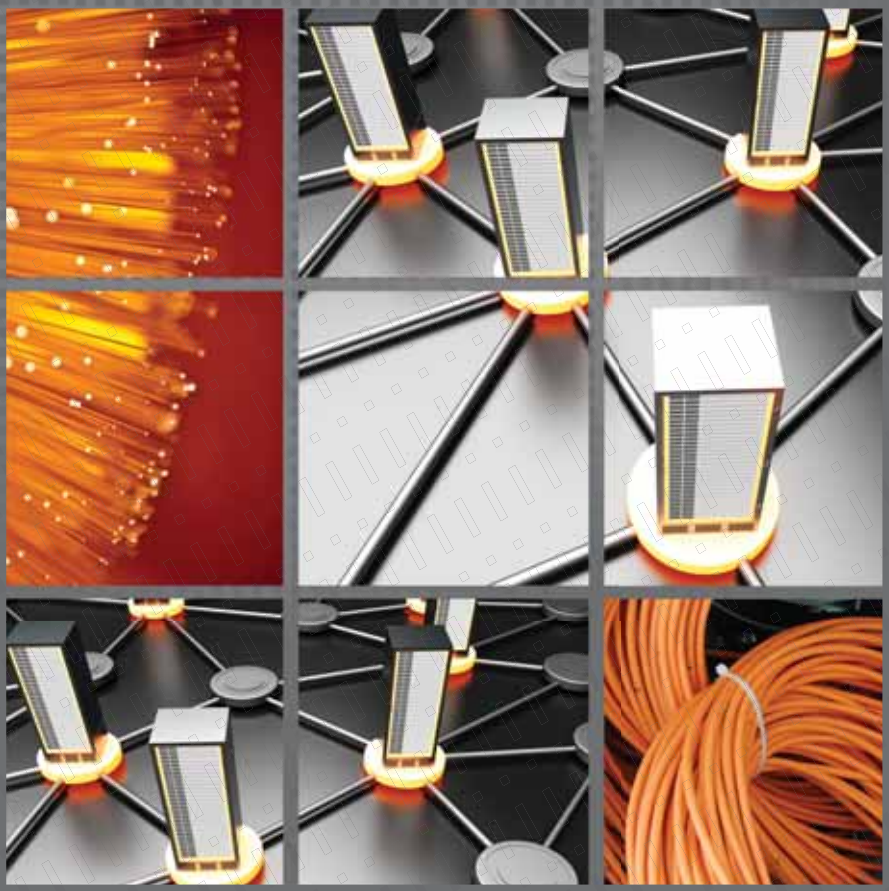
INFRASTRUCTURE

NGN ACCESS NETWORK PLANNING:
A CASE STUDY OF BTCL NETWORK IN BANGLADESH

Report



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Telecommunication Development Sector

NGN Access Network Planning:

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This report was prepared by ITU expert Mr Oscar González Soto.

The International Telecommunication Union (ITU) would like to express sincere gratitude to the Bangladesh Telecommunications Company Limited (BTCL), the Ministry of Post and Telecommunications (MOPT), the Bangladesh Telecommunication Regulatory Commission (BTRC) for their support and assistance to the project realization, as well as to individual staff in those organizations in particular, for their support, information gathering to fulfil the objectives and challenges of this study.

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1 Executive Summary

1.1 Background and objectives

This report results from a project initiated by the International Telecommunications Union (ITU) and the Bangladesh Telecommunications Company Limited (BTCL)[1] concerning the access evolution towards NGN and triple play services in Dhaka, Bangladesh, for which Sameer Sharma, Senior Advisor, ITU Regional Office of Asia and the Pacific and ITU expert Oscar González Soto, undertook a field visit to Dhaka and carried out a series of interviews with key experts in BTCL, Bangladesh Telecommunication Regulatory Commission (BTRC)[2] and Ministry of Post and Telecommunications (MOPT)[3].

A survey of the access network infrastructure was conducted with field visits to various Public Switched Telephone Network (PSTN) operation centres, main distribution frames, cabinets and cable plant. Regular meetings were held with BTCL engineers responsible for the planning, engineering, outside plant, operation of the PSTN and data networks.

As the access network segment plays a key role in the provisioning of broadband services and dominates required investments in the network, the focus on this segment with the corresponding network studies and business planning activities becomes essential.

Network planning work carried out by ITU-D has been taken into account for this modelling:

- "Manual on Network Planning for Evolving Network Architectures";[4]
- "Guidelines for Network Planning Tools for Developing Countries and countries with Economies in transition" [5]

Specific objectives defined within the mission include:

1. To undertake network assessment and audit for the status of the existing copper access network infrastructure in Dhaka.
2. Analyse target models and architecture for outside plant (OSP), network systems and services.
3. Evaluate dynamic migration models over time towards target solution based on technical dimensioning and business evaluations.
4. Recommend network modernization to support triple play services with at least 8 Mbps as well as actions to increase operation efficiency derived from performed studies and evolutions in the market.

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1 www.btcl.gov.bd/

2 www.btrc.gov.bd/

3 www.mopt.gov.bd/

4 ITU-D – Technology and network development: "Manual on Network Planning for Evolving Network Architectures". www.itu.int/ITU-D/tech/network-infrastructure/Manual/indexManualNP.html

5 ITU-D – Technology and network development: "Guidelines for Network Planning Tools for Developing Countries and countries with economies in transition" www.itu.int/ITU-D/tech/network-infrastructure/Manual/indexGuidelinesINP.html

1.2 Key findings and conclusions from general assessment

Summary of main findings and recommendations derived from the information gathered on site at meetings with local experts and visit to a sample of places:

R1) Today, BTCL is licensed for fixed services but not for mobile which seriously limits capabilities for convergent service offerings as well as design of service packages.

It is recommended to extend the licence to multiple-play, especially for triple-play with IPTV and for mobile services to be able to compete in a converged market. Mobile services provision by merging with the state-owned mobile operator, Teletalk Bangladesh Ltd, is the preferred solution. Other alternatives should be also considered. Collaboration is recommended between the regulator and other national stakeholders for the definition of specific converged licensing to be applied in the country.

R2) The current organization is basically oriented to the conventional PSTN mode activities. In order to have an efficient operation, it is recommended to perform a structural reorganization taking into account new functional and operational needs, new technologies and to include an updated rewarding system for personnel centred on efficiency and customer orientation.

R3) Currently, there exists only fragmented and partial ICT policies. It is recommended to define an overall coordinated strategy for ICT, e-services and broadband development in coordination with relevant ministries/departments (ICT, education, health, finance, agriculture, tourism, etc.), stakeholders, service providers and related sectors.

R4) Today available broadband offers have relatively low speeds. High prices for medium speeds seriously limit the deployment of many services. It is recommended to extend the offer of higher speeds and redefine the pricing structure taking into account the benefits of economy of scale as indicated in chapter 5. This implies corresponding actions on network provisioning and the commercial plans.

R5) Network migration and services introduction is taking place through partial core sub-network evolution, access and edge segments with limited overall view. It is recommended to develop a specific NGN migration operations group to coordinate all implementations for network elements, including terminals, access, edge, core, services, and operating and business support systems, and assure correct service handling during the transition phases. Accelerate the deployment of ADSL2+ for 8 to 10 Mbps as the quickest way for higher speeds.

R6) As major technological changes are required for migration to NGN, many new issues due to the technical functionalities, interfaces, operation, etc. need to be addressed. It is recommended to identify convenient strategic technology partners for collaboration at the initial phases of the evolution in order to solve the inherent operational issues with any new technology and avoid unnecessary delays and bottlenecks.

R7) Most operational employees have a good background of traditional technologies but very few are familiar with IP-based technologies. It is recommended to develop a comprehensive training programme for operational staff on NGN and IP techniques, protocols, security, engineering and dimensioning, starting at the metropolitan areas and to be extended to all regions to avoid operational issues and service deployment delays. In order to facilitate that training programme, support should be obtained from international organizations like ITU, ICANN, etc. as well as from regional organizations like APT.

R8) Quality of service for IP services is 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, often the cause of decreases in broadband speed and quality at busy hours. It is recommended to develop a team with capability and specialization in IP traffic measurement, processing, projection, dimensioning and planning in relation to new operating support systems applications, the conclusion of service level agreements, and ensure efficient utilization of resources.

R9) Currently, information on cable types and OSP infrastructure is in paper format (not digitalized and not integrated in a common data base). This fact does not facilitate the knowledge of network capabilities for an efficient planning of broadband deployment. In order to have a convenient access network characterization for a wider broadband deployment, it is recommended to have OSP information and inventory in digital and integrated form by deployment and utilization of the applications associated with the operating support system.

R10) According to the data analysed in the Dhaka area and the observation of the aerial installations in Dhaka, it is clear that a significant proportion of cables are more than 15 or 20 years old. This fact determines an urgent need for OSP modernization. In addition, in order to avoid multiple sequential civil works, it is recommended to agree among different players for a common deployment or passive infrastructure sharing (i.e.: common works with assigned ducts per operator or even shared ducts options).

1.3 Key findings and conclusions from access business planning

Summary of main findings and recommendations of the technical and business analysis carried out for network migration towards multiservice NGN:

R11) Access modernization for NGN solutions with OSP enhancement to allow triple play services (at 8 Mbps.) will generate an important increase in the net present value (NPV) of the network due to convergence efficiencies. It is recommended to accelerate the deployment of ADSL2+ and position the company for higher levels of revenue and competition in the market as the net present value starts to have an effect after the three years and will continue to grow over time. Migration is suitable to an "island strategy" with priority to the areas with obsolete equipment and new development areas.

R12) The migration of the network towards NGN at edge and core levels in triple play has the benefits of costs decreasing in OPEX and CAPEX with better business performance assuming an increase of investment in the first three years. It is recommended to migrate Dhaka to NGN in the proposed four year timescale to avoid too much overlap of networks and introduce the new services from the very beginning of deployment in order to anticipate the increase of new revenues. An "overlay strategy" is desired for core and edge network segments to facilitate service continuity. Corporate customers should receive priority and differentiated service quality to get their loyalty and accelerate revenue increases.

R13) A series of sensitivity studies were performed in order to know business behaviour as a function of services tariffs on voice, Internet and IPTV with the three scenarios defined in chapter 5.1. The high importance of tariffs in the overall economic behaviour and for the required external investments was noted. It is recommended to give preference to the scenario that provides optimum tuning and allows affordability to customers, and investment recovery. With a variety of tariff combinations, it will be best practice to maintain the tariffs within the analysed feasibility band.

R14) Introduction of IPTV and video on demand (VOD) should be based on negotiations with content providers that provide attractive and high quality content in order to assure important customer adoption rates and loyalty. It is recommended to start negotiations with content providers at the time of solution design. This will ensure a more varied offer in channels and quality than is available today as well as generating revenue sharing agreements.

R15) Although price and speed of broadband services is an important factor to attract customers in a competitive market, once a sufficient speed is reached, it is quality of service (QoS), service availability, customer care and sustained bit rate (SBR) guarantee that will become the decisive factors for customers when selecting or changing to a new provider. Thus, attention to quality becomes decisive for market positioning and especially for an incumbent operator that traditionally relies on quality.

R16) The number of cable pairs used for broadband today is very low compared to the available OSP infrastructure while a rapid deployment of broadband services is required. It is recommended to increase the utilization of that sleeping investment both with the quick deployment of broadband by BTCL as well as by the parallel deployment by other service providers by using local loop unbundling (LLU). Prices should be defined both by cost evaluations by BTCL of the OSP to be rented with the corresponding life cycle amortization and by the retail minus procedure according to the selected tariff scenario.

R17) In order to benefit from experience of other countries in business related issues, it is recommended to benchmark periodically performance results with other operators within the country and with internationally recognized best practices in order to detect improvement areas and apply solutions to reach a high quality service provision and better business profitability.

2 Context of Bangladesh

2.1 General context

At the end of 2009, Bangladesh had more than 124 million inhabitants and one of the highest population densities in the world at more than 840 people per km^2. GDP per capita at purchasing power parity (PPP) was USD 1572[6] in 2010, and growing at a rate of 6 per cent. The dominant economic activity is related to services.

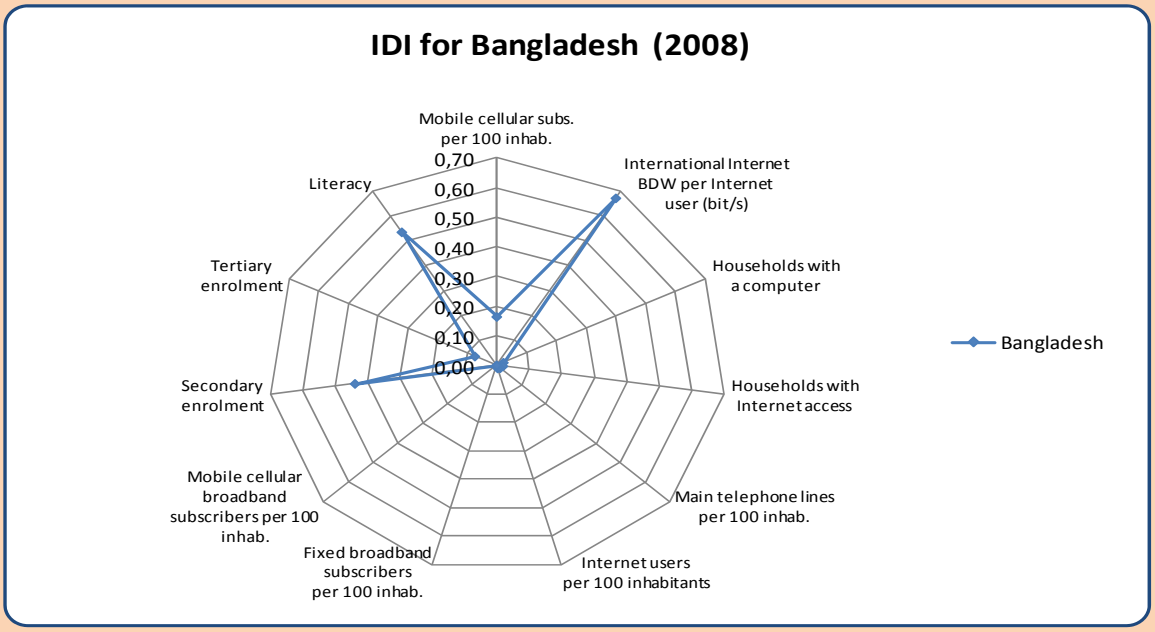
Information and Communication Technology (ICT) development is characterized by low value indicators in all communication factors with a general ICT development index (IDI) of 1.41. In 2010, penetration of mobile terminals was around 39 per cent, with fixed-line penetration of 0.7 per cent and with higher values (4.6 per cent) at Dhaka metropolitan area. International bandwidth per Internet user and basic literacy are in a relatively better position as indicated in Figure 1.

Ministry of Post and Telecommunications (MOPT) has the mission to determine the general policy of the government and to encourage the development of the telecommunication sector in Bangladesh. Specific objectives for telecommunications are:

- To take appropriate actions to facilitate exchange of information through telecommunication within and outside Bangladesh.
- To identify the areas where telecommunication technology can be applied for the purpose of developing the local culture and social cohesion; and to encourage the use of such technology in those areas.
- To identify the fields of public and private sector investment for the purpose of developing an effective and modern telecommunication infrastructure and to encourage such investment on the basis of co-operation between the public and private sectors.
- To undertake, on its own, research and development initiatives in telecommunication in Bangladesh and also to undertake such initiatives jointly with regional and other organizations interested in this regard.

[6] World Economic Outlook Database-April 2011, International Monetary Fund. April, 2011.

Figure1: ICT development index (IDI) for Bangladesh



Source: ITU

- To undertake educational and training programmes for human resources development of enterprises which establish telecommunication system, provide telecommunication services and manufacture related products.
- To assist all concerned for the purpose of enhancing the local telecommunication manufacturing capability and developing innovative telecommunication services.
- To facilitate measures to control or abolish discriminatory conduct in providing telecommunication services or extension of such services.
- To arrange a forum where the ministry, government, commission, operators, consumers and other interested persons may meet to discuss matters of common interest.
- To co-ordinate participation of Bangladesh in the activities of the International Telecommunication Union and other international organizations regarding policies, standards and procedure to be followed in the telecommunication sector, and undergo training on such matters.
- To formulate policies regarding the development and administration of postal and telecommunication sector in the country.
- To look after and supervise the activities of Teletalk Bangladesh Ltd, Telephone Shilpa Shangtha, Bangladesh Cable Shilpa Limited, and Bangladesh Submarine Cable Company Limited.

Bangladesh Telecommunication Regulatory Commission (BTRC) is an independent Commission established under the Bangladesh Telecommunication Act, 2001 (Act no. 18 of 2001) published by parliament in the Bangladesh Gazette, extraordinary issue of 16 April 2001. BTRC started functioning from 31 January 2002. The following specific objectives were mandated:

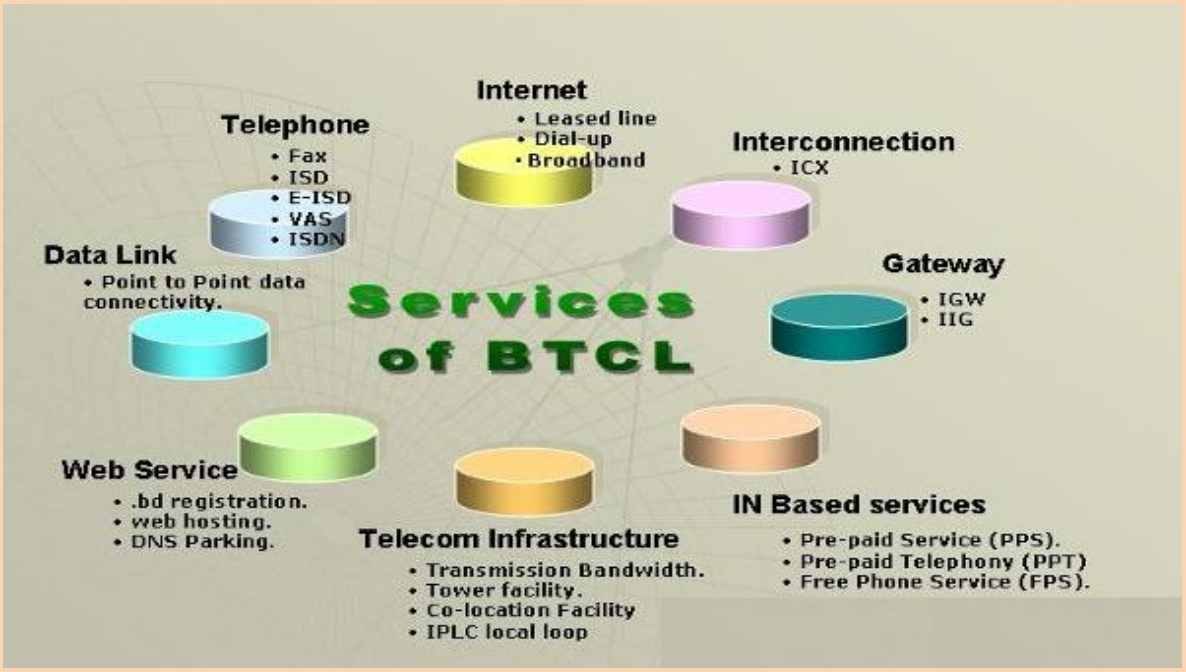
- In order to give a thrust to the ICT sector and timely development of the software industry and its export, required infrastructure facilities and legal framework will be created.
- Provide effective incentives for the development of the ICT sector to both local and foreign entrepreneurs.

