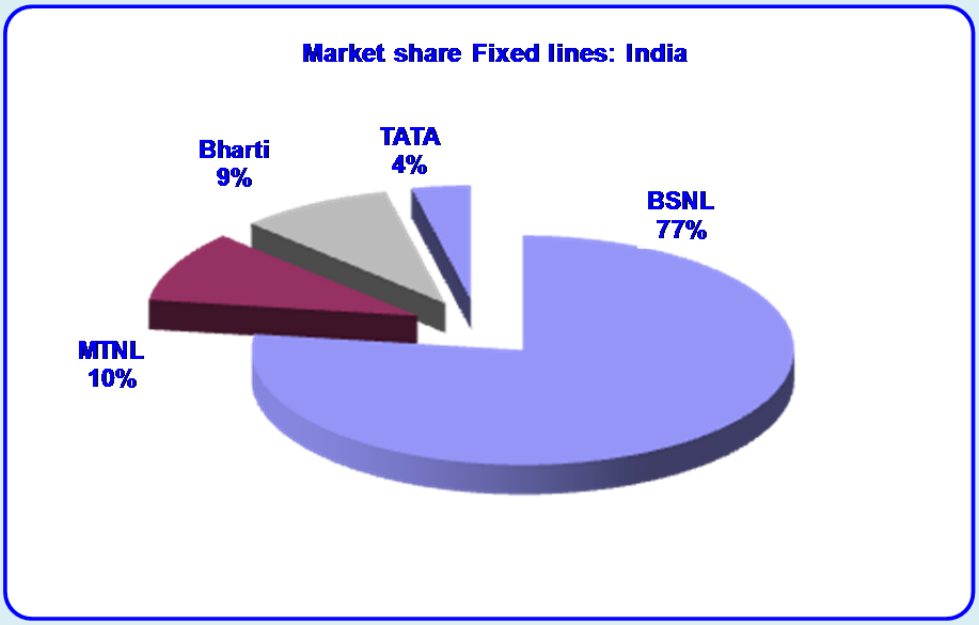
37 Tata Communications Limited: www.tatacommunications.com/about/

38 Reliance: www.rcom.co.in/Rcom/personal/home/index.html

39 Vodafone India: www.vodafone.in/pages/index.aspx

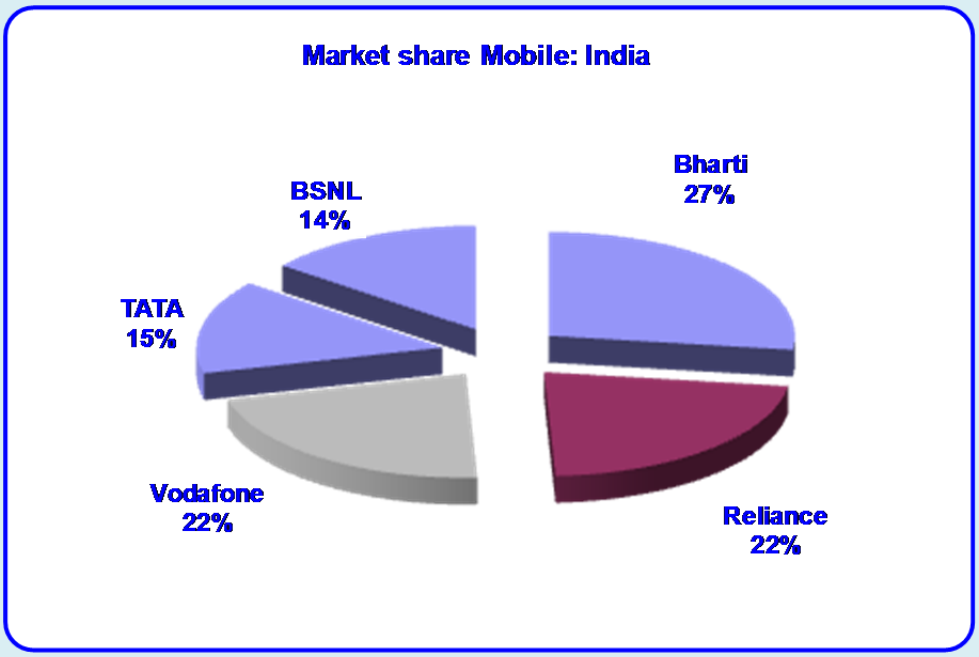
have about a 70 per cent market share. This indicates that despite having a licence for provisioning of broadband services, the majority of service providers are unable to penetrate the market and the market is still dominated by only a few players.

Figure 12: Market share in India for fixed lines



Source: Working Team: India

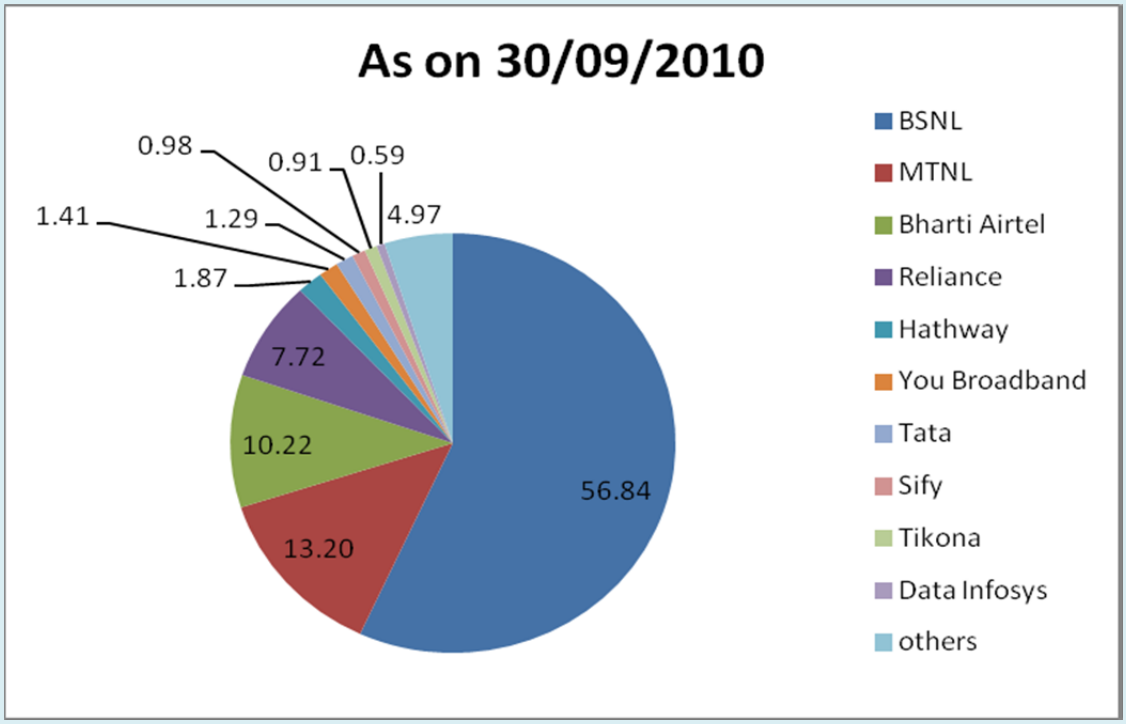
Figure 13: Market share in India for mobile lines



Source: Working Team: India

Figure 14 gives the market share of different service providers.

Figure 14: Market share for broadband



Source: Telecom Regulatory Authority of India (TRAI)

One way to assess concentration of market power is by using HHI[40][41] (Herfindahl Hirschman Index). Based on the market share of the top ten service providers, HHI changes in the last five years are given in Figure 15. The figure shows that not only the market is concentrated but the concentration is getting worse with time.

Internet Access points: It is important to note that a large proportion of users access the Internet from office and cyber cafés. Cyber cafes continue to dominate the share (37 per cent) among various sources. However, accessing Internet through home has steadily declined over the years. This year, an interesting pattern has emerged with 4 per cent of users accessing this medium through alternative sources such as mobile and kiosks. Figure 16 gives locations from where users access the Internet[42].

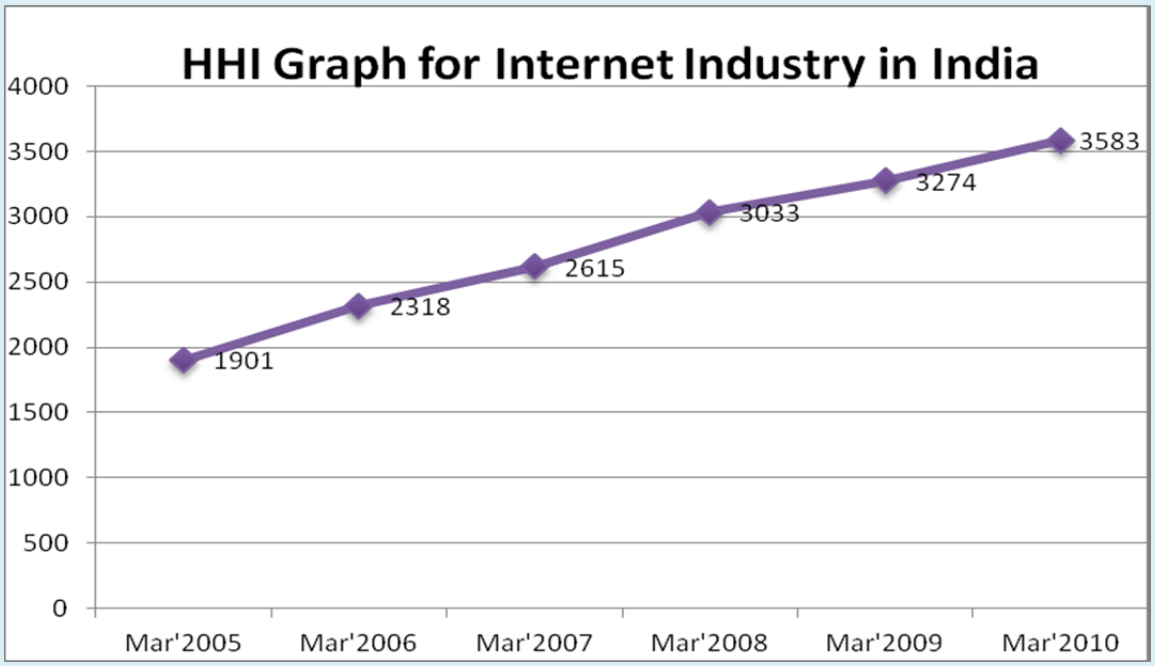
There were about 1.8 million data card subscribers at the end of September 2010, whose advertised speed is up to 3.1 Mbps. There were also 274.05 million wireless data subscribers who are able to use the Internet from their mobile device at the end of September 2010. At the end of September 2010, a growth of 94.11 per cent on a year-on-year basis has been noted in wireless data subscribers. However, most of these are on 2G mobile networks with limited data capabilities.

[40] Quantitative Tests for Market Power: InfoDev-ITU www.ictregulationtoolkit.org/en/PracticeNote.aspx?id=2880

[41] HHI means the Herfindahl-Hirschman Index, a commonly accepted measure of market concentration. It is calculated by squaring the market share of each firm competing in the market and then summing the resulting numbers. Value of HHI more than 1800 is considered as concentrated market. Nevertheless due to new economies of scale inherent in telecommunications it may be needed to review application rules and values.

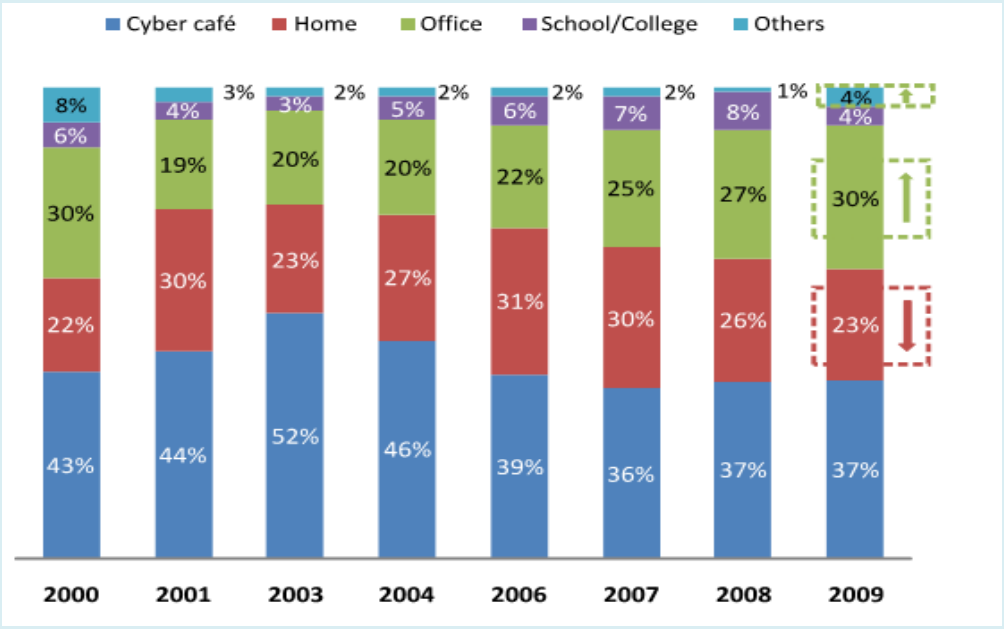
[42] Source: IMRB & IAMAI I-cube report 2009

Figure 15: HHI for Indian Internet market



Source: Telecom Regulatory Authority of India (TRAI)

Figure 16: Internet access points by type



Source: IMRB & IAMAI I-cube report 2009

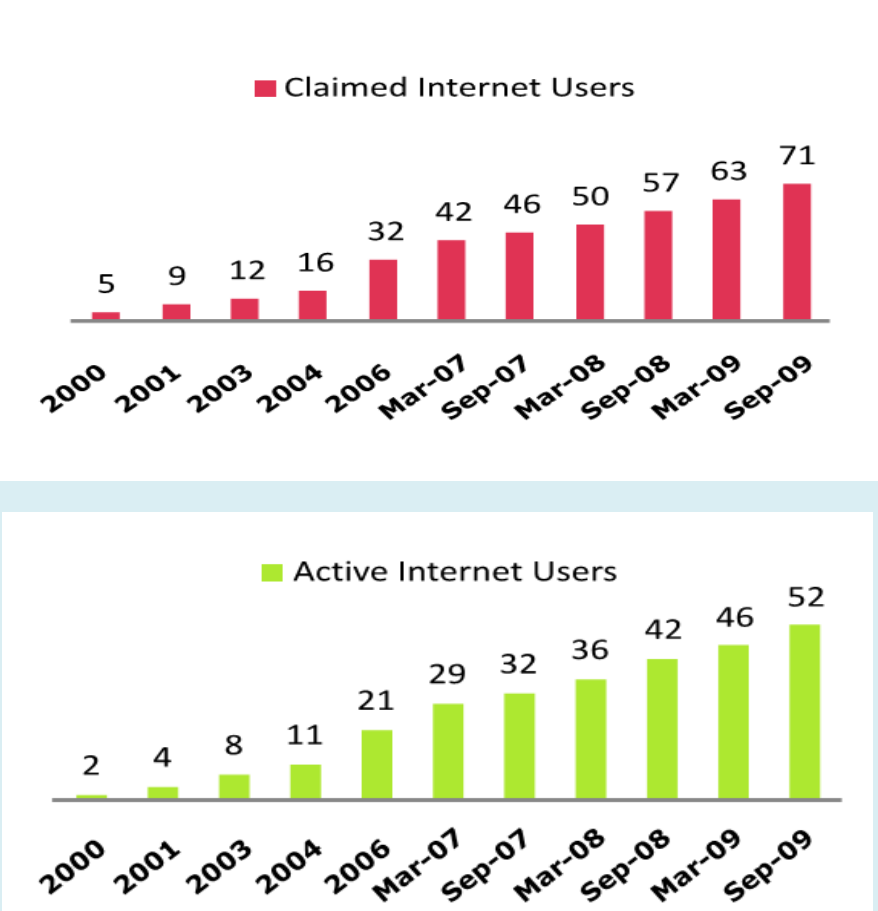
2.2.3 Infrastructure and NGN status

2.2.3.1 Services demand and broadband penetration

Internet Users claimed and active: In India, claimed Internet users have been increased by 20 per cent over the period of September 2008 to September 2009. Similarly active Internet users have also increased from 42 million to 52 million from September 2008 to September 2009.

Nearly 25 per cent of the India population lives in cities. Out of which, 32 per cent are PC literate. Of the PC literate population, 72 per cent claim to have used the Internet, of which 73 per cent are actively using it. The penetration of Internet usage is low at 24 per cent (i.e. claimed Internet user / urban population) among the urban population. Figure 17 gives details of claimed and active Internet users through time[43].

Figure 17: Internet users claimed and active

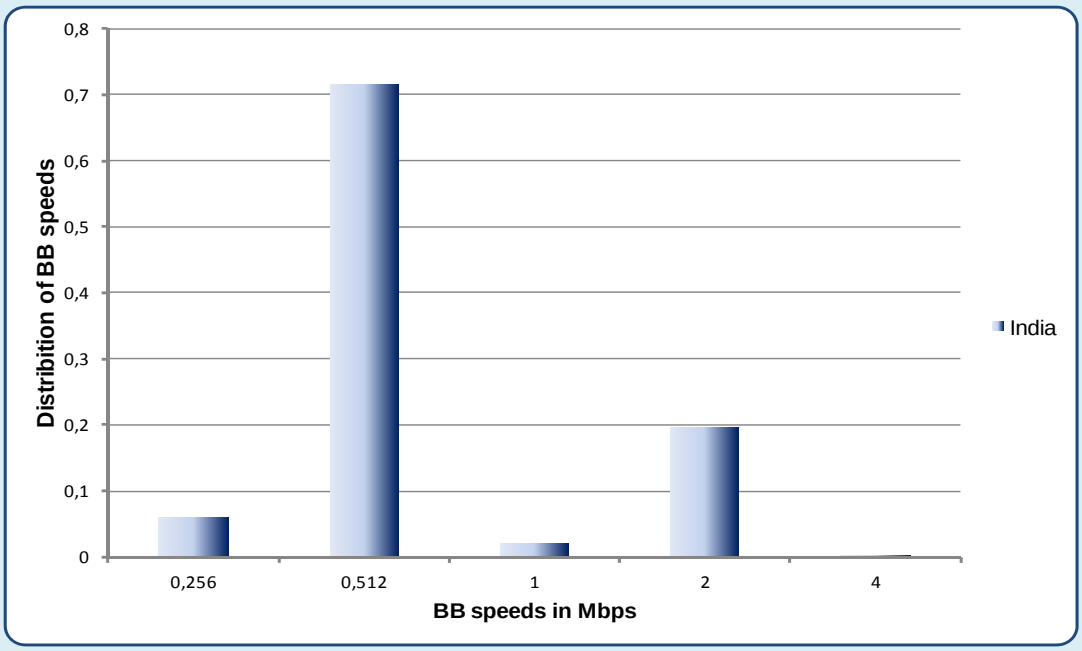


Source: Telecom Regulatory Authority of India (TRAI)

Major offered stable speeds (not including transitory marketing offers) are illustrated in Figure 18 as aggregated for those operators where speed distribution was available during the study and show a dominant frequency of 512 Kbps.

[43] Source: IAMAI & IMRB Survey- I-cube report 2009-2010 TRAI

Figure 18: Distribution for major broadband speeds of stable offers by main operators



Source: Working Team: India

Although broadband penetration is low in India, the entry level tariff for broadband services has come down drastically from Rs. 1500/- per month in 2004 to Rs 200/- a month in 2007. Most of the service providers are charging broadband monthly rental between Rs 200/- to Rs 1600/- and providing various options for data transfer. Some service providers even provide unlimited download packages. Some of the service providers are already offering broadband services having zero rental schemes. However, in such schemes per Mb download charges are comparatively high ranging from Rs. 1.00/- to Rs. 2.00/- per Mb.

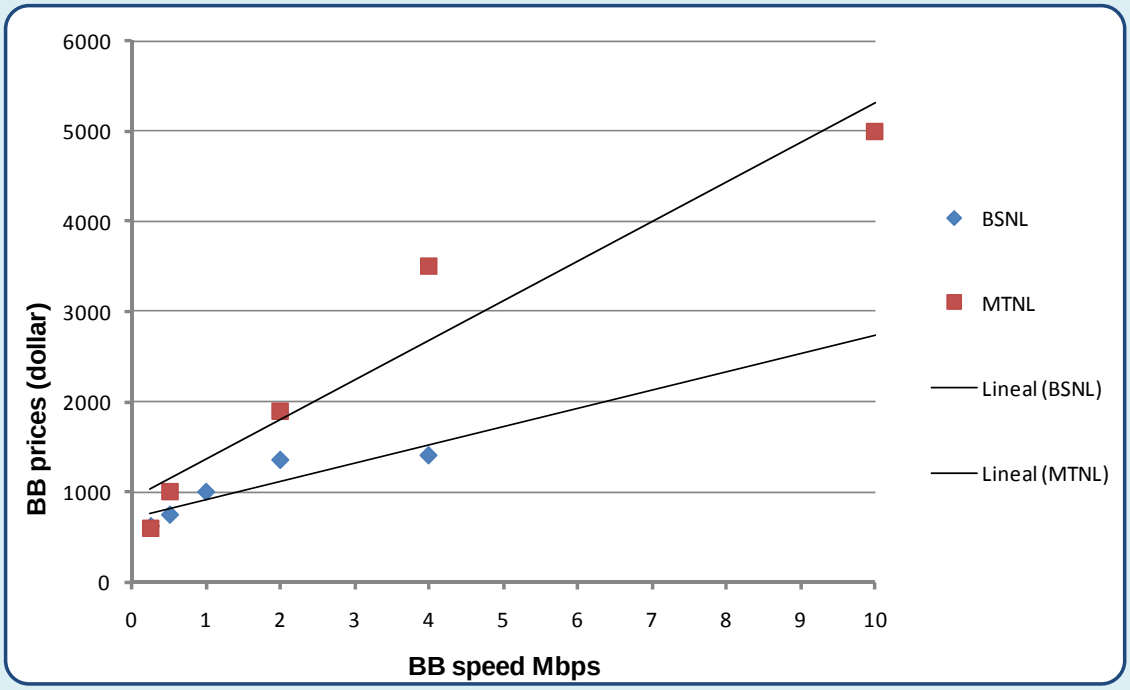
With the same concept of stable offers, Figure 19 illustrates the relations between speeds and prices that are close between operators and show a significant linear increase with speeds. It is derived that economies of scale inherent to the technologies are not applied in order to reduce prices at higher speeds and competition level is low as similar behavior is present in all offers.

Pan-African e-Network Project[44]

An excellent case for the implementation of e-services in an intercontinental network is the Initiative of the Government of India in collaboration with the African Union that was defined under the auspices of Dr. A P J Abdul Kalam, the former President of India during his inaugural address to the African Parliament in Johannesburg on 16 September 2004, which proposed to connect all 53 African Union (AU) member countries with Indian institutions with a satellite and fibre-optic network to share India's expertise in the fields of education and health care for the accelerated socio-economic development of Africa.

[44] Stimulating Broadband through ICT Applications: ITU ABBMN Ministerial Forum "Digital Inclusion: Connecting Responsibly" R.K Upadyay; Telecommunications Consultants India Limited (TCIL) Maldives, 3 – 5 August 2010

Figure 19: Relations between broadband speeds and prices for the main stable market offers in India



Source: Working Team: India

The network is composed of the following elements:

- satellite hub station,
- VSATs in 169 locations in Africa,
- data centre and studio set up in TCIL HQ,
- data centre at the satellite hub station,
- ICT equipment at 170 locations in Africa,
- computer hardware,
- system software,
- networking equipment,
- studio equipment,
- UPS,
- data centre at the hub,
- data centre at Delhi,
- 19 locations in India (7 UC and 12 SSH)
- medical equipments at 53 patient-end hospitals,
- Tele-Ed and Tele-Med application software.

Major benefits are summarized in the following results:

Education to 10,000 African students over five-year period (2009-14):

- 2000 in post-graduate programmes,

- 3000 in undergraduate programmes, and
- 5000 in skill enabling Certificate, Diploma and PGD programmes.

Tele-medicine components:

- Online medical consultation for one hour everyday to each country for five years,
- Offline advice for five patients per day to each country for five years,
- Continuing Medical Education (CME) for practicing doctors and physicians' assistants, to update their medical knowledge and upgrade their clinical skills.

2.2.3.2 Transit and network local/edge segments

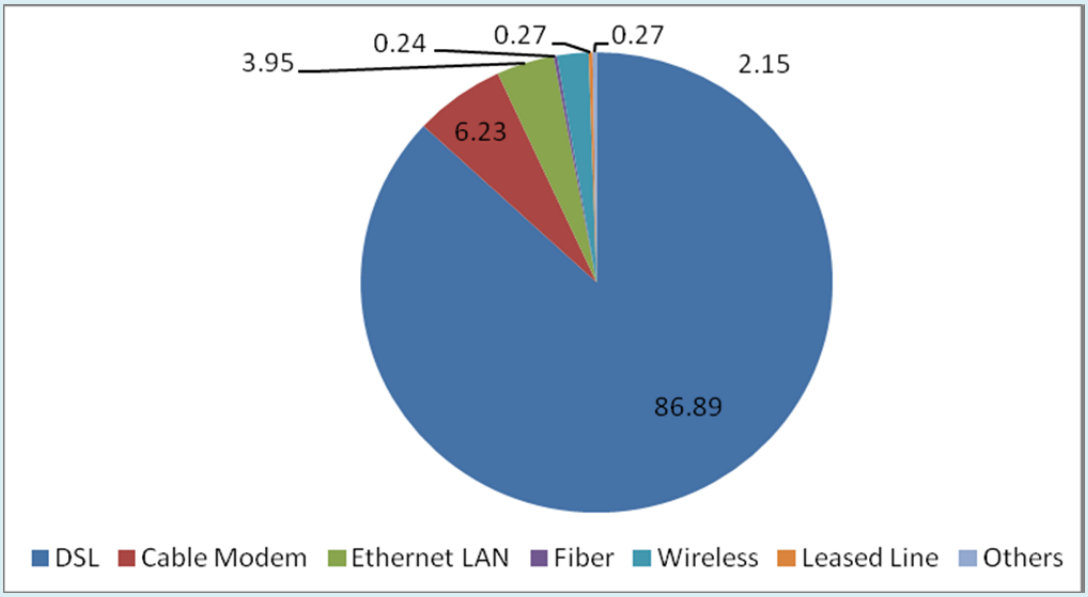
Existing network layout for the largest network of BSNL has a traditional PSTN topology with more than 450 transit exchanges and a total of 38000 Points of Presence (POP) of which around 28 000 are local exchanges. NGN network is at an initial phase and an evaluation is being made for the introduction of softswitches or Internet Protocol Multimedia Subsystem (IMS). The objective is to decrease substantially the number of attended local exchanges to be converted in non-attended POP in a similar manner to the structure being implemented by BT (British Telecom) in the United Kingdom.

Concerning MTNL, the current structure is composed of four transit exchanges and 305 local exchanges with one IP core node, three edge/aggregation nodes and one softswitch. The total installed fibre optic cable reaches 220 834 Km and there are 868 installed mobile base transceiver stations for 2G and 630 for 3G technologies.

2.2.3.3 Access network segment

While broadband has been deployed using cable modems, fibre, and wireless, in India xDSL technology has been predominantly used. xDSL can be easily deployed on existing copper pairs going to subscriber's premises. Figure 20 gives the breakdown of broadband connections by type. It is evident from the figure that 86.89 per cent of total broadband connections are on DSL. The most common DSL technology deployed is ADSL2 and ADSL 2+. These technologies typically support download speeds of up to 2 Mbps for copper loop length of less than 3km from the exchange. Higher speeds are possible on shorter loop lengths and pre-qualified copper pairs.

Figure 20: Broadband connections distribution by technology type (Sept 2010)



Source: Telecom Regulatory Authority of India (TRAI)

2.2.3.4 Interconnection

Due to the network organization in India by circles, the point of interconnection differs on the basis of network and flow of traffic described above. At present, interconnection between basic service providers for local calls is at the short distance charging centre Tandem. The intra circle long distance traffic originated in one basic service providers network is either handed over to another licensed service provider for termination at the far – end i.e. short distance charging area in which the traffic is to be terminated or at the near-end, i.e. long distance charging centre TAX (Level II TAX) in the long distance charging area in which the traffic has originated. The originating inter-circle traffic in a basic service operator network is handed over to national long distance operator for further carriage at the short distance charging centre tandem in which it has originated or by mutual agreement as per licence terms and conditions at the short distance charging centre long distance charging centre Level-II Tax of the originating short distance charging area. International long distance traffic originated in a basic service operator network is routed through the network of national long distance service providers to the international long distance service provider's gateways for onward transmission to international networks.

An intra-circle mobile to fixed call is being handed over by mobile operator to the basic service operator at Level-II TAX in circles and at short distance charging centre Tandem in metro service areas. An inter-circle mobile to fixed line call is handed over at short distance charging centre Tandem by the national long distance operator carrying the call to the terminating fixed line operator. For Inter-circle and intra-circle mobile to mobile calls operators are interconnected at the MSC level.

To facilitate the early migration to NGN, the interconnection regime will need to undergo the requisite changes so that interconnection of PSTN/PLMN networks is permitted with the ISPs network.

2.2.3.5 Operation/business support systems and network management

The phenomenal growth in the India telecommunication industry has led to the increased demand for advance operation support system and business support system (OSS/BSS) solutions. Decreasing average revenue per user (ARPU) in a predominantly pre-paid telecommunication market has forced telecommunication service providers to look for alternate sources of revenue in terms of value added service and increase focus on customer satisfaction. They also have to meet increasing demand in capacity requirement to cope with a rapidly increasing subscriber base. These factors have fuelled growth of OSS/BSS solutions brought about by emerging services like service delivery platforms, which help in faster rollout of services.

The India telecommunication industry has been going through a rapid growth phase, with the mobile subscriber base growing exponentially. It has also led to greater levels of penetration and adoption across mobile, pay TV and broadband technologies. The proliferation in value-added services, such as ringtones, ring-back tones, premium SMS services etc. have pushed India to the forefront of widespread mobile content and applications use. In the midst of this rapid upward trend, communication service providers are wary of the challenges imposed by increasing penetration levels, the need to focus on the lower-ARPU rural markets for sustained subscriber growth levels and the imminent introduction of mobile number portability (MNP). All these factors have been instrumental in elevating the role and importance of operational and billing support systems in the communication service provider infrastructure.

The communication service providers in the India market have been early adopters of packaged software application that address certain aspects of the OSS and BSS. Well thought through mediation, billing and service activation systems have been deployed by India communication service providersfor several years. The focus in recent years has shifted to systems that address the less tangible business objectives, such as operational efficiency and customer satisfaction and experience. These business objectives call attention to specific process related areas such as customer care and relationship management (through customer relations management systems), automated service fulfillment (through order management systems) and network asset optimization (through more functional inventory management systems). These (customer relations management, order management, inventory management) are all critical aspects of the BSS/OSS solution set and it is a sign of the maturity of the Indian communication service providers industry where

focus has shifted in this direction. Technology, no doubt, has become a strategic business enabler for telecommunication companies. Greenfield operators are using technology for faster rollout of their services, while existing players are using it to retain their customers and maximize ARPU.

The OSS/BSS products have come a long way and so has their market in India. The industry has seen them gradually evolve from being manually operated switch management systems to creating automated interfaces. Post period of spurt in demand for systems with value-added services compatibility, the focus is now on open, interoperable OSS/BSS solutions. This focus-shift can be attributed to the fact that carriers and service providers have come under greater pressure to increase revenues and decrease operating costs in order to survive, leading to a greater demand for OSS integration.

The highly segmented India OSS/BSS market is set for a facelift. Industry experts say consolidation in this space is inevitable. Some industry pundits predict that with 3G, WiMAX and MNP all coming into play, OSS/BSS vendors will be forced to strengthen their profiles to be able to offer a wider range of services.

The demand on OSS/BSS capabilities and capacities will increase as the operators migrate their networks to NGN to exploit the multi-play services and applications potential of the network.

2.2.3.6 Quality of service and security

Overall performance indicators and QoS are provided regularly by TRAI for fixed, mobile, broadband, CATV and broadcasting networks.[45] For current broadband performance or supervision through quarterly performance monitoring, a report is filed by the broadband service providers in compliance with the broadband regulations. Further supervision through quarterly audits and assessment of quality of service and survey reports are conducted by independent agencies. In addition, customer perception of service is carried out through direct quarterly surveys.

2.3 Sri Lanka

Information and data summarized in the sections below were obtained during the mission to the country as planned in the project with additional post processing and input by stakeholders in Sri Lanka[46].

2.3.0 General context

2.3.0.1 Socio-economic context: role of broadband in the economy

Sri Lanka being a large island country, had a population of 20,450,000 inhabitants in 2009, with 21.5 per cent in urban areas and 78.5 per cent in suburban and low population density areas[47]; GDP per capita was USD 1996 in 2008 and mean household income per month was Rs. 35,495 with an average household size of four. More than 85 per cent is literate and 21 per cent has a degree. Those characteristics position the country for a potential growth of broadband services.

The telecommunication sector in Sri Lanka was initially state owned, i.e. the Department of Telecommunications. The sector was liberalized in 1991 by introducing reforms with the enactment of the Sri Lanka Telecommunications Act No. 25 of 1991. In the same year the Office of the Director-General of Telecommunications was established as the regulator. Thereafter, the Department of Telecommunications, was converted to a state owned Corporation i.e., Sri Lanka Telecom Corporation. System operator licences were also issued to several private operators to provide telecommunication facilities such as data, mobile and payphone services, which paved the way towards de-regulation in Sri

[45] TRAI: The Indian Telecom Services Performance Indicators. October 2010

[46] Sri Lanka country information by TRCSL and Service providers: Templates on data for General Telecom, Regulation and Networks. October 2010

[47] LankaStat Interactive Database System (LIDS): Department of Census and Statistics. www.statistics.gov.lk/MDG/

Lanka. The liberalization of the telecommunication industry was an important step towards developing the infrastructure that would provide the country with a solid platform for economic and social growth.

In 1996, the Office of the Director-General of Telecommunications, the independent body established to regulate the sector was converted to the *Telecommunications Regulatory Commission of Sri Lanka (TRCSL)*[48] by the Sri Lanka Telecommunications (Amendment) Act. No. 27 of 1996. The Commission consists of five members.

With reference to the promotion of ICT there are operational tax holidays ranging from 5 – 12 years. In addition, a concessionary rate of income tax (maximum period of 20) years is also extended after the tax holiday period. Government special assistance is provided for real estate acquisition based on investment and employment generation. Government also provides substantial cash grants for companies in the IT-BPO sector business development and encourage investments. Grants are provided for training, marketing, quality enhancements (CMMi, COPC, ISO, etc.) and for a host of other developments.

Sri Lanka Telecom corporate profile and history

Sri Lanka Telecom (www.slt.lk) is one of the country's most valuable blue chip companies with an annual turnover in excess of Rs 50 billion. Global Telecommunication Holdings N.V. of Netherlands owns 44.9 per cent stake in Sri Lanka Telecom (SLT) as of 2 June 2008 and 49.5 per cent is owned by the Government of Sri Lanka, with the remaining shares owned by the general public.