- Develop an efficient ICT infrastructure that provides open access to international and national networks.
- Promote and facilitate use of ICT in all sectors of the economy for transparency, good governance and efficiency improvement.
- Establish a legal and regulatory framework for ICT issues like intellectual property rights, data security and protection, digital signature, e-Commerce, ICT education etc. as well as to ensure quality ICT education provided by different private organizations.
- Set up national databases that are reliable and easily accessible to all the people of the country.
- Promote use of ICT by providing special allocations for ICT project implementation in the public sector. Train the decision makers in ICT use and promote an ICT culture.
- Develop a large pool of world-class ICT professionals to meet the needs of local and global markets.
- Set up a very high quality ICT institution to continuously promote and foster the ICT industry.
- Enact laws and regulations for uninterrupted growth of ICT, in conformity with World Trade Organization (WTO) stipulations.

2.2 Players

In Bangladesh, the main global player for fixed lines and telecommunication infrastructure is Bangladesh Telecommunications Company Limited (BTCL)[7], created from the previous Bangladesh Telegraph and Telephone Board (BTTB) on 1 July 2008. The Bangladesh Government owns all shares of BTCL and shares will be sold later to the public.

Figure 2: Main services per category provided by BTCL



Souce: BTCL

[7] Bangladesh Telecommunications Company Limited (BTCL), www.btcl.gov.bd/

BTCL has a mandate to provide basic telecommunication services throughout the country. At present, BTCL is providing telephone service to about 1 million telephone subscribers. Most of them can also use dial-up Internet service. BTCL has the largest telecom infrastructure comprising of copper cabling, microwave links, satellite links, optical fibre networks etc. ADSL broadband Internet service is available now with a 33 000 capacity. BTCL earned 15 653 million taka revenue in 2007-08 and 20 813 million taka revenue in the 2008-09 fiscal years. On 30 June 2009, BTCL employed 10 325 regular staff. In addition to this, about 5 000 positions are project specific or short-term.

BTCL has a wide range of fixed network key services, but is excluded from mobile services.

In January 2010, the number of subscriber lines in service reached 951 894, with the majority (800 866) in urban areas and the remainder (151 028) in rural areas, and the total number of equipped lines in Bangladesh reached 1 318 684[8].

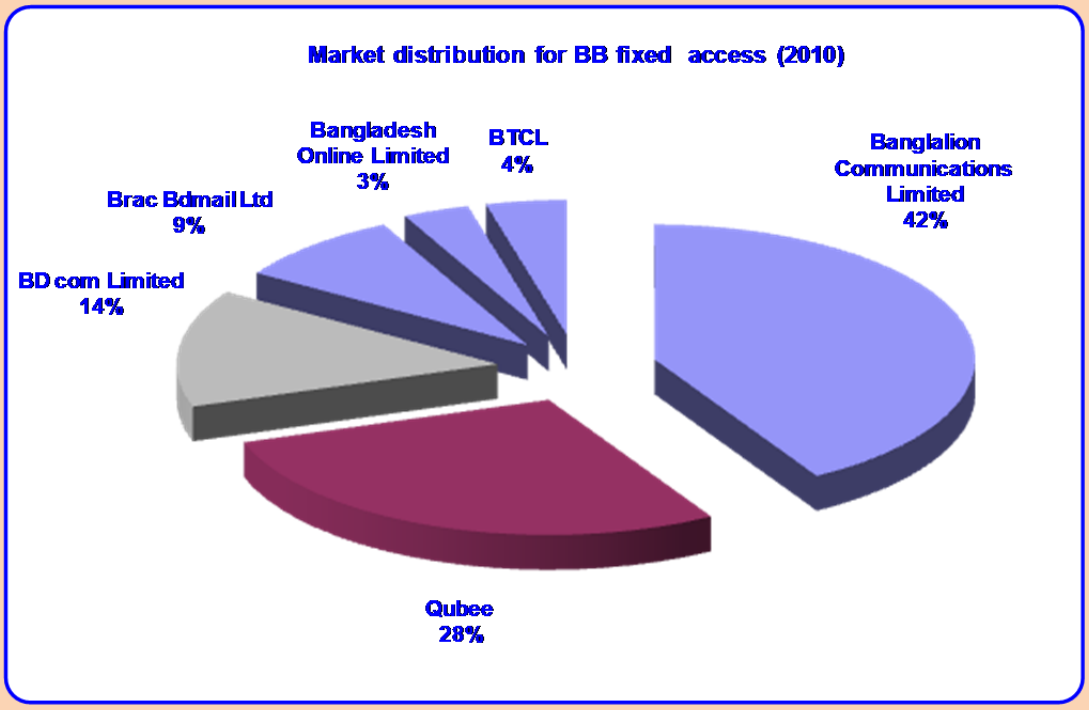
Tariffs for voice calls are relatively low with values of Tk. 0.30 /min for BTCL to BTCL (local/nationwide) and Tk. 0.65/min for BTCL to other fixed-line phone (PSTN)/cell phone.

The mobile market development and its level of market competition has been high in recent years and is served by six main players:

- Grameenphone – Joint venture ownership 62 per cent Telenor and 38 per cent Grameen Telecom.
- Banglalink – Joint venture with Orascom Telecom Co. originated from Egypt.
- Aktel – Joint venture between Telecom Malaysia Berhad TM and A. K. Khan & company limited.
- Waried Telecom – An investment of Dubai and Abu Dhabi Group UAE.
- TeleTalk – Public limited company owned with 100 per cent share by the Government of Bangladesh.
- Citycell – Joint venture with SingTel Asia Pacific investment Pvt. limited.
- The broadband market remains underdeveloped with the market share distributed as indicated in Figure 3 between three main operators. The access network is owned and provided by: BTCL with ADSL, Banglalion Communications Limited and Qubee with WiMax. Other ISPs provide services such as BD com Limited, Brac Bdmail Ltd and Bangladesh Online Limited.

[8] www.btcl.gov.bd/home/main/statistics/telephone_status.php

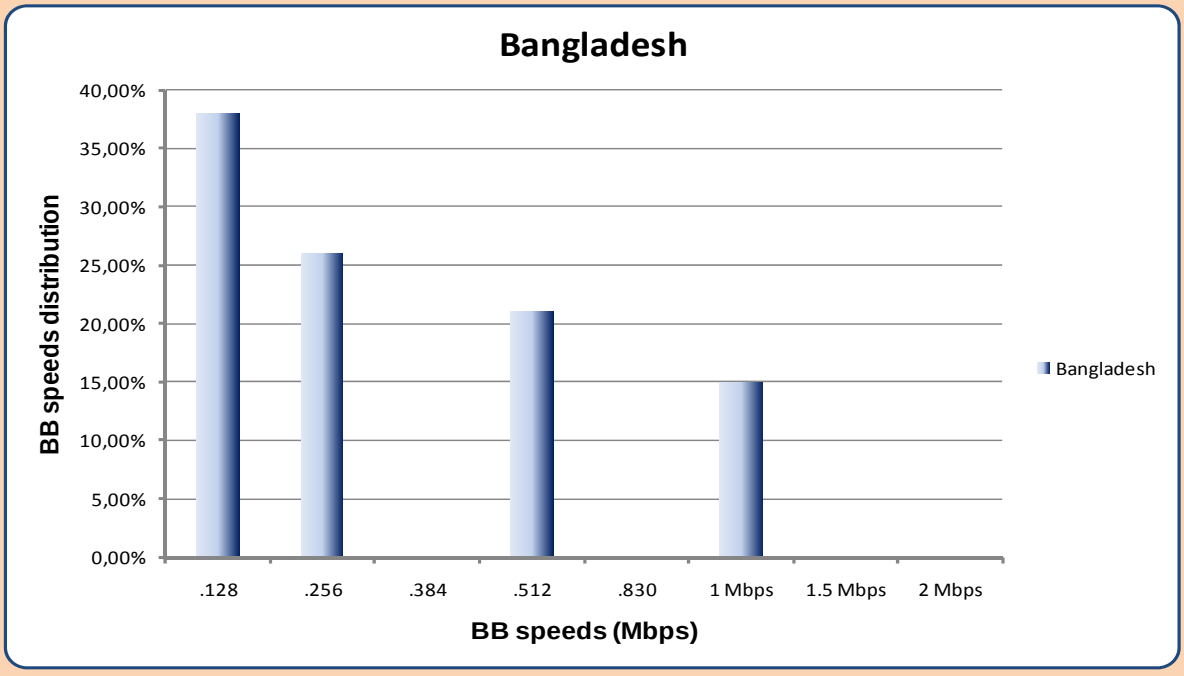
Figure 3: Market distribution for broadband access including operators with and without ownership of the access network



Source: Working Team: Bangladesh

Major offered stable speeds (not including transitory marketing offers) are illustrated in the Figure 4 for BTCL that show a dominant frequency of 128 Kbps followed by 256 Kbps, 512 Mbps and 1 Mbps. 128 Kbps is considered a broadband service at a national level, although most definitions start at 256 Kbps.

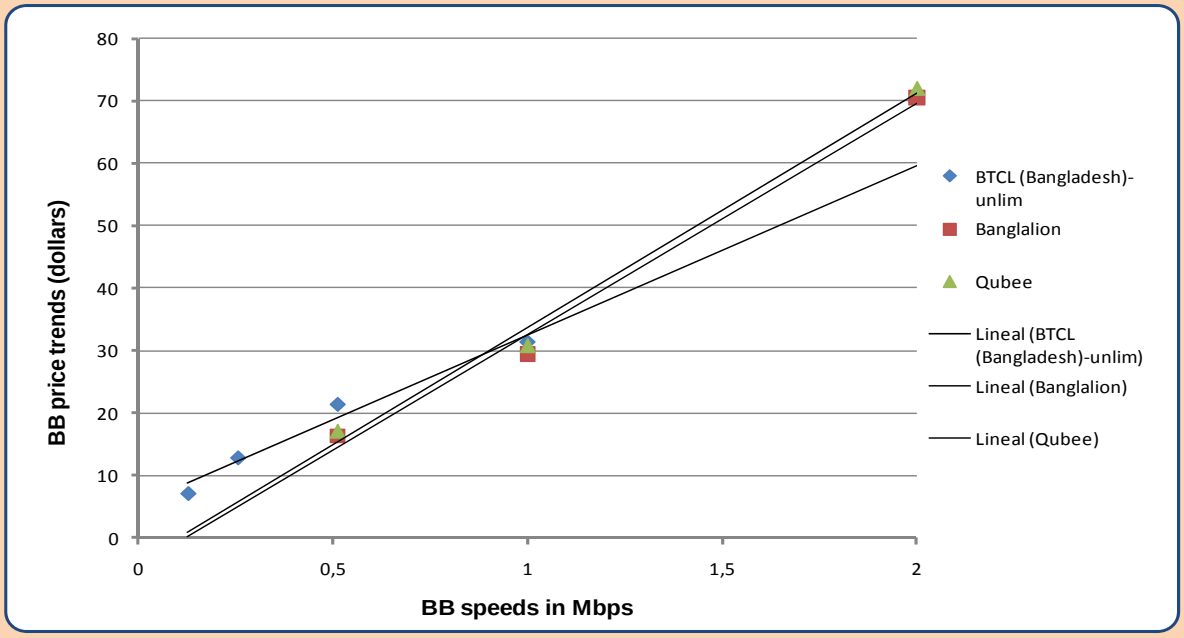
Figure 4: Distribution for major broadband speeds of stable offers by main operators



Source: Working Team: Bangladesh

With the same concept of stable offers, Figure 5 illustrates the relationship between speeds and prices including WiMax providers with offers of up to 2 Mbps. Prices are close between operators and show a significant linear increase with speed. It is derived that economies of scale inherent to the network design and technologies in use are not applied in order to reduce prices at higher speeds, and competition level is low as similar behaviour is present in all offers.

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



Source: Working Team: Bangladesh

2.3 Network architectures

The Bangladesh Telecommunications Company Limited (BTCL) has a traditional PSTN network architecture with hierarchical structure based on five international trunk exchanges, 18 transit exchanges , 585 digital exchanges and additional local or remote switching units associated to the areas called “upazilla”, equivalent to sub-districts or counties in other countries. There is more than 3200 km of optical fibre network and Internet international capacity has 9xSTM4 (5.6Gbps) bandwidth via the submarine cable SEA-ME-WE4, with an additional 72 Mbps (48 down+24 up) by satellite.

Concerning the access network, BTCL also has more than 110 DSLAMs, with 32 located in Dhaka and a total capacity higher than 47 000 lines. Co-located DSLAMs with local exchanges are connected through shared 1 Gbps Ethernet and remote DSLAMs by STM-1 circuits up to the closest local exchange. The network is completed with 5 212 cabinets, with 4 233 in urban areas and 979 in rural areas. Total distribution points in all areas reaches 104 399.

In recent years, an effort was devoted to plan and implement an Internet Information Network Expansion Project or INFO-BAHAN The designed IP backbone of BTCL[9] consists of six OSPF (Open Shortest Path First: the most commonly used IP networking protocol) areas. There are two core routers at two physically different places (one at Moghbazar and the other at Ramna) which form the IP core. The two core routers work in load sharing mode and also provide redundancy in the event of failure of one of the core routers.

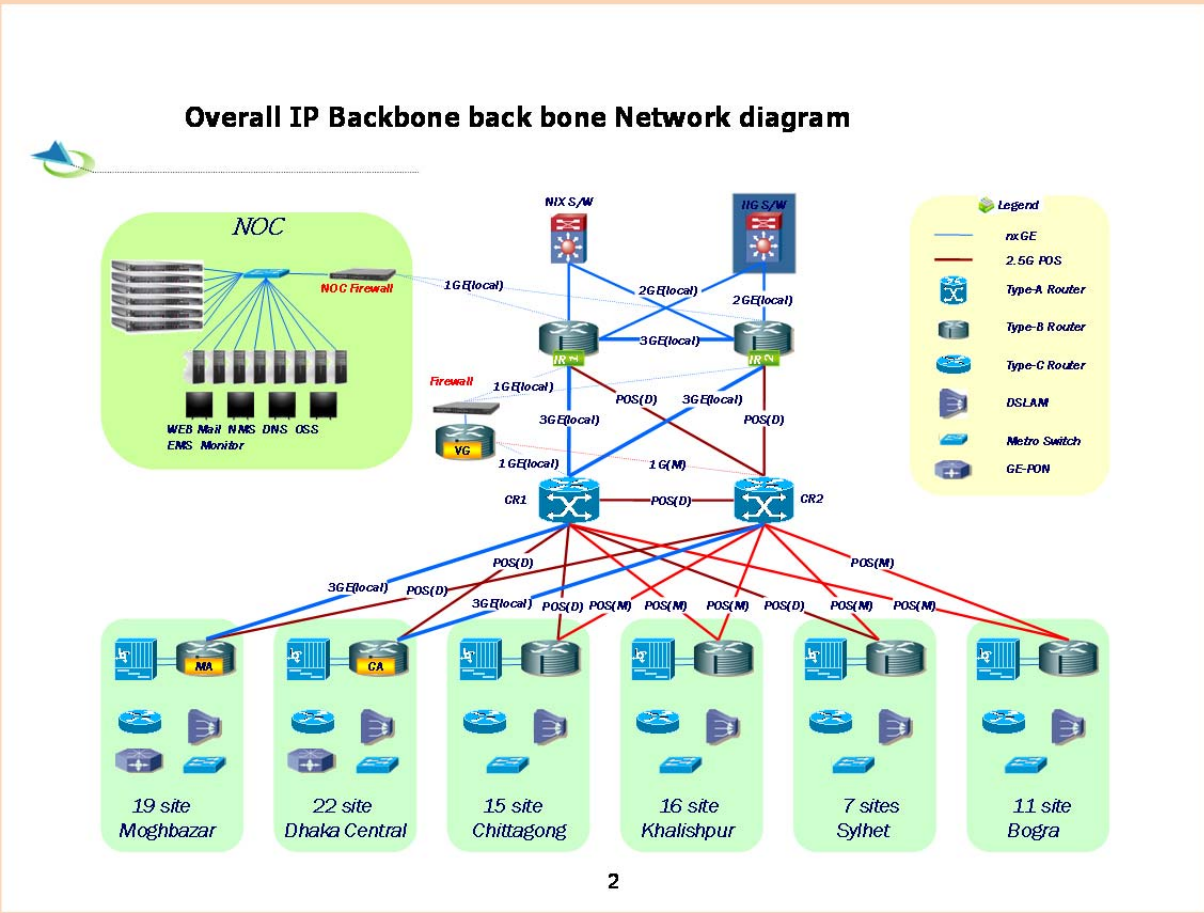
[9] BTCL, IP Backbone and Access Network of BTCL: *Mashiur Rahman*

There is an area boarder router (ABR) at each OSPF area, which is connected to the core routers through two separate STM-16 POS links or through several GE links (if the ABR and Core router is in the same building).

The designed six OSPF areas are:

1. Moghbazar Area (Area-1).
2. Dhaka Central Area at Ramna (Area-2).
3. Chittagong Area at Nandankanon (Area-3).
4. Khulna Area at Khalispur (Area-4).
5. Sylhet Area (Area-5).
6. Bogra Area (Area-6).

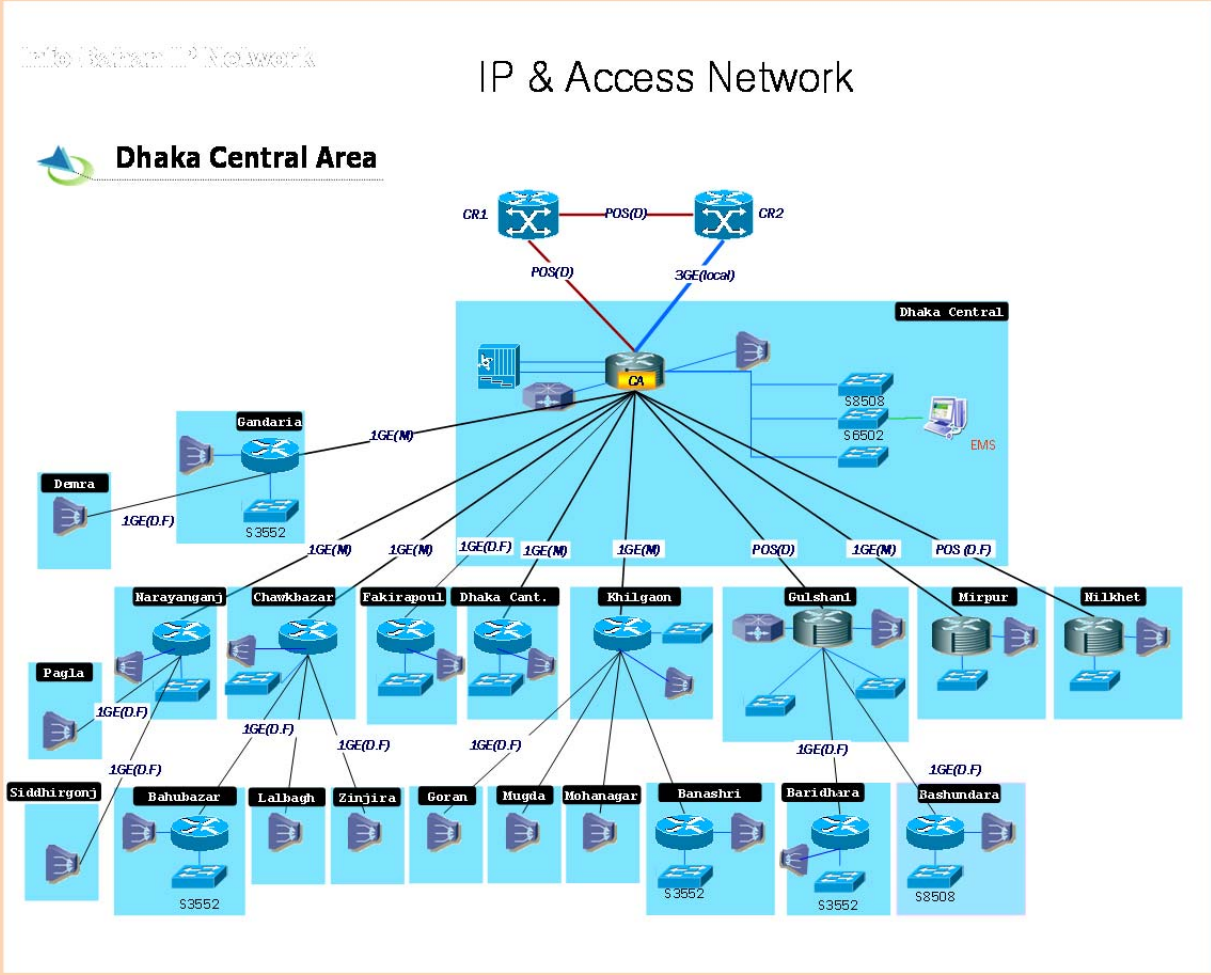
Figure 6: IP network structure at national level



Source: BTCL

In the Dhaka Central (Ramna) area, there are 22 sites of which 8 sites have only ADSL nodes (DSLAM). Another 14 sites are IP point of presence sites with routers and switches as well as DSLAMs for access. Each of the Dhaka Central (Ramna) and Gulshan sites also has an optical line termination for GE-PON (Gigabit Ethernet Passive Optical Network) based optical access network of limited capacity. The network diagram of Dhaka Central OSPF area is shown below:

Figure 7: IP network structure at the Dhaka metropolitan area



Source: BTCL

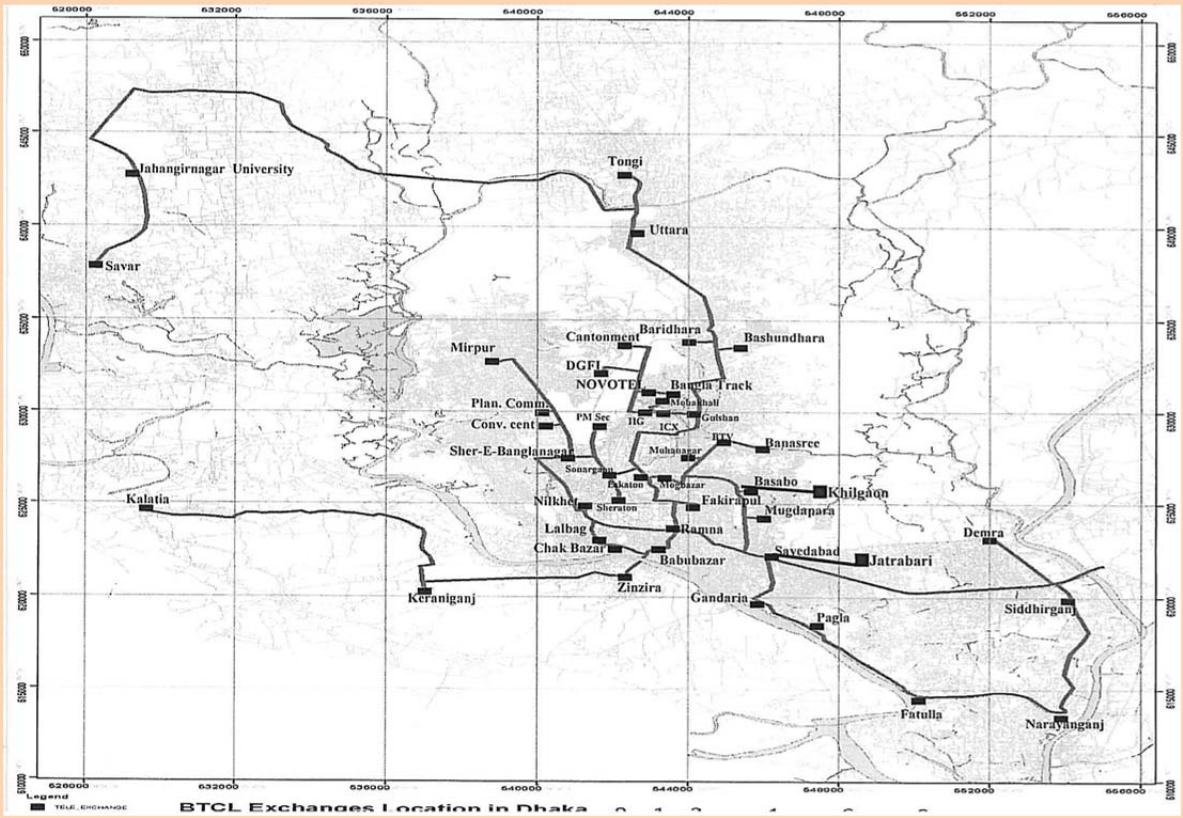
The main service which is being provided through the IP network is the broadband Internet service. All the routers of the IP backbone network are IP/multiprotocol labelled switch (MPLS) enabled. Hence, lots of other MPLS enabled services can be provided through this network which includes the following services:

- Virtual leased line service.
- Layer 2/Layer 3 VPN service (Silver).
- Layer 2/Layer 3 VPN service (Gold: Silver+QoS).
- Layer 2/Layer 3 VPN service (Premium: Gold + Managed network service).

3 Assessment on Access

Project objectives for the assessment of current access network infrastructure were defined for the urban area of Dhaka in order to analyse capabilities of the physical network for a further provisioning of broadband services and to value the required enhancements. Dhaka had 10.8 million inhabitants in 2009 and is served by BCTL in an area of 1.460 square kilometres with a structure and location of exchanges as indicated in Figure 8.

Figure 8: Map of Dhaka service area and location of current exchanges



Source: BTCL

A visit was paid to selected network locations in Dhaka in order to directly observe network elements, equipment practices and aging status. Aerial distribution cables are in below-average condition and lack the required quality.

Main key factors influencing due to cable characteristics critical for broadband services are:

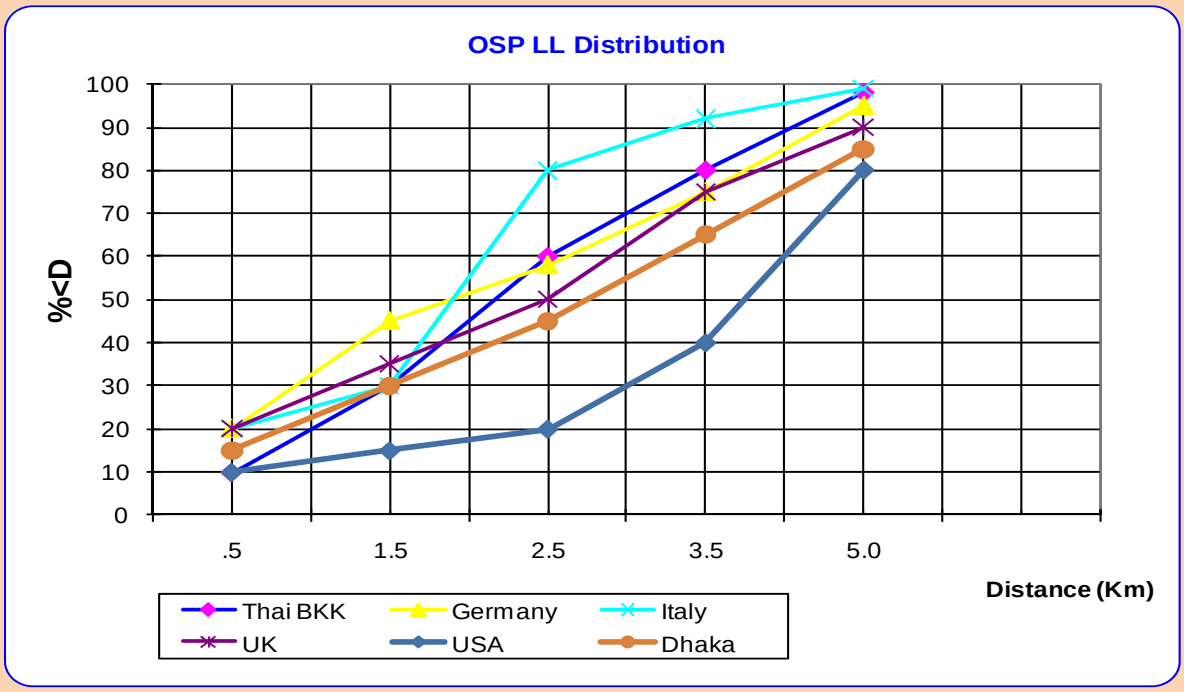
- The length of cable.
- Cable aging.
- Cable gauge and material.
- Amount of crosstalk between adjacent cables (function of cable age, isolation, humidity and filling degree).
- Cable discontinuities through the path (function of the historical connection practices).
- Noise gathered by induction of electromagnetic sources at customer premises or along the cable path (i.e.: radio emission, electrical power, etc. as a function of the electromagnetic compatibility practices).

Due to the large variety of cables and cable conditions, it is recommended to use measurements with proper sampling techniques for a first step characterization. Specific testing equipment for measurement may also be used for a better loop pre-qualification with results of the order of 95 per cent certainty. Final qualification has to be done on a per customer base at installation phase.

From the data gathered in Dhaka, the characterization of first influencing parameters to be observed is given in the following charts:

- Local loop (LL) length distribution within Dhaka (brown) shows a relatively good shape not far from the case of UK as indicated in Figure 9 with network topology design associated to the population settlements around a nucleus. Nevertheless, more than 10 per cent of cables have distances larger than 5 km that allow only low data speeds.

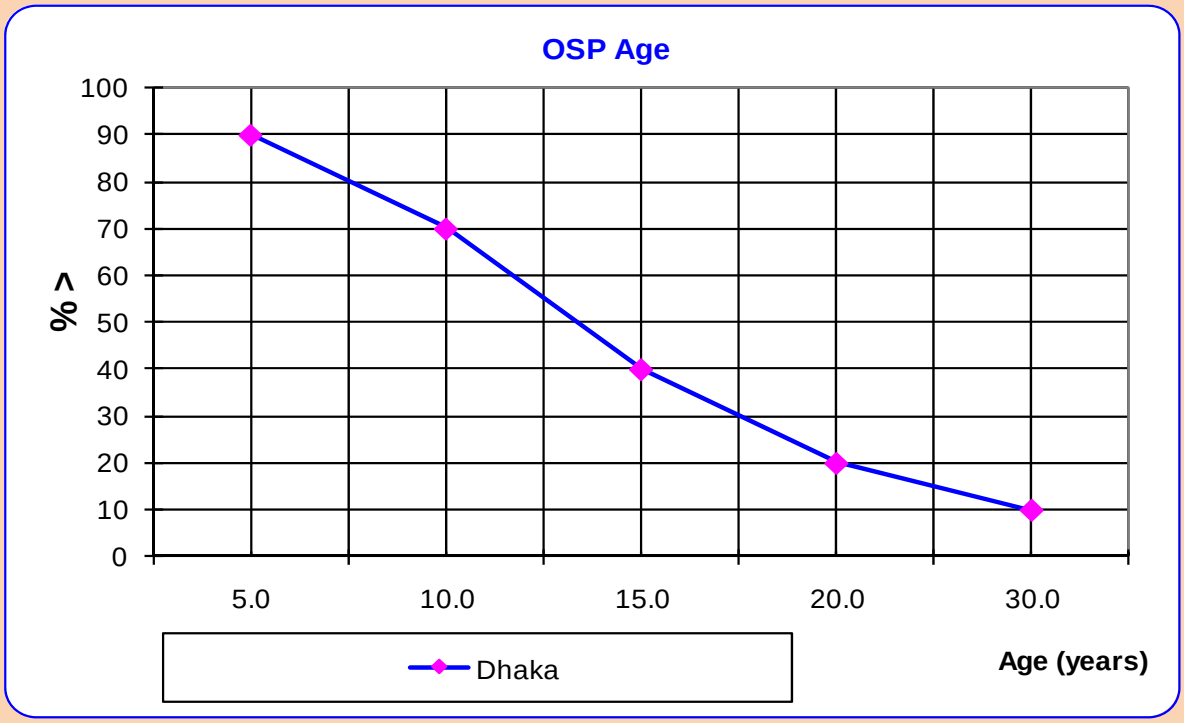
Figure 9: Cable length distribution sample at Dhaka compared to typical countries



Source: Oscar González Soto

- Cable ages in Dhaka obtained by sampling of several installations follow the distribution indicated in Figure 10 with a significant proportion of cables at the end or close to the end of life cycle (more than 20 years) to be renovated in the short term as well as many (more than 15 years) that should be renovated in the medium term.
- Concerning the equipment practices observed in the visits to the exchanges in Dhaka it may be concluded that the equipment practice has different qualities according to network element type; some of them like local exchanges and data equipment show a high quality as compared to typical international standards while others are below required quality, especially cable cabinets in which protection rules from the street is not maintained of cable paths show a deterioration due to multiple interventions over time.

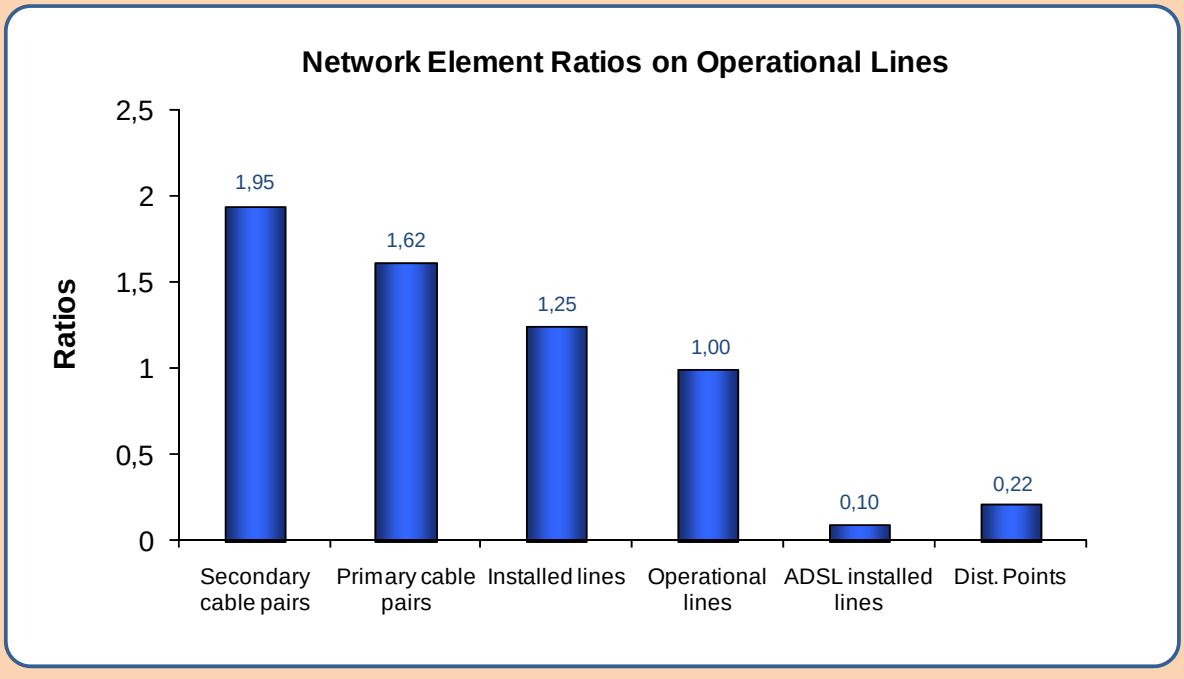
Figure 10: Distribution of cable aging in a sample of installations in Dhaka



Source: Oscar González Soto

Ratios of installed cables at primary and secondary segments follow good reservation capacity for network growth as indicated in Figure 11. The number of ADSL installed lines is very low compared to available capacity that is ready for an important increase.

Figure 11: Access infrastructure ratios as a function of operational lines



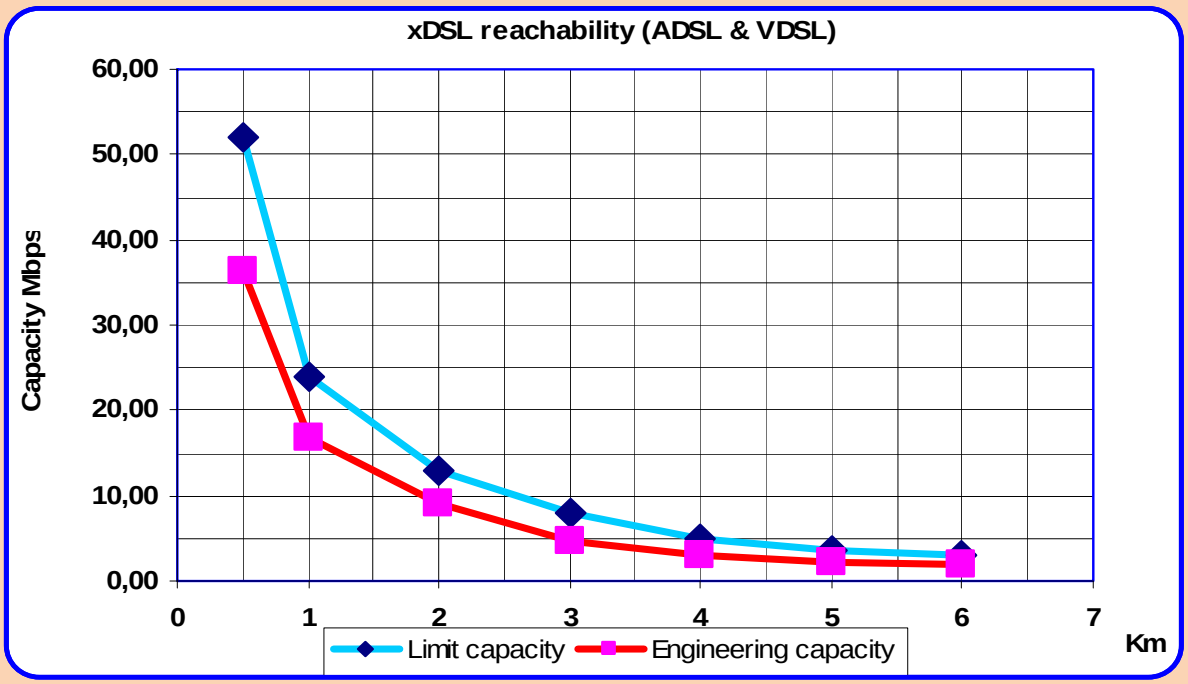
Source: Oscar González Soto

An important parameter for ADSL quality is the fill-in degree or ratio between operational lines and available cable pairs in the same cable, that is on average 2 per cent and is far from the fill-in degrees in which cross-talk starts to be important, 60 per cent for medium frequencies and short distances, and 25 per cent for high frequencies and longer distances. Although this is not expected to be an influencing factor until higher ADSL penetration take place in several years from now, a more detailed analysis should be made to know the dispersion of fill-in degrees in different zones as compared to the average.

The level of cable plant modernization will be a function of previous characterization and the Mbps capacity reachability by xDSL technologies, which depend on the cable distance to the main or feeder distribution frame. From analysis in lab cables and experience in existing networks, Figure 12 summarizes the xDSL technologies including both ADSL and VDSL capacities as a function of the distance: the blue line gives the maximum theoretical capacity in Mbps with cables in lab conditions while the red line illustrates the engineering capability of field conditions where many practical details of actual cable installation decrease the maximum theoretical reached distance. In order to assure the contract capacity in a commercial offer, the dimensioning has to be done with the engineering capacity in such a way that at least more than 98 per cent of lines fulfil the capacity in peak periods.