Sri Lanka Telecom has contributed to the development of the telecommunication industry in Sri Lanka for more than 150 years. In 1991, Sri Lanka Telecom Corporation, a fully government owned organization, was formed. In 1996, the liberalization of the local telecom industry ended the monopoly status of Sri Lanka Telecom Corporation. During the same year, the Corporation was privatized and became known as Sri Lanka Telecom Limited.

The decade following privatization was a very successful and significant period for Sri Lanka Telecom which saw many dramatic changes taking place within the company. In 1997, Nippon Telegraph and Telephone Corporation (NTT) invested in a 35 per cent stake of the company and also took over its management. In 1998, the 450 000th telephone connection was provided. 143 075 connections were provided in the year to clear the back log, placing Sri Lanka Telecom sixth in the world in the speed with which telephone connections were given. Sri Lanka Telecom introduced the ISDN technology to Sri Lanka for the first time in 1999, enabling faster than ever Internet access. The year 2000 saw the implementation of a high-tech fault reporting and clearing system to ensure customer service as well as the commissioning of Sri Lanka's first ever optical fibre transmission ring. In 2001, Sri Lanka Telecom established a state-of-the-art call centre, dedicated to customer care services.

The growth of Sri Lanka Telecom (SLT) customer base and revenue was fuelled by its 100 per cent acquisition of Mobitel in 2002. The company also introduced ADSL technology in the same year. The year 2003 saw the liberalization of international services and Sri Lanka Telecom shares were traded on the Colombo Stock Exchange. In 2006, Sri Lanka Telecom formed a subsidiary, Sri Lanka Telecom Hong Kong to function as a point of presence, in line with the company's growth strategy. In 2008, NTT sold their entire holdings in Sri Lanka Telecom to Global Telecommunications Holdings N.V. of Netherlands which currently owns 44.98 per cent stake of the company while the Government of Sri Lanka holds 49.5 per cent and the balance remains with the public.

2.3.0.2 Overall characterization

Taking as a reference the consolidated data for end 2009 and September 2010, the Figure 21 summarizes the main telecommunication parameters. It shows the high difference of fixed line penetration between

[48] Telecommunications Regulatory Commission of Sri Lanka (TRCSL) www.trc.gov.lk/

the capital Colombo (one of the highest within the region) and the rest of the country due to the very heterogeneous development level between areas.

Figure 21: Main data for country telecommunication characterization

Country Profile	
Population (2009)	20 450,000
Total number of fixed lines (September 2010)	3508057
Teledensity (fixed lines per 100 inhabitants)	17
Teledensity (fixed) in Colombo District	39
Number of cellular mobile subscribers (September 2010)	16 305 417
Mobile subscription per 100 people	79
Internet and email subscribers (fixed) (September 2010)	288441
Internet and email subscribers (Mobile) – (September 2010)	176355

With a view to making Sri Lanka a broadband enabled island, SLT is in the process of introducing the necessary NGN infrastructure using optical fibre backbone and broadband services such as IMS, IPTV etc. SLT also provides high speed global connectivity to countries in the South Asian region through its investments in international submarine cables such as SMW3, SMW4, Bharat Lanka submarine cable system (between India and Sri Lanka) and Dhirragu-SLT submarine cable system (between Maldives Islands and Sri Lanka).

SLT's aim is to see all Sri Lanka seamlessly connected to world class information, communications and entertainment services. One of the major targets is to deliver broadband access bandwidths of over 20 Mbps to 90 per cent to wired customers and to integrate this with future wireless access technologies into a national fabric, enabling customers to access and enjoy the full range of services broadband will provide.Combining of platforms and transmission capacities to maximize economies of scale and scope is a primary aim of Next Generation Networks: one efficient platform supporting multiple services.

SLT is now three years into its NGN migration plan. The first two phases have been completed, with over 20 per cent of customers successfully migrated. The bulk of SLT customer migration will be completed over the next 3-5 years according to the plan. SLT has also migrated the following additional services onto the NGN core transport network: Backhaul for xDSL broadband services, backhaul for operator circuits Layer 3 IP VPN and Layer 2 Ethernet VPN services and connectivity for a hosted business IP telephony service. SLT is in the process of developing legacy service migration programs for consumer, business and wholesale products that are currently supported by TDM platforms. The intention of these programs is to migrate, where possible, all services and products onto the NGN transport network and retire the legacy network platforms. These programs are developed within the SLT NGN transformation program, which is dependent on the TDM replacement program to implement the necessary transport infrastructure (Service Edge Metro Nodes) and next generation access nodes.

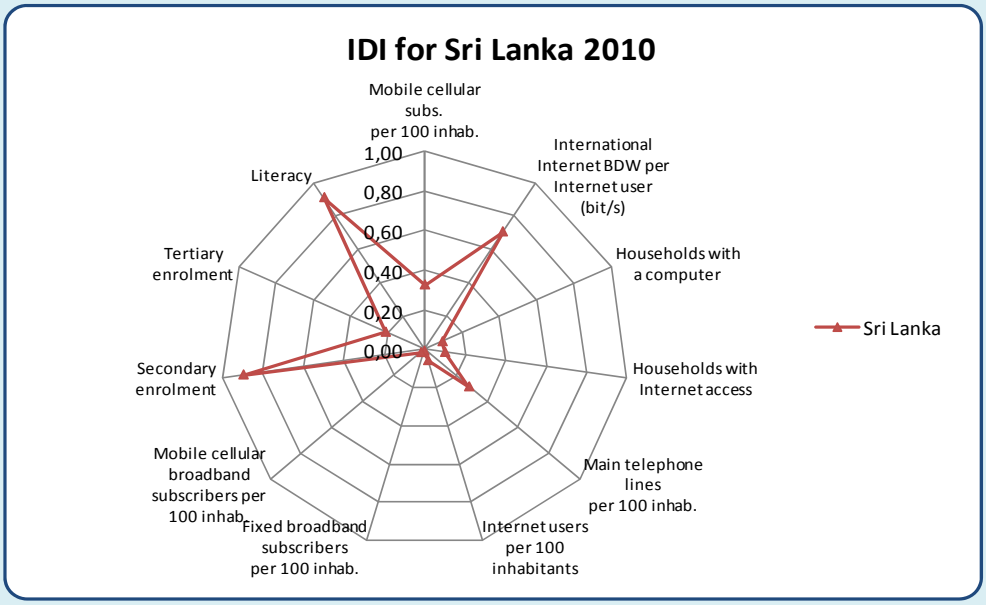
2.3.0.3 IT index per dimension: IDI

In 2008, Sri Lanka was 105 out of 159 countries in terms of ICT development index (IDI) with a value of 2,51[49]. Observing the spike diagram for the 11 parameters that characterize the IDI indicator in Figure 22, it becomes clear that maturity level is high in the literacy, second enrollment and available bandwidth per Internet user parameters. In addition, the penetration of fixed lines is relatively high compared with the

[49] Measuring the Information Society, ICT Development Index (IDI). 2010 ITU

values in the region. Indicators for the specific Internet penetration and broadband access both on fixed network and mobile are significantly low.

Figure 22: ICT Development Index components for Sri Lanka in 2010



Source: ITU

2.3.1 Policy and regulation

2.3.1.1 Licensing regime

Telecommunication sector liberalization started in 1991 with licences given to private operators and a "light", mostly ex-post regulation and bilateral agreements between market forces. This environment facilitated introduction of competition in the telecommunication market however the framework did not stipulate converged licensing to allow for licensed operators to introduce multiple services due to technology / service specific licensing.

Licensing for 3G was done early and operators are planning to introduce LTE services in near future.

2.3.1.2 Interconnection

Interconnection rules are defined both for fixed and mobile networks under the traditional PSTN model. Access providers are mandated to provide interconnection services at any technically feasible point in the access provider network as per the rule defined in 2003[50].

With regard to the interconnection charges / costs, definitions are considered in the same document for fixed and mobile networks for both peak and off-peak hours.

However, although there are no specific rules relating to the capacity of interconnection, when the parties sign interconnection agreements they incorporate capacity requirements and the procedure to follow when needs arise as a condition of the interconnection agreements which have to be approved by the commission for legal validity.

[50] Rule 8 of the Interconnection rules of 2003: (www.trc.gov.lk/images/pdf/ic_rules.pdf)

2.3.1.3 Cost allocation, charging and billing

Charging and billing for conventional PSTN services follow common practice and no definition of principles was applied for the IP mode services or cost allocation principles to be followed by service providers.

2.3.1.4 Infrastructure sharing:

Passive infrastructure sharing has been mandated by TRCSL for cellular base stations while other sharing procedures are left to the bilateral agreements of the service providers. No local loop unbundling rules has been defined.

2.3.1.5 Quality of service

Quality of service for interconnection defined the set of parameters for every connectable operator to provide service quality reports to the Commission once in every six months including:

(a) time to confirm acceptance of service request or order;

(b) time to provision of service;

(c) time to confirm fault report;

(d) time to repair fault;

(e) outage time (or bit error rate, as applicable);

(f) call completion ratios;

(g) route congestion;

(h) time period of notifications of network changes which could affect interconnected parties;

(i) any other information required by the Commission from time to time; and

(j) where the reporting operator is a dominant operator, the equivalent performance measures of supply to itself.

2.3.1.6 Security, privacy, lawful interception

Provisions are applicable for unlawful interception under the terms of the Sri Lanka Telecommunications Act[51] which also ensures privacy protection and action to be taken in the event of unlawful interception / intrusion. Intrusion into the contents of a message without lawful authority is an offence punishable under the act. (Section 52)

Willful interception with the intention of improperly acquainting oneself with the contents of any telecommunication transmission not intended for general reception is also an offence punishable under the act.

Intentional interception and disclosure of contents of messages by a telecommunication officer other than in connection with official duties is an offence.

- The act also provides for lawful interception in terms of section 54 of the Sri Lanka Telecommunications Act with the following exceptional circumstances:

  a) Interception and disclosure of contents of messages done in obedience to any direction given by the minister.

  b) Disclosure of the contents of a message by a telecommunication officer is lawful for the purpose of criminal investigation or criminal proceedings.

[51] Under the Sri Lanka Telecommunication Act: (www.trc.gov.lk/about-us/legislation.html)

- Security for the network and information is ensured by the following provision:

  Intentionally damaging / tampering with a telecommunication installation preventing or obstructing the transmission of any message or interrupting or acquainting with the contents of any message.

2.3.1.7 Public consultation on NGN policy and regulatory framework

In September 2010, the Telecommunications Regulatory Commission of Sri Lanka (TRCSL) issued a consultation paper[52] on "Policy and regulatory framework for next-generation networks (NGNs)" to all key telecoms stakeholders in Sri Lanka in order to explain the benefits of NGN and obtain the views and comments of stakeholders with a view to formulate the NGN policy and regulatory framework.

Based on the consultation responses, TRCSL considers the following key issues when formulating the policy and regulatory framework for NGN[53]:

- In general, the NGN policies would ensure a level playing field for all the industry players consulted in Sri Lanka.
- In terms of the Sri Lanka Telecommunications Act, an NGN advisory body, comprising of industry representatives, will be formed to advise TRCSL in respect of technical aspects of both interconnection and migration issues associated with NGNs. TRCSL would determine technical industry standards for the migration to NGN, as well as an interconnection inter-operability framework in consultation with the NGN advisory body. In addition, TRCSL would define a regulatory regime that facilitates customer and service migration and accepts the withdrawal of legacy services and platforms.
- An independent not-for-profit Internet exchange will be established subject to TRCSL regulation for exchanging Internet traffic
- In order to ensure a consistent end-to-end quality of service (QoS) for NGN end users, TRCSL plans to define network performance parameters (based on the ITU-T Y.1541 Recommendation) and the associated threshold that will be used as a benchmark standard by operators. For this, the advice of the NGN advisory body would be sought by TRCSL, especially to determine threshold values of the performance parameters.
- National numbering plans would be revised with the introduction of NGN to accommodate nomadic services. TRCSL agrees with stakeholders that ENUM has to be considered when devising the regulatory policy for NGNs as it will provide essential translation between legacy E.164 numbers and IP/SIP (Session Initiation Protocol) addresses. However, the numbers of the existing customers, whenever possible, will remain unchanged.
- TRCSL will strive to ensure that infrastructure operators would not be disadvantaged *vis a vis* the service providers. Respondents' requests to review the existing licensing regime would be considered; and the licensing regime currently envisaged by TRCSL would be a two-tier structure, flexible enough to minimize administrative burden, as well as being technology neutral. The relevant competition rules, investigation and enforcement powers would also be introduced at the time of implementation of the new NGN licensing regime in order to realize the full benefits of NGN.

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[52] Public Consultation on Policy & Regulatory Framework for Next Generation Networks (NGN). Telecommunications Regulatory Commission of Sri Lanka. September 2010

[53] Report on the Public Consultation on Next-Generation Network (NGN) Policy and Regulatory Framework. Telecommunications Regulatory Commission of Sri Lanka. February 2011

- A universal service obligation (USO) model will be implemented for the deployment of NGN in rural areas, particularly for funding development in underserved areas. An advisory body for USO will be established, consisting of representatives from TRCSL and the operators.
- The existing Interconnection Rules 2003 will be reviewed to create a non-discriminative, fair and transparent interconnection regime required for the smooth transition to NGN. TRCSL also recognizes the requirement for the dominant operator to offer a reference interconnection offer (RIO).
- Regulatory measures will be taken to thwart anti-competitive issues that might arise as a result of the deployment of NGN, as well as encouraging open access to core and access networks.
- Wholesale access to the access network will be introduced for the provision of NGN services that are expected to benefit customers immensely.
- Principles of net neutrality and technology neutrality would be adopted to promote service based competition under an NGN environment to the maximum extent possible.
- Consumer-protection measures would be imposed on all NGN operators irrespective of their market share in order to safeguard the interest of the consumers, especially in the areas of access to emergency services, number portability, QoS, provision of location information, privacy and security.
- An informal industry group will be established to educate the consumers about the consequences they might experience as a result of migration to NGN and to resolve any migration issues in order to provide consumers a migration that is as seamless and painless as possible.

Based on the consultation paper as well as responses by the stakeholder comments, TRCSL is expected to propose an appropriate regulatory framework that would stimulate the deployment and growth of NGN in Sri Lanka.

2.3.2 Players

2.3.2.1 Main national players

The major players for fixed line market are as indicated in Figure 23 with Sri Lanka Telecom (SLT)[54] as a leader with market share of 42 per cent closely followed by Lankabell[55] with 35 per cent, Suntel[56] with 17 per cent and Dialog [57]with 6 per cent.

Market players for mobile are indicated in the Figure 24 with a leading position by Dialog with 45 per cent market share followed by Mobitel with 24 per cent, Tigo with 16 per cent, Airtel with 10 per cent and Hutch with 5 per cent.

2.3.3 Infrastructure and NGN status

2.3.3.1 Services demand and broadband penetration

Broadband penetration levels in 2009 were 0.83 per cent nationaly and 1.40 per cent for the city of Colombo. These values are rather low as compared to the infrastructure potential and society requirements as more than 10 per cent have a PC and demand is growing for higher speed services.

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54 SLT: www.slt.lk/index.asp

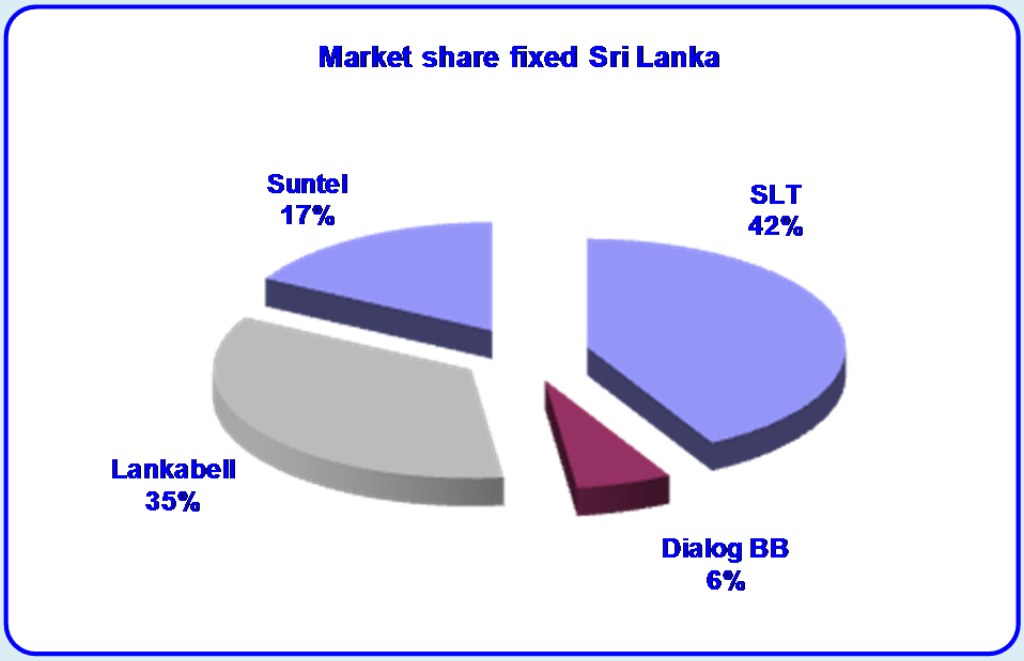
55 Lankabell: www.lankabell.net/index.htm

56 Suntel: www.suntel.lk/home/

57 Dialog: www.dialog.lk/

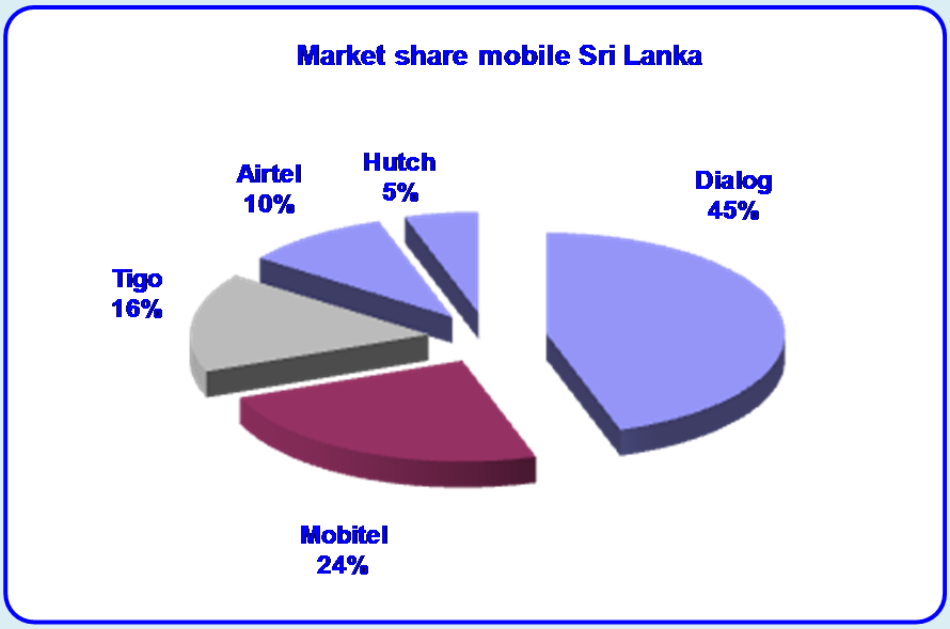
Major offered stable speeds (not including transitory marketing offers) are illustrated in Figure 25 and show concentration towards 512 Kbps followed by 1 Mbps.

Figure 23: Market share in Sri Lanka for fixed lines



Source: Working Team: Sri Lanka

Figure 24: Market share in Sri Lanka for mobile lines

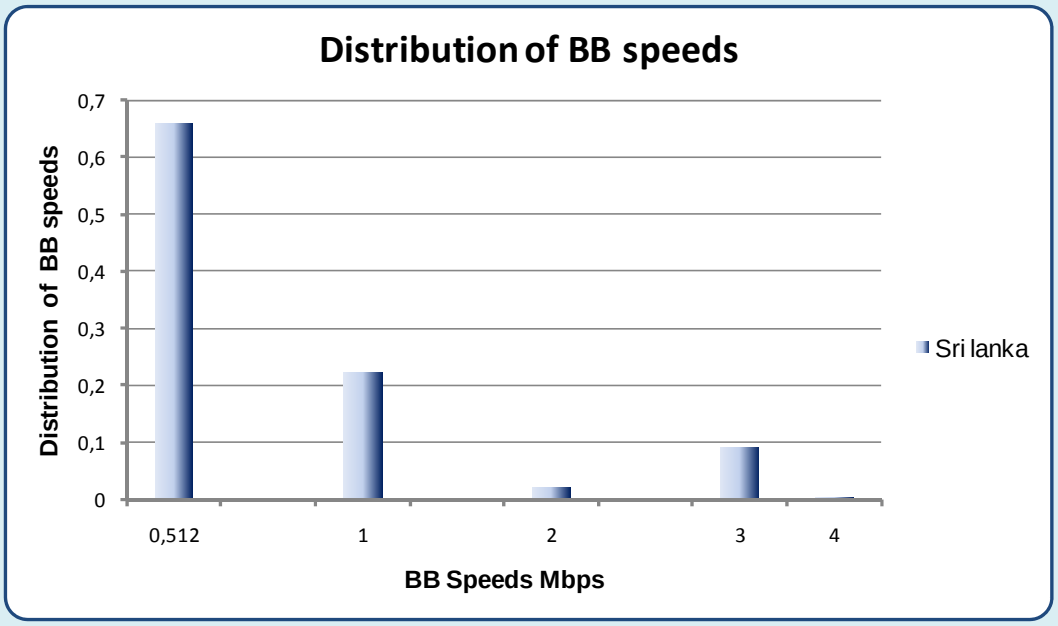


Source: Working Team: Sri Lanka

With the same concept of stable offers Figure 26 illustrates the relationship between speed and price that are close between operators and shows a significant linear increase of price with speed. It is derived that economies of scale inherent to the technologies are not applied in order to reduce prices at higher speeds and the level of competition is relatively low as similar behaviour is present in all offers.

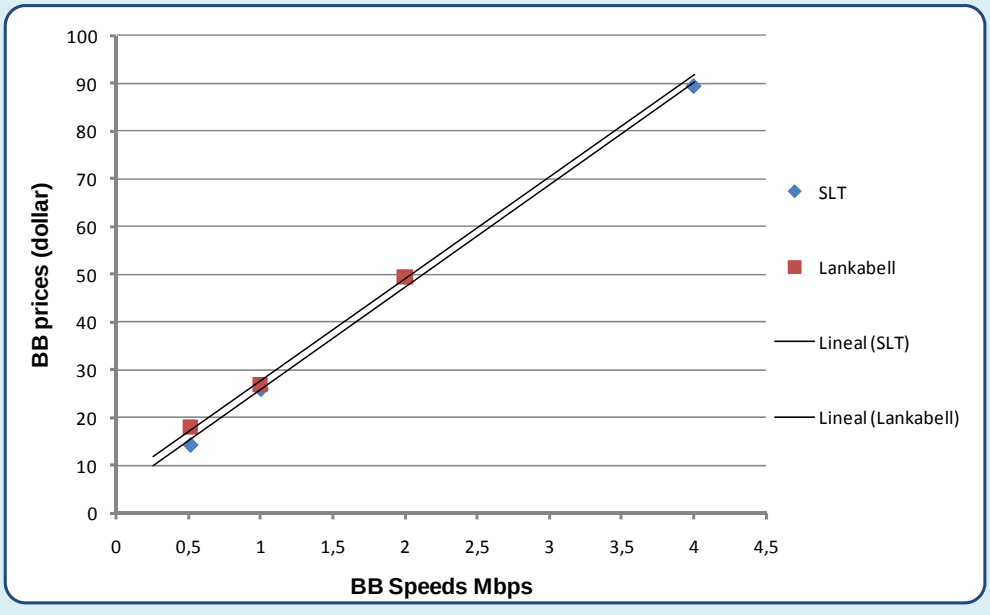
Average revenue per user (ARPU) is now LKR 400 for fixed customers and LKR 375 for the mobile customers in 2G. 2G coverage by population is higher than 75 per cent and 3G solutions are being deployed for more than 30 per cent population coverage.

Figure 25: Distribution for major broadband speeds of stable offers



Source: Working Team: Sri Lanka

Figure 26: Relations between broadband speeds and prices for the main stable market offers in Sri Lanka



Source: Working Team: Sri Lanka

2.3.3.2 Transit and local/edge network segments

Existing network layout for the main fixed network has a traditional PSTN topology with five transit exchanges and more than 530 points of presence including local exchanges and active access units. Up to now more than 6000 km of fibre optics are installed and NGN network is at an initial phase with two softswitches. The objective is to decrease substantially the number of attended local exchanges to be converted in non attended points of presence.

Concerning the main mobile network, the current structure is composed of two local exchanges and more than 800 installed mobile BST (base stations). Migration to NGN is in progress with commissioning of two softswiches and mobile switching centres with the introduction of the 3G equipment.

2.3.3.3 Access network segment

Currently most broadband installed lines are ADSL at speeds up to 2 Mbps mainly in urban areas while WiMax is dominant at rural zones. Infrastructure of installed copper pairs is available with a 75 per cent extra capacity to the copper lines being used for voice and there is a lot of room to extend implementation of xDSL lines as well as to increase speeds with ADSL2+ up to 8 Mbps.

Remote areas have broadband connectivity for 601 locations with expected duplication at short-mediumterm plan.

2.3.3.4 Interconnection

Currently interconnection is defined and working for the conventional TDM equipment and an interconnection regime will require an upgrading for the interconnection of PSTN/PLMN networks with respect to the IP mode NGN.

2.3.3.5 Operation/business support systems and network management

Currently there a number of specific platforms for operation support systems associated to each technology and equipment provider in fixed, mobile and data networks that have been increasing in variety and functionality over the recent years. The number of functionalities for new services is growing especially for mobile applications and business support system capabilities.

2.3.3.6 Quality of service and security

Each telecommunication operator has its own management of quality of service (QoS) taking ITU standards as a reference. In addition, consumer surveys/research and development are conducted with the assistance of universities in Sri Lanka.

Network security rules also follow ITU standards and country specific security requirements. National SLCERTs[58] and Computer Security Incident Response Teams are responsible for cyber security issues under the Computer Crimes Act.

[58] SLCERT: www.slcert.gov.lk

3 Summary of Identified Best Practices

This chapter provides an overview of some of the identified best practices covering national policies for the promotion of broadband, forward looking / converged licensing framework, market regulation, migration towards NGN with converged services and QoS.

3.1 Overall national policies and strategies for ICT

When analyzing the role of the ICT sector and specifically broadband on country development, the importance of the sector on societies and various strategies and policies that are decided at national level as well as across various key institutions is widely recognized.

Different levels of intervention by the public sector take place from high level with direct funding to specific programs to low level with simple promotion of services utilization as summarized in the ICT Regulation Toolkit[59]:

- Strengthening and harmonization of the internal uses of ICT infrastructures and services in public institutions.
- Construction of communication systems and structures in relation to the citizens and business enterprises, with influences on the take-up and forms of communication used in the society at large.
- Facilitation of the development of communication systems. This may include creating more transparency in the markets by way of public information on qualities and prices of communication services, and it may include the setting up of forums for discussion of, for instance, interconnection and frequency issues among the competing operators and the public authorities.
- Regulation proper setting the 'rules of the game' in the markets and the enforcement of these rules.
- Support for the demand for communication systems and services, which may be based on either the direct demand from public institutions or support for the demand from private citizens and business enterprises. Education initiatives teaching people to use ICT equipment and services can also be included in this category.
- Support for the supply of ICT equipment and services, which may involve public funding of ICT companies, but which may also be of a more indirect character involving public research and development and also public education of people who will be employed in business enterprises.

A selected sample of most representative trends in policies and strategies for ICT development in specific countries is summarized below:

The Republic of Korea has followed a coordinated strategy for all ICT sector as good example of a long term view for society modernization. Now it is ready to provide next generation broadband through its u-Korea (ubiquitous Korea) initiative as well as its Broadband convergence Network (BcN).

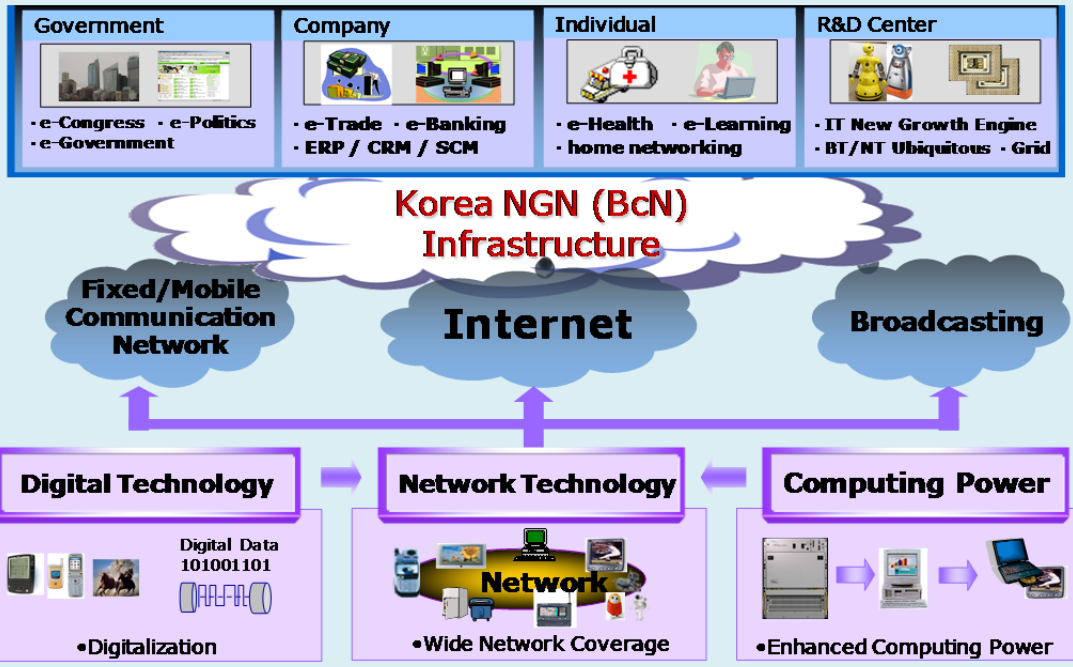
The government launched the BcN project in 2004[60] with the vision of providing the core infrastructure for broadband. The BcN target is to provide broadband service to 20 million subscribers (10 million wired, 10 million wireless) by 2010. It is estimated that the investment would require KRW 40.3 trillion from 2006 to 2010.

[59] ICT Regulation Toolkit: ITU-infoDev

[60] Korea Communications Commission, Policy Information, Outline of BcN.29-03-2009 http://eng.kcc.go.kr/

Figure 27 shows an overall vision of the Korea BcN for the integration of consumer and industry sectors. The Korea BcN provides network infrastructure to the whole new society such as e-Society for government, business, R&D centres and individuals, and takes a leading role in the research for converging interactive with broadcasting networks to support ubiquitous mobile services with emphasis on the u-life care services (Figure 28).

Figure 27: Korea vision for the BcN role on technologies supporting e-services



Source: Korea Communications Commission

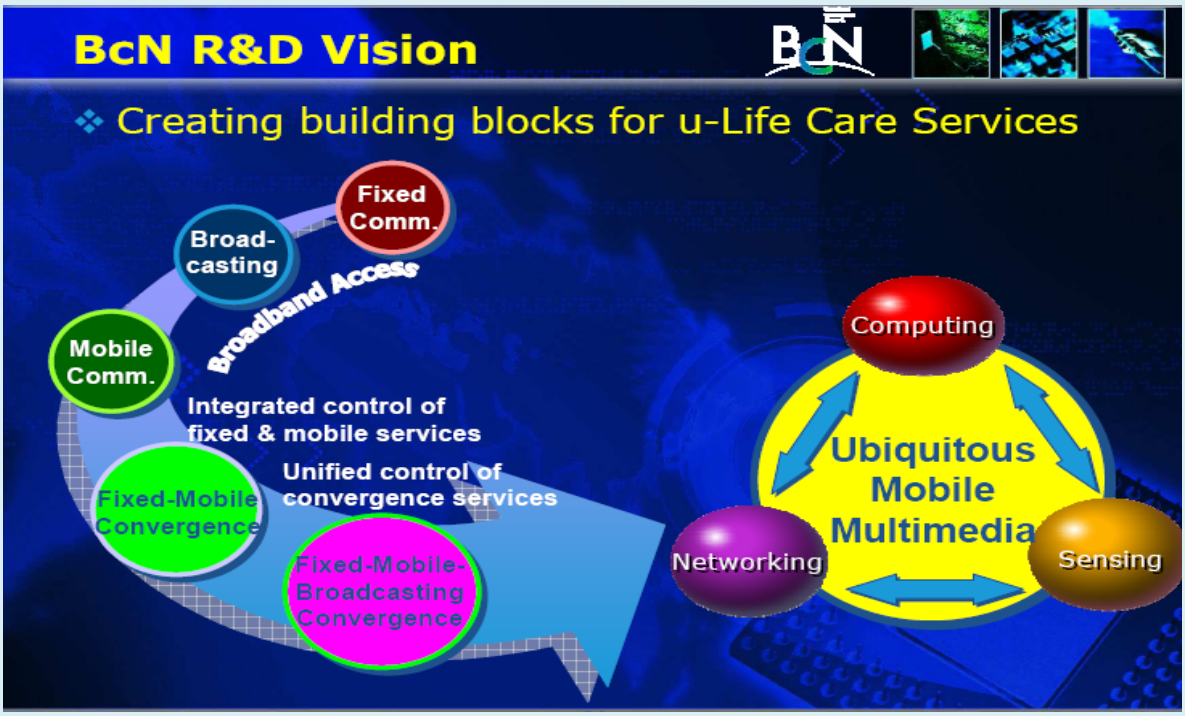
Japan has encouraged a wide deployment of convergent networks and fibre optic infrastructure by means of the e-Japan, which is a national plan to create a wired and wireless broadband nation by 2010. Japan has also stipulated a supplementary plan, u-Japan**,** which mandates the creation of business applications to meet its social and economic needs.

In order for Japan to make itself a "knowledge-emergent society" the following four priority policy areas are intensively developed for a new national IT infrastructure: 1) establishment of an ultra high-speed network infrastructure and competition policies, 2) facilitation of electronic commerce, 3) realization of an electronic government, and 4) nurturing high-quality human resources.

Since 2005, the Japan Ministry of Internal Affairs and Communications (MIC)[61] has initiated two studies relevant to regulatory responses to the emergence of NGN, one dealing with competition rules, and the other dealing with technical architecture. Japan has the largest number of fibre to the home (FTTH) connections worldwide with more than 13 million homes and is very active with a study group to define the future architecture of networks, by optimization of the protocols across network segments, performance and end to end security.

[61] Information and Communications in Japan, MIC, www.soumu.go.jp/menu_seisaku/ict/u-japan_en/index.html

Figure 28: Role of research for the convergence path towards u-Life care services



Source: Korea Communications Commission

High speed broadband reaches very fast 1 Gbps connections for more than 24 per cent of customers and more recently the government issued a new policy plan called "Zero Broadband Areas Elimination" aiming at 100 per cent broadband penetration by 2011.