It has to be noted that continuous progress in the DSL techniques are increasing the speeds with new coding techniques and bundling of cable pairs especially on short distances where transfer rates may reach up to 100 Mbps.

Figure 12: Speed for xDSL technologies relative to cable distance to card



Source: Oscar González Soto

When considering the end-to-end access network across the different network elements from the user terminal to the ISP gateway (national or international), data flow capacities should be dimensioned for all transmission and processing elements in the entire path. Current dimensioning is performed by an empiric value of the concentration factor from the user peak rate up to the IP network for residential customers and by other values for business customers. In addition an empiric percentage of IP flows are assumed to be international.

Some customers complain of a decrease of speed at peak hours that may be due to the backhauling capacity limit and the lack of a well-established path dimensioning.

It is recommended to follow the concept of sustained bit rate (SBR)[10] or bit rate measured over a well-defined period (i.e.: 5 minutes) with the corresponding quality of service (QoS) parameters and measure those factors in the access network to have a more realistic dimensioning. A better characterization proposed for network design and planning based on the main influencing factors imply the measurement of the following parameters that will provide the overall concentration factor knowing the cause and behaviour of each customer class:

- **ρ:** Customer connection ratio or percentage of time a user is connected to the network.
- **α:** Activity ratio or percentage of time that a connected user is active at any Internet application.
- **μ:** Transmission ratio or percentage of the activity time that the user is effectively transmitting packets according to the application types being used.

The overall average sustained bit rate: **τ** (i) generated by a customer of class (i) will be:

$$\mathbf{T}(\mathbf{i}) = \boldsymbol{\rho}(\mathbf{i}) \times \boldsymbol{\alpha}(\mathbf{i}) \times \boldsymbol{\mu}(\mathbf{i}),$$

And the aggregation of traffic for n classes of the same QoS:

$$\mathbf{T} = \sum \mathbf{T}(\mathbf{i}); \text{ i=1 to n}$$

This more detailed characterization allows for a good knowledge of user behaviour and for a definition of parameters that are either stable over time or a function of customer contract type and access speed. Using the SBR calculated or measured over the same time period, facilitates the aggregation of SBR (i) for different users and classes of the same quality at a given network element (transmission link or node) to assure a correct dimensioning of access paths for the required QoS.

4 Techno-economic Modelling for Access Evolution

The techno-economic evaluation of the access network acquires greater relevance due to the heavy investment requirements, and is the key decision factor when selecting target solutions and migration paths among the many alternatives that the equipment suppliers are offering.

The main issues for access modelling are identified in this section as well as key drivers for the evolution, scenario definition and tool based business evaluations. Performed activities are described in the following chapters.

4.1 Issues and modelling

The following issues are associated with the planning of the access evolution:

- Knowledge of the total market volume, competitor market share, and offered services.
- Required multilayer network characterization with physical and functional levels due to the high interdependency between them and influence on costs of the civil infrastructure.
- Selection of target network architecture and technology within the many alternatives that the suppliers are offering.
- Definition of evolution path, steps and timing from initial status to target solution.

[10] ITU-D – Technology and network development: "Manual on Network Planning for Evolving Network Architectures" www.itu.int/ITU-D/tech/network-infrastructure/Manual/indexManualNP.html

- High impact of physical network status, coverage, quality, etc. that have to be quantified for adequate decision making.
- High investments required high for physical infrastructure that conduct to the need for optimization and sharing.
- Investment recovery time higher than in core segment as a function of reusability of existing networks (from zero at greenfield areas to high in areas with a modern and flexible infrastructure) that cannot be recovered by voice service only and requires revenues generated by new multiservices.
- Selected access modelling methodology following the principles defined by ITU[11] that is extended specifically for fixed network of the access segment in an urban area.
- Evaluation methodology is based on the development of techno-economic models and interrelations for the agreed scenarios in order to establish dependencies among customer population, market share, services demand, resource dimensioning, costing, evaluation of operational expenditures and network profitability with the capability to compare equipment installation rates, capacity required, traffic, CAPEX, OPEX, cash flows, net present value (NPV), etc.
- Data gathering is structured for inputs related to generic market values, selected scenarios in the Bangkok area from the current infrastructure, cables, local exchanges and access units as well as for future technology to be used following the defined templates at the Annex 1: T1. – Template for data gathering on main socio-economic inputs, T2.-Template for data gathering on main physical network inputs and T3. – Template for data gathering on main Functional Network inputs
- Due to the need for multiple evaluations and the "what-if" analysis associated, STEM tool[12] is the selected planning platform for implementation of the variety of access configurations, the dynamic migration from current status to the future one, capability to perform sensitivity analysis and ability to incorporate new market solutions.
- In any techno-economical evaluation, it is important to select those key drivers that impact in the solution dimensioning, costing and business results. The following are considered as the main drivers:
  - Demand related:
    - Deployment geographical area characterization.
    - Services penetration at planning year 0 and planning period.
    - Traffic in erlangs for voice circuit though time.
    - Traffic in Mbs for VoIP, broadband Internet and IPTV through time.
  - Equipment and network element (NE) related.
    - Network demand units (customers, lines, ports, Erlangs, Mbps, nodes, platforms, etc.).
    - Capacities of each network element as a function of the dominant capacity driver.
    - NE modularities for realistic dimensioning with equipment practices.

[11] ITU-D – Technology and network development: "Manual on Network Planning for Evolving Network Architectures" www.itu.int/ITU-D/tech/network-infrastructure/Manual/indexManualNP.html

[12] STEM business-modelling tool for Telecom. Robin Bailey. www.impliedlogic.com/STEM/

  - Speed for migration for customers and associated network equipment.
- Cost/revenue related:
  - Capital investment for extended or new equipment.
  - Leasing, Maintenance, Operation per NE.
  - Generic project and network transformation.
  - Tariffs per service associated to a new connection, monthly fee or traffic consumption).
  - Global socio-economic parameters as interest rates, depreciation policy, etc.

4.2 Migration scenario definition

Best practice cases within countries with advanced levels of ICT development perform a careful planning for introduction of new services in parallel to the network modernization for IP mode in order to satisfy demand for broadband capacity and ensure a positive return for the investments in a medium term (two to five years).

The process for network transformation recommended 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.

On top of the project objectives for access, a parallel network evolution on the other network segments has to be provided with the corresponding modernization.

Due to the initial stages of IMS implementations, 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.

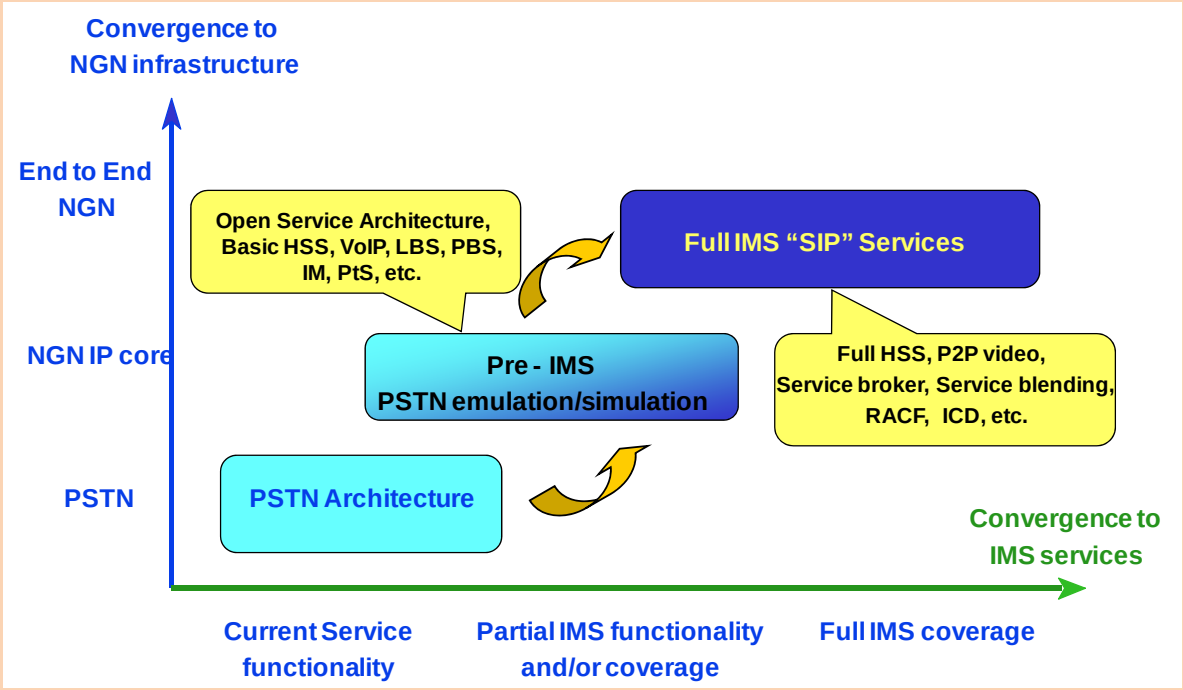
- At a first phase, the Open Service Architecture and a basic Home Subscriber Server (HSS) are mandatory from the starting process in the so called Pre-IMS or Early-IMS that will implement the easiest user entity supporting IPv6. PSTN emulation and simulation are used in order to extend services to all customers either connected to the full IP mode 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 Session Initiation Protocol (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.

A phased approach is proposed in Figure 13[13].

Figure 13: Coordinated convergence for the NGN infrastructure and the full IMS services



Source: ITU

Transit or equivalent core network at NGN has the main responsibility of routing high capacity flows at the upper network layer with the following best practices:

- Design new topology with less layers and nodes and higher connectivity degree (greater than three) to ensure full capacity when single failure of a node, a ling or a route occurs[14].
- 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.

[13] ITU-D – "Manual on Network Planning for Evolving Network Architectures". 2007. Chapter 6: Converged Networks www.itu.int/ITU-D/tech/network-infrastructure/Manual/indexManualNP.html

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

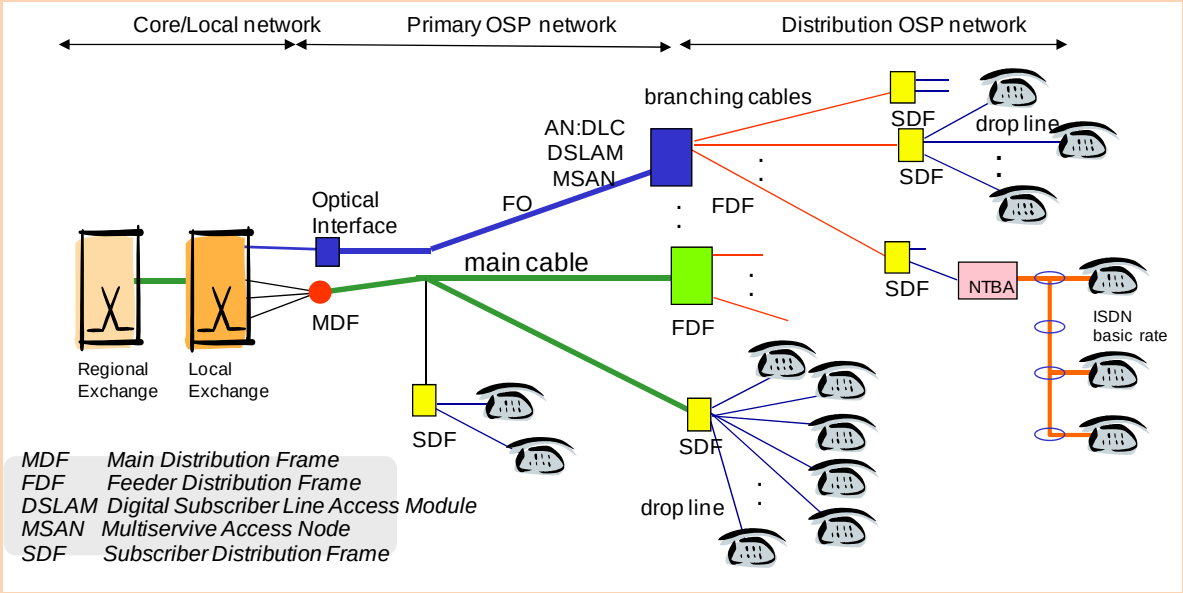
- Re-optimization for location of new nodes as the number will be much lower than the classical TDM ones and similar for the network interconnection points.
- Considering the initial availability of a softswitch, this operation may continue until main subsystems of IMS that are today fully developed are implemented with SIP for all IP new services.

The local network or equivalent Edge network in NGN terminology has the role of backhauling from access to 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, catching and interfaces according to new technology capabilities and service offers.
- Introduction of the IP mode network elements with priority in new areas and areas with obsolete PSTN equipment.
- Continue with IP mode implementation at the rest of network 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 service level agreement commitments.
- Depending on country geographical size and scenario diversity, full migration may frequently take five to ten years to be completed.

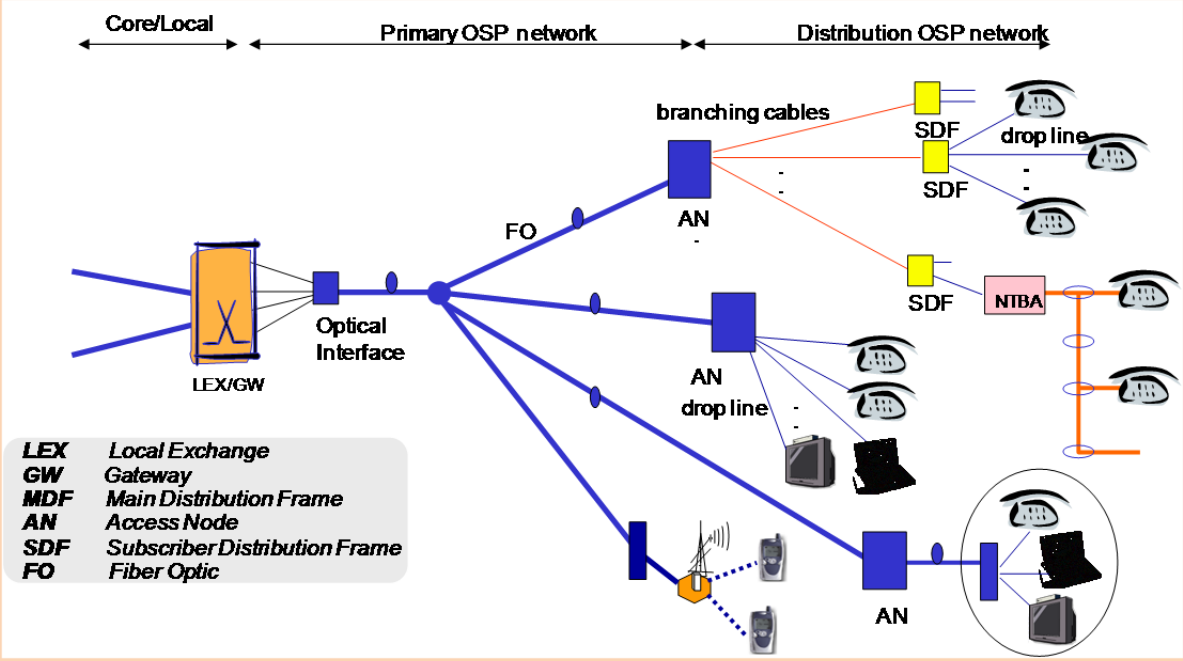
Access network is the main objective of current project with the analysis of migration at technical and business dimensions and consequently the rest of the chapter is focused on access issues. Figures 14 to 17 illustrate structure migration and access modelling.

Figure 14: Typical access plant structure with copper pairs and some fibre optics



Source: ITU

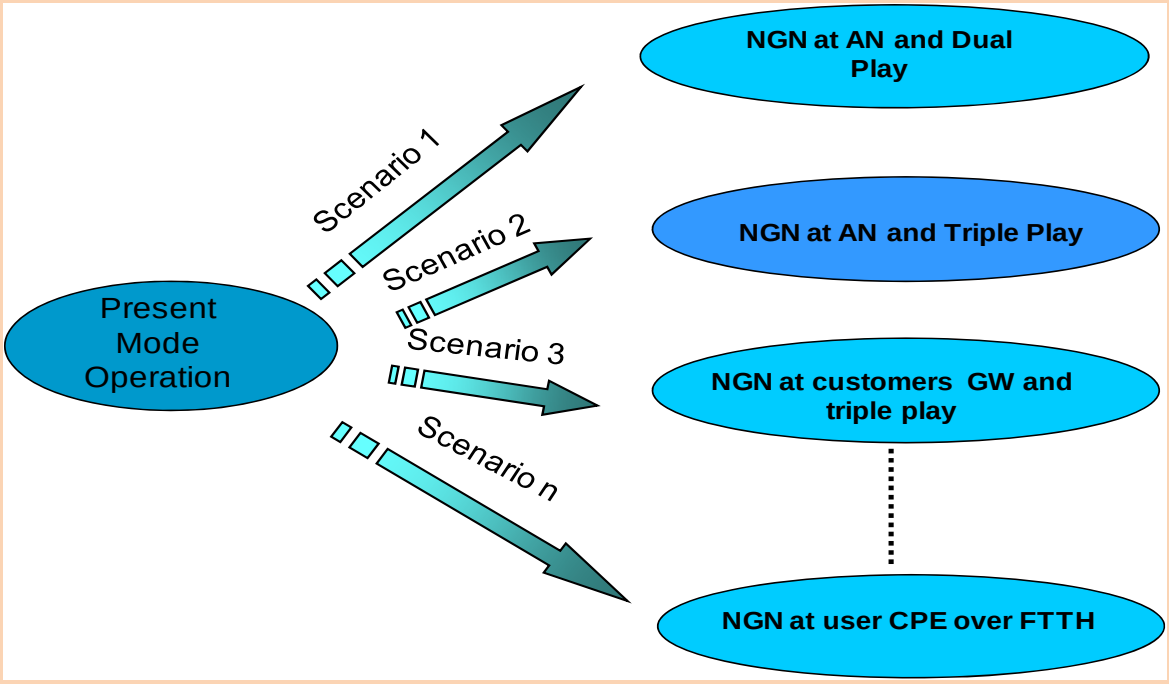
Figure 15: Evolution of the access plant structure towards close and up to the customer fibre optics



Source: ITU

– In order to evaluate the consequences of different evolution directions, a number of alternatives or generic migration scenarios need to be defined at the network technology level and also for modernization of the access physical infrastructure.

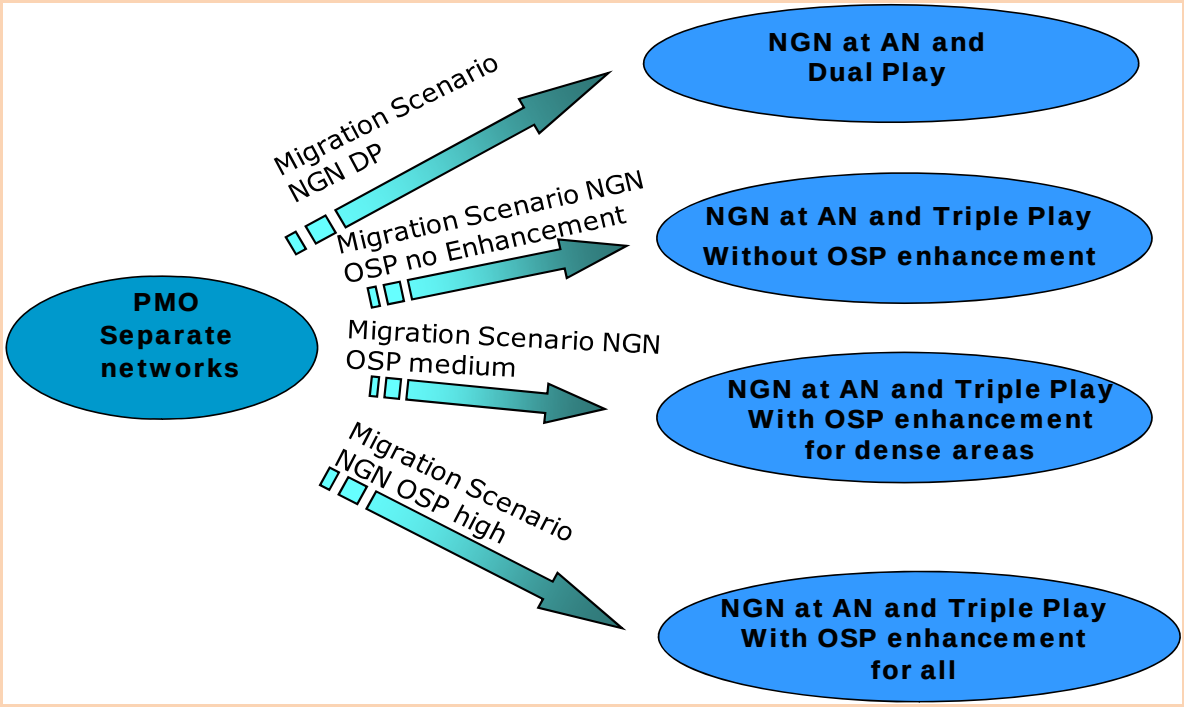
Figure 16: Generic migration scenarios for diverse countries



Source: Oscar González Soto

- In the context of the Dhaka area and the current ICT development level, the most appropriate migration scenarios are considered for the defined objectives of this transformation project. A migration scenario here is defined by the pair or original network configuration and the final network configuration with the corresponding dynamic evolution from old to new technologies at a given pace.

Figure 17: Specific migration scenarios analysed for the Dhaka area

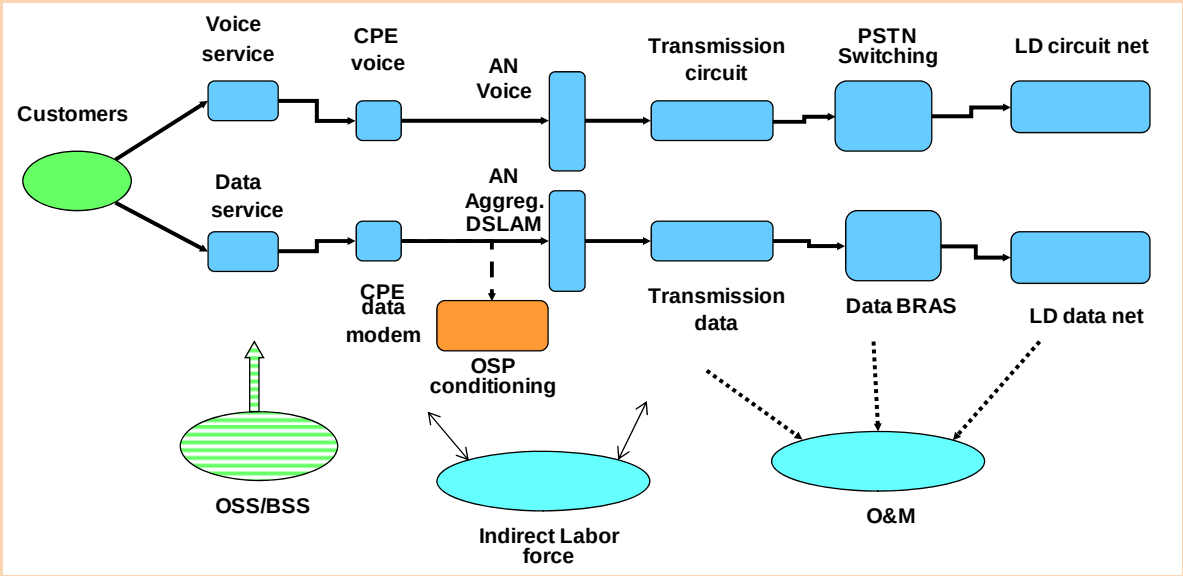


Source: Oscar González Soto

- Scenario 0 or present mode of operation in which voice and data services are carried as in the historical networks: dual play with circuit mode PSTN for voice and Internet over separate data network. This reflects the dominant solution today and to be used as basic reference for other cases.
- Scenario 1 or migration towards NGN in the upper network segments with dual play in which services flows continue separated from the user up to the access node type where flows are integrated in IP mode towards an NGN core network.
- Scenario 2 or NGN without outside plant (OSP) enhancement and with convergence of services is made at triple play based on multiservice access nodes (MSAN). This incorporates to Scenario 2 the IPTV and Video on Demand (VOD) services thus requiring corresponding elements at the network and 8 Mbps capacity at user side. Here only for those users in the area close to the local exchange and active nodes (< than 2 km cable length).
- Scenario 3 or upper segments in NGN with additional OSP enhancement at medium level that implies triple play as in the Scenario 3 but extending modernization of the OSP cables and civil infrastructure with additional remote units to cover more dense and easy zones.
- Scenario 4 or NGN with high OSP enhancement that implies to install the necessary number of remote access nodes and modernization for OSP cables and civil infrastructure to reach all customers in the area and fulfilling the non-discrimination rule among customers in the area.

Simplified functional diagrams associated to these scenarios and used as a base for the modelling of resources to be evaluated are described in Figure 18 and 19. Historical configuration is modelled as a solution scenario of present mode of operation with separated voice and data networks as simplified in the Figure 18.

Figure 18: Linear functional diagrams for current PSTN and data operation

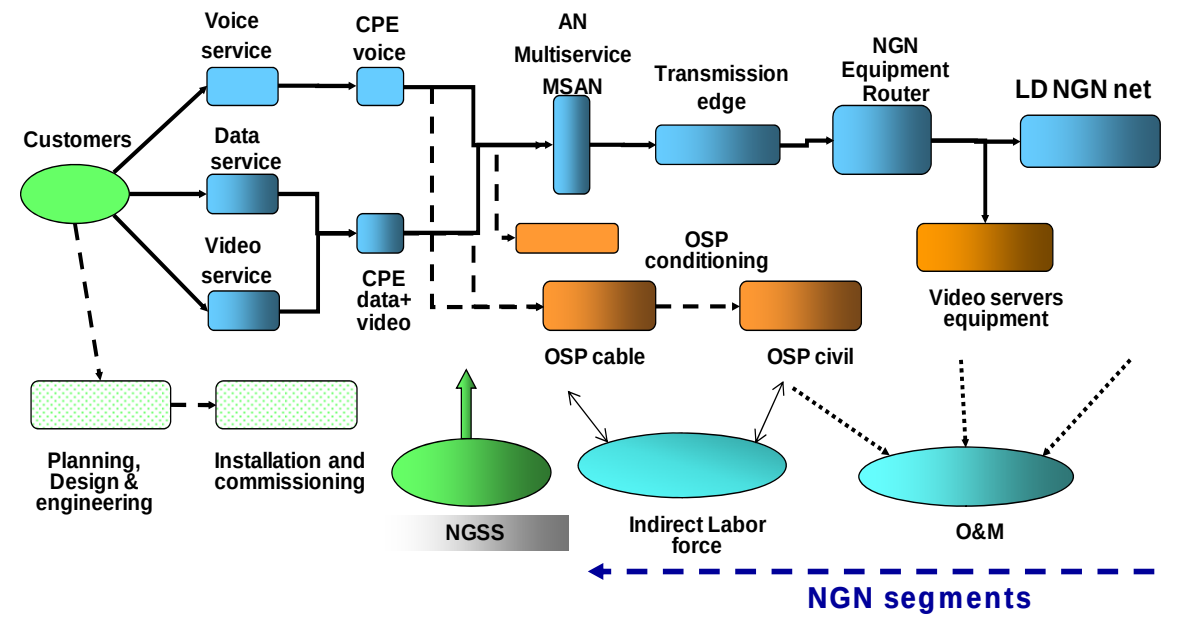


Source: Oscar González Soto

- Access related equipment is modelled with the corresponding modular dimensioning, costing, and substitution at the end of life cycle as a function of the services demands and flows.
- Upper network segments are modelled as more generic elements with the associated dimensioning and costing to allow the economic evaluations for NPV and global project value.
- OSP conditioning here implies only reviewing and adapting LL for ADSL with the possible speeds per user without changing cables or OSP infrastructure that is calculated in 2 to 3 Mbps for all customers at each cell.
- OSS/BSS considers the continuity and maintenance of existing platforms for services and customer care.
- Operation and maintenance (O&M) considers operation and maintenance of the involved historical equipment.
- Indirect labour force considers those activities generic for the company not tied to any specific network element such as marketing, management, etc.

The new configurations to be modelled as NGN scenarios are simplified in Figure 19, and correspond to the NGN alternatives with convergence of network and services at the access node either with provisioning of dual play, with VoIP and broadband Internet, or triple play, with VoIP, broadband Internet and IPTV/VOD.

Figure 19: Linear functional diagrams for proposed NGN multiservice operation



Source: Oscar González Soto

- In all NGN scenarios, initial configuration starts with the configuration of present mode of operation and migrates towards the final solution according to the defined rate for substitution of existing equipment and association of new customers to the new technologies (here simplified by the colour intensification).
- OSP enhancement for cable and civil infrastructure in this case implies modernization of the outside plant with the new cables and/or new ducts as a function of the initial status of OSP and reusability to assure the quality and capability of at least of 8 Mbps required for triple play.
- New Generation Support Systems (NGSS) or integrated OSS and BSS applications in a platform for all services within the NGN.
- O&M here considers operation and maintenance of the mix for involved historical equipment and new equipment according to the assignment of new technology to new customers and substitution of the existing ones.
- Transformation project activities and costs that include the activities of planning, design and engineering as well as the installation and Commissioning for new technologies
- Indirect labour force considers those activities generic for the company not tied to any specific network element such as marketing, management, etc. associated to the provision of new services.

5 Business Evaluation Results

The simulation for the scenario evolution from the present mode of operation towards the selected final scenario is modelled with the consideration of services demand, network resources, traffic flows, dimensioning, costing, tariffs and business quantification with all necessary modelling objects to represent dynamically all parameters as a function of time. In total more than 60 different network objects were represented with an average of eight parameters each.

In order to facilitate the evaluation for all cases and the 'what-if' analysis for changing assumptions, models are implemented with the STEM tool[15]. Data gathered with templates at Annex 1 were used for the tool running after the corresponding testing and validation process for each scenario. Main assumptions used and the results obtained are summarized in the following sections.

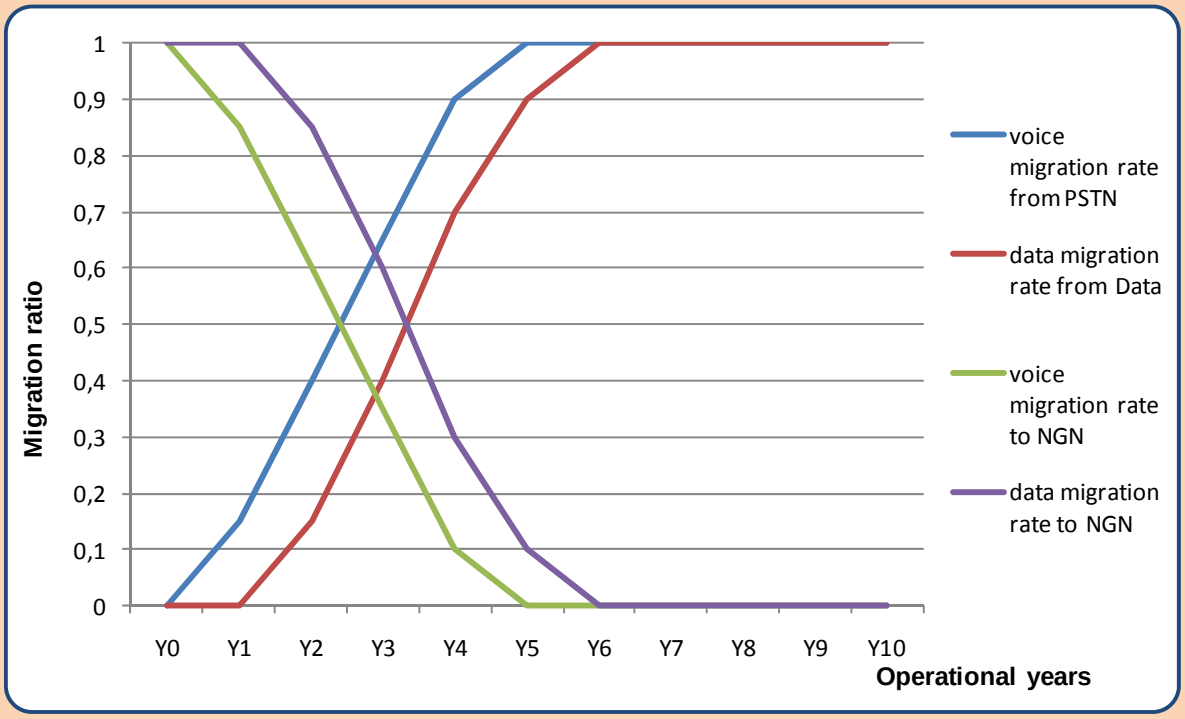
5.1 Assumptions for evaluation

General assumptions for evaluation:

- A ten year analysis period for evaluation was selected in order to be able to see the life-cycle effects of different network element types.
- Standard reference financial parameters were used for discount rates of 10 per cent during the evaluation period, and a long term perpetuity rate to evaluate network terminal values of 3 per cent.
- Standard linear assumptions for the depreciation and amortization rules were considered.
- Life cycles modelled for the different network elements were: four years for customer premises equipment (CPEs), six years for access nodes located at the access network segment (ANs), six to e years for core nodes, and 20 years for OSP.
- Existing installed equipment were considered not to be at the end of life cycle at the start of the period, thus requiring substitution at the corresponding life cycle expiration.
- Population, population density, and customer volume considered as described in chapter 3.
- ADSL LL length for 8 Mbps guarantee: 2 km for cable length or 1.43 geographical radius.
- Migration speed towards NGN at a medium pace in four consecutive years with feasible rates in the region indicated in Figure 20 according to the initial maturity of network and services combined with the economic affordability. Migration of data services starts one year after voice services due to the need of the end to end deployment for high speed and quality grade data flows. It should be emphasized that a quicker speed is difficult to implement for a new technology (first time) and a lower speed will imply a longer period of both technologies working in parallel that do not facilitate savings in OPEX. Those migration rates apply both to the existing services carried by the traditional technology as well as for the new services demand.
- Company financed CPEs for users: 30 per cent for traditional modems and higher values for new terminals due to the modernization promotion, 50 per cent for new voice/data CPEs, and 60 per cent for new IPTV set-top boxes.

[15] STEM business-modelling tool for Telecom. Robin Bailey. www.impliedlogic.com/STEM/

Figure 20: Migration rates for voice and data services in the dynamic modelling



Source: Oscar González Soto

- Three cases were defined for the services tariffs in order to perform sensitivity studies of the feasible values considering the affordability in the country and the business sustainability as follows:

  a) Reference tariffs case as the most appropriate taking into account the country GDP per capita, initial development level and project business optimization:

  - Voice rental at an average of USD 3 per month decreasing by 5 per cent per year.
  - Internet access at an average of USD 28 per month (for broadband access at 8 Mbps) and decreasing by 3 per cent per year.
  - IPTV service equivalent to market value of “silver type” with a reference of USD 6 per month.

  b) Minimum tariffs case with low tariff values for higher services penetration but maintaining positive NPV, with investment recovery delayed:

  - Voice rental at an average of USD 1 per month decreasing by 5 per cent per year.
  - Internet access at an average of USD 14 per month (for broadband access at 8 Mbps) and decreasing by 3 per cent per year.
  - IPTV service equivalent to market value of “basic type” with a reference of USD 3 per month

  c) Maximum tariffs case with tariffs for services in line with typical values in other countries:

  - Voice rental at an average of USD 6 per month decreasing by 5 per cent per year.
  - Internet access at an average of USD 30 per month (for broadband access at 8 Mbps) and decreasing by 3 per cent per year.

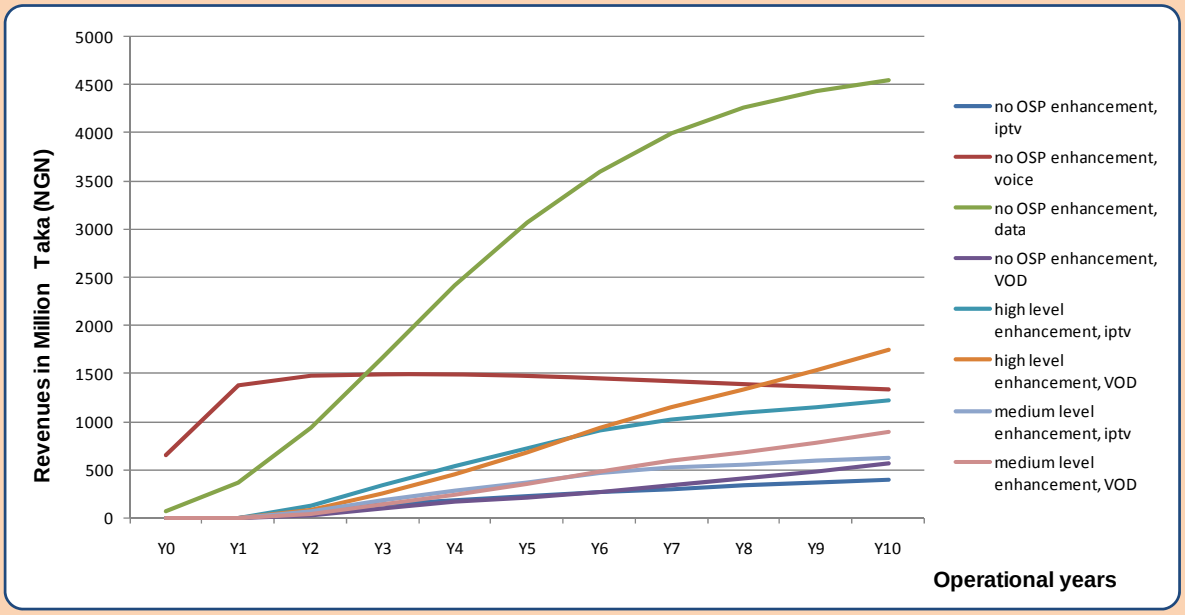
- IPTV service equivalent to market value of "basic type" with a reference of USD 10 per month.

These scenarios will define an operational band for feasible operations helping BTCL to adapt tariffs according to social, political, and competitive situation during the period.

5.2 Business results for evaluated scenarios

- A high number of results were obtained for all scenarios and alternatives analysed. The most important results for comparison of solutions and decision making are summarized below and include: net present value (NPV) for the overall project, services revenues, CAPEX and OPEX.
- Figure 21 illustrates the projection of revenues per service type over the study period. The most important income is provided by the 8 Mbps Internet service that becomes dominant in year two due to the very low tariffs in voice. IPTV and video on demand (VOD) revenues start with the required shifting for the provisioning of servers and end to end solution. Voice revenues will decrease due to tariff deterioration by high competition while broadband Internet and IPTV will increase due to the number of customers. IPTV is as high as reachable customers in the area.