The following activities are directly promoted by government in relation to broadband:

- Implementation of tests and experiments and provision of installation models etc.
- Ample support of research and development of next-generation broadband technologies.
- Promotion of the formulation of technical specifications through coordination between private sector organizations, academia ect.
- Ample support measures of broadband installations making full use of next-generation broadband technologies.
- Promotion of implementation of broadband installation through optical fibre networks held by the state and regional public bodies as well as next-generation broadband technologies.

The European Union (EU), after the first ICT common policy agreed at Lisbon in 2002 for all EU countries to emphasize information services, the new digital agenda, the Granada Declaration[62], was adopted on 19 April 2010 by European Union ministers under the chairmanship of Spain. All Member States agree that the EU requires a new digital strategy based on the latest technologies and the implementation of the society of information and knowledge.

[62] Granada Ministerial Declaration on the European Digital Agenda: Agreed on 19 April 2010. www.eu2010.es/export/sites/presidencia/comun/descargas/Documentacion/en_ndep_granada_acc.pdf

The ICT sector is directly responsible for 5 per cent of European GDP, with a market value of € 660 billion annually, and is contributing 50 per cent to productivity growth and jobs in the EU economy[63]. Recognizing that the ICT sector is a crucial driver of growth, and a key source of innovation and new business opportunities the following decisions were taken:

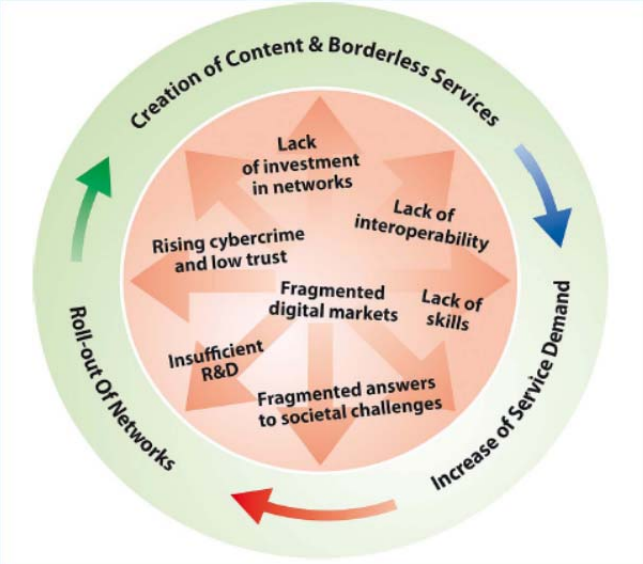
It considers that the future digital strategy should be based on the following eight central themes:

- *Infrastructures*: ie: Take concrete steps to overcome the digital divide by meeting the target of 100 per cent coverage of basic broadband to all citizens by 2013 and promote wide take-up of high speed broadband by 2020.
- *Advanced use of the open Internet, security and trust* such as: the extensive use of ICT in education and learning, for example the widespread take-up of mobile computers and digital interactive content and tools, as well as digital literacy amongst citizens and e-skills for businesses, especially SMEs; smart and open public services such as e-health and e-government.
- *User rights;* Promote awareness of current EU rules protecting users of electronic communications and online services by the preparation and dissemination of an easily available and understandable "Code of Digital Rights of e-Communications and online services".
- *Digital Single Market;* Stimulate trans-border e-commerce by the promotion and government adoption of interoperable e-procurement, e-invoicing and e-payment systems based on open and flexible technologies.
- *Digital Public Services;* Ensure the implementation of e-Government strategies at an organizational, legal and technical level including e-ID and e-signatures. Deploy e-Health and ICT assisted elder care services systematically across the EU in order to reduce costs while raising efficiency and the quality of care.
- *Strengthening the Competitiveness of Europe's ICT sector;* Support ICT innovation through R&D in areas where Europe has a lead market potential, e.g. health, green mobility, smart grids and meters and energy efficiency; or which are strategic such as future Internet or cloud computing.
- *International dimension of the Digital Agenda;* Ensure that Internet governance continues to evolve in line with the principles established in the Tunis Agenda, such as transparency, multilateralism, democracy and the full involvement of all stakeholders; and that the Internet Governance Forum (IGF) develops as an open place for meeting, policy dialogue and exchange of best practices between governments, civil society and the private sector.
- *Benchmarking Information Society:* Benchmark progress annually through harmonized methodologies and indicators, adaptable to the evolution of technology and its use by citizens, enterprises and public administrations, allowing for a robust and comparable measurement of ICT use and impact on sustainable economic growth and social welfare.

The outer circle of Figure 29 reflects the positive self reinforcing activities for content creation, services demand and networks rollout in the virtuous cycle of the digital economy. This stimulates demand for higher speeds and capacity, which in turn creates the business case for investments in faster networks. The inner arrows summarize the challenges that need to be resolved by the communities and national entities in order to facilitate the benefits of ICT.

[63] European Commission: Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions; A Digital Agenda for Europe. Brussels, 19.05.2010 COM(2010) 245

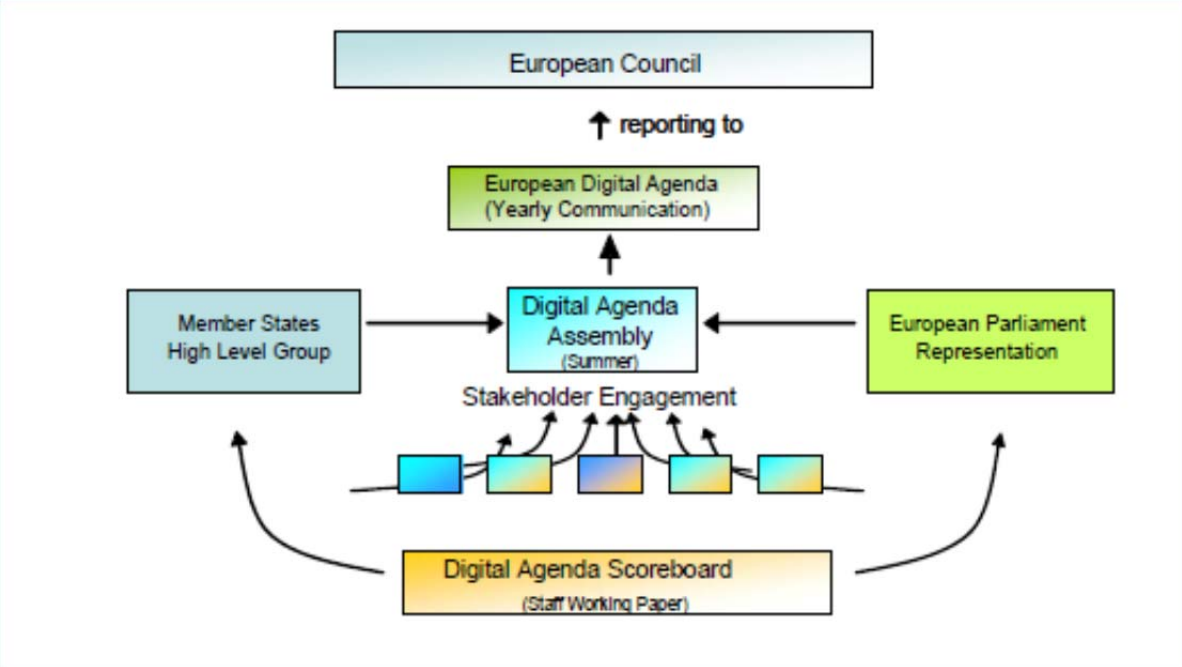
Figure 29: The virtuous cycle of the digital economy and its challenges



Source: European Commission- Digital Agenda for Europe

In order to assure a coordination of the actions among all EU countries, a digital agenda, government cycle is applied as indicated in Figure 30.

Figure 30: The EU Digital Agenda Government cycle



Source: European Commission- Digital Agenda for Europe

In some EU countries like Finland and Spain anticipation of the common directives in broadband access is already being considered influencing the character of universal service in Finland since 2010 and Spain for 2011 with minimum speeds around 2 Mbps and dominant speeds between 8 Mbps and 50 Mbps.

In the UK, in addition to the common EU objectives, the government was giving priority to the deployment of the next generation broadband (NGB) and next generation ccess (NGA)[64] and recently is promoting the synergies of combining the public sector network (PSN) with the superfast broadband by aligning the PSN and the NGB initiatives. This will reduce costs of deployment and accelerate a virtuous circle of benefits for public and private services with the corresponding stimulation of economic activity and increase social inclusion. The government has committed about £300 million to fund broadband schemes and BT is spending £2.5 billion to introduce a new fibre-optic based network in Britain[65].

3.2 NGN regulation and licensing regime

3.2.1 Licensing regime: unified versus segmented

Based on regulatory experience of some advanced countries and the convergence of networks, the main focus of the regulation and licensing for operation is oriented towards the management of customer's right to better services at lower costs as an ultimate goal. In order to reach that objective, the following strategic actions define the most recent trends:

- Have a vision of market evolution on overall services and business development.
- Focus on end customer's orientation.
- Simplify application process at "macroscopic" level.
- Always promote innovation, reducing barriers for innovation.
- Promote convergence of IT, telecommunication and broadcasting.
- Measure accountability of regulatory actions by the availability and affordability of services as well as for the end customer's satisfaction.

All those trends are applied on top of the well defined fundamental principles for regulation by ITU[66] that continue to be valid across the different evolutions of solutions and country context.

- *Fairness:* The regulatory rules should be neutral and fair so that all players will be treated equally.
- *Transparency:* The regulatory rules, decisions making process and results should be carried out transparently and the outcomes made public and open to all.
- *Independence:* The regulatory bodies should be independent from the policy making body in its functions.
- *Quality and consistency*: Quality and predictability of regulatory decision making with focus on interests of end users.
- *Effectiveness:* Mechanism for checks and balances to reward innovation whereas discourages market distortion.
- *Accountability:* Establishment of accountability of regulatory bodies and mechanism for appeal against decisions of regulator.

The means and speed of application of previous trends and principles, starting from an initial segmented technology / service specific licence, varies as a function of state of development of the country and national strategy to modernize ICT infrastructures as well as delivery of affordable broadband to citizens.

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[64] Ofcom: Regulatory challenges posed by next generation access networks. 2006

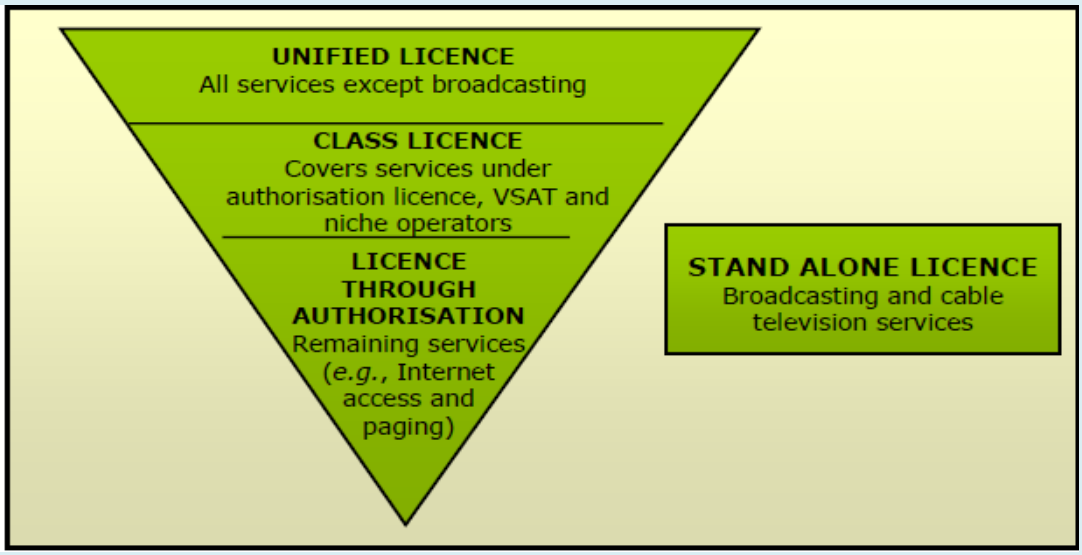
[65] BT investment on fibre: www.itpro.co.uk/623254/bt-adds-1-billion-to-fibre-rollout-to-cover-two-thirds-of-uk

[66] ITU regulatory references

Current trends are moving towards convergence in three main modes:

- *L1) Convergence with general authorization for operation*. This simplification takes place in the EU were many countries have to agree on a set of common principles that have to be compatible with the other laws already existing in all economic sectors and should not overlap. All electronic communication services and networks will be covered under a general authorization regime, with individual rights of use being confined to the assignment of radio frequencies and numbers only.
- Three categories of conditions apply from the generic to the specific:
  - Conditions under general law, applicable to all undertakings in all economic sectors.
  - Conditions under the general authorization applicable to all telecommunication services and networks such as financing contribution to universal service, administrative charges, interoperability for services and network interconnection, measures to ensure compliance with standards and specifications, etc.
  - Conditions attached to rights of use for radio frequencies and numbers as scarce resources.
- *L2) Convergence towards unified licence:* This unification takes place in India[67] where all public networks including switched networks irrespective of media and technology capable of offering voice and/or non-voice (data services) including Internet telephony, cable television, Direct To Home (DTH), TV and radio broadcasting shall be covered under this category. Unified licence implies that a customer can get all types of telecommunication services, from *a Unified License Operator.* The operator can use wireline or wireless media.
- In addition to this unified licence, three other cases are available for subsets of services as indicated in Figure 31.

Figure 31: Licence classes in India



Source: Telecom Regulatory Authority of India (TRAI)

- *L3)* Convergence *towards multiservices by network layers and/or value chain facilities:* This type of convergence takes place in various countries within the Asia and Pacific region such as Malaysia, Singapore, etc. Separation by network layers and/or facilities varies from country to

[67] Telecom Regulatory Authority of India: Recommendations on issues relating to Convergence and Competition in Broadcasting and Telecommunications. New Delhi-.March 20, 2006

country and the specific case of Malaysia considers the following four layered licensing framework:

- Network Facility Providers (NFPs), which include owners of satellite earth stations, fibre optic cables, communications lines and exchanges, radio communication and transmission equipment, mobile communication base stations and broadcasting towers and equipment.
- Network Service Providers (NSPs) for entities that provide basic connectivity and bandwidth to support a variety of applications.
- Application Service Providers (ASPs) for licensees that provide particular functions such as voice services, data services, Internet access services, IP telephony and other transmission services.
- Content Application Service Providers (CASPs): A special subset of applications service providers, including traditional broadcast services and services such as online publishing and information services.

In addition to the classical role of spectrum authorization in a stable market with technology availability, a set of trends appear with the liberalization of the telecommunication sector and the rapid introduction of new technologies with powerful and flexible capabilities. Spectrum regulation has moved from a basic coordination task towards an active planning and management of use of bands with the following purposes:

- Grant the exclusive rights of a scarce resource with a given continuity.
- Ensure efficient use of a limited resource both at technical and economic levels.
- Promote competition for a better services offer.

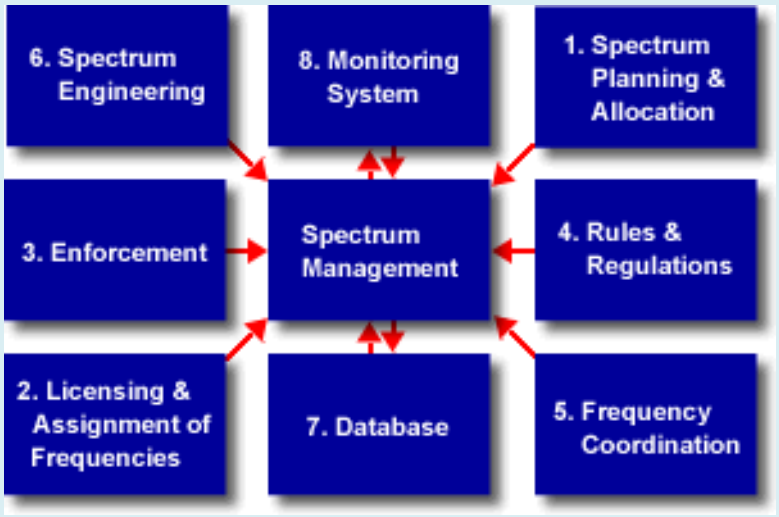
The spectrum management activities require active co-operation between national and international bodies to ensure compatibility with utilization policies and get a high economy of scale which will result in affordable access. Those activities require three basic processes:

- Spectrum allocation – Division of the spectrum in blocks of frequencies to be used for specific services classes.
- Spectrum assignment – Choice among potential users of allocated channels or frequency bands with a given technical and market driven criteria.
- Spectrum monitoring and compliance involves the monitoring of the use of the radio spectrum and the implementation of measures to control unauthorized use.

These activities are either performed directly by the ministry of communications, the national regulatory authority or by a specialized agency in a delegated manner. A good illustration of the later case in the region is given by the case of OFTA in Hong Kong, China[68] that has the status of a Trading Fund and has the legal requirement to cover its costs and make a limited return on capital after paying a dividend to the government.The main source of revenue is the income from licence fees and the use of spectrum. OFTA organizes all activities related to spectrum management as in Figure 32 which illustrates the strong interrelation among tasks and the associated complexity.

[68] OFTA: www.elearning.trpc.com.hk/spectrum/section6.php

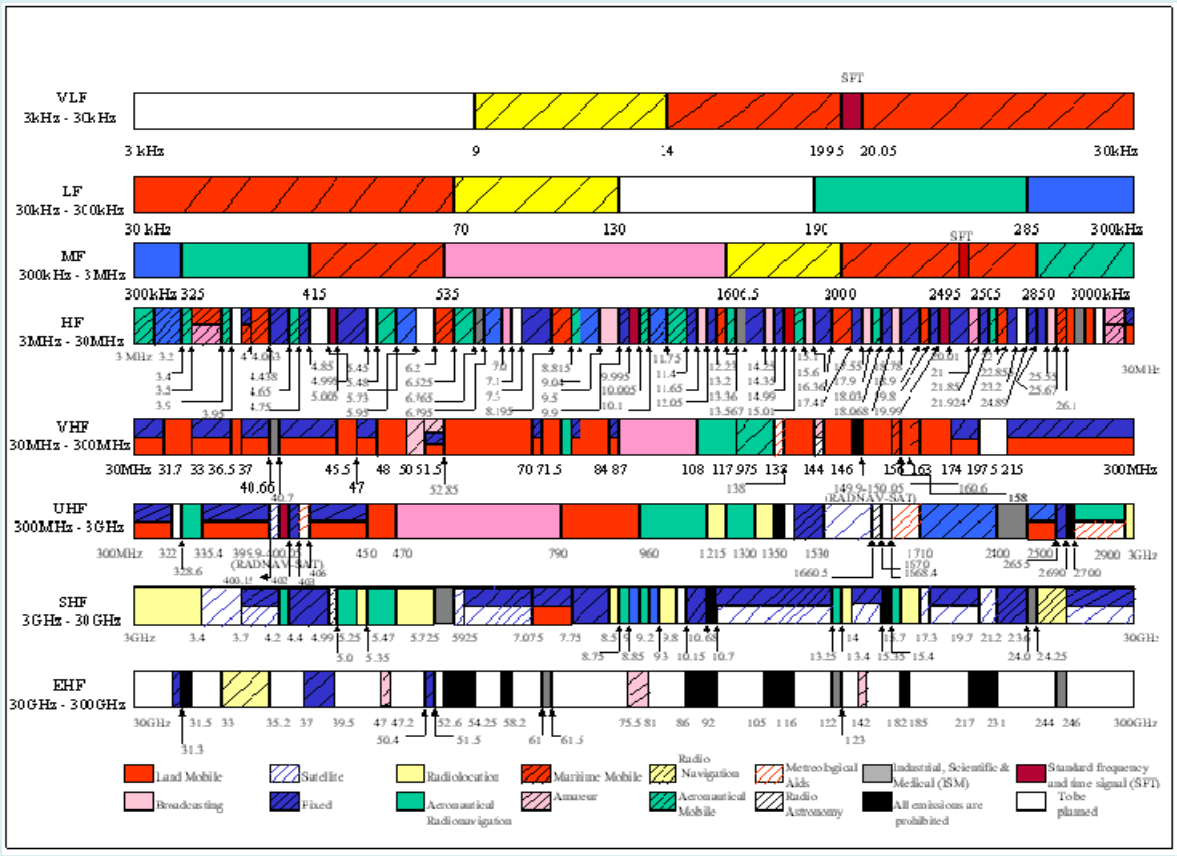
Figure 32: Related spectrum management activities at OFTA Hong Kong, China



Source: OFTA Hong Kong, China

Spectrum allocation is following international standards and constraints derived from the country history which requires a specific customization per country. A significative example is provided for Hong Kong, China, in Figure 33 with division into bands and in turn into blocks per band.

Figure 33: Illustration of map for spectrum bands allocation in Hong Kong, China



Source: OFTA Hong Kong, China

Spectrum Assignment is the more complex activity due to the diversification of details in the procedures and associated evolution based on previous experiences with better or lower results. Most common best practices for a competitive environment are based on the comparative hearing/beauty contest procedure, in auctions based on quality-financial rating or hybrid procedure of both. Once a market is mature there are moves towards spectrum trading and self regulation following market rules.

- In a *comparative hearing or beauty contest*, companies are selected on the basis of offerings covering a wide set of parameters with their corresponding weighting factors that include qualitative and quantitative measures such as company technical and financial capabilities, infrastructure deployment, services offered, quality of service, geographical coverage, number of customers, etc.
- In the *auctions method*, licences are assigned, from a preselection based on fulfillment of technical requirements, to those who are able to profit most from use of the spectrum by creating valuable services, as they will come with the highest bids. A proper equilibrium between pre-conditions and bidding is required to avoid an excessive focus on the prices that will generate distortion as became evident during the UMTS auctions in the UK, Germany, and some cases in the US.
- In addition to these main methods and in well developed markets it is starting an a-posteriori procedure to optimize spectrum utility by means of *Spectrum Trading* or secondary reassignment between organizations based on the supply-demand market rules, assuming that the regulator allows that flexibility.
- For that part of the spectrum that is open to use or *unlicensed,* the frequencies are available to all users who comply with certain pre-determined technical limits (e.g., total transmission power/output limits) and equipment certification requirements to guard against interference. This open model is generally flexible and is applicable to applications like Wi-Fi.

Spectrum monitoring becomes a key activity to ensure fulfillment of the assignments, protection from non-authorized use and to ensure an efficient utilization with the following tasks:

- Improving spectrum efficiency by determining actual frequency usage and occupancy, assessing availability of spectrum for future uses.
- Ensuring compliance with national spectrum management regulations to shape and sustain radio environments and user behaviour, maximizing the benefit of the spectrum resource to society.
- Resolution of interference problems for existing and potential users.

A common lesson derived from spectrum handling evolutions is the trend towards the simplification in all the licence processes and the required support with specialized computer tools to obtain greater efficiency and flexibility for the market evolution in a shorter time.

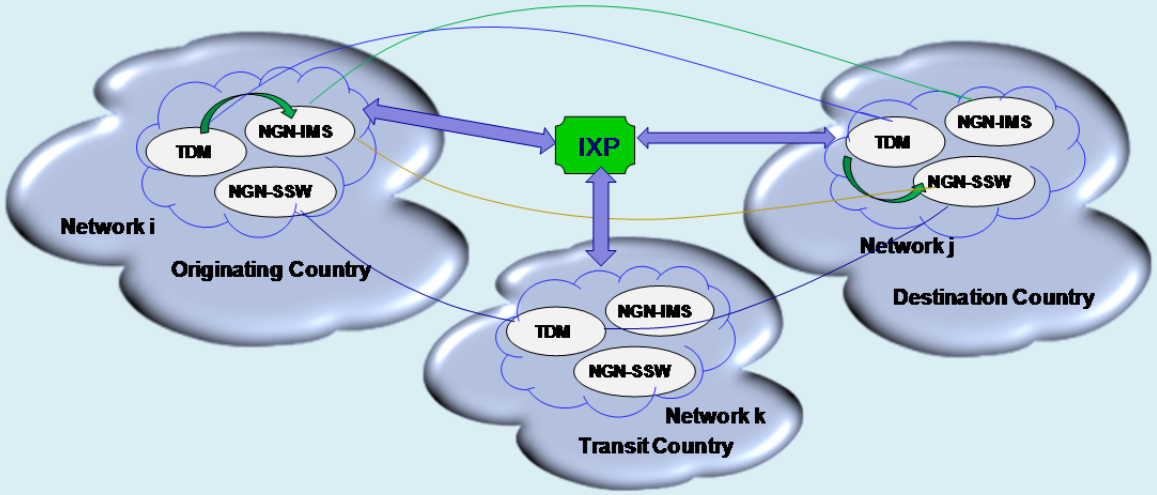
3.2.2 IP based interconnection

The type of interconnection to be addressed by the regulator should consider both the interconnection between two IP based networks as well as the interconnection between an IP based network and a TDM network as well as at different evolution or maturity phases as indicated in Figure 34. It becomes clear the high number of combinations that appear during the intermediate evolution and the need for simplification of the regulatory rules and the convenience to use the neutral interconnection exchanges when a high number of networks (in the order of thousands) need to be related. Applicability should consider cases of points of interconnection located at a given operator as well as the common location at a neutral point: IXP that implements all required functionalities for numbering, routing, charging, billing, etc.

The Internet today operates as a hierarchy as indicated in Figure 35. Thousands of small, local, regional and small country ISPs operates at the bottom of an Internet pyramid. These operators typically have to pay for access to the networks and customers operated by larger ISPs. At the middle of the pyramid are several dozen Tier-2 ISPs with a regional coverage that typically pay to transit the networks of the largest

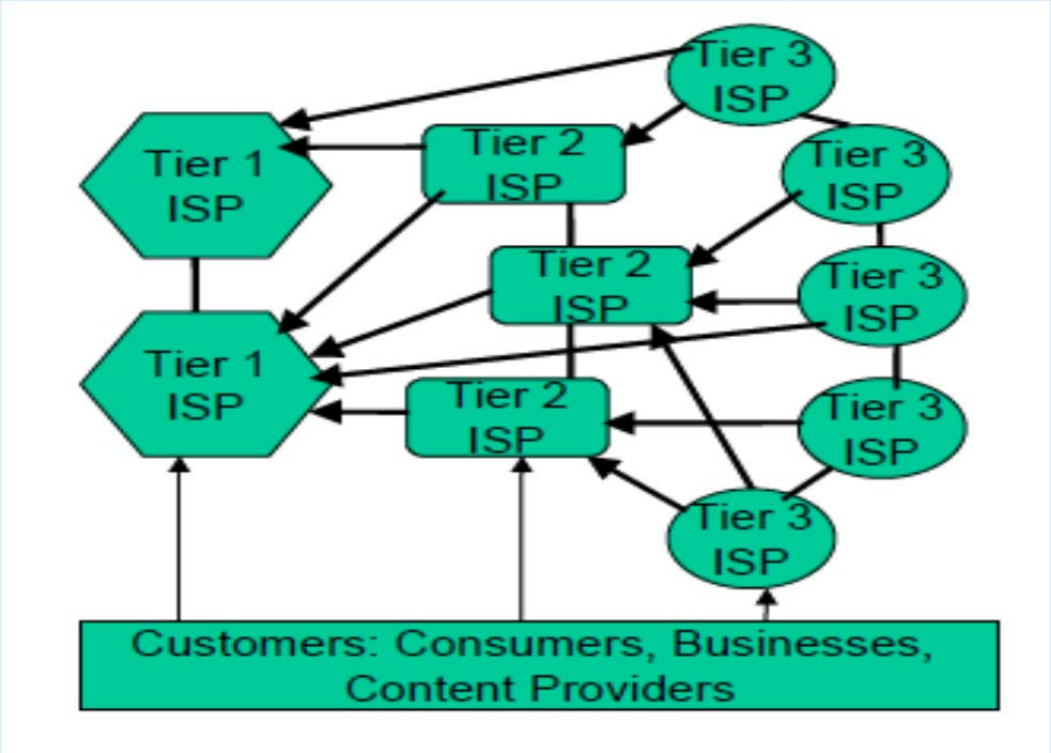
ISPs. Tier-2 ISPs seek to interconnect on a *"peering"* basis with other, Tier-2 ISPs. At the top of the pyramid are a set of Tier-1 ISPs with international coverage. IXP nodes at neutral points will optimize interconnection by reducing the number of hops in a path with proper location between groups of Tier x ISPs according to traffic flow demand.

Figure 34: Scenarios for interconnection between networks at different evolution phases



Source: O. González Soto

Figure 35: Hierarchical structure of the Internet ISPs



Source: IDC

Due to the fact that IP transmission is more efficient and flexible than the circuit switched, it is recommended to implement the interconnection points in IP mode with service level agreements (SLA) procedures to guarantee quality of service unless both parties agree on another solution (ie: when both parties have networks operating in circuit switched mode). When hybrid implementations are present and also for efficiency reasons IP interconnection is recommended by conversion of circuit mode to IP by means of gateways.

Principles to guide the recommendations are generic for all regulatory activities and the following are more specific:

- The main goal of interconnection is to ensure expanded services and economic gains for the entire market.
- Non-discrimination between operators in the interconnection points and traffic flows.
- Interconnecting parties should generally pay for costs that they cause and should have a fair share of common costs.
- Interconnection should be technically equivalent for all operators, resulting in the same requirements for the quality of service.
- All procedures and vital information should be transparent to all parties.

Most common and best regulatory practices apply the following issues[69]:

- *Points of interconnection*. The physical locations where interconnection will take place and the technical standards to be employed in the interconnection are defined. A process for requesting and obtaining additional points of interconnection should be established.
- *Transport (conveyance) charges and traffic routing*. Definition must be made for how calls will be routed: if there are multiple interconnection points, what is the proper routing and hand-off point for each type of call. The applicability of transport charges in the receiving network for calls that must be carried beyond the area local to the point of interconnection must be defined.
- *Quality of service standards*. Quality standards are defined, particularly for time to provision circuits, for availability of resources, for call blocking levels, and remedies are defined for when those standards are not met. Often, an incumbent provider is required to provide at least as high a level of quality to interconnecting carriers as is provided to the incumbent's retail customers.
- *Prices and adjustment of prices over time*. This includes the initial level of interconnection charges, a definition of the currency in which interconnection charges are to be paid and how prices will adjust over the term of the agreement to account for exchange rate changes and inflation. The "ownership" of the call must be defined. Liability for bad debt and uncollectable bills should also be defined.
- *Billing and collection.* When and how to collect traffic data, when and how to exchange bills, and when and how to make payment should be specified. A process for reconciling traffic data and for making inquiries to the other party and for handling claims also should be incorporated. A procedure for resolving discrepancies is useful, which often involves seeking recourse to arbitration.
- *Traffic measurement and settlement*. The responsibilities of each interconnecting operator to measure traffic are defined, as are settlement procedures both for deterministic and statistical parameters. Special importance is given to the common agreement for the same measurement period for the IP mode flows. These measurements also apply to the obligations to cooperate in fraud detection, and enforcement activities should be specified.

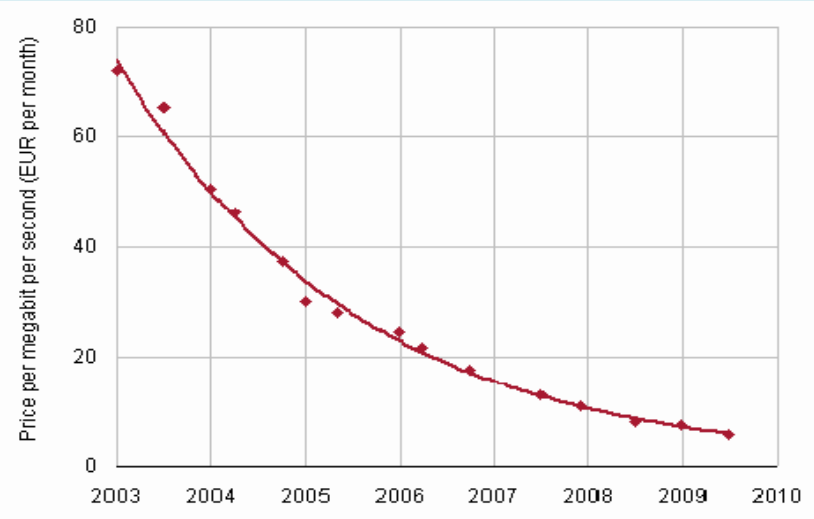
[69] ITU-D: Trends in Telecommunication Reform 2007: The Road to NGNs

- *Numbering resources*. Access of each operator to the country's numbering plan and numbering resources must be defined. It is particularly important that numbers be provided in a timely manner so that potential sales are not blocked. If number portability is part of the local regulatory regime then terms of participation should be defined.
- *Forecasting network needs*. A planning process must be followed between the interconnecting operators so that investment for additional capacity can be agreed, budgeted, and installed in time to meet the forecasted demand. Procedures to resolve differences over forecasts must be defined in order to avoid traffic blocking by a lack of balance in the dimensioning capacity. At a minimum, a mutual obligation to notify the other party of network changes and upgrades well in advance is needed to avoid disadvantaging one competitor over another.
- *Access to customer information*. By necessity, when completing calls and billing for them, interconnecting operators pass back and forth information about each other's clients. Limits on the permitted uses of this information should be defined, particularly regarding the temptation to engage in marketing activities in approaching another operator's clients based on information obtained through interconnection activities. Safeguards are also necessary to protect customer privacy.

3.2.3 Cost allocation, charging and billing

Successful deployment of every service and in particular those of the ICT sector require market and economic rules for efficiency and sustainable business and this is the principle that should guide pricing policies in the long term. A good illustration of pricing trends over time is provided in Figure 36 for broadband services in the EU from 2003 to 2010[70].