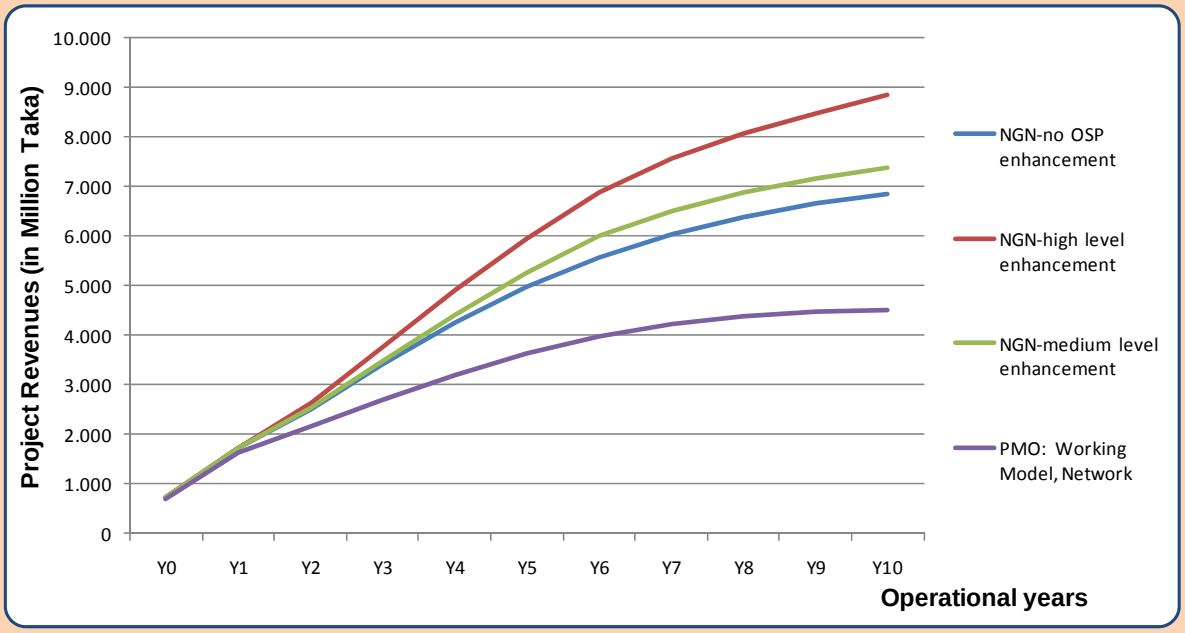
Figure 21: Revenue projections for the defined migration scenarios with different levels of OSP enhancement



Source: Oscar González Soto

Overall service revenues are provided in Figure 22 in which all triple play solutions have significant better values than the present mode of operation with higher revenues as better reachability of IPTV services at 8 Mbps.

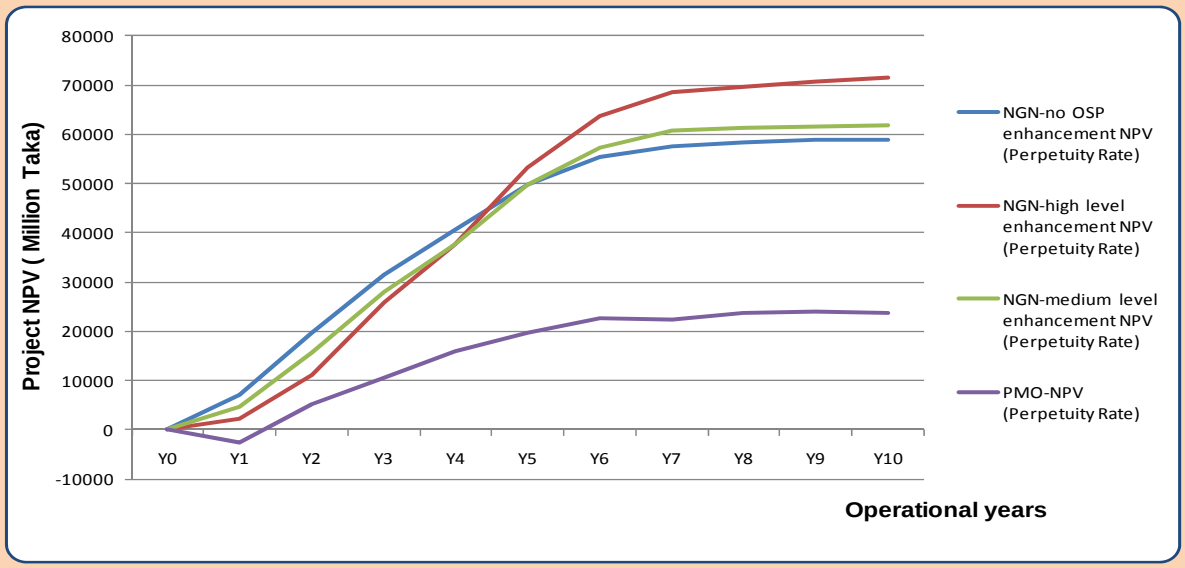
Figure 22: Projected overall revenues for the 4 analysed scenarios



Source: Oscar González Soto

Figure 23 illustrates the global project evaluator: net present value at perpetuity rate for all simulated scenarios: present mode of operation and NGN alternatives. It shows a gain for all NGN alternatives that increases with wider enhancement of OSP and more customers take up broadband services and IPTV. This is due to the new revenues and economies of scale through convergence that largely compensate for the high OSP investments. That level of OSP enhancement would not provide positive results if based only on voice and Internet at speeds lower than 2 Mbps. Note that in all figures using year 0 (Y0), this is a common initialization of the simulation cases and does not have a specific meaning. All triple play scenarios show better performance than dual play over the first years and the full OSP enhancement case outperforms the others after year 4.

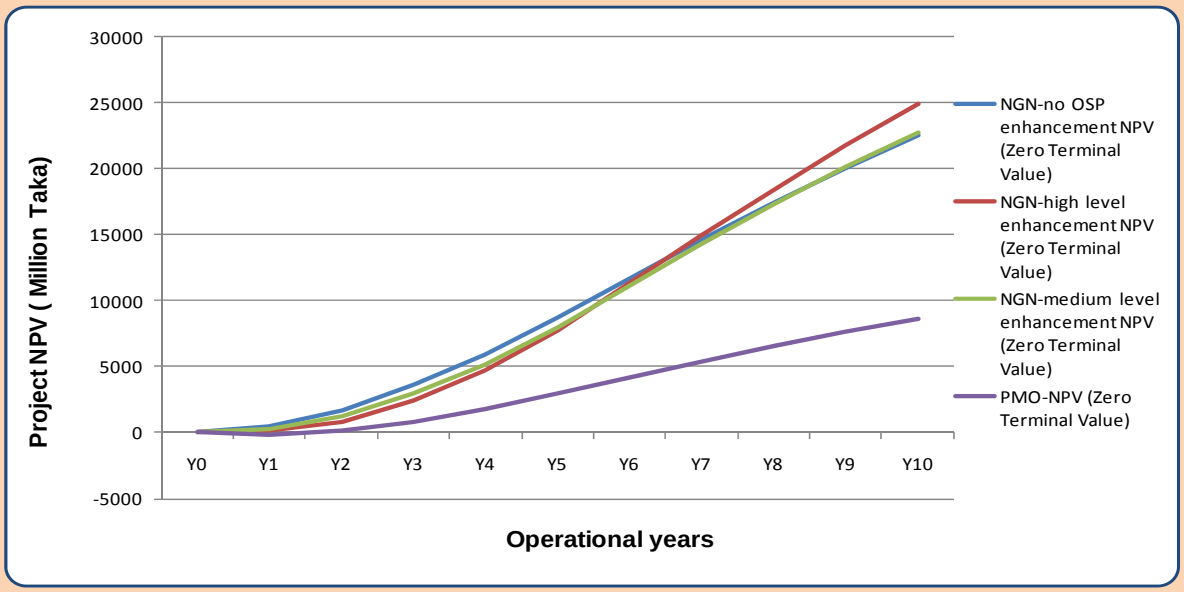
Figure 23: Net present value (at perpetuity rate) for the four analysed scenarios



Source: Oscar González Soto

When considering the metric defined by the NPV at zero terminal value, similar relative results are obtained for the scenarios but, with less sensitivity for the economic value due to the lack of consideration of the residual value for major investments made in infrastructure with longer life cycles than those observed within the study period.

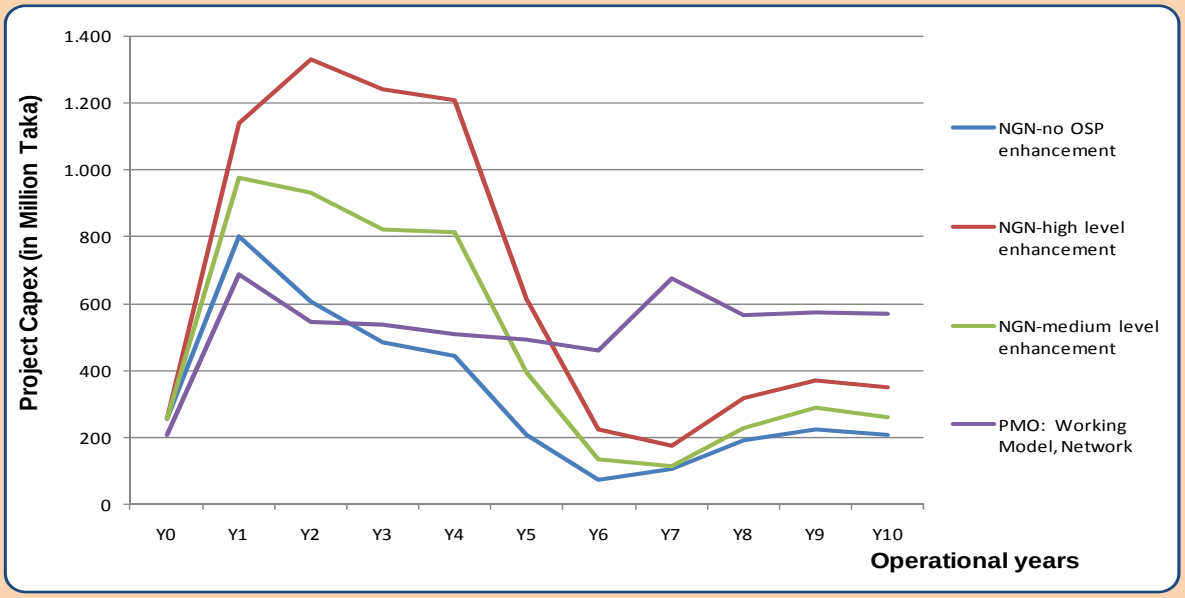
Figure 24: NPV at zero terminal value for the four analysed scenarios



Source: Oscar González Soto

Capital expenditure in Figure 25 shows a different profile to the four scenarios due to the major investments in the transition years in OSP modernization, new integrated access nodes, and renovation of multiservice CPEs, but these converge in the medium term when modernization is complete. Better efficiency of high capacity NGN architectures provide important savings, following network modernization, between years three and five as a function of the OSP renovation.

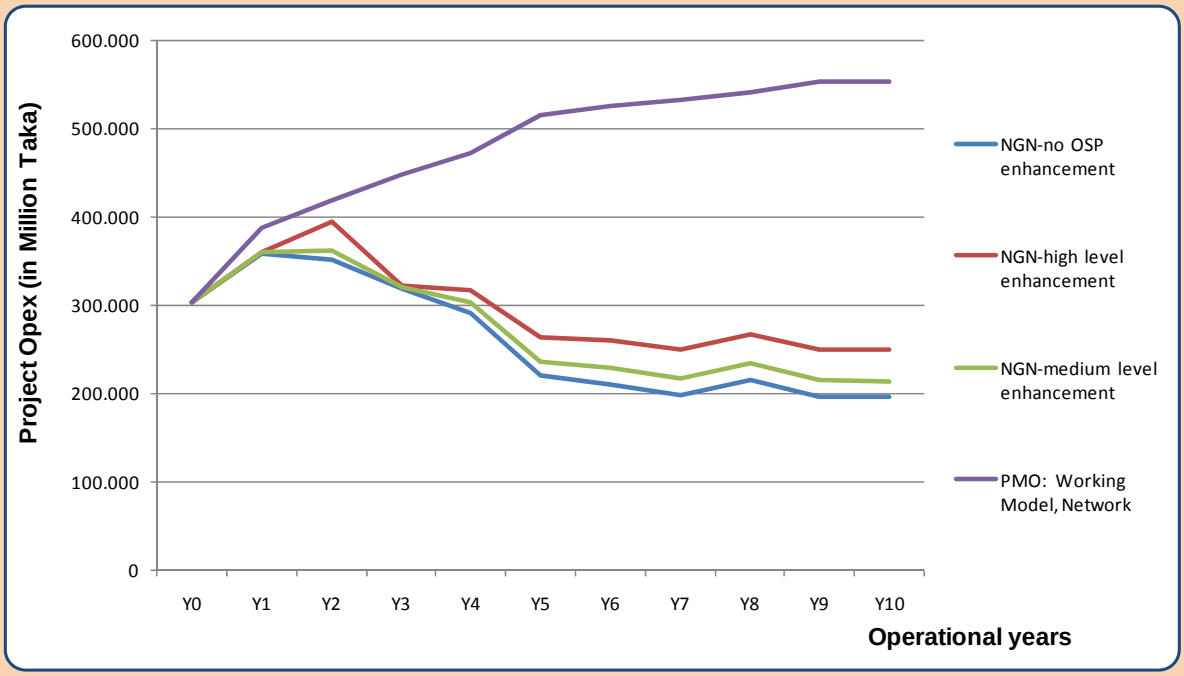
Figure 25: Required investment CAPEX for the four analysed scenarios



Source: Oscar González Soto

OPEX for the four scenarios is given in Figure 26. Major savings on all NGN scenarios are obtained compared to the present mode of operation due to the more efficient operation of the NGN technologies. While the traditional implementation shows a sustained growth of operational expenditure, NGN solutions provide savings from the beginning and increase as the migration period comes to an end.

Figure 26: Projected OPEX for the four analysed scenarios

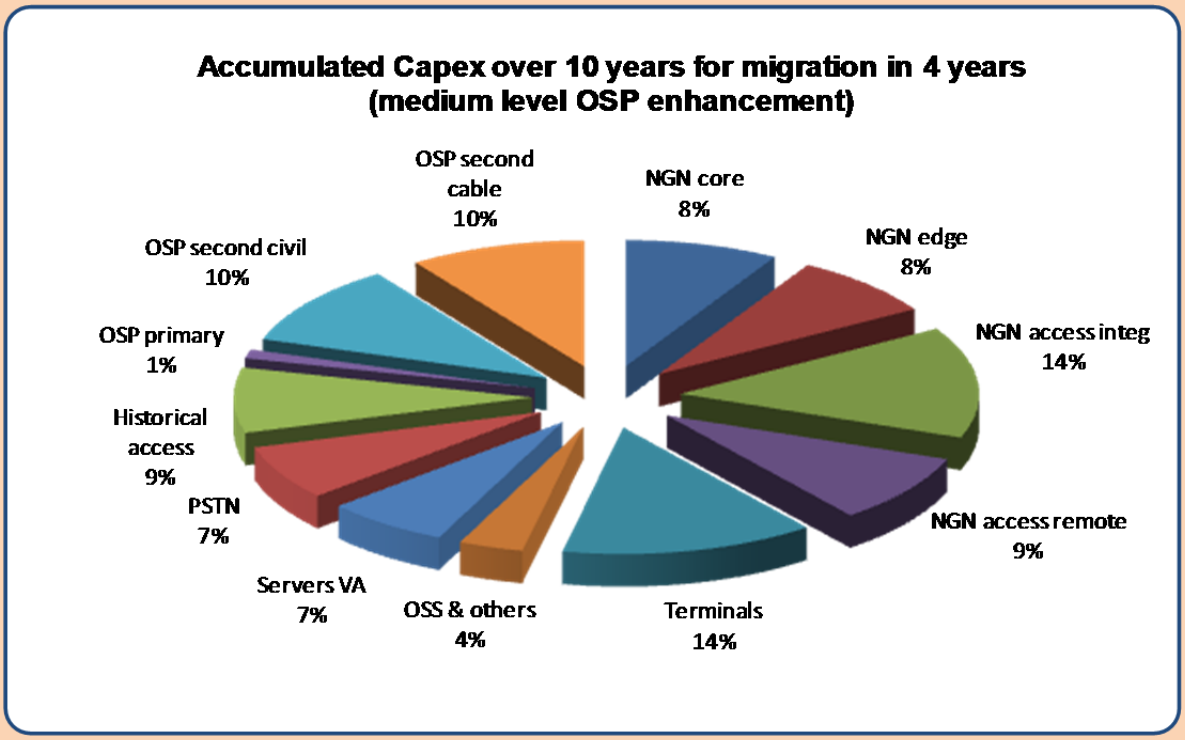


Source: Oscar González Soto

Figure 27 illustrates the investment per category of network elements for the accumulated value for the ten year period in the medium level network enhancement scenario that implies higher investments in OSP. It has to be taken into account that different time periods apply to old and new technologies due to the substitution rhythm during the fourth year.

The three main investments correspond to the modernization of the secondary network, the provisioning of new CPEs with video capability, and the multiservice nodes to reach large parts of population. Investment in video platforms here has been considered associated to the value added servers although according to the network design and location could also be associated to the edge network.

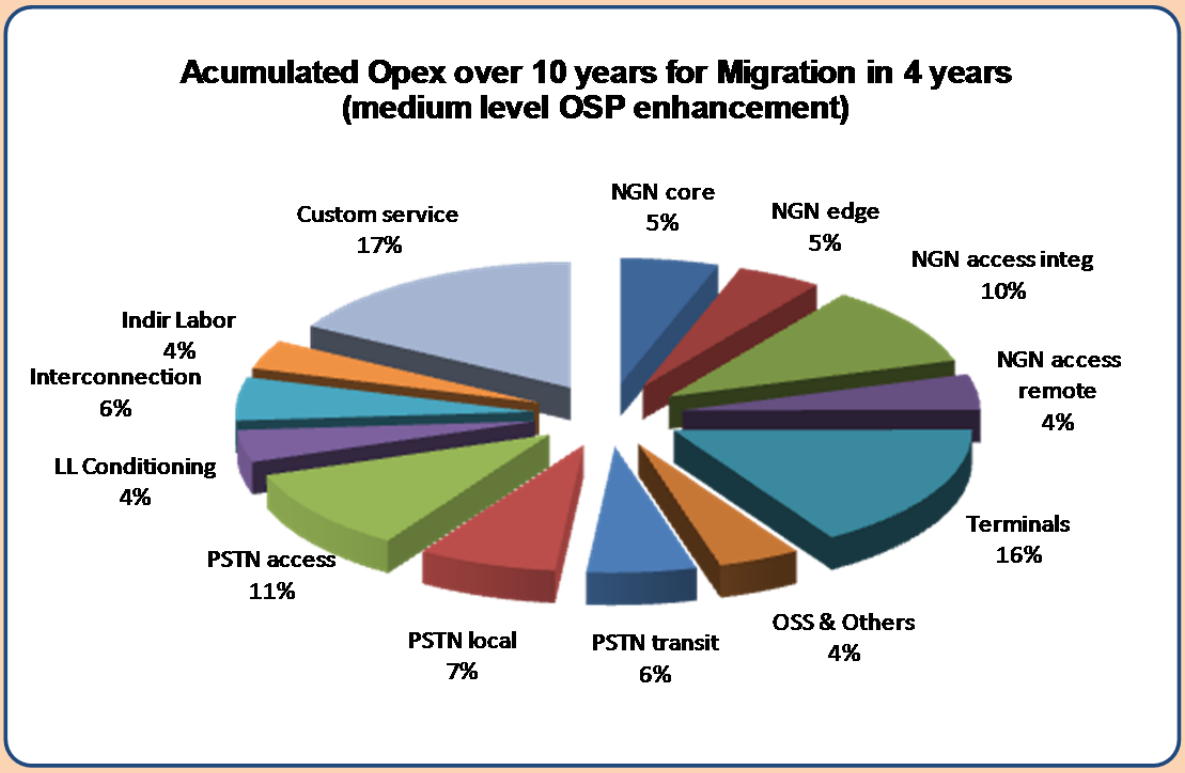
Figure 27: Ten year CAPEX distribution with a four year migration period of medium level OSP enhancement



Source: Oscar González Soto

Figure 28 illustrates the operational costs in percentage per category of elements subject to operation and maintenance expenses accumulated for the ten year period in the medium level OSP enhancement scenario. It has to be taken into account that different time periods apply to old and new technologies due to the substitution rhythm during the fourth year. Operation and maintenance for the equipment and activities at the network periphery are the main contributors to the expenses with customer service and multiservice nodes and IPTV capable terminals taking the lead.