Figure 36: Mean price per megabit per second for residential fixed broadband access over time



Source: Analysys Mason, 2010

The decrease in price is matched by an increase of customers as indicated in Figure 37[71] and combined with a sustained increase of access speed, from a most frequent speed of 1 Mbps towards a most

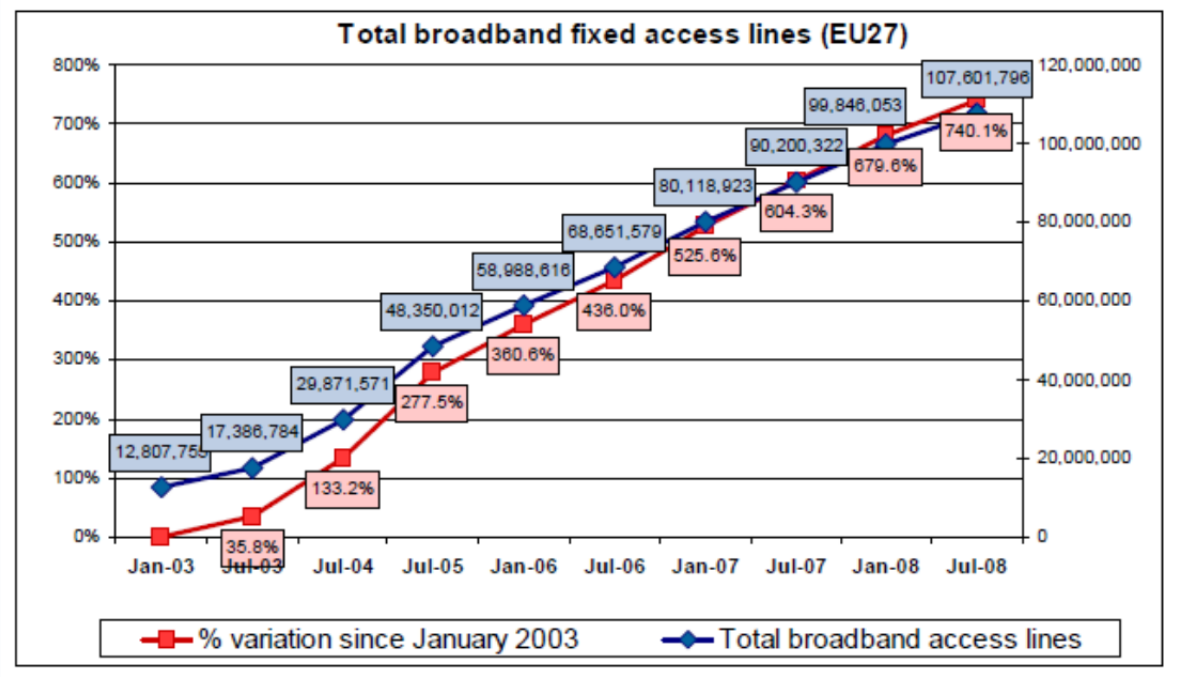
[70] Analysys Mason: www.analysysmason.com/AboutUs/News/Insight/Fixed_broadband_pricing_Insight_Aug2010/

[71] European Commission: Europe's Digital Competitiveness Report. ICT Country Profiles, Brussels, 17.5.2010

frequent speed of 8 Mbps with DSL and 50 Mbps with fibre to the building due to an equilibrium between market dynamics and the technology economy of scale.

Another interesting case in the Asia-Pacific region concerns India, where mobile services have quickly evolved to the rates given in Figure 38[72]. A parallel decrease of pricing, growing competition with an increase of customers and traffic allowed for a worldwide reference case of business feasibility with low tariffs and high customer base growth.

Figure 37: Evolution of broadband lines in EU since 2003



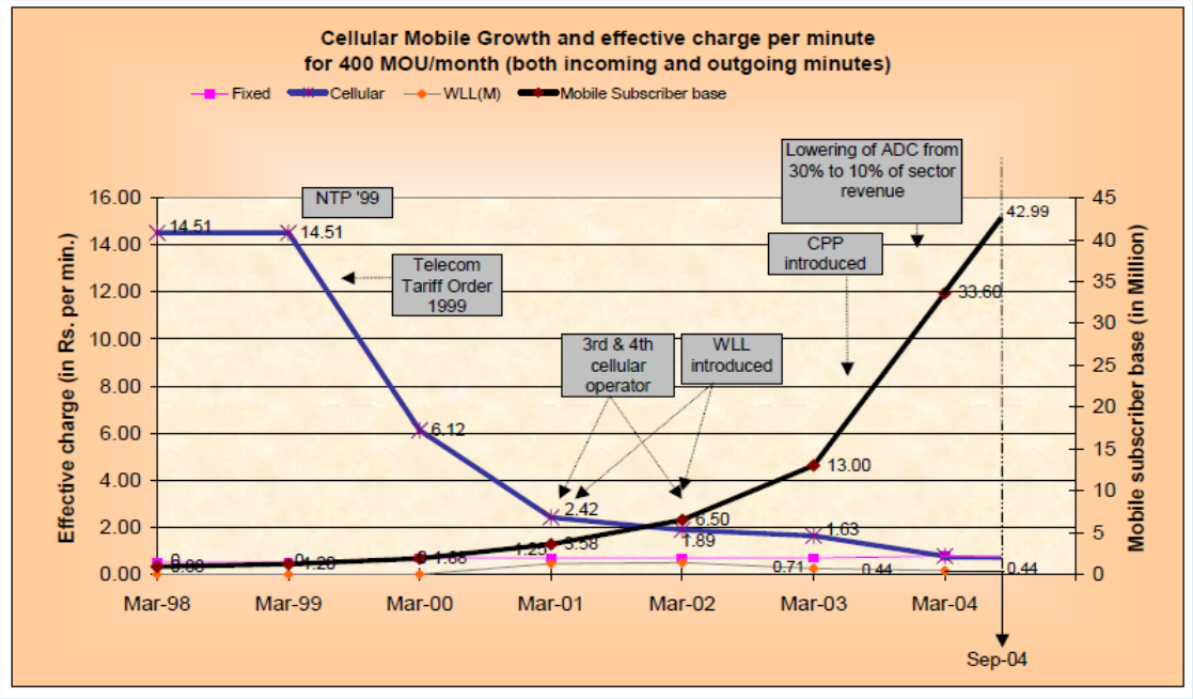
Source: European Commission 2010

Regulation has to recognize those principles and act to promote services penetration and cost reduction while maintaining business feasibility in operation. The most common role of regulation is to deal with interconnection pricing, costing methods, and services price guidelines when applicable, based on the following economic principles:

- *Allocation efficiency* requires that resources, products, and services are allocated to the person or persons who value them the most. For this to happen, consumers of final products or services should pay prices that reflect the cost of the resources used to provide those products or services.
- *Productive efficiency* requires that market participants use scarce resources as productively as possible. This means that the most efficient provider should not be precluded from serving customers.
- *Dynamic efficiency* requires that all firms (entrants and incumbents) should have proper incentives to invest in technologies that reduce costs and/or expand product offerings.

[72] Telecom Regulatory Authority of India: Notification No.409-8/2004-FN.New Delhi, the 6th January 2005.

Figure 38: Relation between charges, customer base and competition in India



Source TRAI India

When pricing guidelines are applicable, interconnection prices may be based on the additional cost to the incumbent from providing interconnection services. In order to evaluate a price reference basis for further regulatory and commercial decissions, three main pricing methods are being used:

- *Cost-based pricing***.** Interconnection prices are based on the involved costs associated to the necessary network resources to be used. Most common costing procedure is the long-run incremental cost (LRIC) of providing interconnection. Several variants for calculating x-LRIC were used in the past as a function of the considered cost components and now it is recommended to have a complete consideration for all incurred costs in the planning life cycle of the involved resources TSLRIC (Total Service Long Run Incremental Cost) and also ensuring the standard revenue margins to guarantee business sustainability and neutrality for the different types of operators. Costing to be based on capacity in terms of resources utilized. When applying these generic economic procedures to the specific IP technologies it has to take into account that packet switching uses resources as a function of the packet flows through the network and not time. In this case, an activity-based costing (ABC) methodology is recommended for the high diversity of resources used. Two main procedures for evaluation are applied:
  - *Utilization-based costing (UBC)* in which for any network resource used, costing and charging is calculated as a function of the resource reserved capacity and occupancy or utilization for a given QoS or SLA type. Payment in this case is proportional to the level of utilization and required quality. A more complete and generic view calculates the costs considering also the number of events generated and value of content with a polynomial model.
  - *Capacity-based costing (CBC)* in which calculation is simplified considering only the reserved capacity independently of the level of utilization.

  UBC is the most complete method and it is the one recommended for mature and large networks although for small networks at the starting phase CBC is frequently used due to the inherent simplicity.

- *Retail minus pricing***.** This approach takes as a reference the incumbent's retail price for the downstream service, and subtracts the associated retail costs. The final interconnection price should also include any additional costs to the carrier that arise directly from providing interconnection services. When correct application of all factors is considered and in a stable market a certain convergence should arise with the previous method and will serve as a checking reference.
- *Bill and keep***.** With "bill and keep" the calling party's network retains revenues raising through retail usage charges. Neither the calling nor receiving parties' networks pay each other — the interconnection charge is effectively zero. Bill and keep only applies to two-way interconnection and when the traffic exchanged between networks is roughly in balance, the net payments in either direction would be relatively small. One advantage of a bill and keep policy is that it can be adopted quickly without the need to employ a cost analysis and may be used in transitory phases until the proper policy is defined.

Previous principles are applied to all services within the NGN environment although the case of VoIP requires special attention due to the high sensitivity of charges and the long period of transition from TDM to IP mode that requires application of same generic economic procedures but with hybrid use of TDM parameters and IP parameters.

The generic activity-based costing (ABC) allocates direct and indirect costs to a service as a function of the cost drivers for any service on the network resources; indirect costs are allocated according to an analysis of cost drivers. These activity-based costs constitute the directly and indirectly attributable costs, and therefore the incremental costs of a product or group of products. Evaluation may be done with a gross model and only main cost factors or in more complete detail that implies a very careful cost assignment to each service and the use of powerful tools like the Strategic Telecom Evaluation Model (STEM)[73]

Trends in charging: Taking into account the consumer side and from the initial most common charging on PSTN, based on few parameters like origin-destination, call duration and daily time, a major evolution is taking place on two dimensions:

- Migration from a static charging per customer based on few parameters towards the aggregation of multiple parameters for multimedia services like bandwidth, content and QoS values in a dynamic manner.
- Incorporation of market driven procedures like the Online Charging Systems (OCS) that take into account competition influence with per call personalized offers as a function of service bundles, service buckets based on consumption volume, service priority, time of the day and week, negotiated SLA, etc.

All those new procedures add more variables and complexity to the charging process but generate benefits; efficient use of network capacities, adaptation to the customer needs, and attraction/retention of customers in an open market.

3.2.4 Infrastructure sharing

Telecommunication physical infrastructure is responsible for a large proportion of investment, estimated at more than 70 per cent of the total for a greenfield network, and consequently in a competitive market with many operators, there is no economic sense in multiplying those investments for all scenarios. In addition, some network elements are scarce by nature (like spectrum) or by availability (like ducts, cables, transmission towers, etc.). These are the main reasons why infrastructure sharing started recently and becomes more necessary in the economic downturn.

[73] STEM: Strategic Telecom Evaluation Model. Implied Logic Limited, Cambridge, UK

Sharing has many dimensions: per network layer, network segment or single common network element and offers numerous potential business strategies to provide more and cheaper services to society by the proper utilization of common elements. In order to maintain equilibrium between economic efficiency and respect for competition rules, regulatory approaches are needed. A good example of sharing is the unbundling of the local loop which generated a lot of regulatory rules but which has helped the growth of broadband in many countries.

Observing the sharing principles in a wide sense, ITU has proposed the concept of "six degrees of sharing"[74] in order to have a wider and more systematic approach than in the past and reflects the most recent trends in most advanced countries.

The main themes in the document address the issues in current negotiations that need specific positioning by the regulators and concern to the following domains:

- *Passive Infrastructure* at any segment like: ducts, cables, rights of way, poles, masts, trenches, towers, equipment rooms and Technical premises
- *Active Infrastructure* that include all electronic network elements like Optical network unit (ONU), access node switches, Routers, Broadband access remote server (BRAS), Management systems, Application Servers, etc.
- *Accessibility to fibre and access elements*: Access network segment is one of the most critical aspects for promoting broadband use both in economic terms and customer accessibility to broadband services.
- *Mobile network sharing:* considers both passive and active network elements to help operators to attain better coverage, reduce number of sites, and comply with environmental constraints and save investments. A large diversity of sharing degrees in the Mobile Virtual Network Operation (MVNO) is feasible between the extremes of only spectrum sharing up to the simple services reselling.
- *Spectrum sharing*: may be implemented in several dimensions: in time, in space, in geography, with dynamic spectrum access and through licensing and/or commercial arrangements involving spectrum leasing and trading.
- *International gateway liberalization*: The international cable and satellite systems that link multiple countries form a capacity bottleneck especially in countries with large dependency on satellite and submarine cables connectivity. Liberalizing access to these international gateway facilities through infrastructure sharing can lower infrastructure costs while multiplying the amount of international capacity available to operators.
- *Functional separation or operational separation*: has the objective of maintaining the fixed line access infrastructure within the incumbent in an independent division and open the operation for all services to other operators. This needs to assure a non-discriminatory treatment in the support applications to all competitors.

International mobile roaming:

- International mobile roaming is a form of services sharing that allow customers of one mobile network operator to use mobile services when travelling abroad. These services are enabled by a direct or indirect relationship between the "home" and "visited" operators.
- *IPTV and mobile TV:* IPTV and mobile TV are being introduced with a converged content that could be shared among diverse broadband technologies. In this case, content that may be

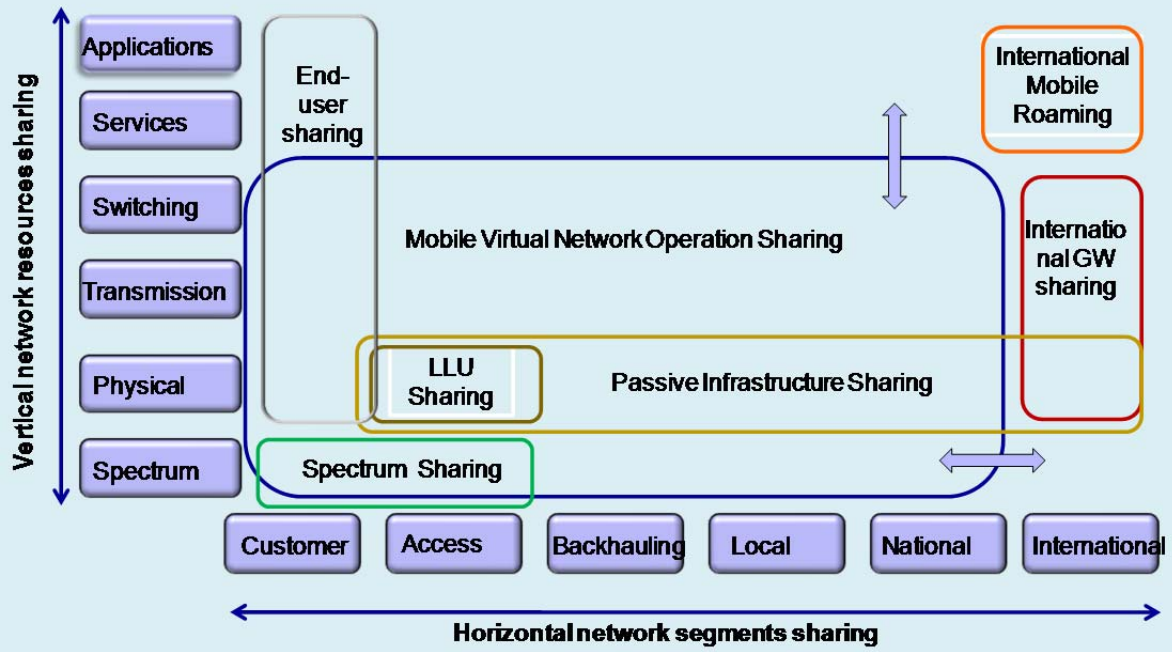
[74] ITU-Trends in Telecommunication Reform 2008: Six degrees of sharing: Innovative Infrastructure sharing and Open Access Strategies to Promote Affordable Access for all.

expensive is distributed through several platforms to increase revenues, reduce return investment period and help quicker broadband deployment.

- *End-user sharing*: End-user sharing started due to availability constraints or cost saving (ie.: line sharing between two customers, public phones) and is being extended for the new IP technologies for the same reasons in developing countries and now includes computing resources and content (such as social networks) that generates new network flows and business benefits.

Due to the rapid evolution of network capabilities and services, new sharing domains appear constantly. Major technical challenge for sharing is derived from the constant evolution of technologies and related interfaces that do not facilitate a stable definition of borders for sharing; this is easier when all networks belong to the same technology. A way to facilitate a more generic mapping is proposed to organize all network elements across technologies on a clear assignment to network layers in the vertical domain (i.e.: spectrum, physical, transmission, switching, services , applications) and, network segments in the horizontal domain (i.e.: customer, access, backhauling, local/edge, national, international). Figure 39 illustrates in graphical form mapping of the most frequent sharing domains, represented by the seven boxes in the middle, to network segments in the horizontal axis and network resources in the vertical axis[75].

Figure 39: Mapping of sharing domains to network segments and network resource layers



Source: O. González Soto

[75] Sharing domains and mapping to network resources. O. Gonzalez Soto. Workshop on NGN Regulation and Migration Strategies: TRCSL, Colombo, Sri Lanka. October 2010

3.2.5 Quality of service

Quality of service as defined by ITU-T[76][77] is "a set of service requirements to be met by the network while transporting a Connection or flow; the collective effect of service performance which determine the Degree of satisfaction of a *user* of the *service"*. Various documents on the P, E and Y series define and recommend parameters to be considered and quantified in order to fulfill performance in relation to customer expectations.

In a wide sense QoS may be considered as a characterization of service accessibility and quality both with quantitative and qualitative (user perception) parameters and values to have a good reference of the associated performance that end-users could obtain and is an area that has been part of telecommunication regulation from the very beginning.

Best practices for the evaluation of QoS are those that consider all the following interrelated domains:

- Grade of Service;
- Service accessibility: Capability to access a service;
- Connection establishment: Performance on the process to get connection;
- Information transfer: Quality of information delivery;
- Reliability: Failure probability for an established connection;
- Availability: Probability of system being active for expected capacities;
- Survivability: Capability to provide service in abnormal conditions;
- Security**:** Protection levels both for involved systems and handled information;
- Qualitative: Intelligibility, audibility, visualization, etc. of information content as derived from user perception.

In order to reach the desired values of QoS, framework architecture and a series of mechanisms are recommended by the ITU Y series[78] at the control, data and management planes as indicated in Figure 40.

Different flows within NGN requiring different priorities and classes of treatment are defined as a function of the degree of detail in network processing. Most common QoS classes are defined in the guidance given in Figure 41 for different application examples and their corresponding node and newtwork techniques to be applied. It has to be taken into account that quick evolution of services and technologies may require an extension or update of those classes.

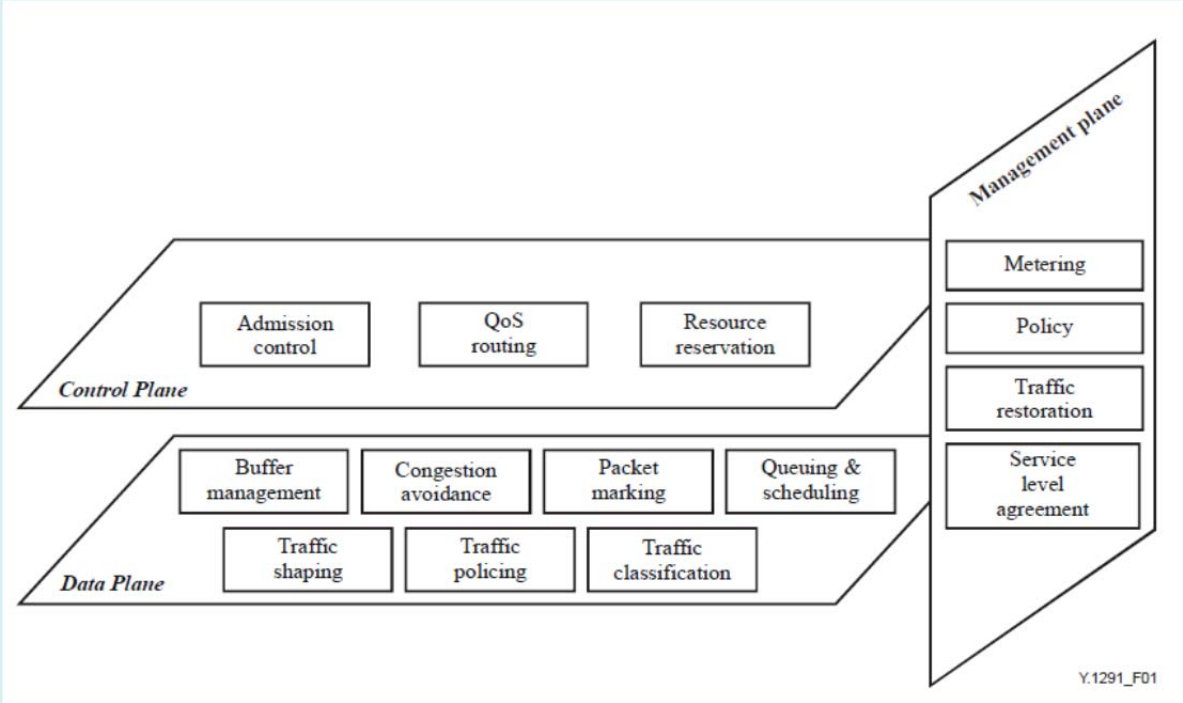
For each of the previously identified five classes to be differentiated, a set of values are defined for the key network performance parameters given in the Figure 42 in such a way that quality perceived by the user corresponds to the user expectations.

[76] ITU-T, E series and E.360.1: Overall network operation, Telephone Service, Service Operation and Human Factors. Definition of terms related to QoS.

[77] ITU-T, Series P: Telephone Transmission Quality, Telephone installations, Local line networks; Vocabulary for Performance and QoS.

[78] ITU-T. Y-Series Recommendations: Global Information Infrastructure, Internet Protocol Aspects and Next Generation Networks. Y.1200–Y.1299, Y.1500–Y.1599

Figure 40: Y.1291 – Architectural framework for QoS support



Source: ITU

Figure 41: Y.1541 – Guidance for IP QoS classes

QoS class	Applications (examples)	Node mechanisms	Network techniques
0	Real-time, jitter sensitive, high interaction (VoIP, VTC)	Separate queue with preferential servicing, traffic grooming	Constrained routing and distance
1	Real-time, jitter sensitive, interactive (VoIP, VTC).		Less constrained routing and distances
2	Transaction data, highly interactive (Signalling)	Separate queue, drop priority	Constrained routing and distance
3	Transaction data, interactive		Less constrained routing and distances
4	Low loss only (short transactions, bulk data, video streaming)	Long queue, drop priority	Any route/path
5	Traditional applications of default IP networks	Separate queue (lowest priority)	Any route/path

Source: ITU

Figure 42: Y.1541 – IP network QoS class definitions and network performance objectives

Network performance parameter	Nature of network performance objective	QoS Classes					
		Class 0	Class 1	Class 2	Class 3	Class 4	Class 5 Unspecified
IPTD	Upper bound on the mean IPTD (Note 1)	100 ms	400 ms	100 ms	400 ms	1 s	U
IPDV	Upper bound on the $1 - 10^{-3}$ quantile of IPTD minus the minimum IPTD (Note 2)	50 ms (Note 3)	50 ms (Note 3)	U	U	U	U
IPLR	Upper bound on the packet loss probability	1×10^{-3} (Note 4)	1×10^{-3} (Note 4)	1×10^{-3}	1×10^{-3}	1×10^{-3}	U
IPER	Upper bound	1×10^{-4} (Note 5)					U

Source: ITU

From a statistical point of view, measured QoS values should be consistent in the same measurement period that should be the same for all flows in order to allow for correct aggregations and further dimensioning. In addition, for IP flows, the measurement period should be lower than in traditional circuit mode networks as holding time of packet flows is shorter than for circuit calls. Statistically measurement period should be sufficiently long to include enough packets of the desired flow, with respect to the period of typical usage/flow lifetime and user evaluation and at the same time sufficiently short to ensure a balance of acceptable performance throughout each interval and avoid non representative oscillations.

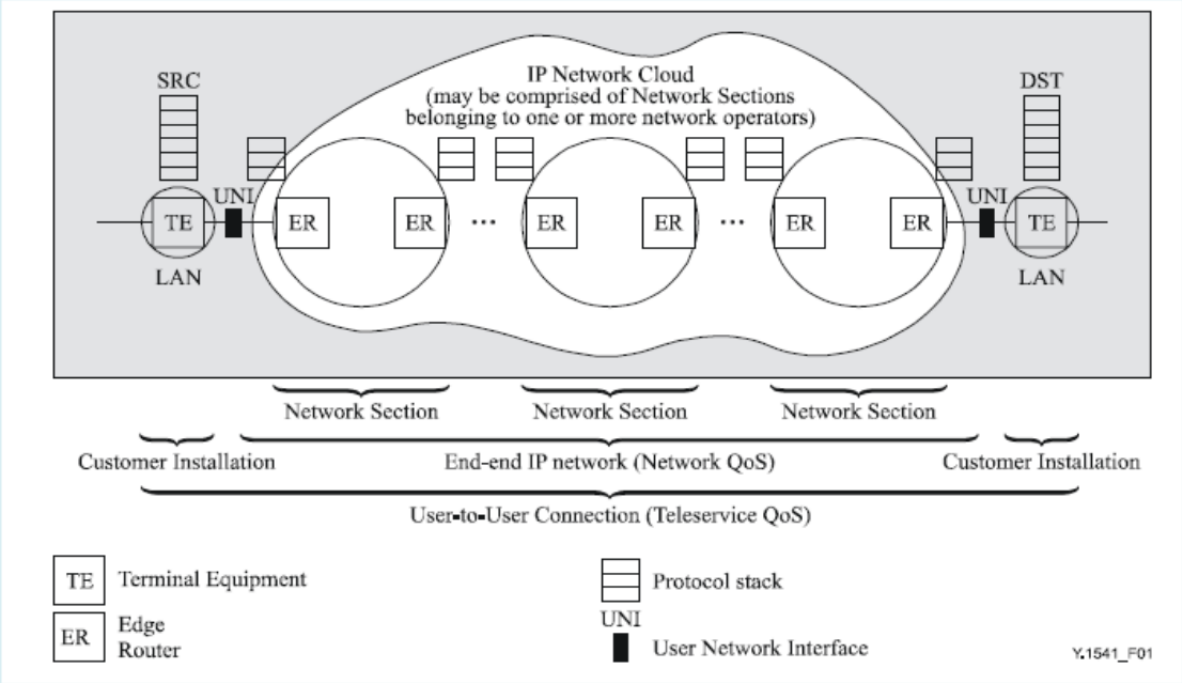
For evaluations associated with telephony, values between one and five minutes are suggested and, in any case, the value used must be recorded with the observed period and consistent for all measurements. Currently best practices use five minutes to maintain a balance between degree of detail and volume of information to be stored.

In order to evaluate correctly the end to end path of the network flows and define/distribute performance values among the different network sections, it is necessary to have a common reference network path. A definition for the path between user network interface pairs is given in Figure 43 and performance values for each section should take into account reference distances and technology capabilities in each case.

Very recently and due to the multiplicity of multimedia services, the concept of quality of experience has been incorporated into the evaluations as indicated in Figure 44 and comprises, in addition to the network paths, the customer equipment performance and the subjective perception by the user[79]. For the user equipment, a technical measurement may be carried out, as with external networks but, for user perception, customer satisfaction enquires are also needed by sampling. This is important for instance in video quality perception in which experts panels are used to convert a qualitative perception in a quantitative comparable value. The systematic treatment of quality of experience is the subject of research activities between leading operators and research institutes.

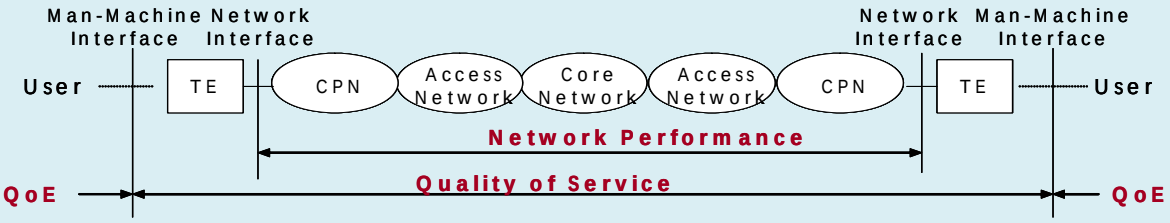
[79] ITU-D/271907 Annex 1

Figure 43: Y.1541 – UNI-to-UNI reference path for network QoS objectives



Source: ITU

Figure 44: Scope for network performance, QoS and QoE



Quality of Experience	Quality of Service	Network Performance
User oriented		Provider oriented
User behavior attribute	Service attribute	Connection/Flow element attribute
Focus on user-expected effects	Focus on user-observable effects	Focus on planning, development (design), operations and maintenance
User subject	Between (at) service access points	End-to-end or network elements capabilities

Source: ITU

3.2.6 Security, privacy, lawful interception

A variety of risks appear in network operation both for the network operator, the third parties and for the customer that are set out by ITU-T[80] in the following groups:

- *Denial* of service access either by overflowing a target, information altering or blocking a resource;
- *Interruption* of a service or network subsystem by an attack on availability once service was established;
- *Destruction* of information or a network element by an attack on availability, deletion of data or modification of the access rights;
- *Corruption* of information content by an attack on integrity or modification of the stored information;
- *Removal* of information by theft or loss by an attack on availability to critical data like billing, service usage, etc.;
- *Disclosure* or unauthorized access to an asset by an attack on confidentiality.

When considering the networks from the vertical layering point of view, each layer has specific risks, vulnerabilities and threads so it is convenient to have a hierarchical grouping of the problems.

Infrastructure Security Layer: Considers all physical and network equipment elements such as switches, routers, transmission nodes, links, storage, energy suppliers, cables, etc. It takes into account not only the elements in isolation but, especially important, their interrelation in the network topology and connectivity, being the topology itself a fundamental element of the overall security.

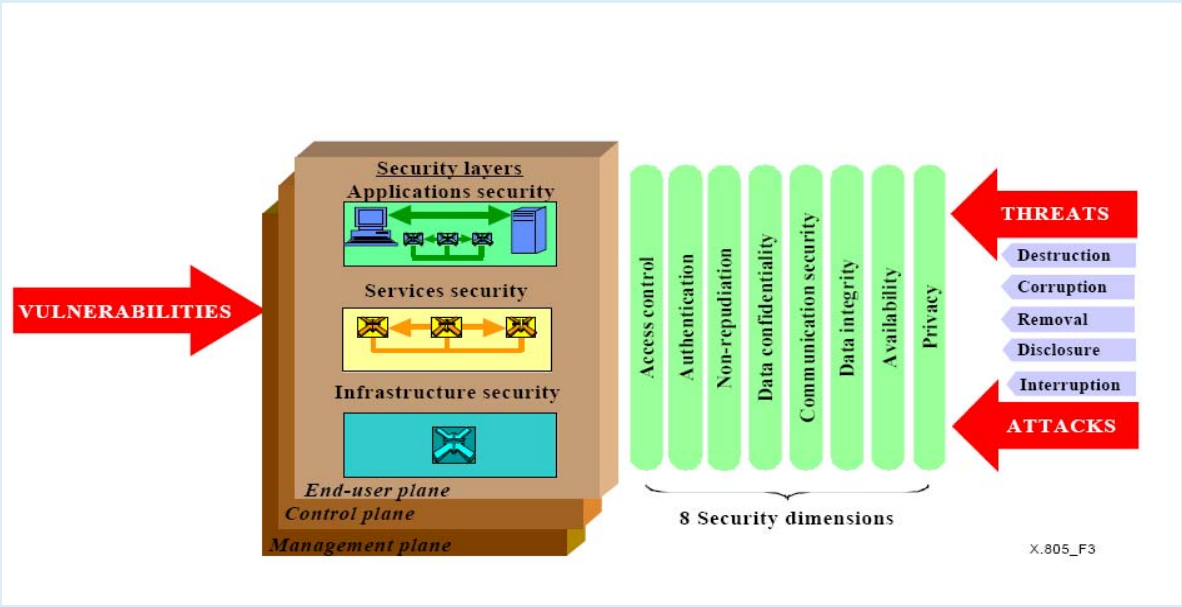
Service Security Layer: Includes the individual services or service bundles provided to the customers such as VoIP, IPTV, IM, LBS, PtT or any combination of these. Those services are based on service delivery platforms and may be provided directly by the own operator or in combination with third parties. The fact that open service provision uses open interfaces or application program interfaces (APIs) implies a new set of risks that have to be managed in strong relation with agreed trust relations among players.

Applications Security Layer: Takes into account all applications either directly used by customer services at the service provider, by third parties or by the operator itself in order to ensure a correct internal operation. Network elements considered here are all the application servers (AS), data centers, web servers, presence based servers, contact centres, etc.

A further observation shows that for each of these network layers, vulnerabilities may apply to the end-user plane, control plane or management plane that should be considered in security management and prevention as illustrated in Figure 45.

[80] ITU-T recommendation X.805: Security architecture for systems providing end-to-end communications

Figure 45: Architecture and dimensions proposed by recommendation ITU-T X.805 to provide security in NGN



Source: ITU

During all transition phases, the various network elements identified in Figure 46 are candidates for attacks and require specific security actions at their interfaces, both for the trusted networks of the same category and implemented security measures, as well as for the un-trusted with different technologies or unknown status.

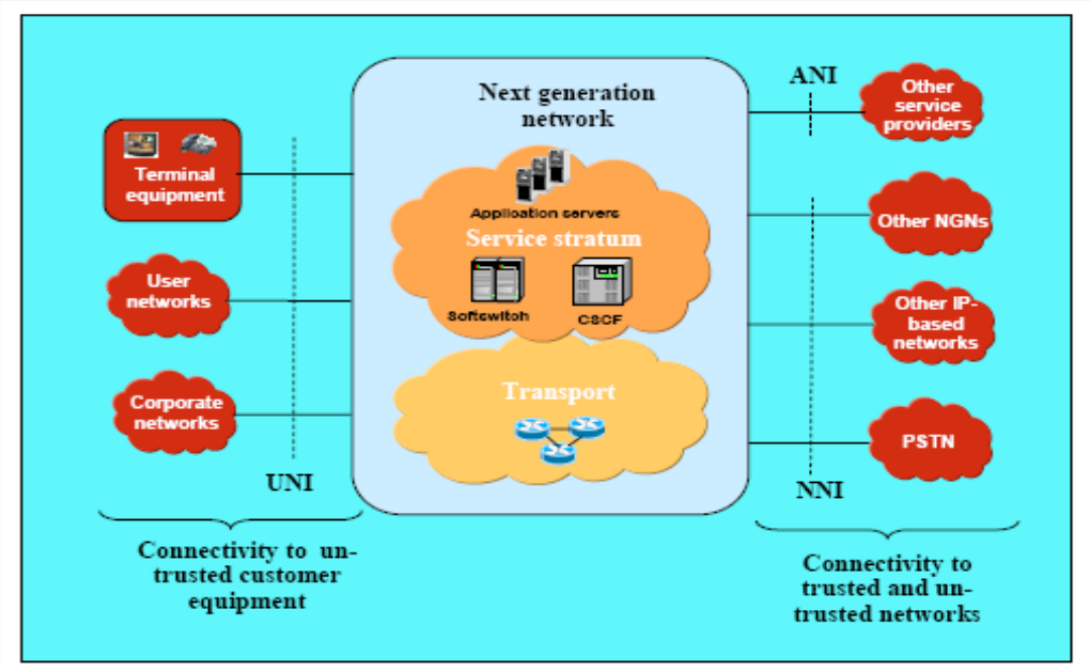
"Lawful Interception (LI) describes the lawfully authorized interception and monitoring of telecommunications pursuant to an order of a government body, to obtain the forensics necessary for pursuing wrongdoers"[81]- Lawful interception plays a crucial role in helping law enforcement agencies to combat criminal activity for all types of cybercrime like terrorist acts, data theft, drugs traffic, pedophilia networks, industrial attacks, etc. Lawful interception of public telecommunications systems in each country is based on national legislation in that country.

ETSI and ITU define the basic entities and flows involved in LI[82] as indicated in Figure 47. Network operators, access providers and service providers should be involved in the process with the request initiated by the law enforcement agency that analyzes information through the corresponding monitoring facility. The LI system must provide transparent interception of specified traffic only, and the intercept subject must not be aware of the interception. Additionally, the service provided to other uninvolved users must not be affected during interception.

[81] Technical Aspects of Lawful Interception: ITU-T Technology Watch Report 6. May 2008

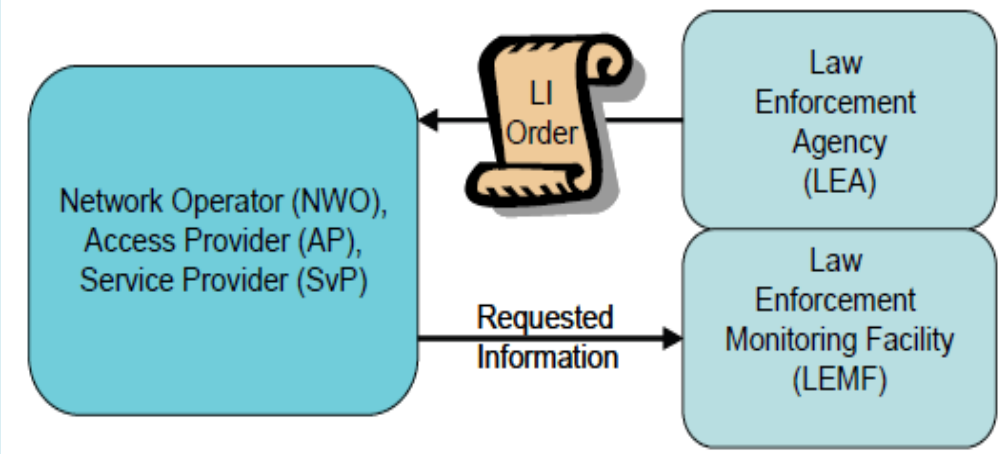
[82] Technical Aspects of Lawful Interception: ITU-T Technology Watch Report 6. May 2008

Figure 46: Elements to be considered for the analysis of security in NGN



Source: ITU

Figure 47: Organization of the lawful interception among involved actors



Source: Adapted from ETSI TS 101 331, Definition of interception

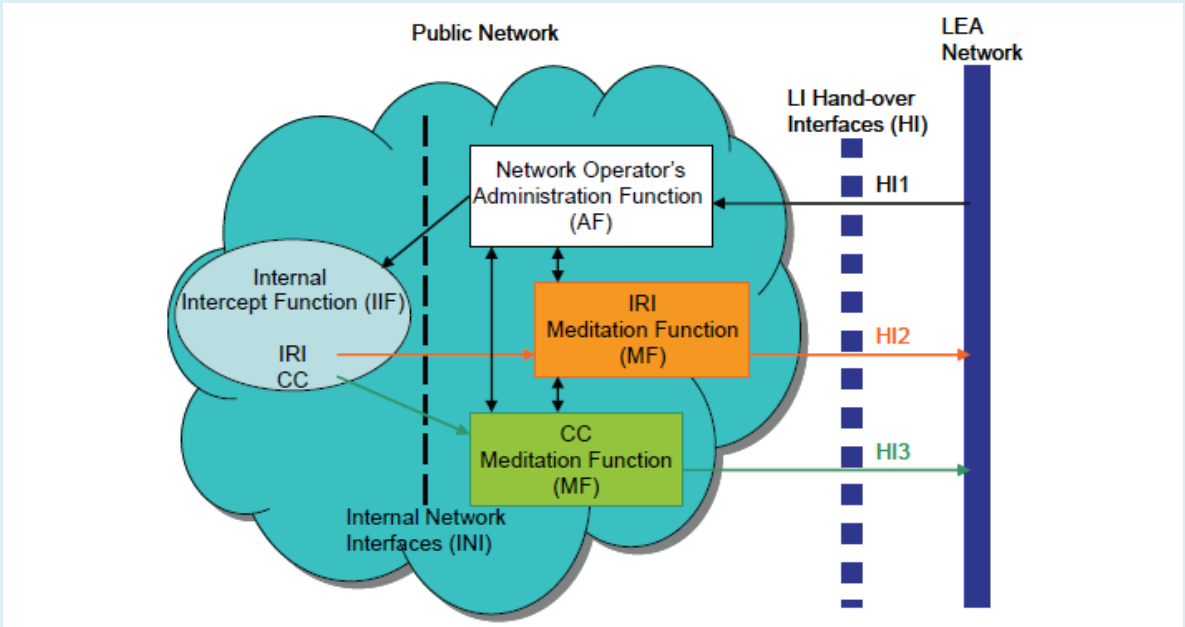
Furthermore, ETSI and ITU adoption also defined a functional architecture for LI in Figure 48 in order to facilitate economic implementation complying with national and international legislation and facilitating interoperability between different networks and operators. The network architecture requires that there be distinct separation between the public telecommunication network and the law enforcement network, with standardized interfaces that manage the hand-over of data between both networks. Three functions are responsible for the work within the public telecommunication network:

- The Administration Function (AF) receives interception orders from the law inforcement agency and hands them for internal processing.

- Internal Intercept Functions (IIF), which are located tactically within network nodes and generate the two desired types of information, Content Communication (CC) and Intercept Related Information (IRI).
- Meditation Functions (MF) take charge of delineation between the two networks. They implement Internal Network Interfaces (INI), which may be proprietary, to communicate within the public telecommunication network, and standardized interfaces, to deliver requested information to one or more Law Enforcement Monitoring Facilitie(s).

Adaptation of legislation to the new threats and technology potential should be performed by all countries including the technical capability to retain data in case a further analysis is required (frequently six months) to facilitate follow up.

Figure 48: Generalized view for the architecture of the lawful interception



Source: Adapted from ETSI TS 201 158

3.3 NGN migration and deployment strategy

3.3.1 Overall strategy

Best practice cases within countries with advanced levels of ICT development carefully plan the introduction of new services in parallel with network modernization for IP in order to satisfy demand for broadband capacity and ensure a positive return on investments in the medium term (two to five years). This planning includes the following activities:

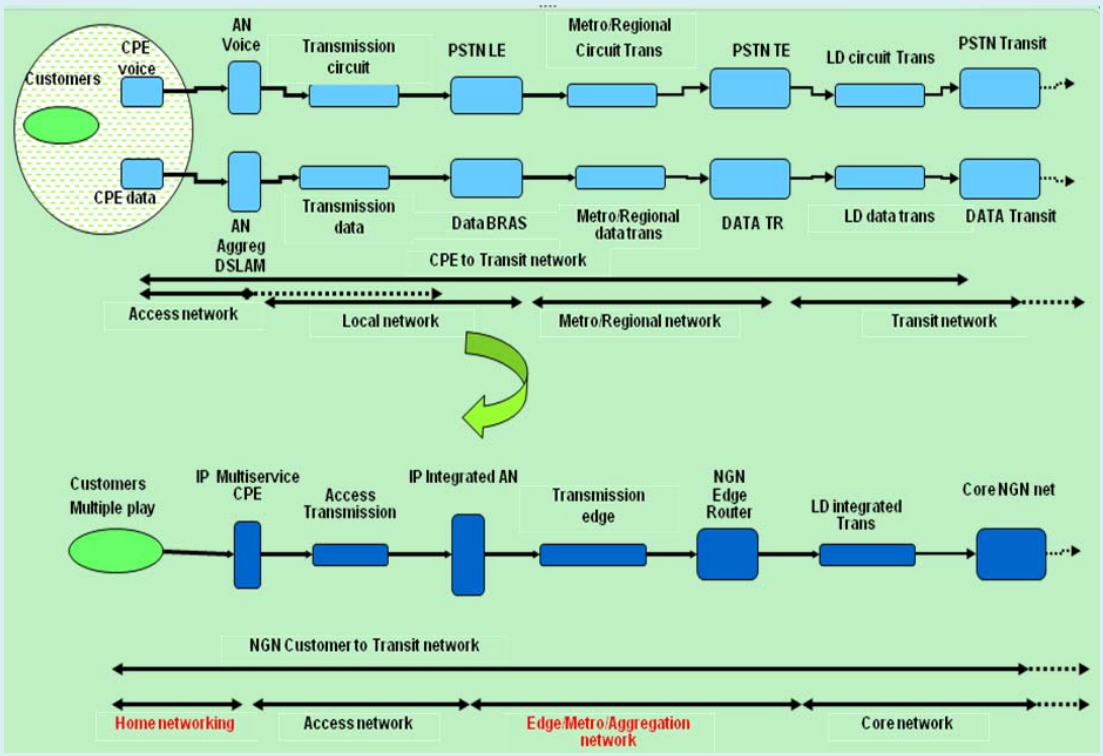
- services demand projection;
- network design and dimensioning for all segments;
- testing of field trial NGN equipment and training operational teams;
- performing business planning for deployment alternatives and speeds;
- deployment of NGN network phases according to business evaluation results with a cap and growth strategy at all network segments: access, core and edge;
- upgrading OSS/BSS systems for automation of processes and treatment of new services requirements;

- operation of new network with management of new services and equipment providing feedback for next phase;
- cyclic realization of previous activities (demand-business-dimensioning-deployment-operation) until all network migrates towards the NGN mode.

From a topological point of view: reduction of number of layers and upper level nodes due to the much higher capacity of nodes and links.

From the end to end network segments point of view: redefinition of segments and segment borders[83] as in Figure 49 due to the new roles of the local/edge segment in the flow aggregation/control and the integration of metro and local segments. A much higher importance of the home equipment and functionality generates the "home networking" segment that is going to change the distribution of intelligence across the overall network.

Figure 49: Migration from the traditional network segments for voice and data towards NGN integrated network segments

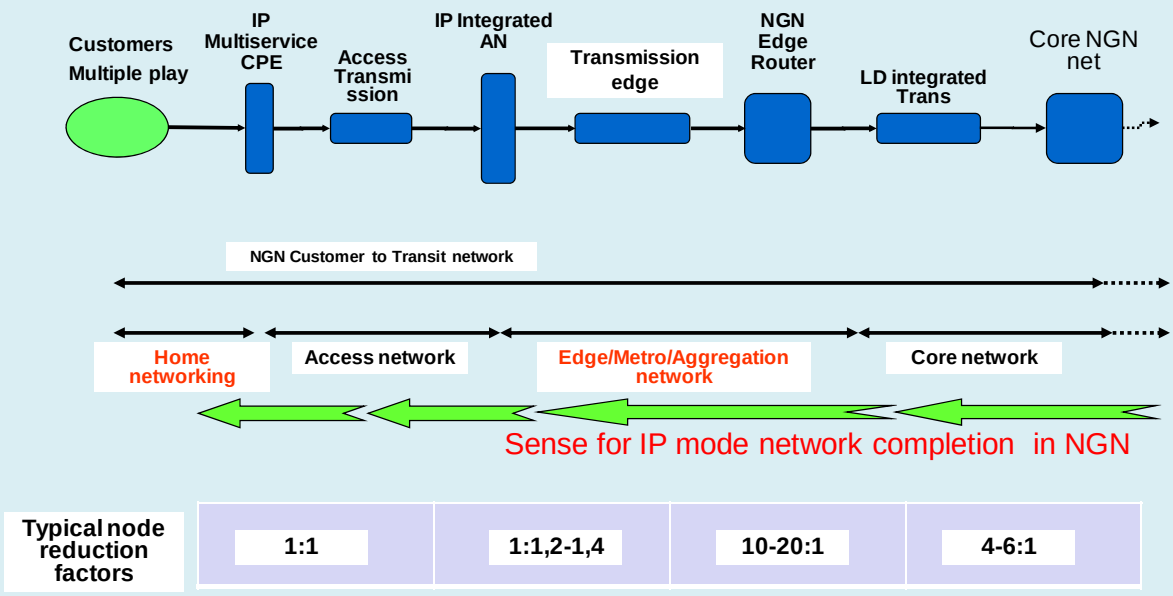


Source: O. González Soto

From NGN deployment point of view: the completion follows the ordering as indicated at Figure 50 below and the reduction of nodes is a function of the degree of optimization of the network when migration starts. Typical reference ratios imply a strong reduction in the upper network nodes and equal number or slight increase at the last access network elements due to the need to shorten local loop lengths.

[83] Linear network segments for NGN. O. Gonzalez Soto: ITU-D Regional Development Forum for the Asia Pacific Region NGN and Broadband, Opportunities and Challenges. Yogyakarta, Indonesia, July 2009.

Figure 50: Typical ratios between existing and new nodes with ordering for update completion



Source: O. González Soto

Implementation of control functions is gaining favour towards the IMS architecture that is now maturing and has the following advantages:

- Service delivery with IMS integrated architecture provides important advantages over the classical "pile" separated applications and functionalities once the structure is implemented. The main advantage is the higher flexibility of the IMS functionality to adapt to the customer services, irrespective of the technology they use and the access method to reach the network.
- Savings in time and effort for the development and deployment of a new service is considerably reduced once the architecture is ready at the network, implying economies and better time to market for a given service provider in a competitive market. This advantage in time to market will allow the service provider a higher capture of new customers, better market share and reduction of churn.
- Efficient introduction on new services at a lower cost will increase the service provider revenues, ARPU and profitability which is the major business driver for the healthy operation, market growth and financial results.
- From the end customers' point of view, a common use and feel for all services and applications will facilitate the higher utilization of services and better personalization of functions to specific requirements.

Due to the initial stages of IMS implementation, a phased approach is required that will take, as in all network transitions, several years. It has to be taken into account that availability of a core NGN IP based network is a prerequisite for an IMS solution and an end to end all IP needed for a fully fledged IMS solution.

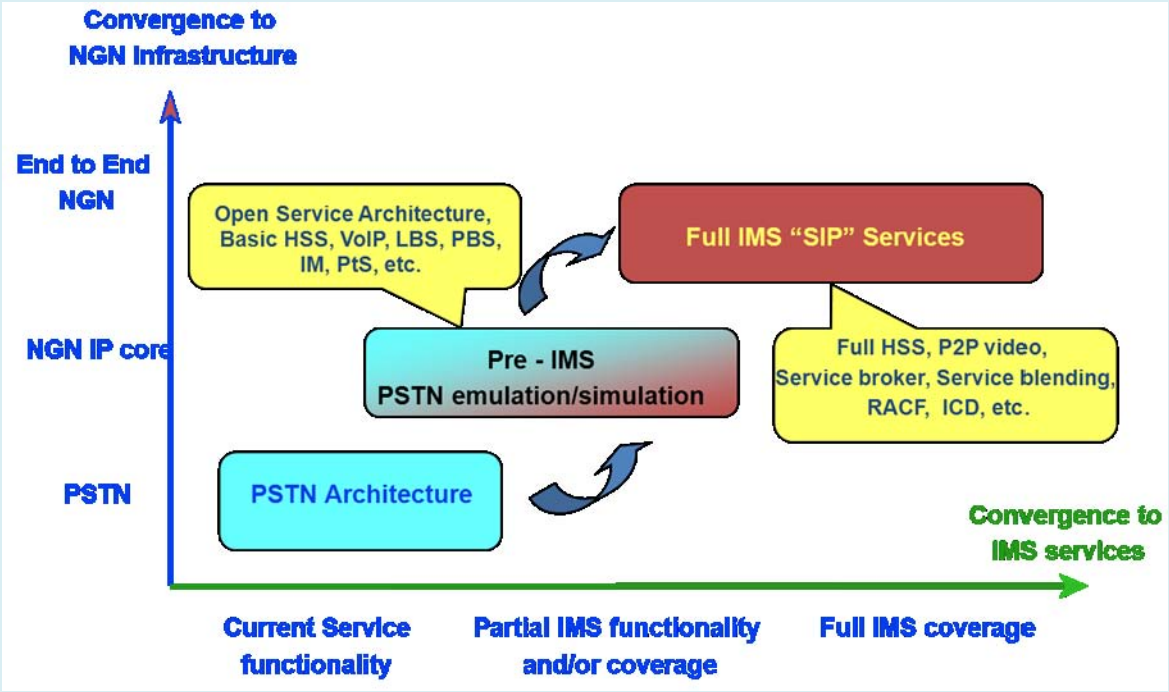
- At a first phase, the Open Service Architecture and a basic Home Subscriber Server (HSS) are mandatory from the starting process in the so called Pre-IMS or Early-IMS that will implement the easiest user entity supporting IPv6. PSTN emulation and simulation are used in order to extend services to all customers either connected to the full IP NGN or conventional TDM. Services expected to have priority in this phase include VoIP, Location Based Services (LBS), Presence Based Services (PBS), Instant Messaging (IM) and Push to Speak (PtS).

- At a later phase, an ambitious fully fledged IMS solution requires, in addition, a more complete end to end NGN infrastructure, complete coverage of SIP with a full functionality of the application servers and HSS. User entities need to support IPv6 and the corresponding facilities of the IPsec are exploited. Services expected at this stage include Peer to Peer video (P2P), Service Broker (SBr) function to manage interactions among applications, Service Blending (SBle) for services grouping and personalization, Resource Acceptance Control Function (RACF) to ensure QoS with a common network policy for resource management across network subsystems and Intelligent Content Delivery (ICD).

From the overall network functionality point of view IMS introduction should be coordinated with the migration to NGN in all network segments and the introduction of IP mode at end to end is a prerequisite for a fully fledged IMS solution with all services potential.

Due to the initial stages of IMS implementation, a phased approach is required as proposed in Figure 51[84] that will take, as in all network transitions, several years.

Figure 51: Coordinated convergence for the NGN infrastructure and the full IMS services



Source: ITU

IMT 2000 advanced: In parallel to the modernization for the entire fixed network infrastructure, the mobile network is evolving at the same pace within the upper network segments (Core and Edge) with the corresponding evolution in the radio related part towards the IMT 2000 advanced[85]. It should be noted that the full NGN core network and edge/metro IP capabilities are needed for technologies up to 3.xG and the full end to end IP is required for 4G that implies coordination for both evolutions within the

[84] ITU-D – Reference manual on network planning for evolving network architectures, 2007. Chapter 6.4: Converged Networks. www.itu.int/ITU-D/tech/NGN/Manual/Version4/NPM_V04_February2007.pdf

[85] ITU-R – ITU global standard for international mobile communications ´IMT advanced´

convergence process and ensuring backwards compatibility for voice between the circuit mode and packet mode handling.

Rich Communication Suite[86]*:* In order to exploit the high capabilities of IMS based NGN technologies with new services and revenues, the Rich Communication Suite (RCS) initiative has been launched as a cross-industry group by main industry players and is focused on the provision of rich communications on top of voice services both on mobile and fixed environments. Major operators, manufacturers and device vendors are involved with a leading implementation by Telefónica – Movistar/ TIM and Orange in the European region with KT / NTT in the Asia-Pacific region.

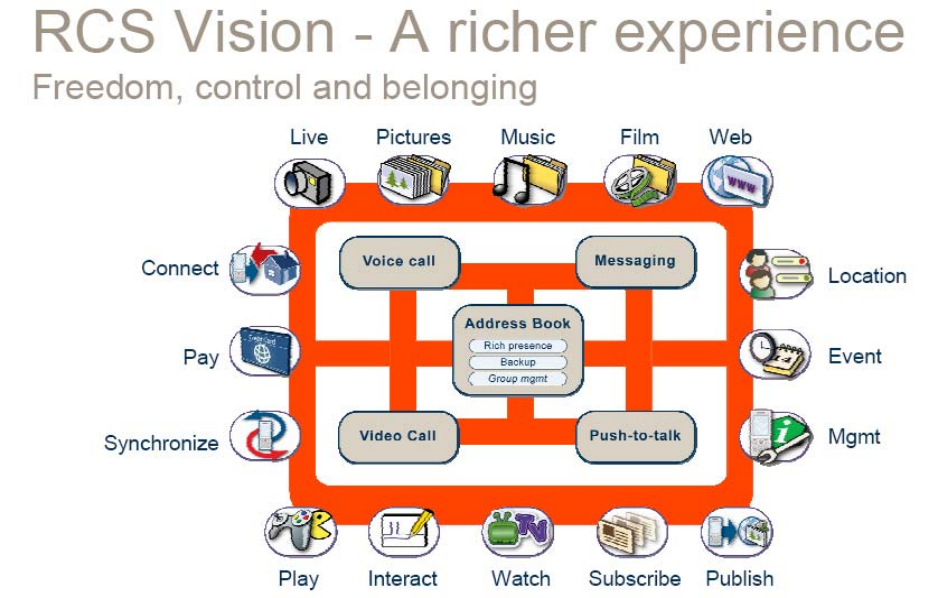
Primary features of RCS are:

- Enhanced directories, with service capabilities and presence enhanced contacts information.
- Enhanced messaging, which enables a large variety of messaging options including chat and messaging history.
- Enriched call, which enables multimedia content sharing during a voice call.

The initiative pursues a wider and large scale IMS deployment, interoperability between different terminal vendor RCS clients and RCS service interworking between operators.

Current developments are oriented towards a structured organization of services as indicated in Figure 52 with specific protocols to ensure interoperability across different domains of multimedia services with shared contents.

Figure 52: Structure and service categories considered for standardization in the Rich Communication Suite



Source: RCS

[86] RCS: www.richcommunicationsuite.com/initiative

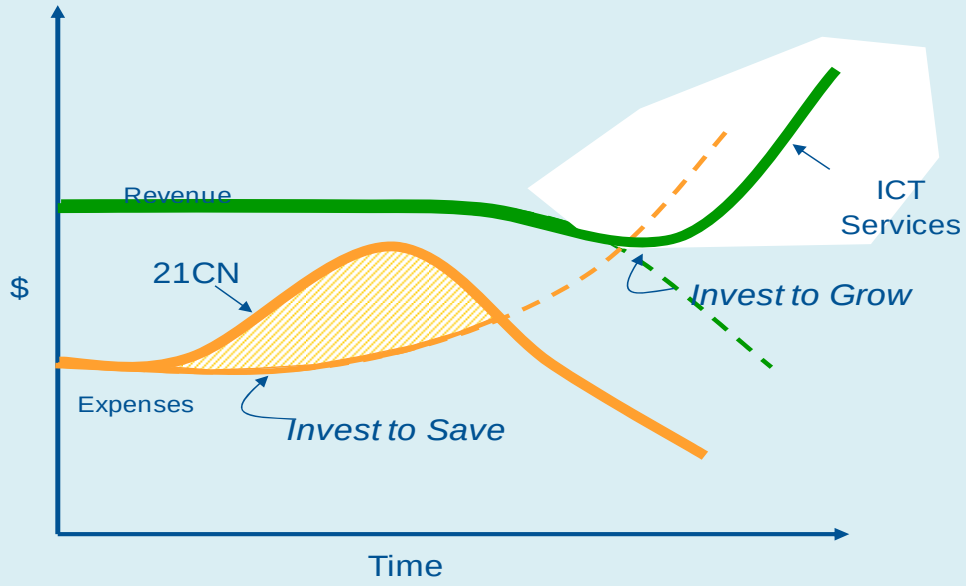
The case of BT modernization[87] is one of the most representative examples of migration as it was planned very early with an overall perspective and complete application of the planning cycle. Also BT published the main phases for the evolution with quantitative values. Figure 53 illustrates the projection for the investments and revenues associated to the network modernization and the introduction of ICT services.

The evolution of the network architecture is very well illustrated in Figures 54 and 55 with the existing and new number of nodes per technology. Currently 20 core nodes of high capacity are installed and 120 edge/metro network aggregator nodes are being completed.

The functional structure of the intelligence control nodes (i-Node) is provided in Figure 56 with the policy control functions OSS/BSS and NM for all customer types. Initial implementation started with the existing soft switching technology and is migrating towards IMS.

Currently all BT core network and more than 50 per cent of the local/access network segments has migrated to NGN technologies and the present phase is extending capacities for very fast speed access with the New Generation Access (NGA).

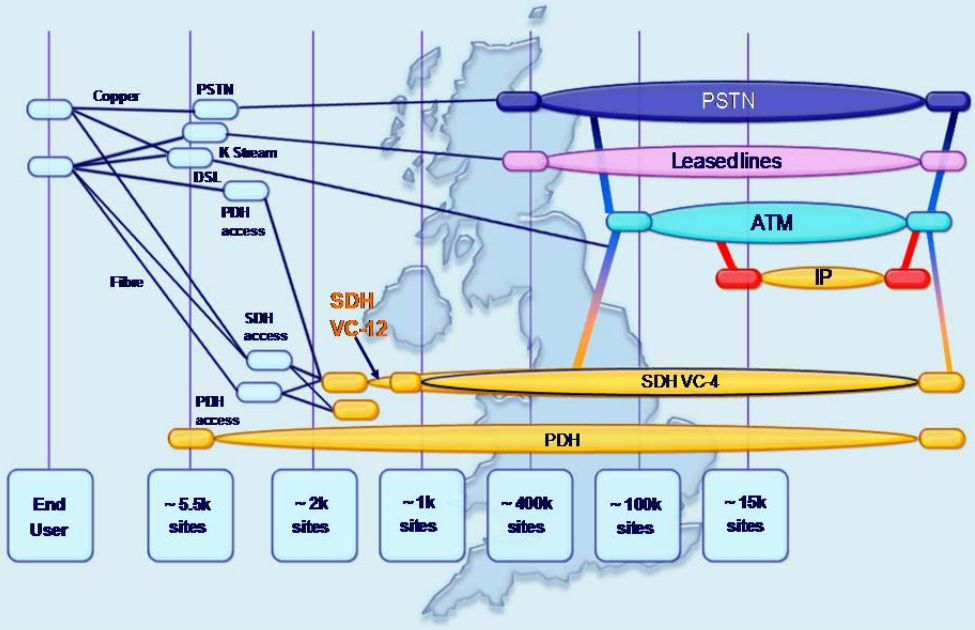
Figure 53: BT projection plans for investments and revenues with 21 core nodes (CN)



Source: Forum on Next Generation Standardization, Colombo, Sri Lanka, 7-10 April 2009. Nigel K J Dye

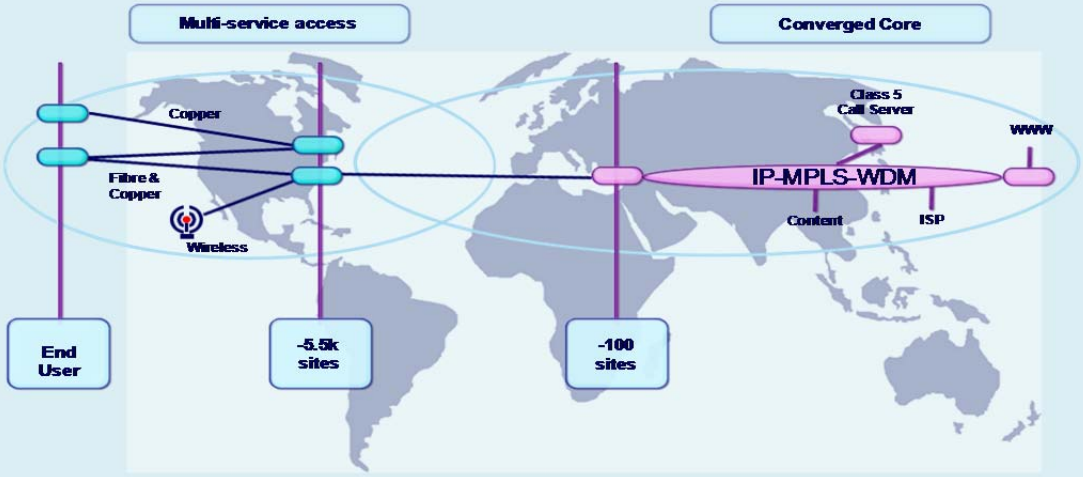
[87] 21st Century Network (21CN). Forum on Next Generation Standardization, Colombo, Sri Lanka, 7-10 April 2009. Nigel K J Dye

Figure 54: BT network historical structure before migration to 21 CN



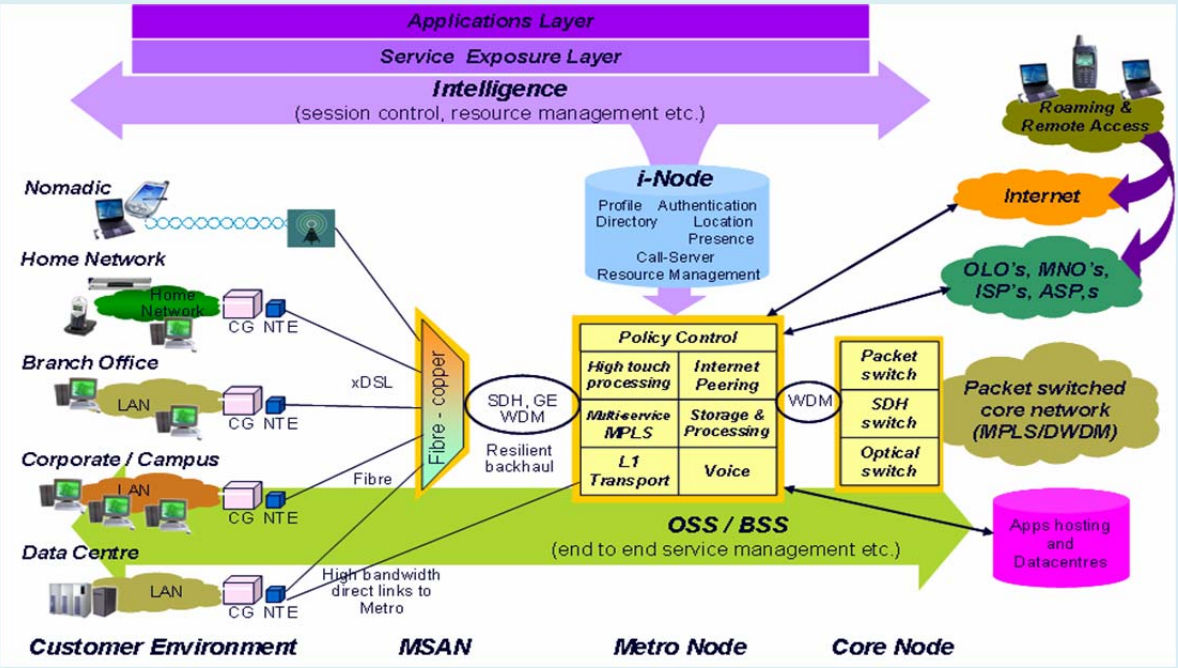
Source: Forum on Next Generation Standardization, Colombo, Sri Lanka, 7-10 April 2009. Nigel K J Dye

Figure 55: BT 21 CN structure after migration to NGN



Source: Forum on Next Generation Standardization, Colombo, Sri Lanka, 7-10 April 2009. Nigel K J Dye

Figure 56: Intelligence controlling network resources at BT 21 CN



Source: Adapted from Forum on Next Generation Standardization, Colombo, Sri Lanka, 7-10 April 2009. Nigel K J Dye

3.3.2 Transit network segment

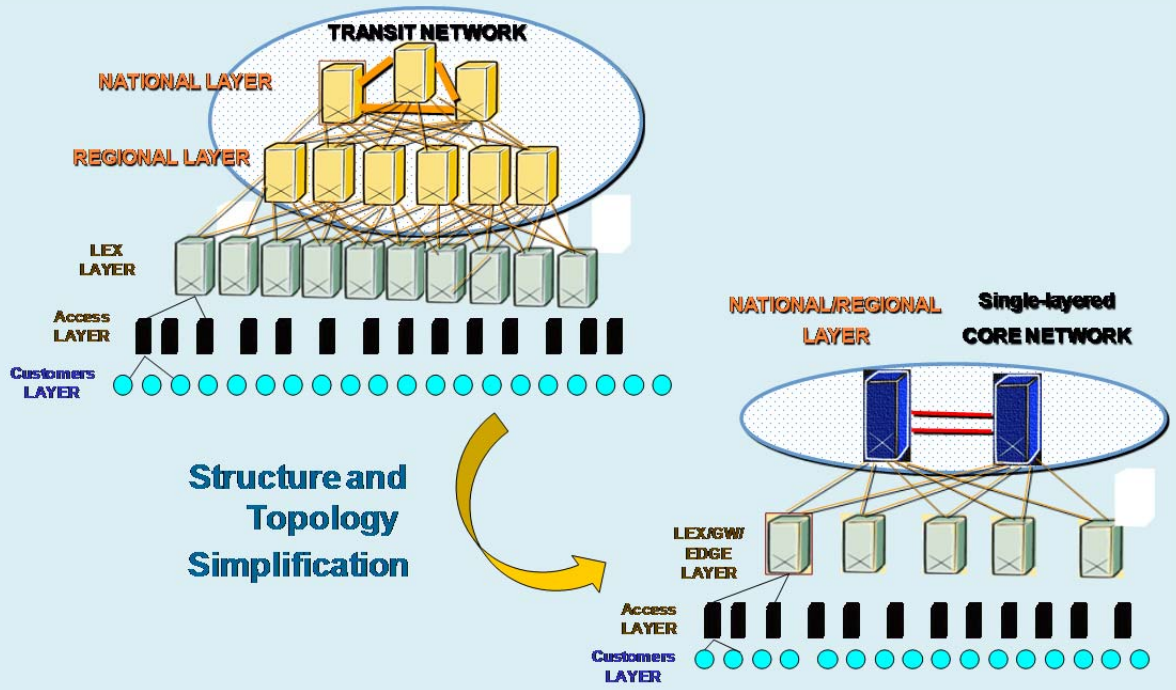
The role of transit or equivalent core network in NGN is the routing of high capacity traffic flows at the upper network layer with the following best practices:

- Design new topology with less layers and nodes and more connectivity (greater than three) to ensure full capacity when a single failure of a node, a link or a route occurs.[88]
- High protection for nodes and routes, both at physical and functional levels.
- Overlay deployment for full coverage in all regions to assure homogeneous end to end connections (usually between two to three years).
- Strong requirements for high levels of QoS, protection and survivability with implementation of active quality assurance mechanisms.
- Re-optimization for location of new nodes as the number will be much lower than the classical TDM and similar for the network interconnection points
- According to the network and services maturity, start either with softswitches for conventional services and SS7 compatibility until IMS is fully operational or directly towards IMS with SIP protocol for all IP new services.

Figure 57 illustrates a simplified diagram of the reduction of layers and nodes at the core segment.

[88] Topology evolution and simplification at network core level. O. Gonzalez Soto: ITU-APT Workshop on NGN Planning March 2007, Bangkok, Thailand.