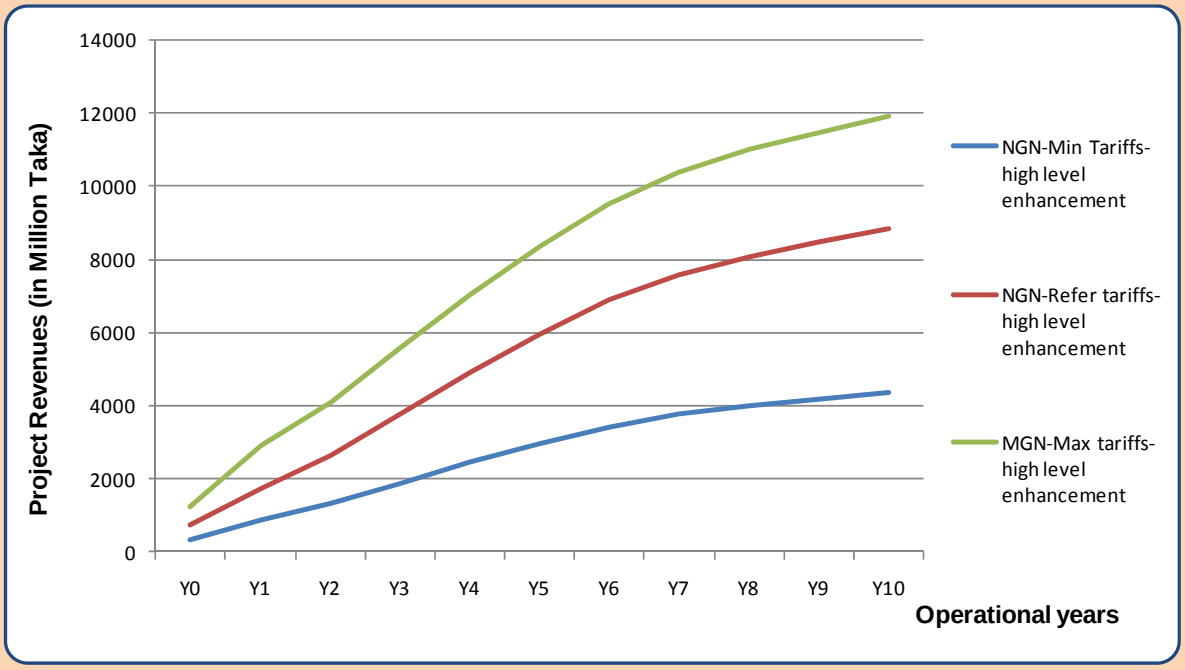
Figure 28: Ten year OPEX distribution with a four year migration period of medium level OSP enhancement



Source: Oscar González Soto

The most uncertain parameters for the future are the tariffs that will be feasible according to the level of market competition, payment capability, and service attraction for customers. A what-if analysis has been made for the three tariff scenarios defined in chapter 5.1: Proposed reference, minimum and maximum. Figure 29 provides the evolution of revenues for the three cases with important differences mainly at the end of period.

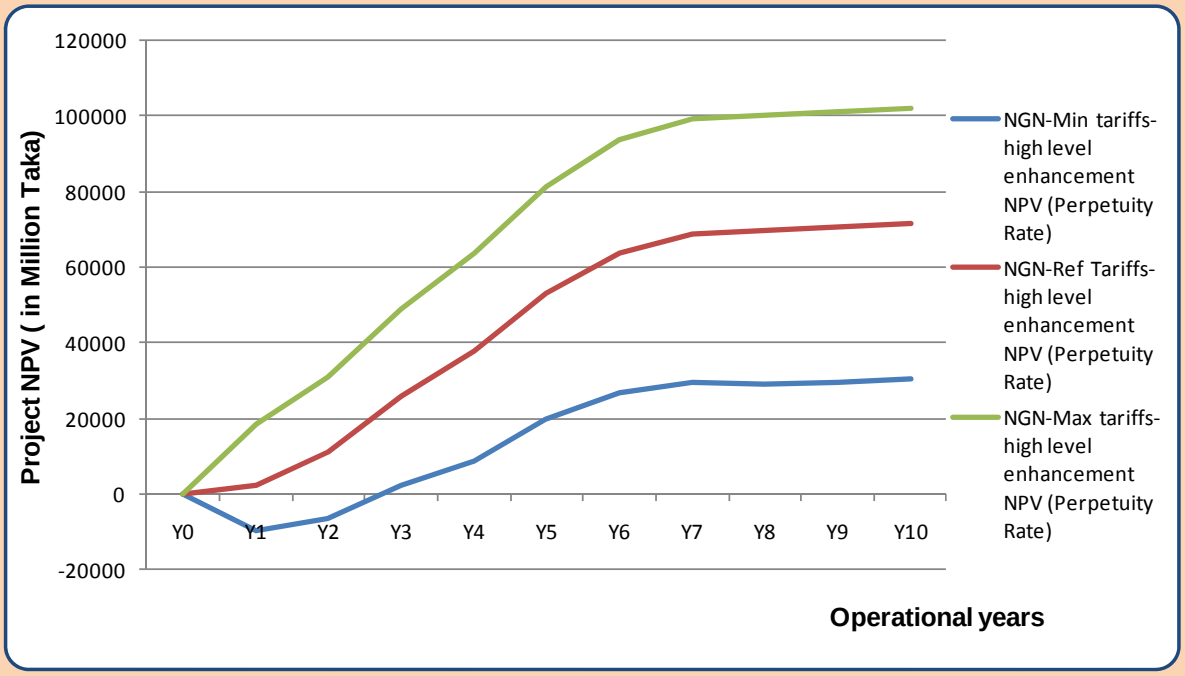
Figure 29: Sensitivity study of services tariffs to define feasible operational band for revenues



Source: Oscar González Soto

Net present value at perpetuity rate for the three tariff scenarios is provided in Figure 30 illustrating the best evaluator for decision making. The minimum tariff scenario (in blue) allows a maximum of customer affordability but generates extra needs for financing during the first years and originates lower project values at the end of the analysis period. The maximum tariff scenario (in green) is very positive for the financing and project value but will limit further extension on customer volume in a competitive environment. The reference tariff scenario (in red) provides the best harmonization between the customer affordability and the business results of the project and is the one recommended. Nevertheless the information provided by the three tariff scenarios defines a feasibility operational band in which tariffs should stay either as independent tariffs or as a set for bundle offering.

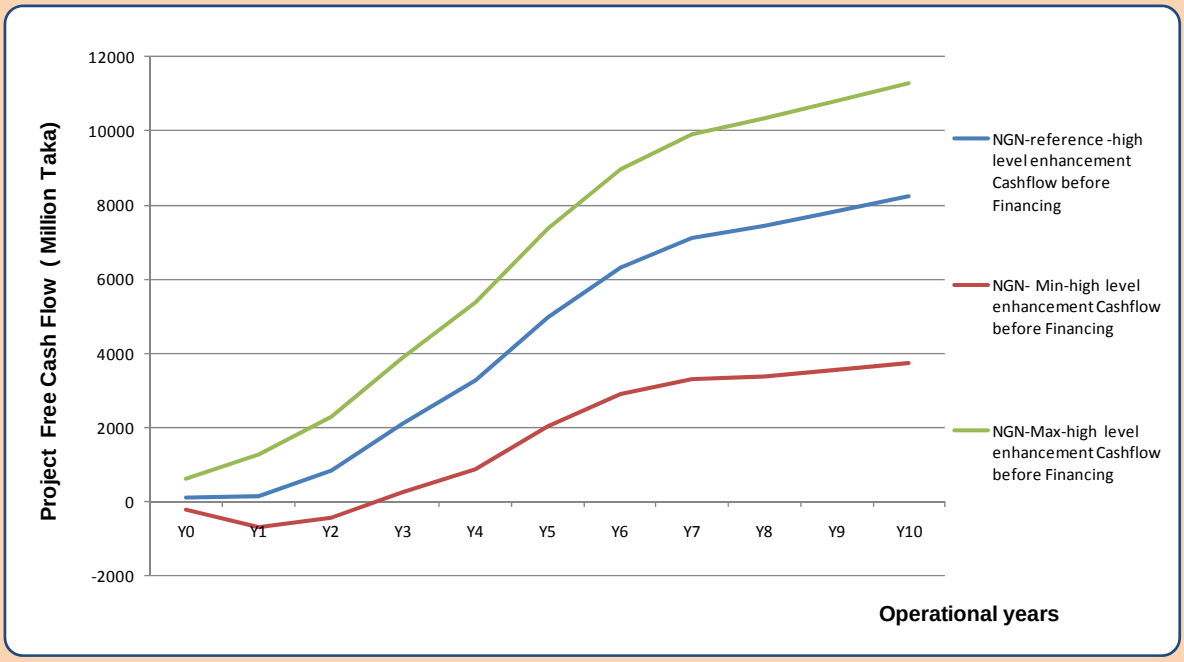
Figure 30: Sensitivity study of NPV to service tariffs to define feasible operational band



Source: Oscar González Soto

From a profitability point of view it is interesting to analyse the cash flow before financing or free-cash flow that indicates investment performance. Again the reference tariff case (in blue) is positive throughout the whole period and will be competitive in the market.

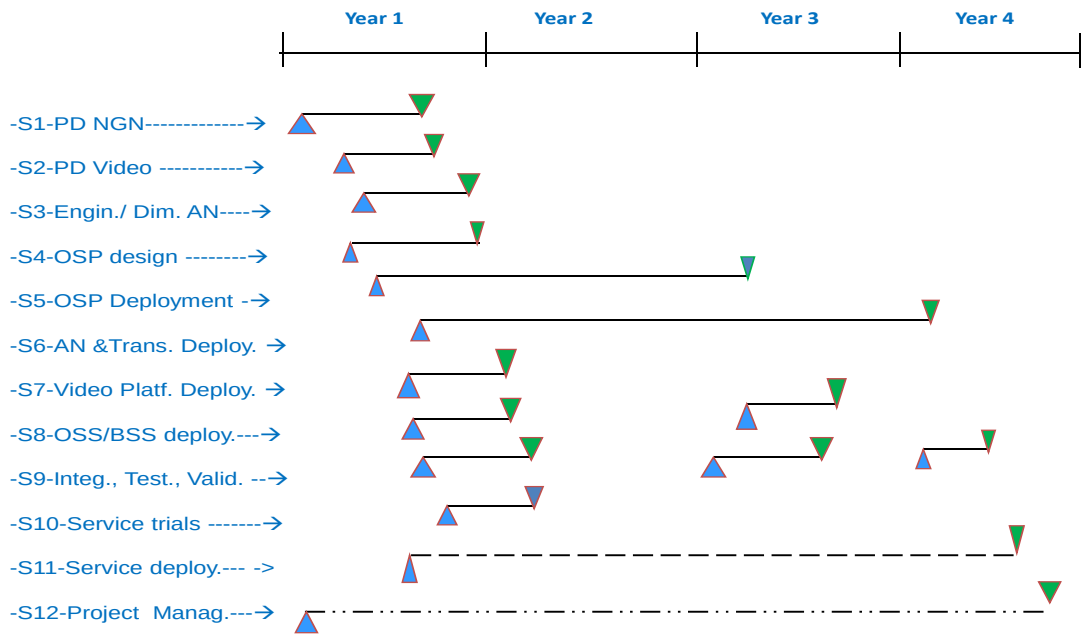
Figure 31: Sensitivity study of the free-cash flow to service tariffs to define feasible operational band



Source: Oscar González Soto

Access migration from the PSTN-based network solution to the NGN target requires a well-coordinated set of steps for several network layers that is a function of the national administrative practices. An illustrative example of the desired sequence in the absence of important constraints in the civil infrastructure works permits is provided in Figure 31. It should be noted that the final activity plan has to be defined according to available national resources, as well as operator and equipment provider resources:

Figure 32: Illustrative sequence of activities for the access migration to broadband 8 Mbps



S1) Project design and engineering for NGN path from user to core network including access nodes location, backhauling capacities and new OSS/BSS.

S2) Project design and engineering for video servers platform and paths from servers to edge network.

S3) Detailed engineering of access nodes.

S4) OSP design for civil infrastructure and cable.

S5) OSP enhancement deployment.

S6) Nodes and transmission deployment:

- Phase 1 for access nodes collocated at local exchange premises.
- Phase 2 for access nodes with reusable civil ducts and/or quick civil works deployment.
- Phase 3 for new and distant access nodes.

S7) Video servers deployment.

S8) OSS/BSS deployment.

S9) Equipment integration, testing and validation.

S10) Service trials for advanced customers.

S11) Service deployment for all area and customers.

S12) Overall project management and coordination.

5.3 Further evaluation activities

From the identified scenarios and analysed cases, a number of interesting case studies are identified as follows:

- Low density versus high density scenarios
  - Enhancement of the OSP showed to be economic in urban scenarios. Due to the high sensitivity of OSP costs to that density, it should be identified up to which lower density (i.e. suburban scenarios) those benefits apply and assure investment recovery.
- IAN versus MSAN
  - Multiservice access nodes (MSAN) prove to be convenient for the current country context and development level. Due to the technological trend to move towards an end-to-end IP solution, it will be interesting to see under which circumstances and timeframe that solutions based on full IP access nodes will produce benefits. A migration towards an Integrated Access Node (IAN) too early for the market will imply a high investment in the forced substitution by the operator of all terminals that should be all IP for all customers even if no new services are required. When the market has reached a high level of maturity, a high proportion of customers will buy terminals themselves and generate higher consumption of new services to compensate the investment.
- FTTH versus VDSL:
  - When moving towards higher capacity access (i.e. 30 to 100 Mbps) and services, consuming higher bandwidth like HDTV, two main alternatives appear:

  a) High capacity VDSL with many more active access nodes closer to the user (distance of 500 to 700 metres) and significant increase in OPEX, and

  b) Fibre to the home (FTTH) based on passive optical infrastructure with higher investment as a function of density in fibre, optoelectronic components and optical customer premises equipment (CPE), but with lower OPEX. The interest is in evaluating which is the cross point when one solution is better than the other for the current status of outside plant, market demand and technology evolution. Key factors for evaluation of the geo-scenarios with each solution advantage are as follows:
    - Customer density.
    - Broadband services demand.
    - Cost of optical CPE.
    - Cost of civil works and fibre optic cable type per distribution segment.
    - Cost of optoelectronic components.
    - Operation and maintenance cost for remote access nodes.
- A generic positioning on FTTH derived from other analysis and market trends includes:
  - Scenarios with advantages for FTTH:
    - Greenfield areas with medium to high density (i.e. development poles).
    - Urban areas with high density and high level of ICT consumers.
    - Easy reuse of installed ducts with spare capacity.
    - Obsolete copper cable on ducts allowing for cable pull procedures.

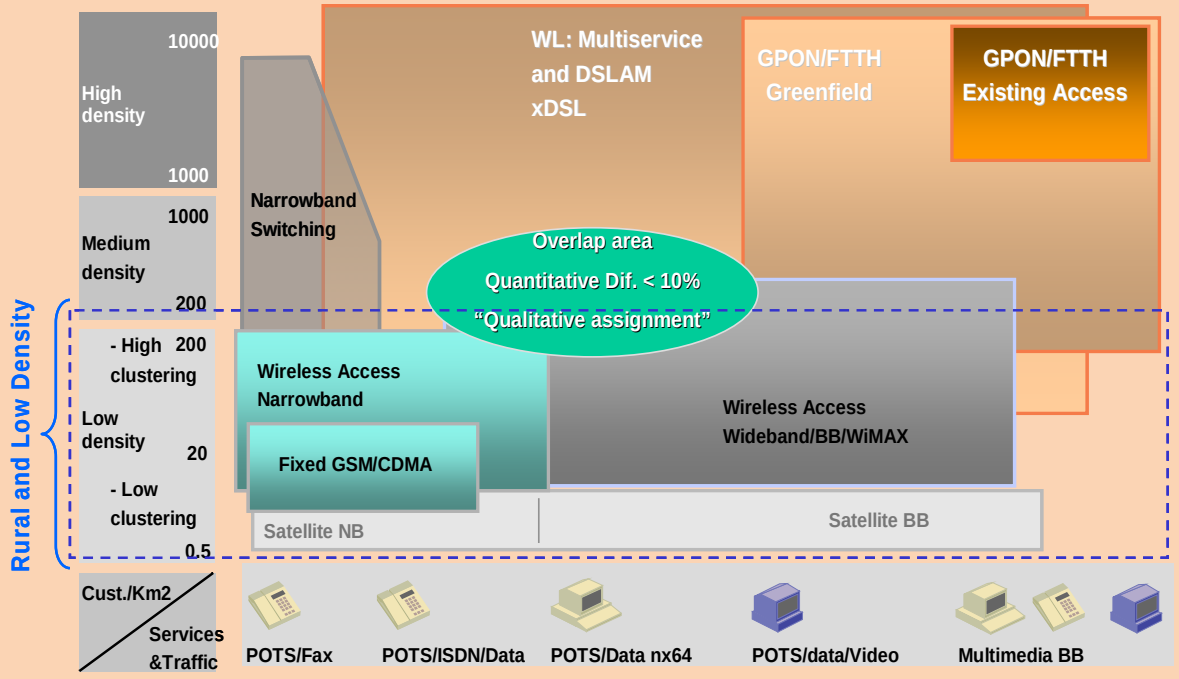
- High manpower operation cost.
- Cost reduced optical CPE due to economy of scale.

– Scenarios with advantages for VDSL:

- Urban and suburban scenarios with medium density and mix of new and traditional services.
- Number of active access nodes required (that increase with quadratic rule versus customer density decrease) under operational cost limit to avoid high OPEX of the remote nodes.
- Newly installed copper cable (less than 10 years old) with underground civil infrastructure.
- Low filling degree and high quality transmission characteristics.
- Low economy of scale impact by size in given country.
- Low manpower cost for O&M.

Figure 33 illustrates scenario advantages for each access solution as a function of customer density and level of services consumption.