Figure 57: Migration for the transit network segment to the single-layer core structure



Source: ITU

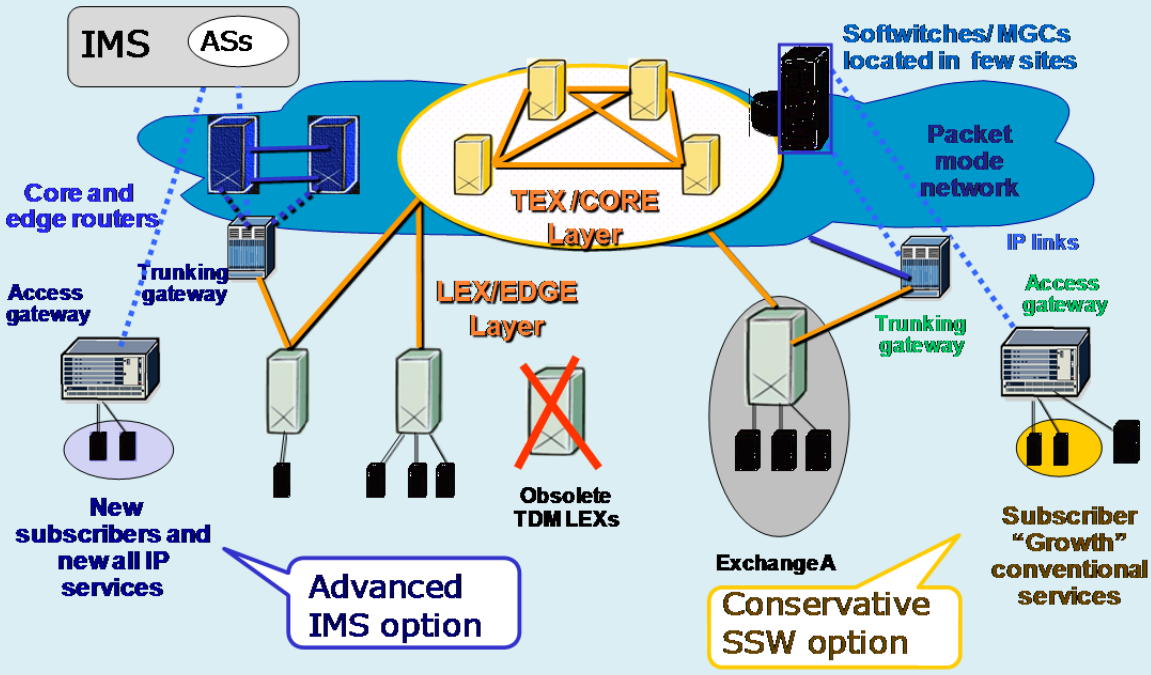
3.3.3 Local/edge network segment

The local network or equivalent edge network in NGN terminology has the role of backhauling from access to the core segment with the aggregation of traffic flows, acceptance control, location of value added servers, etc. Most common best practices are as follows:

- Design with a re-optimization of topology, location of nodes, caching, number and interfaces according to new technology capabilities and service offers.
- Introduction of IP network elements with priority in new areas and areas with obsolete PSTN equipment.
- Continue with IP implementation for high demand areas and following economic criteria based on the Net Present Value.
- Major attention given to the interoperability for multimedia services and traffic flow control according to SLA commitments.
- As a function of country geographical size and dispersion scenarios, full migration may frequently take five years or more to be completed.

The diagram in Figure 58 illustrates the substitution of existing PSTN equipment for the IP edge gateways and routers in a progressive manner either with the use of softswitches or IMS servers.

Figure 58: Migration for the local/edge network towards the NGN with softswitch and/or IMS servers



Source: ITU

3.3.4 Access network segment

Access network has the role of connecting every customer up to the local/edge network nodes at the required capacity for the offered services. Access and related investments are dominated by physical infrastructure cost and deployment time with a variety of available technologies.

The most frequent existing access structures for fixed networks and the target evolution towards an integrated NGN is illustrated[89] in Figures 59 and 60:

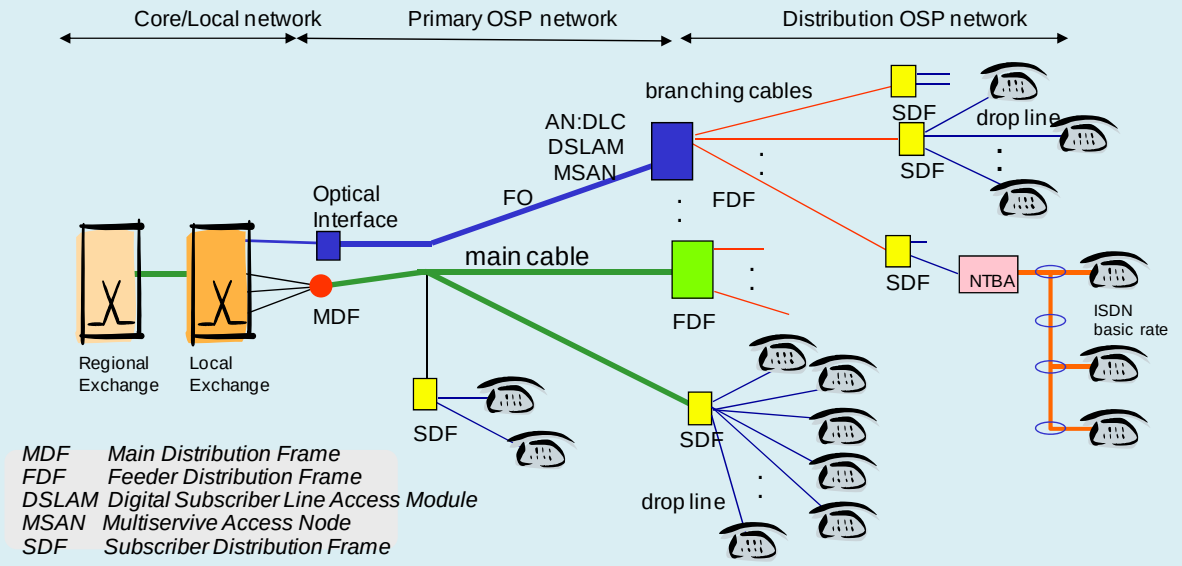
Best practices in access are strongly dependent on the country geo-scenarios, customer density, services demand, terrain topography, availability of physical infrastructure, etc. Most common actions are summarized as follows:

- Start access capacity increase by broadband access with ADSL2+ for areas within reach of existing exchanges with further extension to distant loops installing new remote multiservice nodes for a minimum of 2 Mbps (most essential services) at a distance of 5 km and 8 Mbps (most multimedia services and triple play) at 2 km.
- Introduction of VDSL for higher capacity sophisticated services and HD TV at a distance of 0.5 km.
- Introduction of FTTB and FTTH on high density, high consumption and greenfield areas for speeds up to 100 Mbps.
- Design of local loops with fibre as closer as economically feasible to the customer locations as the best topology that is future safe.
- Introduce new wireless broadband technologies for low density customer scenarios where no existing physical infrastructure is available.

[89] ITU-D – Reference manual on network planning for evolving network architectures, 2007. www.itu.int/ITU-D/tech/NGN/Manual/Version4/WP_Version04.pdf

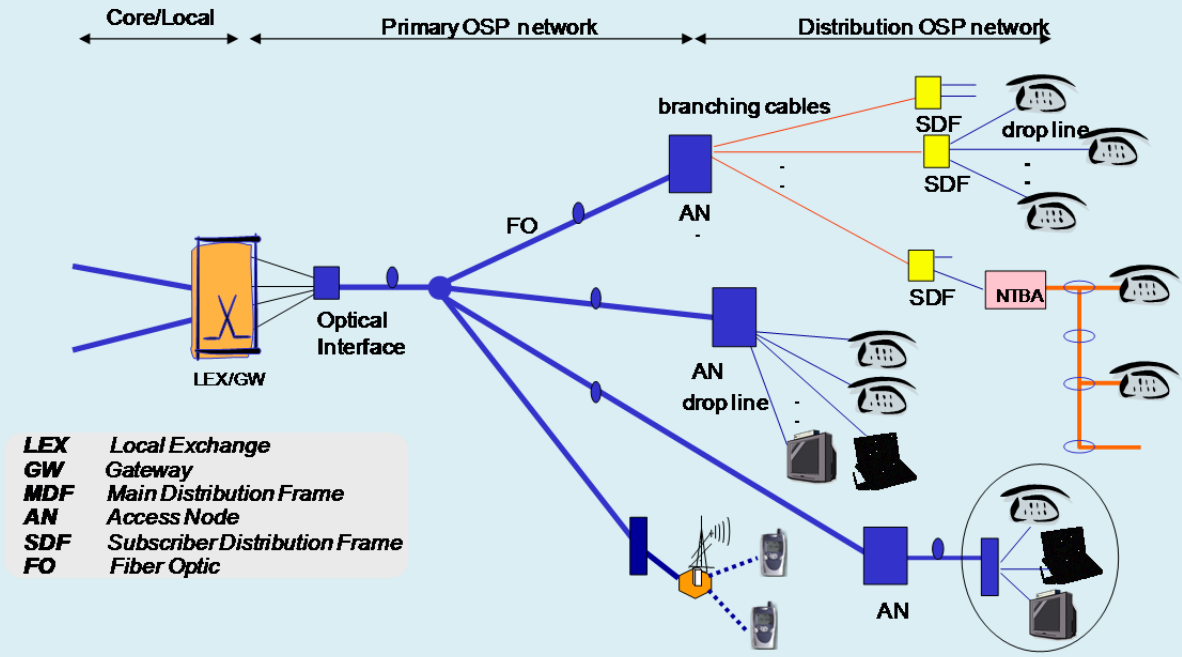
- Completion of local/edge and access migration as a function of country extension and heterogeneity when economically feasible.

Figure 59: Typical access plant structure with copper pairs and some FO



Source: ITU

Figure 60: Evolution of the access plant structure towards FO close and up to the customer

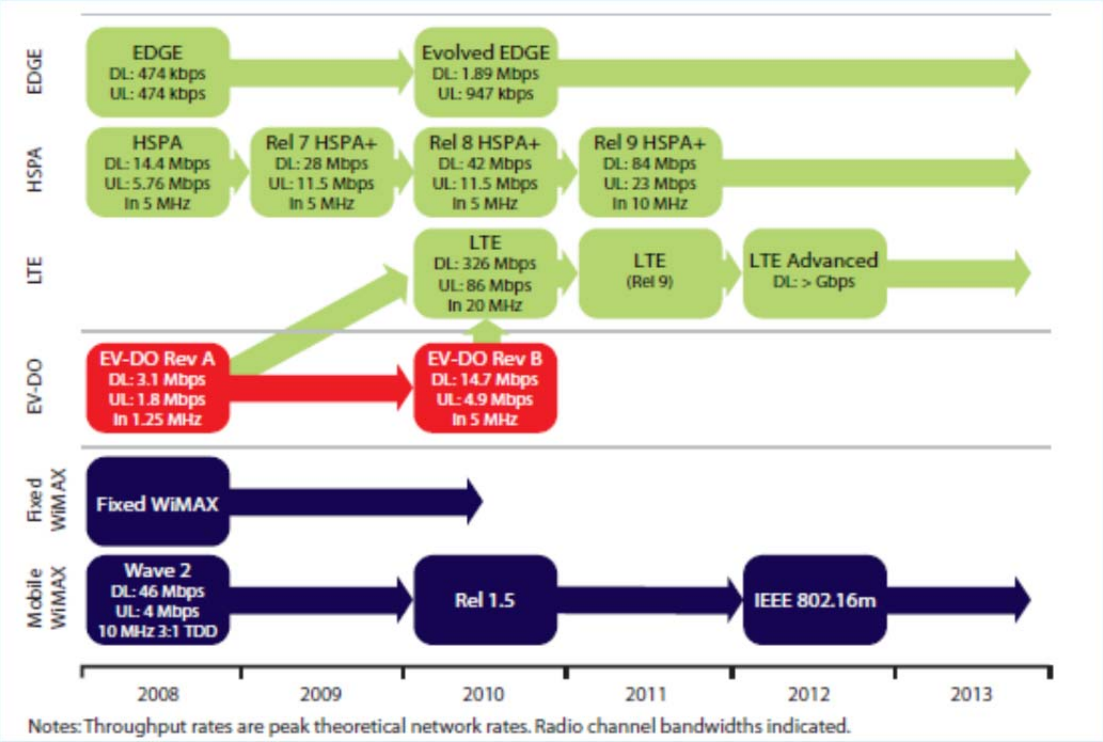


Source: ITU

Due to the investement requirements and long term deployment characteristics of the access network, segment migration towards a broadband NGN is to be the first to be started in order to benefit from the new revenues and is the last to be finished due to the high capillarity need in order to reach each customer irrespective ot its location.

Mobile and nomadic access networks have the radio design procedures as a function of coverage by frequency use within the spectrum, frequency reuse among cells and traffic capability required for the new broadband services. Expected evolution through time is summarized in Figure 61 proposed by the UMTS forum[90]

Figure 61: Timed evolution of releases and speeds per mobile technology



Source: UMTS Forum, 2010

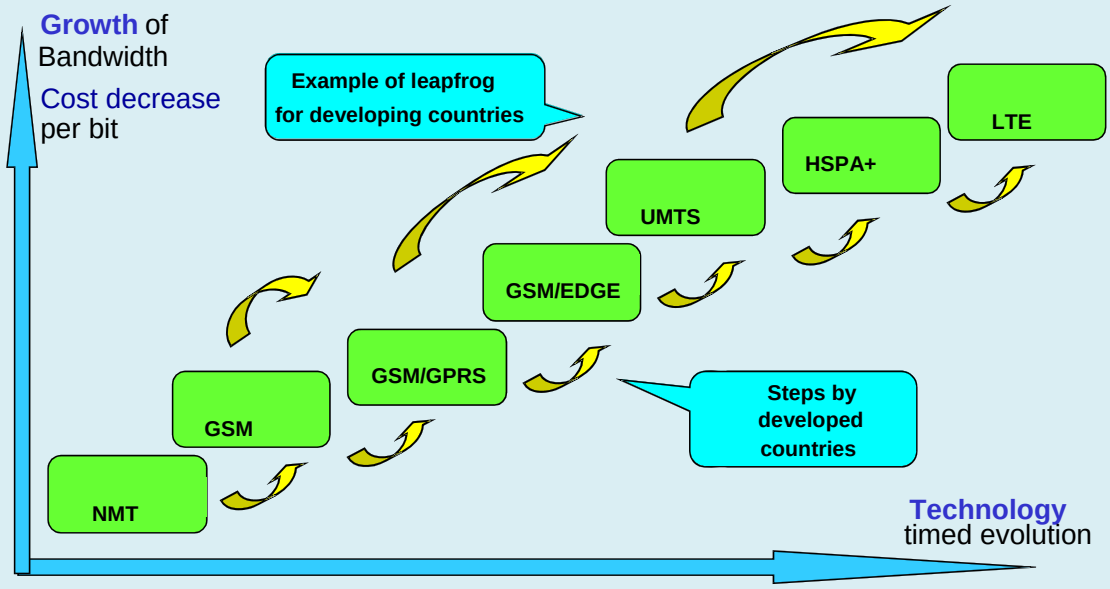
Role of mobile network, initial status and transition...

For developing countries, best practices imply the use of leapfrogging through intermediate technologies in order to benefit from the experience in developed countries, to save operational effort by minimizing number of transitions, and to reduce migration costs. The traditional six steps are reduced to three, and are selected as a function of the initial country status and new demand growth rate. An illustrative example is given in Figure 62[91].

[90] A White Paper from the UMTS Forum: Recognizing the Promise of Mobile Broadband. June 2010

[91] Convergence and Leapfrogging: O. Gonzalez Soto: ITU-D Regional Development Forum for the Asia Pacific Region NGN and Broadband, Opportunities and Challenges. Yogyakarta, Indonesia, July 2009

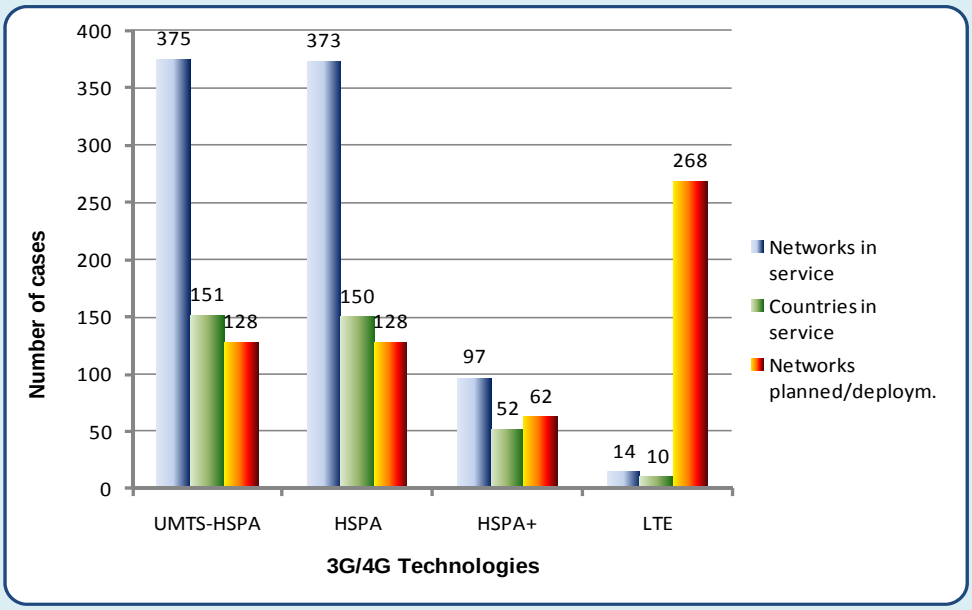
Figure 62: Potential leapfrogging in mobile technologies for developing countries as compared to developed



Source: O. González Soto

A view of current status for December 2010 for the overall number of UMTS based mobile networks and countries is given in Figure 63 that illustrates how the networks migrate towards higher capabilities. LTE is gaining momentum for new deployments and plans with ten networks operational and more than 268 planned or in deployment phase[92].

Figure 63: Distribution of mobile 3G/4G in service and planned technologies as December 2010



Source: Adapted from 4G Americas

[92] 4G Americas: Global 3G Status HSPA / HSPA+ / LTE / December 2010. www.4gamericas.org

3.3.5 Interconnection

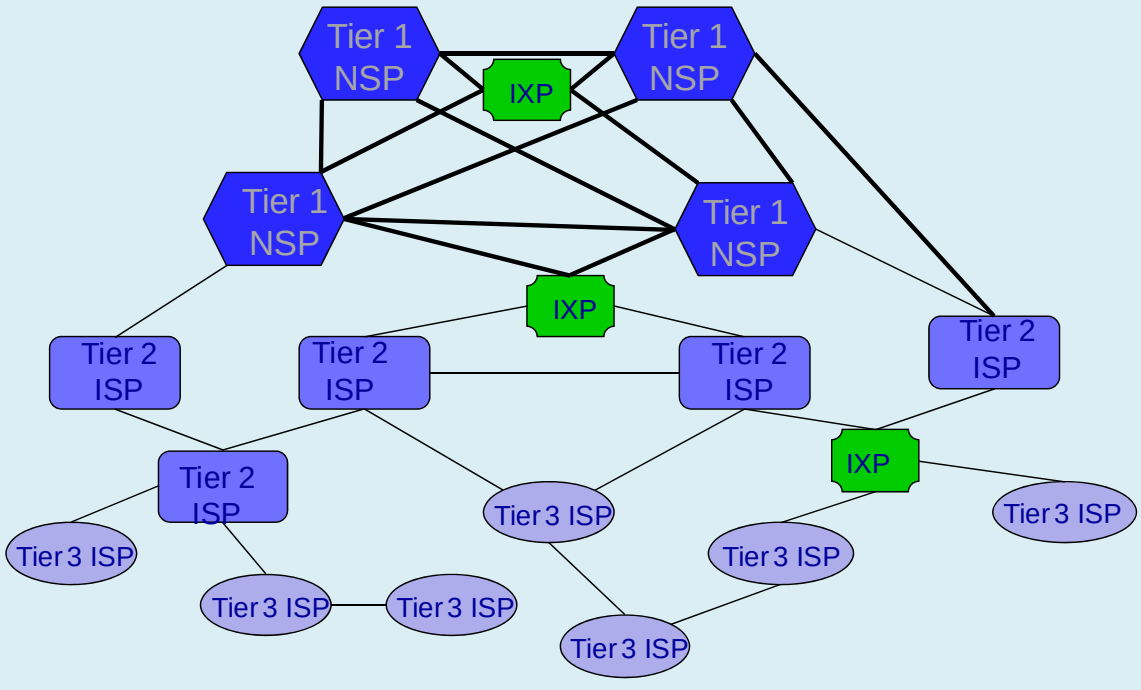
A number of options exist today in order to implement the interconnection among various networks that stay at different migration stages. The main challenges that appear in that context are due to the high number of scenarios where many networks need to be related, such as:

- Network interconnect at IP bilateral or IP multilateral.
- Service interconnect at a service hub or service mediation.
- How to handle service migration, service discovery, service preferences and related end to end QoS.
- Send signaling through IP or SS7.
- Identification of addresses.
- Capabilities available at each network.
- Procedures to find required gateways.
- Communication of charging and billing procedures. etc.

Most common solutions today are based on a global coverage, support by existing SS7, SIP and ENUM, protocol translation and interoperation, address translation, centralized routing management based on origin-destination requirements, statistics monitoring, SLA management, security management, etc.

In cases of small networks or networks in extension phase, best practice for all regions and especially for developing regions is based on the provision of a centralized location for the exchange of traffic, close to both the originators and recipients of traffic and content called IXPs (see Figure 64).

Figure 64: Typical architecture and interconnection for current IXPs and different hierarchy of ISPs



Source: Adapted from CISCO Systems, Inc

Having access to an IXP has a range of benefits for local ISPs, and ISP subscribers due to the following factors:

- reduce the ISP costs, and enable ISPs to manage traffic more efficiently,

- improve quality of service by reducing the transmission time, number of routers, and distance traffic must travel,
- as a result, add value to an ISP service subscription this creates new growth and development opportunities,
- provide a neutral, universally supported "clearing house" for the exchange of traffic, making it possible to keep local traffic local.

Currently, there are more than 150 IXPs with various capacities ranging from the order of 10 Gbps to 100 Gbps and 1000s Gbps. In particular, at the highest level of the hierarchy (TIER I level) there are 11 IXPs (AOL, AT&T, Global Crossing, Level3, British Telecom, Verizon Business, NTT Communications, Qwest, Cogent, SprintLink and Telefónica International Wholesale Services (TIWS)) that typically "peer" with the Tier-1 ISPs with full connectivity in a mesh network and with partial connectivity with large ISP Tier-2.

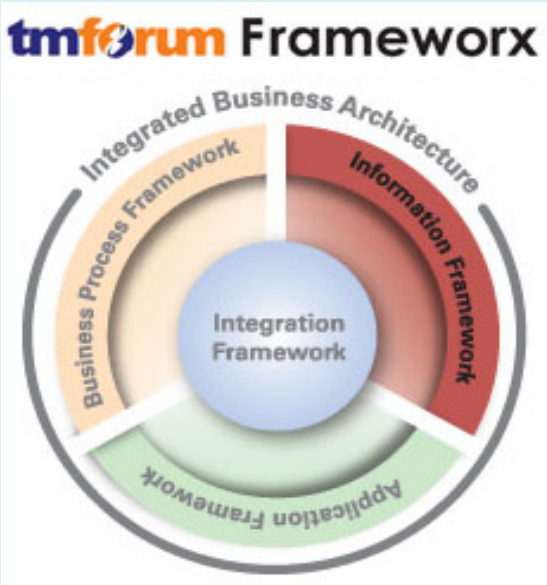
When we consider a large mature network, the number and location of POIs is derived from an optimization process that guarantees end to end performance and minimizes involved costs according to the available transmission resources, origin-destination traffic and existing locations for the TDM and IP transit flows. This has to be determined on a case by case basis.

3.3.6 Operation/business support systems and network management

A view for OSS processes and related development of applications is provided by the TM Forum[93] that is composed of a wide number of operators and equipment suppliers as well as supported by ITU-T. OSS and BSS are integrated within a wider set of reference models as indicated in Figure 65:

- Business Process Framework (eTOM) is the industry's common process architecture for both business and functional processes.
- Information Framework (SID) provides a common reference model for enterprise information that service providers, software providers, and integrators use to describe management information.

Figure 65: Integration framework for Business, Applications and Information by TM Forum



Source: TM forum

[93] TM forum: Business Process Framework (eTOM) www.tmforum.org/BusinessProcessFramework/1647/home.html

- Application Framework (TAM) provides a common language between service providers and their suppliers to describe systems and their functions, as well as a common way of grouping them.
- Integration Framework provides a service oriented integration approach with standardized interfaces and support tools.

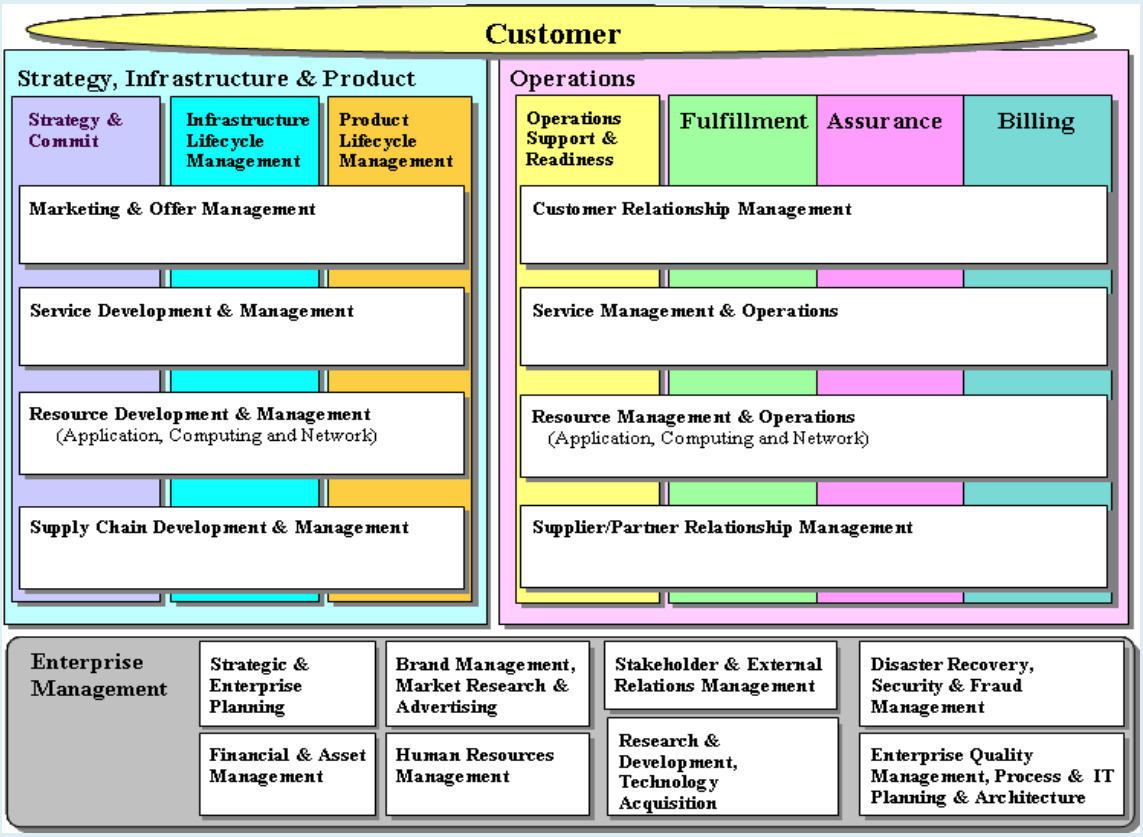
eTOM is the most accepted structure related to the network functionalities and considers all the OSS and BSS tasks in a multi provider environment across coexisting technologies for the different cycles within the management and operational domains as indicated in Figure 66 with three main blocks:

a) Strategy, Infrastructure and product that contain the planning and management for the infrastructure and product life cycles.

b) Operations for all operational end to end processes including Provisioning, assurance and billing.

c) Enterprise management dealing with corporate management and support to business for companies.

Figure 66: Functional structure for OSS/BSS activities in eTOM



Source: TM forum

In addition to conventional typical functions, new requirements and higher relevance for existing tasks are needed in the NGN IP technology as follows:

- managing support to multimedia services with voice, data, video and multiple play,
- security policy management,
- content management,
- managing inter-domain operational activities,

- managing functionalities for the coexistence of legacy and new technologies,
- implementing new business procedures associated to bundled offers,
- manage multimedia/multiparty charging application,
- Service Level Agreements (SLA) management,
- quick service creation and upgrading management.

In order to overcome the limitations from the multiple existing platforms in traditional networks and to address the new requirements, the OSS/BSS solutions have also to evolve from a set of vertical piles per technology to a common integrated platform with a series of transformations that should converge in line with the NGN network evolution.

To assure the service continuity through the migration of both the network itself and the operation support systems, a sequence of steps have to be planned for the OSS/BSS evolution that are a function of the initial operator status and the target network architecture. A typical sequence of six steps is proposed.

A coordinated evolution between the network itself and the support systems is illustrated in Figure 69. As soon as the NGN starts at the core network and partial IMS functionalities are ready, the Open Service Architecture may be expanded for the OSS/BSS systems and higher interaction will be obtained between the network and the support systems.

When full IMS SIP-based services are available in an end to end NGN, all the support processes based on service oriented architecture may exploit the operational functions in an integrated platform.

Converged OSS/BSS applications will provide a series of benefits of the same type as those obtained by the IMS within the network itself but related to the overall company operational activities external to the network with additional advantages such as:

- short time reaction to new services introduction,
- labor force reduction for the operation,
- common look and feel for the support services with easier training,
- incorporation of facilities for agile reaction to business competitive forces,
- increase for the ARPU,
- quick reaction to customer complaints and contract updates.

Figure 67 illustrates the initial integration step in which the variety of IT platforms for different applications at OSS and BSS are integrated into a common platform with the corresponding OSS middleware to aggregate functionalities[94]. The middleware applications provide a separation of common processes from the specific network technologies and interfaces, facilitating also the operation with multivendor solutions. This step provides an important saving in IT platforms investment and could be made before the major steps towards NGN are implemented.

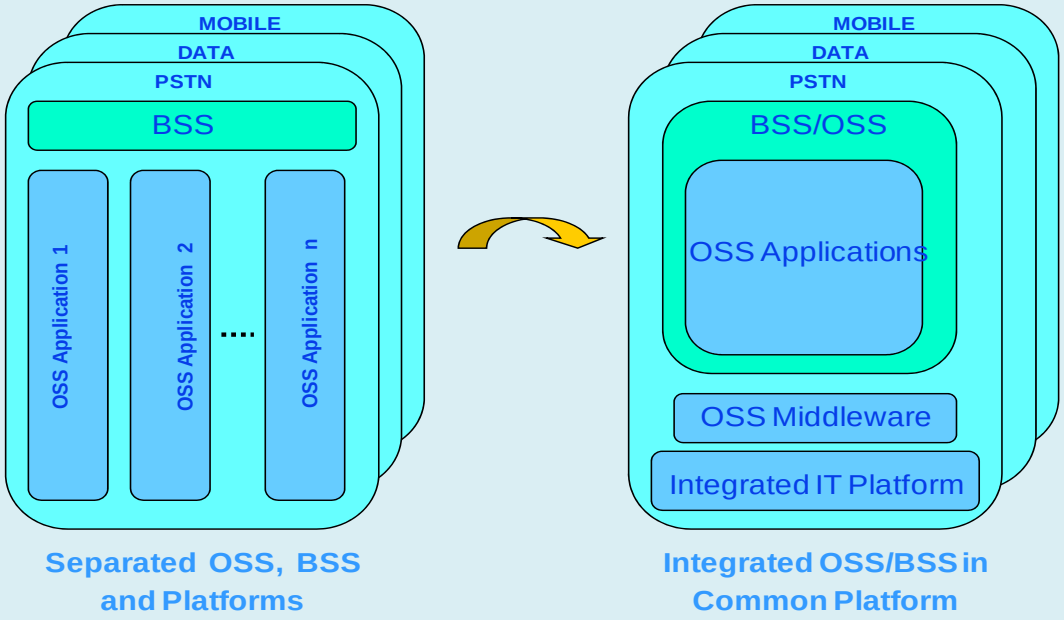
The other steps of the sequence may be implemented one by one or grouped as a function of the speed in the evolution towards the full NGN with a complete availability of full IMS. Figure 68 illustrates the final migration for the OSS/BSS functions and the relation to the IMS architecture[95]. When all the functionalities of the IMS are ready, the interrelation of the control functions within IMS and the support functions within OSS/BSS is stronger than in previous architectures and some on the functionalities will

[94] ITU-D – Reference manual on network planning for evolving network architectures, 2007. Chapter 6.4: Converged Networks. www.itu.int/ITU-D/tech/NGN/Manual/Version4/NPM_V04_February2007.pdf

[95] ITU-D – Reference manual on network planning for evolving network architectures, 2007. Chapter 6.4: Converged Networks. www.itu.int/ITU-D/tech/NGN/Manual/Version4/NPM_V04_February2007.pdf

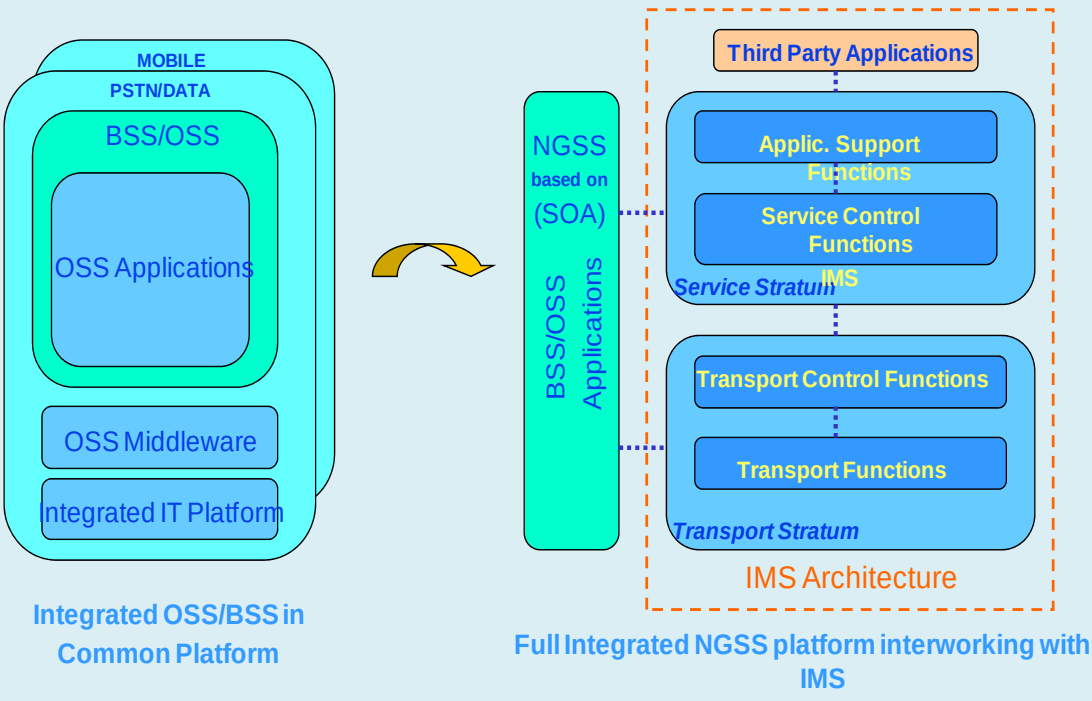
need a cooperative interworking similar to the federated platforms. Those changes will originate much higher and flexible capabilities of the support systems that could be also called a Next Generation of Support Systems (NGSS).

Figure 67: First steps for integration of different applications in OSS and BSS in a common platform



Source: ITU

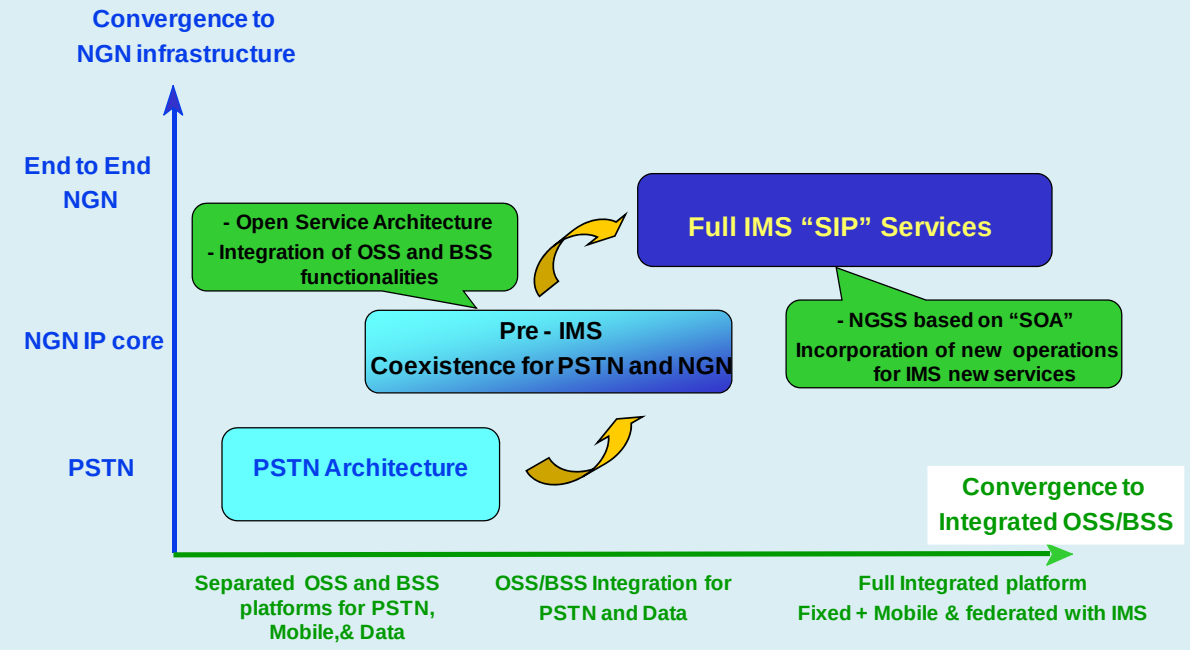
Figure 68: Final step for integration of OSS and BSS from all network types towards a NGSS linked to the IMS based network



Source: ITU

Evolution of the OSS/BSS integration and mapping to the IMS functionalities requires a number of steps in order to ensure adequate cooperation among functions inside the OSS/BSS, within the IMS and the service creation platforms that already exist. The proposed overall steps are illustrated in Figure 69[96]:

Figure 69: Coordination between the convergence to NGN infrastructure and the New Generation Support Systems



Source: ITU

3.3.7 Quality of service and security

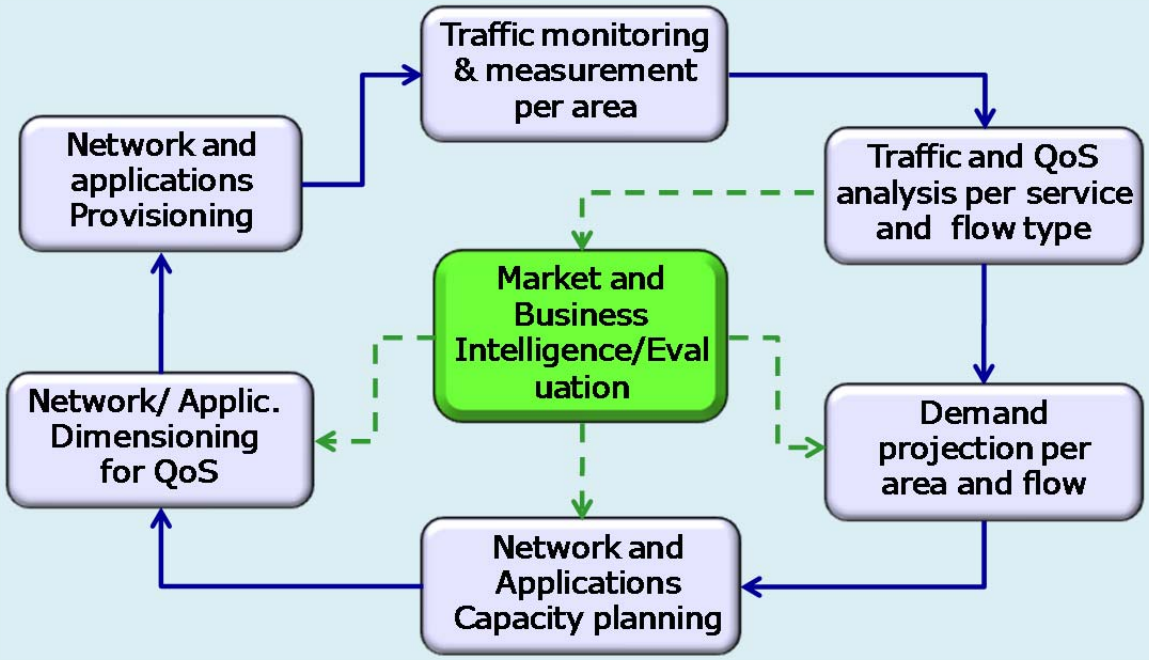
Quality of service and traffic monitoring acquires in a multiservice NGN a much wider dimension than in traditional networks due to the quick creation of new services and the very dynamic relation between customer classes, service adoption rates and traffic volumes generated to the network. The traffic related activities need to be very dynamic as well and interrelated with the market and business intelligence so the process[97] described in Figure 70 is proposed to be able to provide the adequate dimensioning corresponding to traffic demands and market responses in order to guarantee committed QoS.

While traditional traffic projections was made predominantly in yearly cycles, the dynamics in new services is changing rapidly and cycle update should be much shorter (i.e. quarterly, monthly and even shorter for some mobile applications). The frequent gathering of traffic measurements, analysis, projection and dimensioning implies the implementation of functions in the OSS systems with automatic processing and manual supervision of experts. Links between OSS and BSS functions as pricing, bundling, churn, adoption rates, etc. is also needed especially in a competitive environment to assure profitable revenues when multiple offers are present in the market.

[96] ITU-D – Reference manual on network planning for evolving network architectures, 2007. Chapter 6.4: Converged Networks. www.itu.int/ITU-D/tech/NGN/Manual/Version4/NPM_V04_February2007.pdf

[97] Market business intelligence and relation to NGN traffic activities. O. Gonzalez Soto: ITU-D Regional Development Forums 2010 on NGN and Broadband for the Arab Region. December 2010

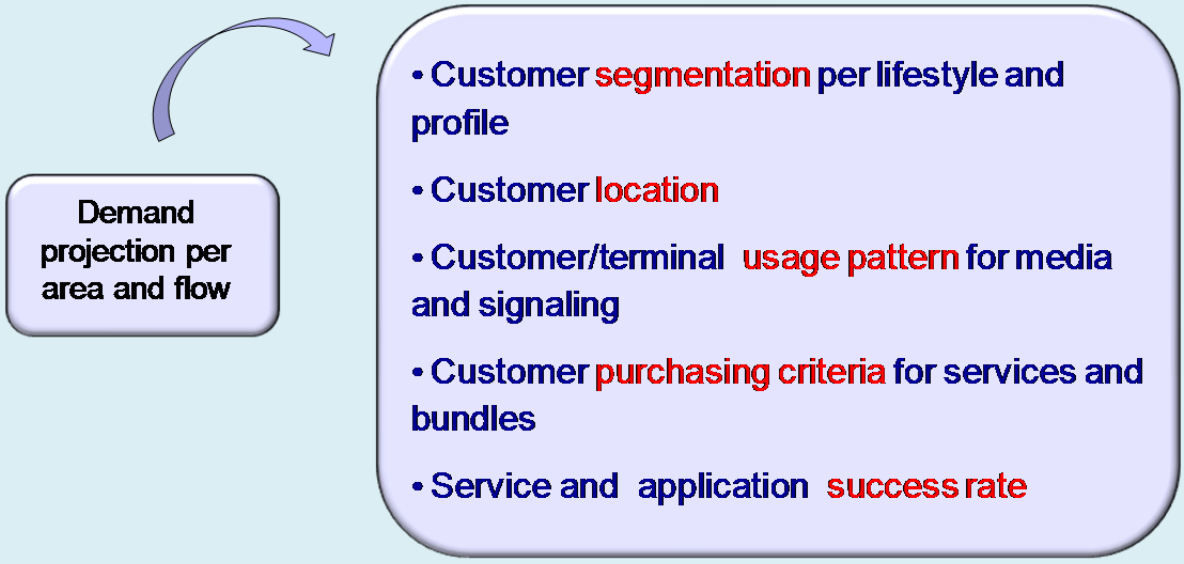
Figure 70: Traffic activities for NGN and relation to market and business intelligence



Source: O. González Soto

Demand projection for new services starts with inputs from the current situation and from the market intelligence according to the country maturity on ICT. Tasks that differentiate that projection from the traditional one are given in Figure 71 below and require the analysis of much more information from the services type and market reaction that exploit the capabilities from the IMS functionality.

Figure 71: Typical activities for new services NGN demand projection



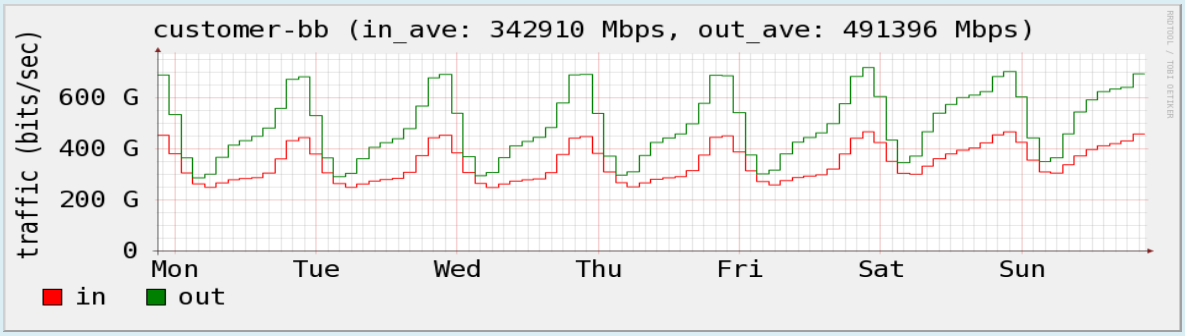
Source: O. González Soto

When generating origin/destination traffic matrices, the time frame of the use (long, medium, short term) and the required degree of detail for the network design phase have to be taken into account. The following cases illustrate the perspectives of a traffic matrix analysis:

- Per dimensioning criteria (constant, guaranteed streaming, best effort) for planning purposes.
- Per O/D network points (end to end user, user to service providers location and multiple to multiple O/D) for design and configuration purposes.
- Per application type (video, Web, bulk, P2P, social networking, gaming, etc.) for design and configuration purposes.
- Per customer category (wholesale, LAN, business, residential) for design and configuration purposes.

A good reference for the overall traffic monitoring and evolution follow up is given in Figure 72 illustrating the daily values for download and upload traffic in a group of six large ISPs in Japan[98]. Periodicity along timings of the day, ratios between output and input traffic and evolution through the years is essential to be monitored both at international gateways and major ISPs in order to plan and dimension the network resources for the proper grade of service.

Figure 72: Illustration for measured daily traffic profile in a group of servers in Japan



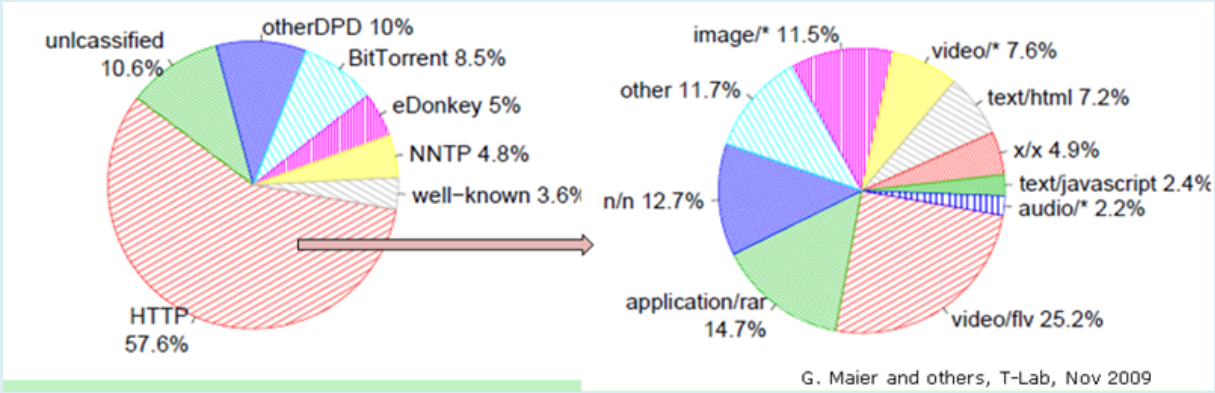
Source: Kenjiro Cho (IIJ/WIDE), November 2009

An illustration from the mentioned traffic monitoring activity for network activity by application type is provided in Figure 73, obtained from more than 20,000 residential DSL customers in an urban area with download speeds between 1200 Kbps and 17000 Kbps. Data were aggregated from points belonging to a large ISP in a EU country[99]. It shows the dominance of HTTP applications over P2P and the importance of video applications that are growing in a sustained manner.

[98] Trends in Japanese Residential Traffic. ISOC Panel on Internet Bandwidth: Dealing with Reality Kenjiro Cho (IIJ/WIDE). 10 November 2009

[99] On Dominant Characteristics of Residential Broadband Internet Traffic: Gregor Maier, Anja Feldmann, Vern Paxson, Mark Allman. TU-Berlin/T-Labs TU-Berlin/T-Labs UC Berkeley/ICSI/ICSI. *IMC'09,* November 4–6, 2009, Chicago, Illinois, USA

Figure 73: Illustration for measured mix of applications in a large ISP within the EU



Source: Adapted from "On Dominant Characteristics of Residential Broadband Internet Traffic": Gregor Maier, Anja Feldmann, Vern Paxson, Mark Allman

Best practices today try to integrate measurements in a platform of platforms during the transition periods in order to have a complete view of the SLA fulfilment towards customers.

QoS by leading operators are equal or better than ITU standards as more completed calls increase the revenue and a better quality of experience reduces the customers churn in a competitive environment. As an example, Internet rate at peak periods for leading operators in quality are better than 80 per cent of the offered peak rates.

At the operational phases on a short term basis, common practices to increase QoS rely on the following procedures:

- Selective allocation of more resources at bottlenecks.
- Resource reservation for high priority flows.
- Traffic shaping for lower priority flows.
- Routing optimization at real time.

Due to the high number of innovations at NGN networks, applications, protocols and interfaces, a prior testing of the equipment for conformance, interoperability and QoS fulfillment is required in addition to all the planning, configuration and deployment activities. Basic methodology for testing is provided by the ITU-T Recommendation Q.3900[100] that includes a classification of NGN testing according to the functionality, testing procedures and definition of model network to apply the testing. The defined approaches consider the following cases:

- Protocol and flow testing.
- End to end functional testing.
- Per service QoS testing procedure.
- Interaction testing with ISP.
- OSS/BSS interaction testing.
- Statistics processing testing.
- Billing system testing, etc.

[100] ITU-T Q 3900: Methods of testing and model network architecture for NGN technical testing. 2006

Best practices for Security are based in the embedded security systems in the products and the training to all operational teams on security issues as a threat may appear at any level of the network and any level of the organization. In order to protect the correct network operation and service delivery, a set of functional requirements or countermeasures are to be ensured and were considered within the NGN capabilities such as:

- *Trust* relations establishment both for the operator towards the network and for the customer towards the operator by well defined relations and service level agreements. This trust also concerns to the content access to legal information and handling of digital rights management.
- *Access control and Authentication* or checking that the user is authorized to use the service by means of mechanisms like firewalls, Public Key Infrastructure (PKI), digital certification, etc. Both for fixed and mobile services the process of customer registration has to consider contract type, user privileges as well as defined preferences.
- *Confidentiality:* avoid access to no unauthorized information by encryption on access interface of user communication and signalling by use of methods like encryption.
- *Communications security*: ensure that the required information only flows between the intended origin and destination by use of specialized routing methods like MPLS, VPNs, etc. that will assign specific separated paths per traffic flow type.
- *Integrity***:** avoid no unauthorized data modification and correct delivery on end to end bases by means of methods like digital signature, antivirus, etc.
- *Non Repudiation***:** ensure that the agreed performed actions for each contract type cannot be denied.
- *Availability***:** ensure no denial of service/ accessibility of services or data under the terms agreed by the corresponding service level agreements and quality of service by means of correct forecasting, dimensioning, redundancy design, dynamic assignment, dynamic routing, etc.
- *Privacy:* avoid non unauthorized profiling, disclosure and modification of content by methods of close access or encryption.

When considering the networks from the vertical layering point of view, each layer has specific risks, vulnerabilities and threads so it is convenient to have a hierarchical grouping by affinity of the problems, corresponding mitigations and solutions. Accepted splitting considers the following three levels comprising with several vertical layers according to the functions:

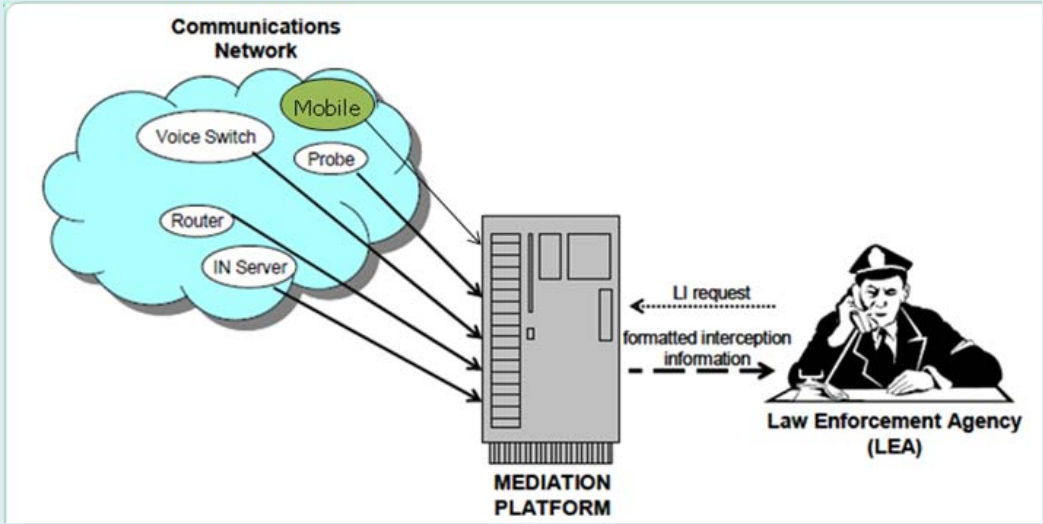
- *Infrastructure Security Layer***:** From the planner point of view, special importance is given to this infrastructure layer as it has stronger requirements on the time anticipation for deployment. The number of processing nodes at a mature NGN is much lower than in a traditional PSTN and is one of the causes for savings in Capex (capital expenditure) and Opex (operational expenditure). Nevertheless, in order to maintain a proper level of survivability to the network and services, the design criteria cannot just be extrapolated from the current networks and very robust methods have to be applied at the following areas:
  - High physical security at topological level with higher connectivity ratios and diversity paths for high capacity and wide influence network nodes.
  - High protection level for the energy supply in all key nodes with duplicated or triplicated sources of energy and diverse physical energy paths.
  - Design of large capacity routes and logical paths with high security criteria.
  - Design of high security and protected buildings for all involved elements and servers associated to key services.
  - High level of protection for intrusion, hacking and security for accessibility to softswitches and key NGN resources considering that within IP all network interfaces are potential gates candidates for access to the control.

- *Service Security Layer:* The fact that open service provision uses open interfaces or application program interfaces (APIs) implies a new set of risks that have to be managed in strong relation with agreed trust relations among players. Examples of the functionalities for the services layer that are subject to security assurance are: Call Admission Control (CAC) , Quality of Service (QoS) based information delivery, policy-based call routing, signaling protocol interworking, reacting to network congestion, policing SLAs, etc.
- *Applications Security Layer:* Security rules should apply to the many types of applications that are more critical as more degree of commonality in the network or higher impact on services and business. From the customer service point of view, the following four classes are identified:
  - Applications and servers for common functionalities to several services: Home Subscriber Server with user profile service function with information on numbering, addressing, user identification, subscription locator function, etc.
  - Applications and servers for common functionalities associated to the operational support: Charging and billing, traffic measurement and engineering, performance control, routing, network monitoring, customer care, etc.
  - Applications and servers that are specific to the services like VoIP, IPTV, Mobile, PtS, IM, etc.
  - Applications and servers related to third parties services like e-commerce, e-mail, conferencing, gaming, music download, alerts, etc. Each layer acts as an enabler of security for the others and the security procedures at all layers require an evolution with the implementation phases of the NGN and IMS from current separated services to integrated services.

Security mechanisms need to be working during the corresponding evolution from closed PSTN networks towards pre-IMS or full IMS NGN scenarios that incorporate more powerful embedded procedures. Especially critical are the real time applications like VoIP or IPTV with stringent constraints on delay and jitter that should not be penalized in performance by the way in which procedures of security are implemented.

Concerning lawful interception, best practices apply: the procedures indicated in section 2.3.1.6 and most advanced countries deploy additionally an independent network that integrates the information from all different networks, either fixed, mobile, Internet with post processing of very powerful information that includes geographical positioning at all times, mail addresses and content, web related activity, etc., as indicated in Figure 74.

Figure 74: Integration of information from multiple networks, flows and content



Source: Adapted from ETSI TS 101 331, Definition of interception

Due to the fact that that information is much more invasive than the traditional voice recording, this also interferes more on privacy, both for the intercepted customer and related counterparts. That characteristic implies the need to redefine roles of authority agents, explicit legal approvals with limits in time and counterparts that will end in completely new laws and not merely extrapolation of existing laws.

4 Assessment and Recommended Actions

4.1 Overall national policies and strategies

Within this chapter, a series of recommendations and assessments are summarized as a function of country status reported in chapter 2 and taking as references best practices identified at chapter 3. Assessment is carried out for the overall country strategy as well as for the regulatory and network migration area.

- Define an overall plan for ICT and broadband development with coordination of the involved ministries (technology, education, health, financing, etc.), stakeholders, service providers and related sectors on top of the current fragmented and partial policies that exist today. Best references include actions by South Korea and EU among all leaders mentioned in chapter 3 that may be applied with a ten-year horizon.
- Allow for all types of fixed and wireless broadband technology solutions (ADSL, fibre, CATV, satellite, 3G, LTE, WiMAX, etc.) with flexibility to be applied in the country as a function of best mapping to each geo-scenario, maintaining technology and service neutrality.
- Facilitate the establishment of national fibre backbones, access to international gateways, cable landing points, satellite and IXP to eliminate dimensioning bottlenecks for all competitors.
- Promote competition to facilitate innovation in broadband services and affordable prices for the different user segments following examples of all advanced countries in telecommunications referenced in chapter 3 as well as example of India in the good relation between demand and prices by exploitation of all economies of scale.
- Provide sufficient spectrum in advance for operators at low frequencies for low density areas and high frequencies for urban areas for all technologies (including 3G, 4G and WiMAX).

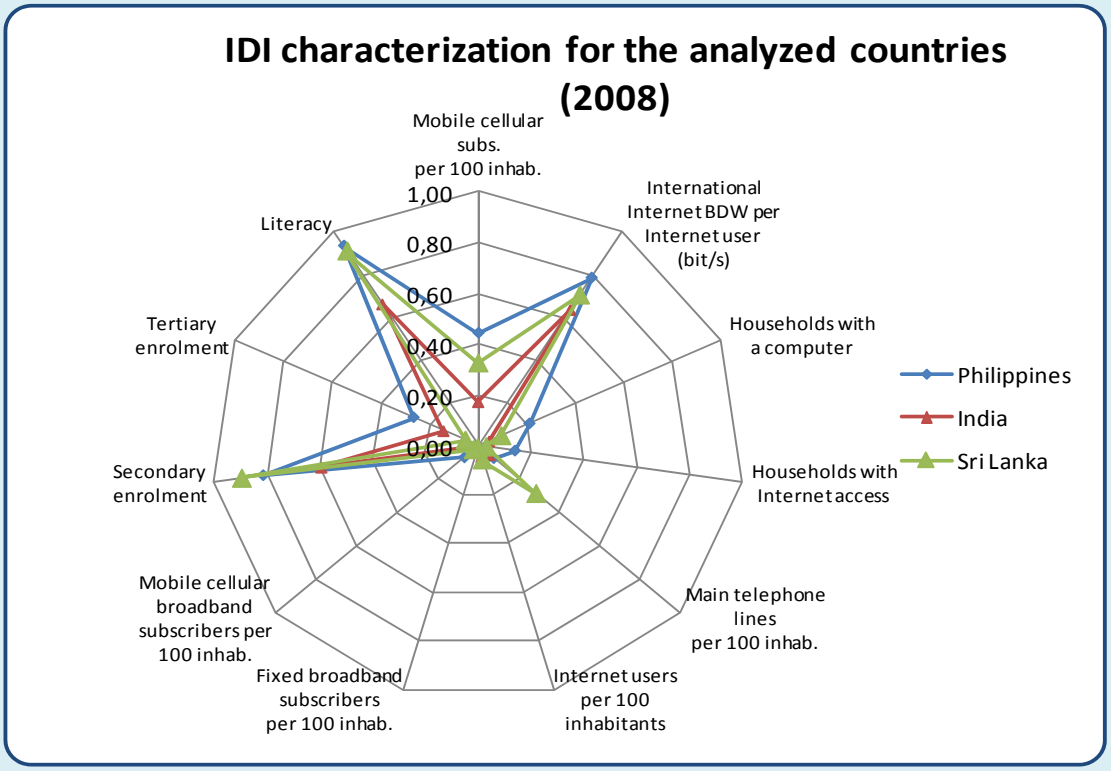
All analyzed countries have some similarities on the profile of the ICT spike diagram that reflects the ICT Development Index: relatively high index on literacy, second enrollment and international bandwidth, while very low values for households with a computer, Internet users, fixed broadband users and mobile broadband users as summarized in Figure 75[101].

– The recommendation here is to prioritize development for those parameters in national plans starting with the objective to reach values similar to the reference of Malaysia in the short term (Figure 76) that has taken coordinated development actions. As a point of reference for potential very long term improvements and possible trends, two of the worldwide leaders, South Korea and Finland, are included in Figure 77.

– Define a special development plan for all e-services (e-administration, e-education, e-health, e-commerce, etc.) with collaboration between the public and the private sector that will guide the further development of many other broadband services that will contribute strongly to a society's progress.

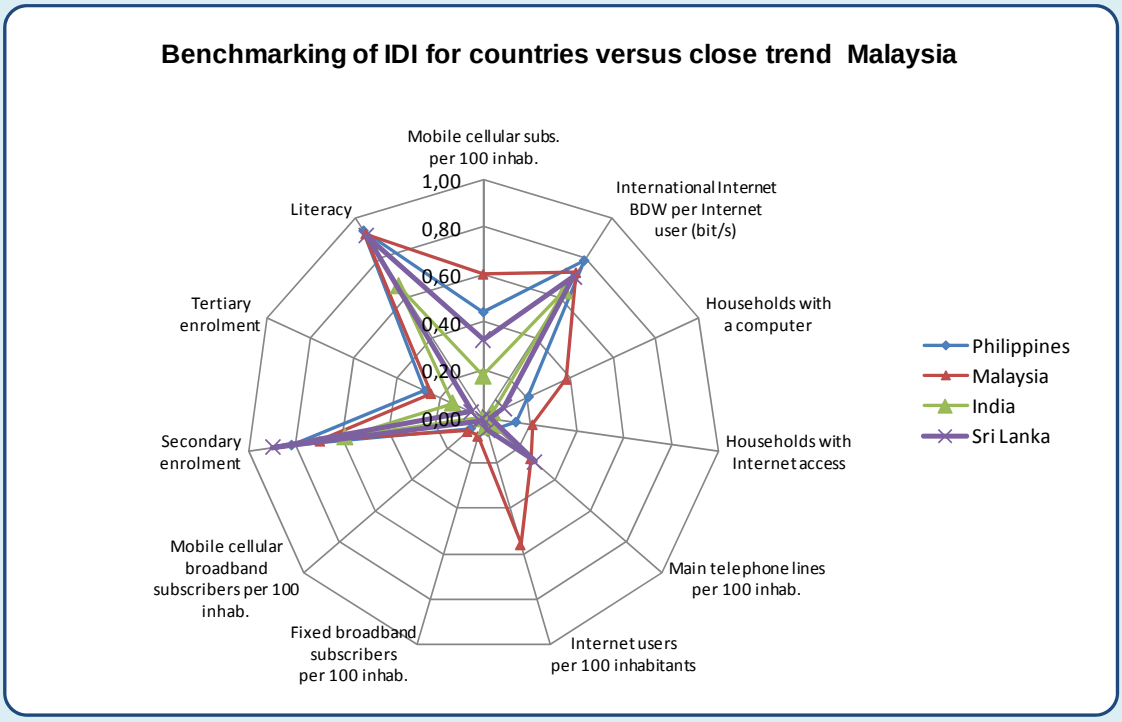
[101] Measuring the Information Society, ICT Development Index (IDI). 2010 ITU International Telecommunication Union.

Figure 75: ICT Development Index components for the three evaluated countries



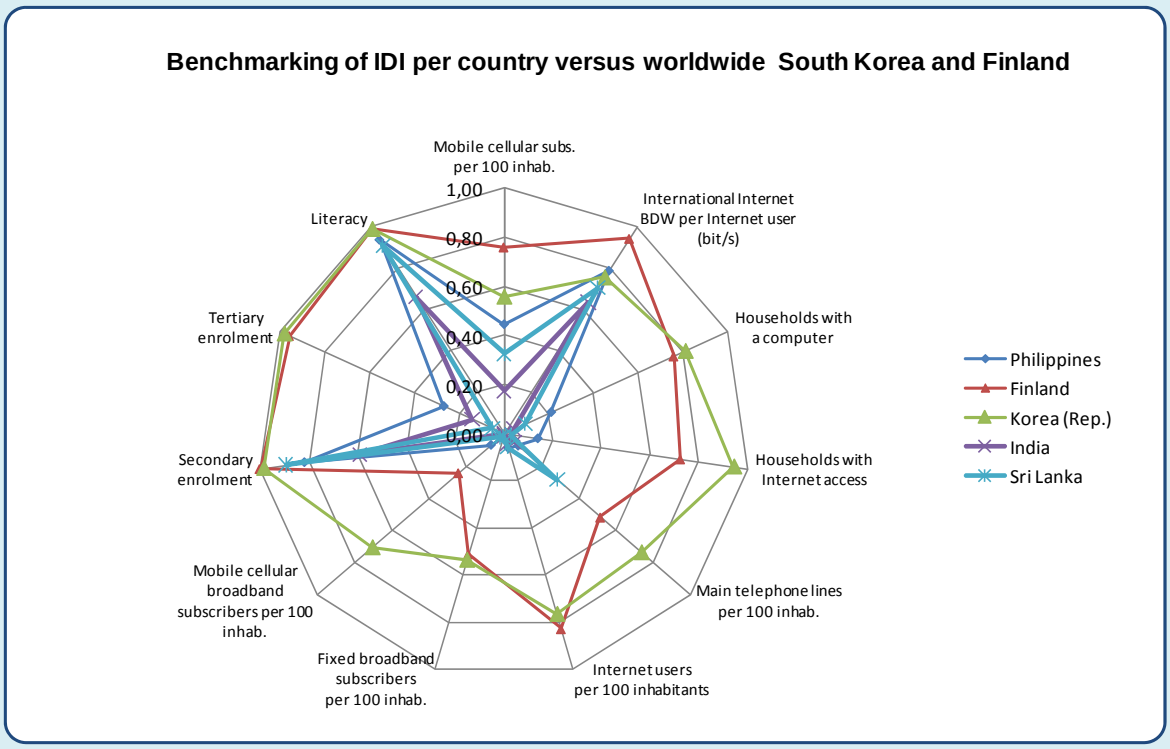
Source: ITU

Figure 76: ICT Development Index components for countries and benchmarked with Malaysia (short term)



Source: ITU

Figure 77: Benchmark for the IDI components with two most advanced countries (very long term)



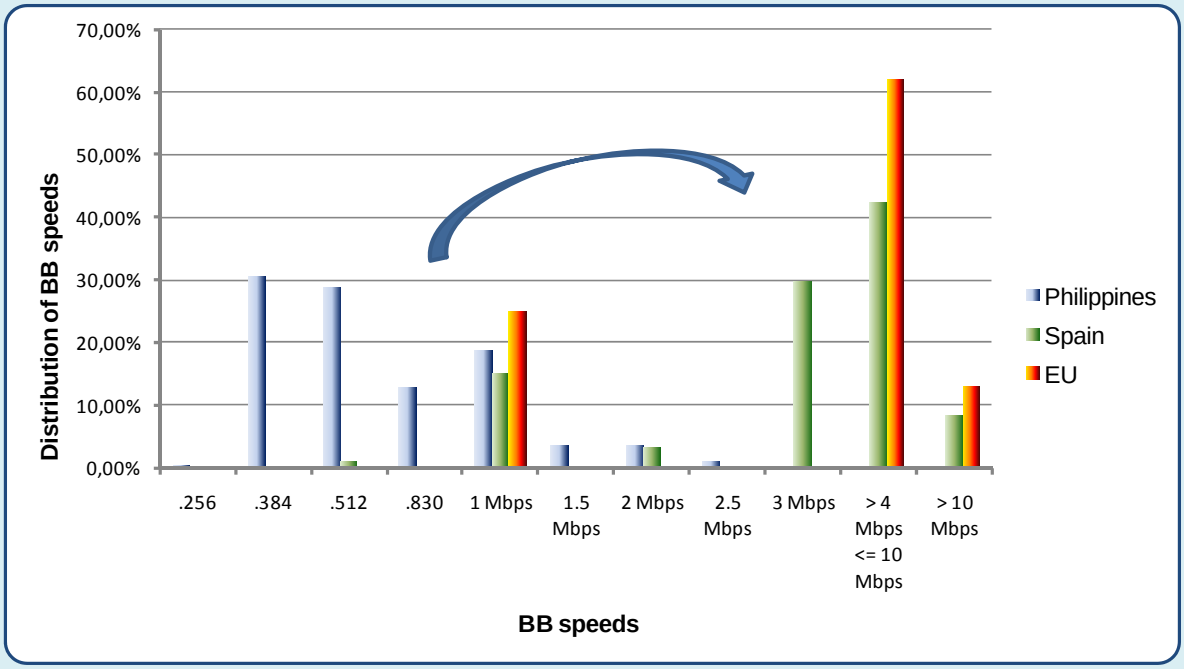
Source: ITU

From the performed benchmarking for the analyzed countries with significative reference to advanced countries or regions, it is derived that in addition to the lower penetration indicated in the previous IDI, the mix of broadband speed distribution is much lower than the references taken from Spain or the average values for the EU[102].

– As low distribution speeds seriously limit the deployment of many broadband services that also generate revenues, it is strongly recommended to extend the offer of higher speeds as indicated in Figures 78, 79 and 80 by the corresponding actions on the network provisioning and the commercial plans.

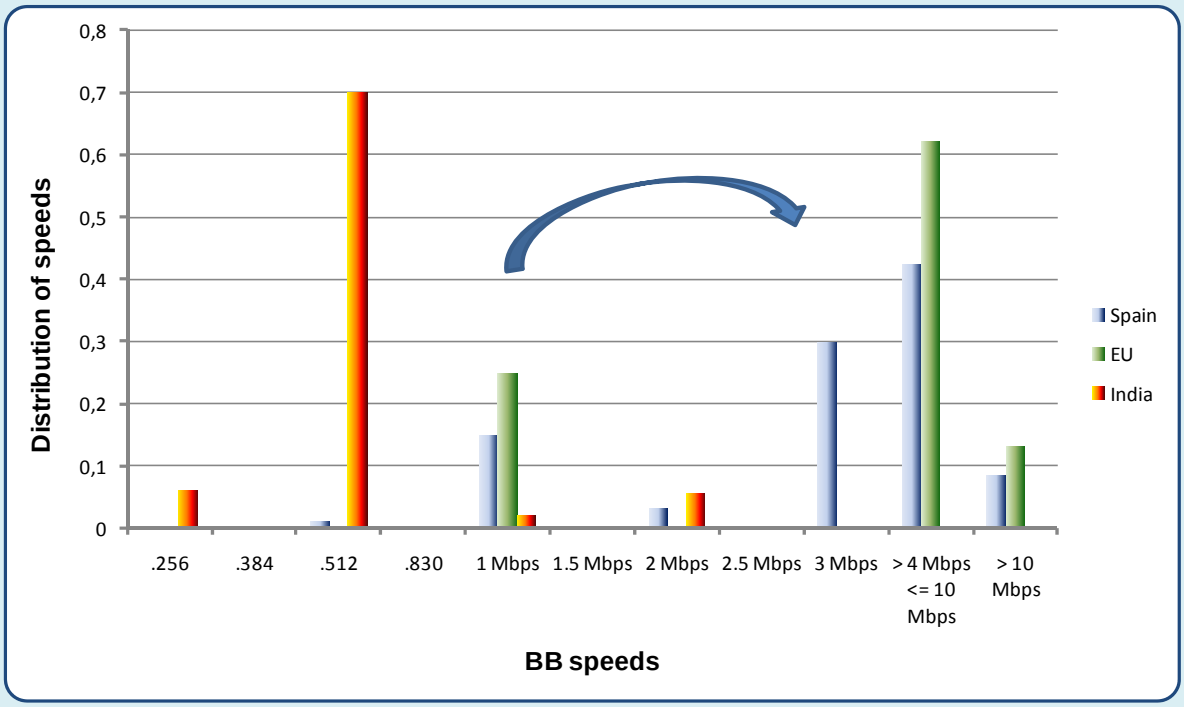
[102] Comparativa Internacional de Ofertas Comerciales de Banda Ancha en La Unión Europea. CMT, Junio de 2009

Figure 78: Benchmarking for broadband speeds distribution with reference countries and recommended evolution towards higher broadband speeds in the Philippines



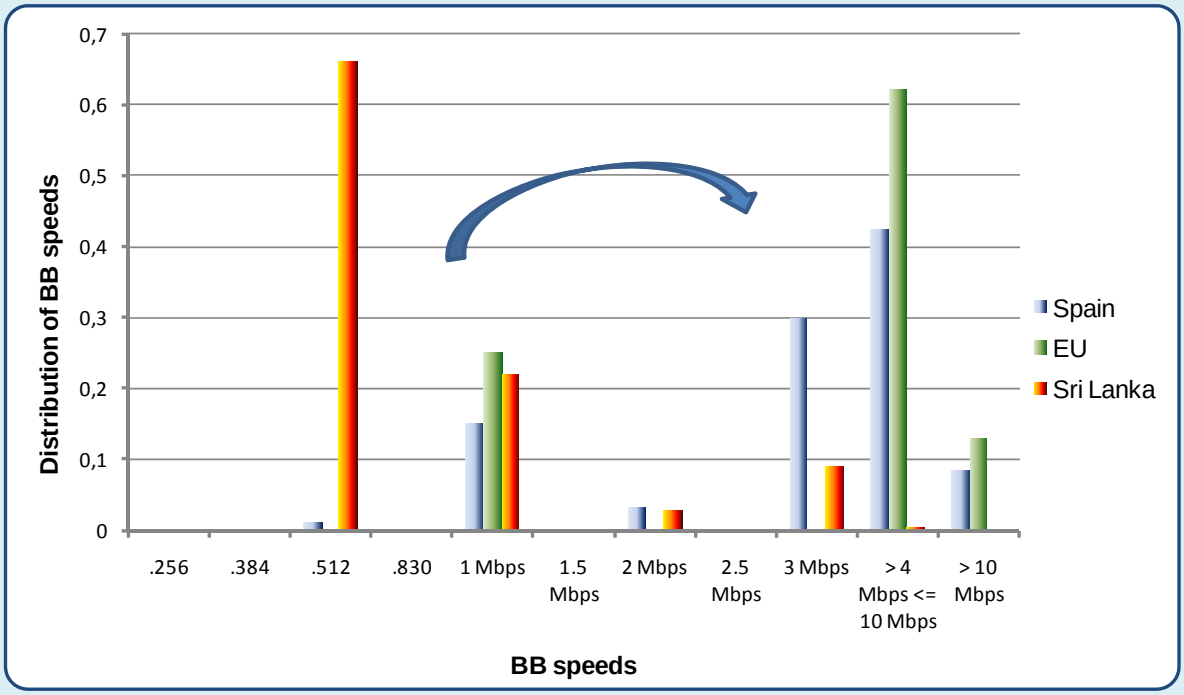
Source: O. González Soto

Figure 79 Benchmarking for broadband speeds distribution with reference countries and recommended evolution towards higher broadband speeds in India



Source: O. González Soto

Figure 80: Benchmarking for broadband speeds distribution with reference countries and recommended evolution towards higher broadband speeds in Sri Lanka



Source: O. González Soto

From the benchmarking for the analyzed countries with significative reference to advanced countries or regions, it appears that the pricing strategy in all countries is too high for higher speeds with a quasi-linear correlation among prices and speeds, more evident in Sri Lanka, which do not reflet the economies of scale in network costs. Figures 81, 82, and 83 show the wide range of differences in price trends for high speeds although no significant differences for low speeds[103].

It is strongly recommended to reconfigure the pricing strategy by adapting prices to include economy of scale towards values similar to Malaysia in the short term and towards values similar to Japan[104] and the EU[105] in the lond term that seem well adjusted to price/speed[106]. It has to be noted that offers do not always contain the same components (i.e. the case of EU incorporates free national calls to fixed numbers).

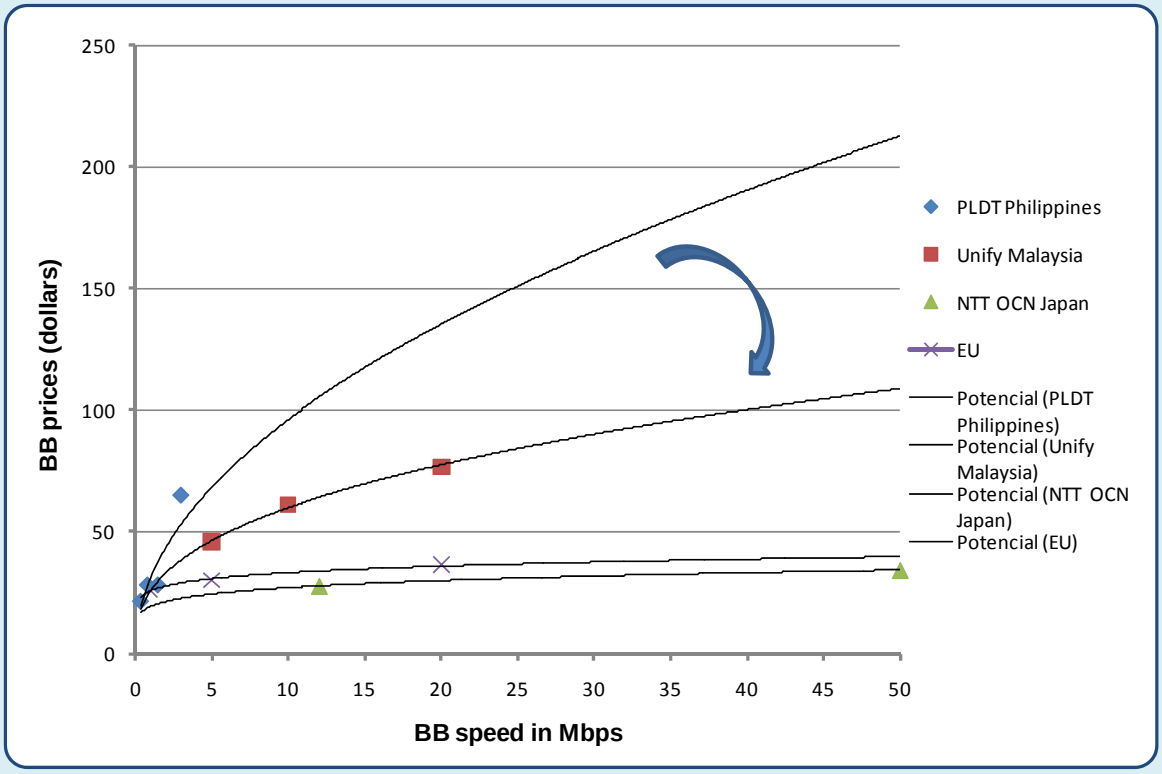
[103] Information data templates for the Philippines, India and Sri Lanka, 2010

[104] NTT Internet services. http://506506.ntt.com/english/internet/

[105] European Commission.. Europe's Digital Competitiveness Report. ICT Country Profiles Brussels, 17.5.2010

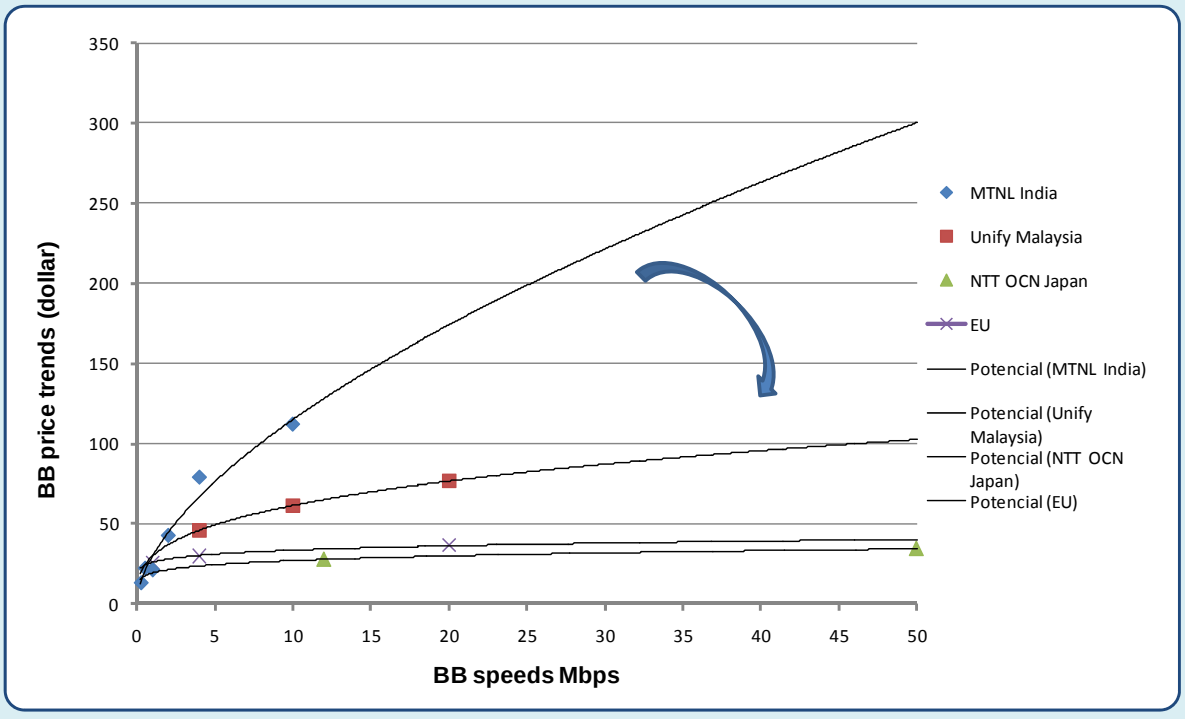
[106] Malaysia Internet services. www.unifi.my/unifi/index.php?option=com_content&view=article&id=58&Itemid=58

Figure 81: Benchmarking for price to speed ratios and recommended evolution for the Philippines



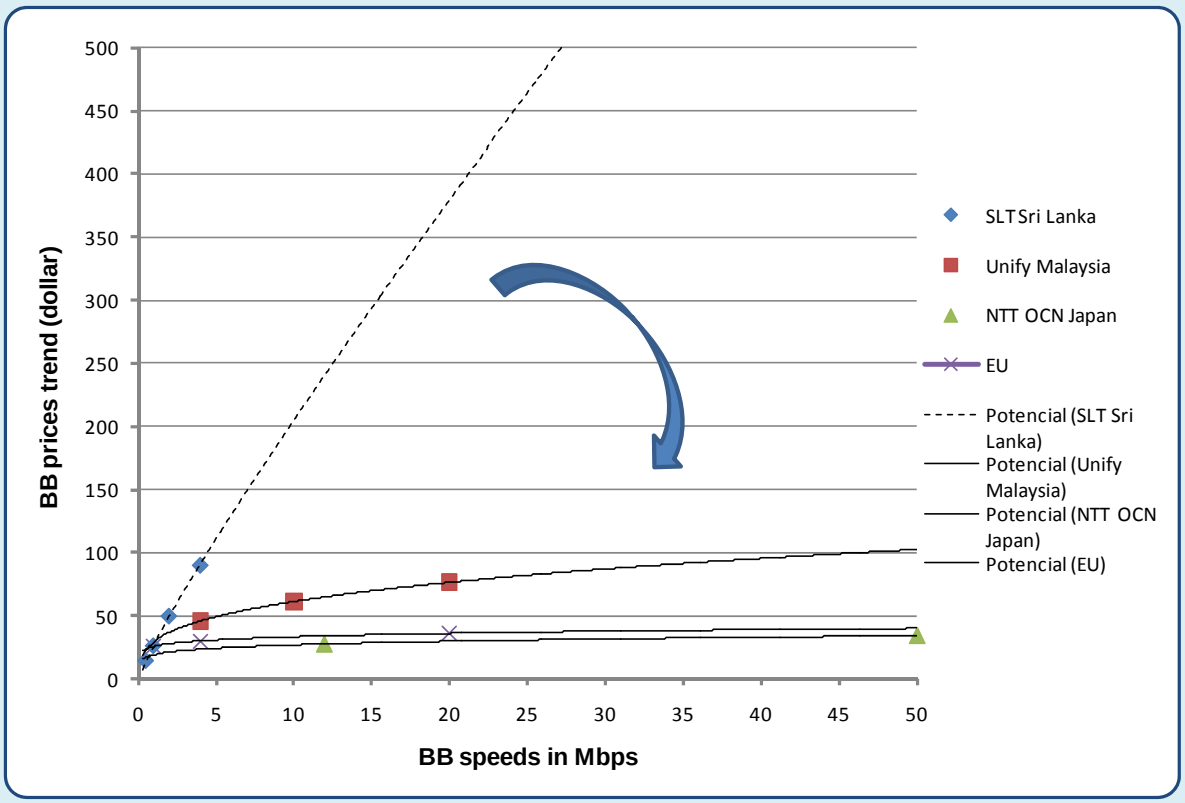
Source: O. González Soto

Figure 82: Benchmarking for price to speed ratios and recommended evolution for India



Source: O. González Soto

Figure 83: Benchmarking for price to speed ratios and recommended evolution for Sri Lanka



Source: O. González Soto

4.2 NGN regulation and licensing

4.2.1 Licensing regime

The analyzed countries have made various levels of progress on licensing rules and today's practices have not generated substantial obstacles to the previous evolution in telecommunication services but need modernization for the next phase.

- The case of India shows a significant advance with unified licensing that may be considered as one of the best practices in the region as mentioned in chapter 3. Nevertheless, geographical coverage, availability of higher broadband speeds and pricing as a function of the economy of scale have to be emphasized.
- The Philippines had started with a light regime with dominant ex-post regulation that provided good flexibility and quick introduction of competence and the Philippines now need to develop rules to enhance broadband service penetration and geographical coverage that has additional difficulties due to the dispersed population in many islands and dependency on the satellite connectivity.
- Sri Lanka also have a light regulation that simplifies the opening start and provides a facilitation of broadband expansion with duty waivers and tax holidays for broadband service providers but requires a reinforcement for the coverage of low density areas, the facilitation of infrastructure sharing and the provision of spectrum for rural regions.

A set of recommendations that are common to all countries is summarized below:

- Concerning upgrades for the Philippines and Sri Lanka for a wide deployment of NGN, it is recommended that the reinforcement of a simplification towards better efficiency for further

convergence of licensing either in line with the unified target in India, or the convergence towards multiservices/network layers in several Asia-Pacific countries, or the Common Authorization in EU. For all countries, a licensing upgrade is recommended and special emphasis should be given to:

- develop a vision of long term market evolution on overall services and business development in order to guide the definition of detailed rules;
- allocate spectrum well in advance of the broadband requirements and develop procedures for the digital reutilization;
- monitor current utilization of spectrum to increase efficiency of frequency usage and assignment of bands;
- promote effective competition at services level, eliminating barriers for new services, and avoiding stabilization on an oligopoly situation that do not facilitate innovation;
- measure accountability of regulatory actions through the availability and affordability of services, as well as for the end customer's satisfaction in the country.

4.2.2 IP based interconnection

All countries have operational and convenient definitions of PSTN interconnection principles but there are no comprehensive procedures available for the multiple options of scenarios combining PSTN with NGN based on softswitches or NGN based on IMS.

- It is recommended to develop consistent and transparent principles for IP interconnection inside each country and inter-countries including: location of IX, functionality, addresses translation, routing, dimensioning principles, service level agreements for QoS and security. A special working group per country is needed to agree on all these issues.

4.2.3 Cost allocation, charging and billing

Currently India has defined cost allocation principles for the existing network solutions while the Philippines and Sri Lanka do not regulate those aspects that remain as open agreements between players.

- It is recommended to upgrade in the case of India, and for the Philippines and Sri Lanka, to develop cost allocation procedures to IP resources based on a complete modelling for overall costs with the net present value over multi life-cycles to guide reference values when *ex-ante* regulation is used or to supervise deviations in the market under the *ex-post* arrangement. To ensure business sustainability and neutrality for the different types of operator, a type of TSLRIC (Total Service Long Run Incremental Cost) with inclusion of standard revenue margins is desirable.
- Charging and billing in most cases follow commercial agreements for value added services. It is recommended to continue in that line of commercial agreements with high transparency procedures and explicit service level agreements. In order to facilitate overall QoS it is convenient to define templates as guidance for involved players. A polynomial modelling for charging based on the number of events per type (ie SMS, MMS), and resource utilization per QoS class is a good trend. Nevertheless, basic procedures like capacity based models and bill and keep may be used in the introduction phases for simplification until powerful OSS/BSS applications are installed for multimedia services.
- Universal service will continue requiring regulatory actions on charging in order to assure the strategiesin each country for the different customer classes and unfavourable areas.

4.2.4 Infrastructure sharing

Today, some degree of infrastructure sharing is being applied, such as transmission towers, through bilateral agreements but there is no strong promotion or regulation in the countries and rarely is it applied to the other areas referred to in chapter 3. Although all six degrees of sharing are desirable, the

following are considered as a high priority to be applied as soon as possible with transparency and simplified rules to avoid delays:

- It is strongly recommended to promote and regulate sharing for all passive infrastructure at network segments such as, ducts, cables, rights of way, poles, masts, trenches, towers, equipment rooms and technical premises. This is one of the most important solutions for high business sustainability and growth of service penetration in all developing countries with low payment capability, as major savings are produced in physical elements that form more than 70 per cent of investments. It is mandatory for 3G, 4G and FTTH technologies that require high investments in infrastructure to be optimized with economy of scale criteria.
- International gateways are to be shared both for the international cable and satellite systems that link multiple countries and are essential for broadband services to grow. This will imply a lowering of the international access costs and provide equal conditions for all service providers. Special attention to this topic is to be taken by the Philippines and Sri Lanka due to the inherent insularity characteristics.
- A further step on sharing has to be regulated for critical capacity resources like Backhauling and Energy provisioning as the active network elements which will provide important cost savings and being easy to share without interfering in the internal operations.
- Due to the scarce resources for broadband at the access segment, access sharing by unbundling is also a requirement in all countries as the quickest way to increase broadband penetration in the short term as well as to reach a more efficient utilization of an expensive resource that requires long term amortization. Experience from successful countries in the implementation of local loop unbundling has to be taken into account to benefit from best practice, as in the EU.

4.2.5 Quality of service

Up to now, the QoS defined by regulators in each country use the standard values defined by the ITU-T in conventional PSTN networks and a subset of the standards defined for the NGN in the end to end network path. Large NGNs require a more detailed definition of parameter values for each service provider, and additional activities are required to apply engineering procedures that still are not common practices within the sector such as:

- To define a national team to harmonize reference networks, dimensioning rules, interoperability and performance parameters that are attributed to each network segment. This team should involve the regulator, service providers and industry.
- To assure a reference nominal broadband speed for customers at peak periods during the day that is relative to the maximum contracted speed (i.e.: at least 80 per cent of peak speed at the busiest periods of the day).
- To define monitoring and sampling principles to evaluate customer satisfaction by using the concept of quality of experience.
- Regulator should compile and publish periodical reports indicating the evolution of the market, speeds, prices and quality (at least yearly and desirable quarterly).

4.2.6 Security, privacy, lawful interception

Lawful interception is well defined and applied in all countries for conventional PSTN networks however, security and privacy issues are less developed. Due to the high level of integration in NGN and the increase of risks in an open IP working mode, the following major improvements are suggested:

- Reinforce national security entities by working with international institutions for an efficient application of the cybersecurity rules related to information flows.
- Define guidelines for a minimum overall network security required for service providers including physical security, minimum level of connectivity and plans for emergencies and disasters. Higher

integration and capacity of networks require higher levels of security in nodes and links than in conventional networks and a mere extrapolation is not valid.

- Re-define principles for practical application of national laws and interception with guarantees for citizens that interventions are carried out under an explicit approval by a judge. New laws should explicity indicate the conditions for intercepting simultaneously fixed, mobile and Internet networks including positioning, mailing, web addressing, content, etc. for limited periods of time and with well defined objectives.

4.3 NGN migration

4.3.1 Overall strategy

All countries have initiated an introduction of NGN and broadband services at medium speeds, with at least a few nodes at the upper network segment with medium broadband speeds by xDSL, WiMAX or mobile 3G technologies. Nevertheless, the penetration level of those services is low and the speeds range from 512 Kbps to 1 Mbps.

- The Philippines has already started the implementation of NGN with several nodes for fixed networks and a higher number for mobile networks which are based on softswitch technology with mainly xDSL solutions in fixed networks. Too many offers of broadband are provided with only minor differences that complicate matters with few advantages for customers, and deployment of broadband at higher speeds is very low.
- India is starting to introduce NGN and discussing the potential implementation of IMS. xDSL solutions are dominant in fixed networks. A high number of local loops are available but due to the lack of agreements or regulation of unbundling solutions, they remain unused. The implemented Pan-African e-Network Project is a good practical example of South-South cooperation for e-services between countries in Africa and India.
- In Sri Lanka NGN implementation has started with a low number of nodes based on softswitch technology installed in fixed networks mainly with xDSL and WiMAX solutions. In addition, some NGN nodes are installed that are upgradable to IMS for mobile networks. There are significant numbers of available copper pairs with broadband capability to extend the services rapidly but deployment continues to be slow and does not include high speeds.

In all countries, the procedures for network design are complete for PSTN but very limited for IP mode flows. In order to benefit from NGN related capacities, the following actions are recommended for the overall network in all cases:

- Perform a national study of each service provider for the medium term (i.e.: 5 years) to evaluate technical and economical consequences for the network modernization and introduction of new services with the corresponding what-if analysis of different migration rates, services introduction, package offers, pricing strategies and related business results including net present value, internal rate of return and payback period.
- Create a specific migration operations group to coordinate all implementations for network elements: terminals, access, edge, core, services and OSS/BSS and assure correct service handling during the transition phases.
- Give priority to the increase of speeds and capacities at access and backhauling with the reduction of prices and adaptation to parabolic shape in the price function of the speed.
- Simplify the number of offers and significantly increase the differences between them.
- Identify convenient strategic technology partners for collaboration at the initial phases of transition in order to solve the inherent operational issues with any new technology.

- Develop a training program for company operational employees on NGN and IP mode techniques, protocols, engineering and capacities, starting with metropolitan areas and to be extended to all regions.

4.3.2 Transit network segment

Within all countries, migration towards NGN has started at the core network level with the introduction of high capacity IP routers in order to integrate data and voice services. Network topology consolidation is in progress with the reduction of transit nodes. Due to the fact that the core network transition is the quickest to be performed, the following recommendations are suggested:

- Carry out a study on topological protection of nodes and routes with diversity of paths at both physical and logical levels. The results will show the number of core nodes, location, capacity and survivability needed to guarantee the carrying of full capacity at least for the period needed until the next capacity augmentation in the case of failures of nodes and links.
- Complete IP transit node implementation following the results of the topological protection study over the short term (ie: 2 to 3 years) in order to avoid a bottleneck for the evolution of the rest of the network segments.

4.3.3 Local/edge network segment

The local/edge network segment plays a crucial role in the network design and for the aggregation of traffic flows coming from the different multimedia services both for fixed and mobile networks. So far, only incipient implementation has been carried out in the analyzed countries, resulting in low capacity compared to the demand for new services. The following recommendations are given:

- Perform a study for the design of the edge segment including aggregation node locations, capacities, traffic flow control, security and other functionalities according to the variety of new services to be carried.
- Identify priority areas of IP mode implementation as a function of national and business strategy considering elements like: new development areas to be created, areas of high service demands that will generate higher revenues, areas with obsolete PSTN equipment, etc. Plan implementation as a result of feasible business plans.
- Accelerate metro-Ethernet solutions as the most adequate for all services to be implemented and give priority to backhauling capacity provisioning for mobile services derived from the 3G and 4G demand explosion.

4.3.4 Access network segment

Status of the access network segment modernization is varies in all countries depending on area type: urban, suburban or rural. Due to the fact that this segment is more expensive to implement and requires longer time to be completed, special attention has to be given to the analysis of the current quality of the physical network, best solutions and related business evaluations as follows:

- Perform a national study to characterize geo-scenarios per country and expected customer volume per scenario. Evaluate adequate mapping of solutions to each geo-scenario with a time frame of 10 years with the comparison of net present value per case and selecting the more feasible type among ADSL2+, VDSL, FTTB, FTTH, WiMAX, VSAT, PLC, etc.
- Extend as quickly as possible the ADSL2+ solutions at urban and suburban scenarios where copper pairs are available with the objective of deploying most common new services including IPTV in triple play with 8 to 10 Mbps.
- Implement higher speeds for business and high consumption customers either with VDSL2 or FTTH/FTTB solutions using the results of the study on geo-scenarios and customer volume. Candidate areas are new development greenfield areas and high density metro areas with a high proportion of business customers.

- Extend initiated WiMAX solutions in low density areas were no physical cable pairs are present and complement this with VSAT solutions at extreme low density and dispersed areas.

4.3.5 Interconnection

Most implementations for interconnection rely on TDM solutions either for the original PSTN networks as well as for the new IP mode networks where flows are converted by gateways to TDM before interconnection is performed. Future interconnection will require a variety of solutions depending on the combination of technologies at each network pair. In line with that variety, the following proposals are made:

- Collaborate with the regulator in the definition of solutions and service level agreements and follow the regulatory rules on the design and implementation of bilateral interconnections as well as in the creation of neutral IX nodes.
- Allow for a variety of solutions according to the different stages of network modernization between TDM, NGN based on softswitch or IMS solutions. Decide on alternatives for each case as a function of technology availability and minimum overall cost for both parties: origin and destination.

4.3.6 Operation/business support systems and network management

In all countries, a high number of installed OSS/BSS platforms are derived from technologies and providers at each network type. The coexistence of more than ten platforms without an overall visibility and requiring multiple licences is typical. In order to assure an end to end management and control of network and service operation, development, monitoring and supervision, a convergence is suggested:

- Integrate existing non-obsolete existing platforms with modern platforms already implemented and develop an umbrella application to allow unified end to end interworking.
- Implement converged platforms for NGN on the basis of best practices identified in section 3.2.6 with first integration of OSS and BSS per network and a later full integration of fixed and mobile applications.
- Combine multiple and fragmented platform softswitch licences today in a lower number of larger size taking benefits of economy of scale for pricing, operation and maintenance.
- Taking the advantage of the initial federated platforms and the later converged platform, define and implement a cycle for the monitoring-measurement-analysis-projection of IP traffic flows derived from the new services with special emphasis on the mobile services that are critical for the limited capacity of the air interface.

4.3.7 Quality of service and security

Current performance of TDM equipment follows the ITU-T defined standards and engineering practices in all countries, but accessibility to all parameters is not always complete and in some cases a periodical publication is issued. The following recommendations are given for the migration towards NGN and broadband services:

- Collaborate with the regulator in the definition of a complete set of parameters, values and performance quota distribution among service providers to be applied at national level as well as in the definition of security procedures to be applied by the service provider. This will allow an efficient and homogeneous performance within the country.
- Follow up the ITU-T standards and the agreed recommendations of the regulator with the implementation of QoS and service level agreement monitoring on top of the OSS applications and aggregated post processing when needed to complete the end to end view.

- Implement procedures to monitor customer satisfaction and quality of experience by using the capabilities of call centers and by creating external procedures to interview a sample of customers with the proper stratification by customer categories and geographical areas.
- Implement within the company the new security procedures derived from the ITU-T standards and agreements with the regulator at the network, information processing, and data privacy levels. Special care should be taken for the control of information related to lawful interception with “strict” ahesion to the national laws on privacy.
- Develop a training plan on security issues for all company personal with special extension and priority to departments handling sensitive information and network management centres.
- Benchmark periodically performance results with other operators within the country and with international operator best practices in order to detect improvement areas and apply solutions to reach a high quality service provision and better business profitability.

Annex 1: List of Acronyms and Abbreviations

2G	Second Generation Mobile Communications
3G	Third Generation Mobile Communications
3GPP	Third Generation Partnership Project
4G	Fourth Generation Mobile Communications
ABC	Activity-based costing
ADSL	Asymmetric Digital Subscriber Line
AN	Access network
AU	African Union
BcN	Broadband convergence Network
BSNL	Bharat Sanchar Nigam Ltd
BSO	Basic Service Operators
BSS	Business Support Systems
BT	British Telecom
C2C	City to City
CAC	Call Admission Control
CAPEX	Capital Expenditure
CASP	Content Application Service Providers
CME	Continuing Medical Education
CMTS	Cellular Mobile Telecommunication Service
CPP	Calling Party Pays
DTH	Direct to Home
EAC	East Asia Crossing
EU	European Union
FTTH	Fibre To The Home
HHI	Herfindahl Hirschman Index
IGF (2)	Internet Governance Forum
ILD	International Long Distance
IM	Instant Messaging
IMS	Internet Protocol Multimedia Subsystem
IMT-2000	International Mobile Telecommunications
INI	Internal Network Interfaces
IP	Internet Protocol
IRI	Intercept Related Information
ISP	Internet Service Provider
ITU	International Telecommunication Union
ITU-D	International Telecommunication Union – Development Sector
ITU-R	International Telecommunication Union – Radiocommunication Sector
ITU-T	International Telecommunication Union – Telecommunication Sector

IXP	Internet Exchange Points
LBS	Location Based Services
LDCAs	Long Distance Charging Areas
LI	Lawful Interception
LRIC	Long Range Incremental Cost
MAC	Medium Access Control
MAN	Metropolitan Area Network
MCR	Minimum Cell Rate
MCTD	Maximum Cell Transfer Delay
MDF	Main Distribution Frame
MF	Mediation Function
MGCF	Media Gateway Control Function
MGF	Media Gateway Function
MGW	Media Gatway
MOS	Mean Opinion Score
MOU	Minutes of Usage
MTNL	Mahanagar Telephone Nigar Limited
NFP	Network Facility Providers
NGA	New Generation Access
NGN	Next Generation Network
NLD	National Long Distance
NLDO	National Long Distance Operator
NSP	Network Service Provider
NTC	National Telecommunication Commission
ONU	Optical Network Unit
OPEX	Operational Expenditure
OSS	Operational Support System
P2P	Peer to Peer
PBS	Presence Based Services
CO	Public Call Office
PCTO	Philippine Chamber of Telecommunications Operators
PHP	Philippine Peso
PKI	Public Key Infrastructure
PLMN	Public Land Mobile Network
PMRTS	Public Mobile Radio Trunk Service
POI	Point of Interconnection
POP	Point of Presence
POTS	Plain Old Telephone Service
PS	Packet Switching
PSTN	Public Switched Telephone Network
PTE	Public Telecommunications Enterprises
PtS	Push to Speak
PTP	Point To Point
QoS	Quality of Service

QoE	Quality of Experience
RAN	Radio Access Network
R&D	Research and Development
RAO	Reference Access Offer
RCPI	Radio Communications of the Philippines Inc.
RCS	Rich Communication Suite
RoCE	Return on Capital Employed
SBle	Service Blending
SBr	Service Broker
SDCA	Short Distance Charging Area
SIP	Session Initiation Protocol
SLA	Service Level Agreement
SLCSERT	Computer Security Emergency Response Team
SLF	Subscriber Location Function
SLT	Sri Lanka Telecom
SSA	Secondary Switching Area
STEM	Strategic Telecom Evaluation Model
TCIL	Telecommunications Consultants India Limited
TIWS	Telefonica International Wholesale Services
TRAI	Telecommunication Regulatory Authority of India
TRCSL	Telecommunications Regulatory Commission of Sri Lanka
TSLRIC	Total Service Long Incremental Cost
UAS	Unified Access Services
USO	Universal Service Obligation
VDSL	Very high Digital Subscriber Line
VNO	Virtual Network Operator
VOD	Video On Demand
VoDSL	Voice over Digital Subscriber Loop
VoIP	Voice over Internet Protocol
VPT	Village Public Telephones
VPN	Virtual Private Network
Wi-Fi	Wireless Fidelity
WiMAX	Worldwide Interoperability for Microwave Access
WLL	Wireless Local Loop
WSIS	World Summit on the Information Society
WTDC	World Telecommunication Development Conference
xDSL	Generic Digital Subscriber Line

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