Figure 33: Mapping of best economic access solutions as a function of customer density and level of ICT demand



Source: Oscar González Soto

5.4 Recommendations for modernization

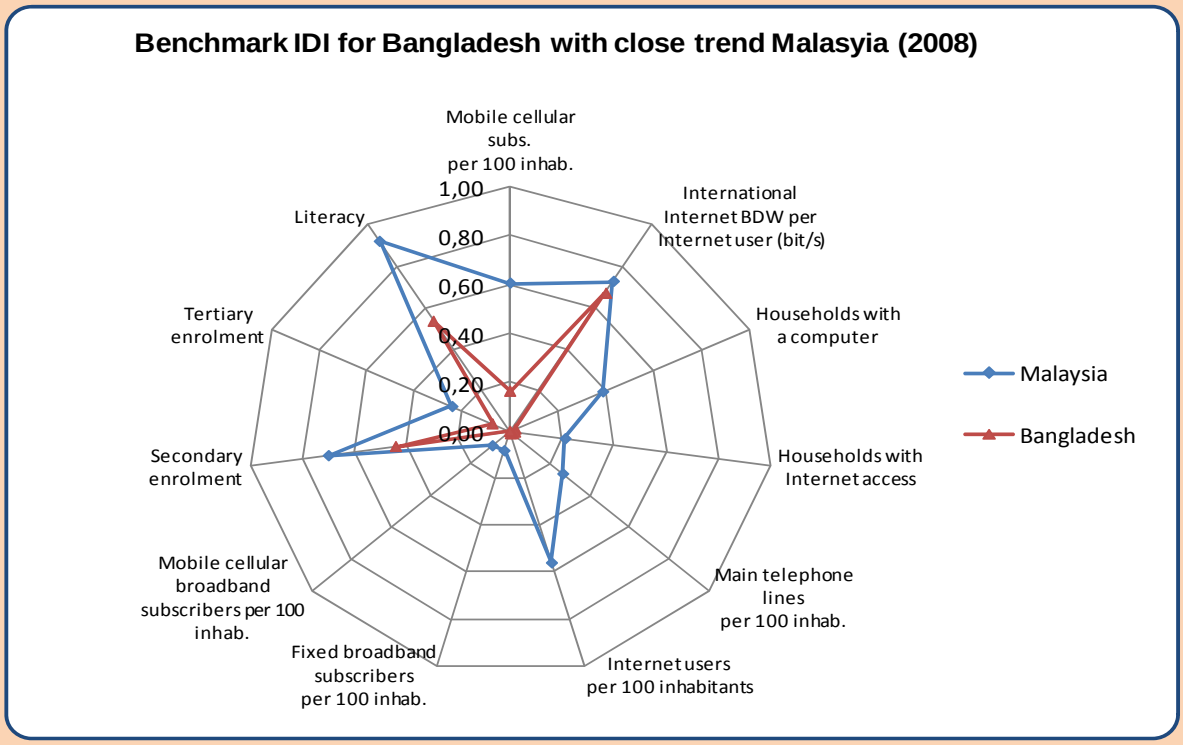
Within this chapter, a series of recommendations and assessments are summarized as a function of national ICT status reported in chapter 2 and taking as into account the evaluations and analysis in chapters 3, 4 and 5.

– Service and technology convergence is necessary to take advantage of economies of scale. Today BTCL has the licence for fixed services but not for mobile that seriously limit capabilities

for convergent service offering as well as the design of service packages. It is recommended to extend the licence to multiple-play and especially for triple play with IPTV and for mobile services to be able to compete in a converged market. Mobile services provision has to be allowed by incorporation of the state-owned mobile operator, Teletalk Bangladesh Ltd., as a preferred solution or by other alternatives to be considered. It is recommended to collaborate with the regulator and other national stakeholders for the definition of specific converged licensing to be applied in Bangladesh.

- The important transformation of market needs and associated technologies has also an impact on the operation structure and organization. The current BTCL organization is basically oriented to the conventional activities in PSTN mode. In order to have an efficient operation, it is recommended to perform the pending structural reorganization according to new needs on functionalities and operation with new technologies including the updated rewarding procedure for personnel centred on efficiency and customer orientation.
- Create a specific migration operations group to coordinate all implementation of network elements, terminals, access, edge, core, services and OSS/BSS, and assure correct service handling during the transition phases.
- Current number of limited plans requires a more general view and orientation. An overall plan for ICT and broadband development should be defined with coordination of the involved ministries/departments (technology, education, health, agriculture, tourism, financing, etc.), stakeholders, service providers and related sectors on top of the current fragmented and partial policies that exist today.
- In order to have a quick increase in the ICT index, it is recommended to prioritize development for those parameters in the national plans starting with the objective to reach values in the short term similar to Malaysia that took coordinated development actions a few years ago.

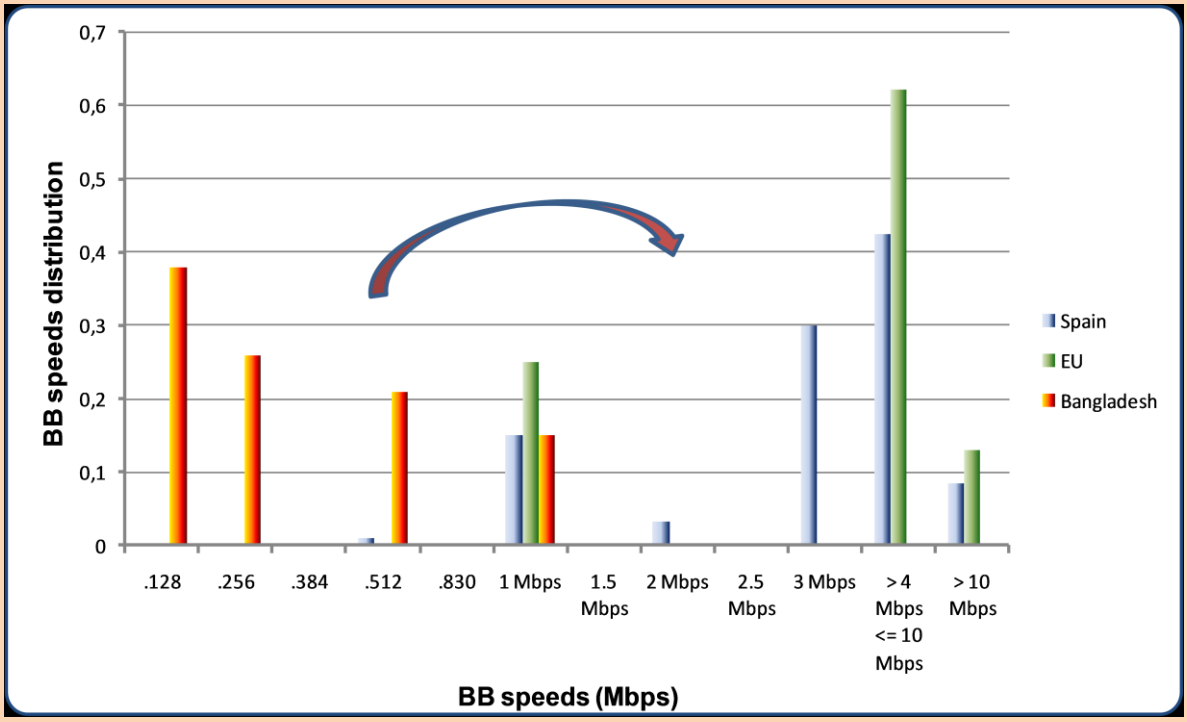
Figure 34: Benchmark IDI for Bangladesh compared with Malaysia as a recommended medium-term path



Source: ITU

- From the performed benchmarking, and in addition to the low penetration indicated in the IDI in Figure 34, the mix of broadband speed distribution compared to developed countries is much lower. As such 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 Figure 35 through network provisioning and the commercial plans.

Figure 35: Recommended increase of broadband speeds distribution at medium term following the trends reached by reference regions



Source: Oscar González Soto

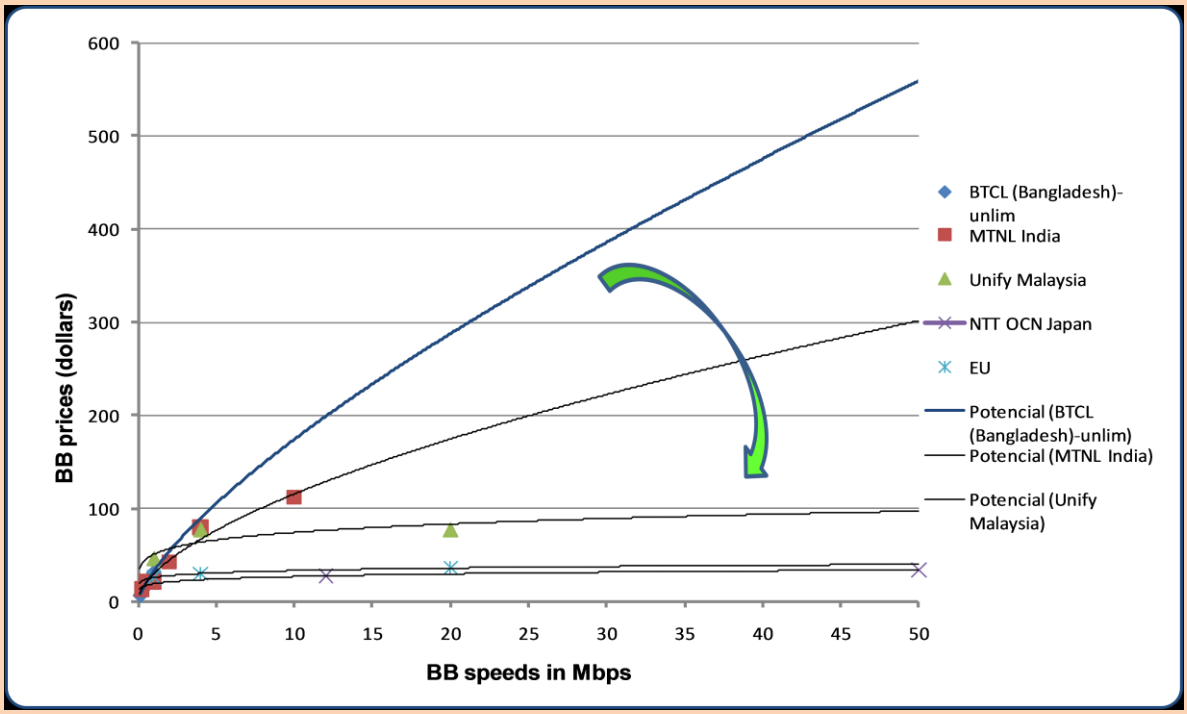
- Derived from the performed benchmarking for the analysed countries with reference advanced countries or regions it is derived a too high pricing strategy for higher speeds with a quasi-linear correlation among prices and speeds that do not take advantage of the economies of scale at network costs. It is recommended to reconfigure the pricing strategy by adapting prices through the benefits of economy of scale towards values similar to Malaysia in the short term and to consider long term evolution towards values similar to Japan[16] and the EU[17] that seem well adjusted to price/speed[18]. It has to be noted that packages offered not always contain the same components (i.e. the case of EU incorporates free national calls to fixed numbers).

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

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

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

Figure 36: Recommended price evolution for broadband services as a function of speed and considering telecom economies of scale



Source: Oscar González Soto

- Due to the high importance of civil investments in access, it is recommended to promote and regulate sharing for all passive infrastructure at any network segment such as ducts, cables, rights of way, poles, masts, trenches, towers, equipment rooms and technical premises, etc. 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.
- With high investment requirements and scarce resources for broadband at the access segment, demand for access sharing through unbundling is the quickest way to increase broadband penetration in the short term as well as reaching a more efficient utilization of an expensive resource that requires long-term amortization. Experience from successful countries in local loop unbundling (LLU) deployment should be taken into account to benefit from best practices. Resource leasing prices should be evaluated taking into account national parameters and the costs involved in the equipment life cycle amortization, cross checked with the retail minus procedure on the local market. As an illustration most common LLU leasing prices at the EU market vary between 8 and 18 Euros depending on speed, involved network elements and service level agreements, with additional equipment prices for cabinets, internal connections, energy, etc. Conditions and prices are recommended to be fixed by the regulator in the corresponding reference access offer (RAO) and customized for the country reference costs as well as for the economic development level.
- Network restructuring in NGN implies the need to redefine reference networks. In order to agree on the solutions, a national team should be defined to harmonize reference networks, dimensioning rules and interoperability with a definition for performance parameters that are attributed to each network segment. This team should involve the regulator, service providers and supplying industry.

- Carry out 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 ten years with the comparison of net present value per case and select 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 the most common new services including IPTV in triple play with 8 to 10 Mbps. Migration is convenient in access with an "island strategy" with priority given to the areas with obsolete equipment and new development areas.
- The migration of the network towards NGN at edge and core levels in triple play has the benefits of decreasing OPEX and CAPEX costs with better business performance assuming an increase of investment in the first three years. It is recommended to migrate Dhaka to NGN in the proposed four-year timescale to avoid too much overlap of networks and introduce the new services from the very beginning of deployment in order to anticipate the increase of new revenues. An "overlay strategy" is desired for core and edge network segments to facilitate service continuity. Corporate customers should receive priority and differentiated service quality to get their loyalty and accelerate revenue increases.
- Carry out studies for the design of the edge segment including aggregation nodes location, capacities, traffic flow control, security and other functionalities according to the variety of new services to be carried. Identify areas, in addition to metropolitan Dhaka, of first priority for IP mode implementation depending on national and business strategy, and 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. Develop implementation as a result of feasible business plans.
- New traffic parameters and behaviour requires the definition of monitoring and sampling principles to evaluate customer satisfaction by using the concept of quality of experience (QoE). Assure that a reference nominal broadband speed for customers at peak periods during the day that is fulfilled as a function of the maximum contracted speed (i.e. at least 80 per cent of peak speed at the busiest periods of the day).
- Define guidelines for adequate overall network security required for service providers including physical security, level of connectivity and emergency plans for 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. Perform study for high topological protection of nodes and routes with diverse paths at physical and logical levels. This will result in a number of core nodes, locations, capacity and survivability, that will guarantee the carrying of full capacity at least for the period needed until next capacity augmentation in the case of combined failures of nodes and links.
- A major technological challenge for migration to NGN is the resolution of many new issues due to the technical functionalities, interfaces, operation, etc. that are not widely known. It is recommended to identify convenient strategic technology partners for collaboration at the initial phases of the evolution in order to solve the inherent operational issues with any new technology and avoid unnecessary delays and bottlenecks. Most typical joint activities pursue a win-win situation both for the operator and the equipment provider in issues like support for network design and dimensioning, support for equipment testing, support for protocol testing and compatibility, support for problem solving in interoperation, and training operator personnel in the new technology functionality.
- Develop a training programme for company operational employees on NGN and IP mode techniques, protocols, engineering and dimensioning, starting at the metropolitan areas and to be extended to all regions. Special attention should be paid to security issues for all company personal with special extension and priority to departments handling sensitive information and network management centres. Most operational employees have a good background on

traditional technologies but very few are familiar with the IP based technologies. In order to facilitate that training program, support has to be obtained from international organizations like ITU, ICANN, etc. as well as from regional organizations like APT.

- Integrate existing, non-obsolete OSS/BSS platforms with the new platforms to be implemented, and develop an umbrella application to allow the end to end interworking in a centralized manner. Implement converged platforms for the NGN with and initial integration of OSS and BSS per network followed by a full integration of fixed and mobile applications. Reduce and combine multiple and fragmented platform software licenses to benefit from economies of scale for pricing, operation and maintenance.
- Taking the advantage of the initial federated platforms and the subsequent converged platform, define and implement a cycle for the "monitoring-measurement-analysis-projection" of IP mode traffic flows derived from the new services. 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 QoE by using the capabilities of the call centres and 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 level, information processing and data privacy. Special care should be paid to the control of information related to lawful interception and "strict" adherence to the national laws on privacy.
- Periodically benchmark performance results with other operators within the country and with internationally recognized best practice in order to detect areas of improvement and apply solutions to reach a high quality service provision and better business profitability.

List of Acronyms and Terms

3G	Third generation of Mobile
4G	Fourth Generation of Mobile
ABR	Area Boarder Router
ADSL	Asymmetric Digital Subscriber Line
BSS	Business Support System
BTCL	Bangladesh Telecommunications Company Limited
BTRC	Bangladesh Telecommunication Regulatory Commission
BTTB	Bangladesh Telegraph and Telephone Board
CAPEX	Capital Expenditure or network expenses that are capitalized and subject to depreciation
CPE	Customer Premises Equipment
DSLAM	Digital Subscriber Line Access Multiplexer
EU	European Union
FO	Fibre Optics
FPS	Free Phone Service
FTTB	Fibre to the building
FTTH	Fibre to the Home
GDP	Gross Domestic Product
GE-PON	Gigabit Ethernet-Passive Optical Network
GSM	Global System for Mobile Communications
HDTV	High Definition Television
HSS	Home Subscriber Server
IAN	Integrated Access Node
ICD	Intelligent Content Delivery
ICT	Information and Communication Technologies
IDI	ICT Development Index
IMS	IP Multimedia Subsystem
ITX	International Trunk Exchange
IP	Internet Protocol
IPv6	Internet Protocol version 6
IPTV	Internet Protocol Television
ISP	Internet Service Provider
ITU	International Telecommunication Union
ITU-D	International Telecommunication Union – Development Sector
LBS	Location Based Services
LE	Local Exchange

LL Local Loop

LLU Local Loop Unbundling

MDF Main Distribution Frame

MOPT Ministry of Post and Telecommunications

MPLS Multiprotocol Labelled Switch

MSAN Multiservice Subscriber Access Node

NE Network Element

NGN Next Generation Networks

NGSS New Generation Support Systems

NPV-perpetuity rate: The net present value of the network, i.e. cumulative discounted cash flow generated to date, including a terminal value based on growth to perpetuity. This is the best evaluator when comparing many heterogeneous solutions

NPV-Zero terminal value: The net present value which ignores the value of the equipment at the end and is adequate when no differences in equipment investments appear but not complete evaluator when different investments are done between solutions. (Some solutions have more value at the end than others)

O&M Operation and Management

OPEX Operation expenses or Operating cost (also called running costs) consider non capitalized costs as maintenance of all installed equipment, administrative costs and direct operation of equipment being in use

Operating charge: Includes not only the direct operation costs but also the operational expenses due to depreciation and amortization at the year at which they appear according to the life cycle and amortization procedure.

Operating expenditures: Reflect the aggregation of capital expenditure and operating cost per year that is used for the evaluation of cash flows

OSP Outside Plant

OSPF Open Shortest Path First

OSS Operating Support System

PLC Power Line Communication

PoP Point of Presence

PPP Purchase Power Parity

PSTN Public Switched Telephone Network

QoE Quality of Experience

QoS Quality of Service

RACF Resource Acceptance Control Function

RAO Reference Access Offer

SBle Service Blending

SBR Sustained Bit Rate

SBr Service Broker

SLA Service Level Agreement

SIP	Session Initiation Protocol
SSW	SoftSwitch
STEM	Strategic Telecom Evaluation Model
STM-1	Synchronous Transmission Module – 1
VAS	Value Added Service
VSAT	Very Small Aperture Terminal
TE	Trunk Exchange
VDSL	Very high Digital Subscriber Line
VoDSL	Voice over Digital Subscriber Loop
VOD	Video On Demand
VoIP	Voice over Internet Protocol
WTO	World Trade Organization
xDSL	Digital Subscriber Line

Annex 1: Tool templates for access data gathering

Tool template 1: Telecom generic inputs

	Telecom Generic Inputs at Country level						
	Bangladesh						
	Guide: Fill template with available data for the most complete "reference year" at December end (desirable 2009) and attach documents as annexes with related information					**For questions or doubts contact: Oscar Gonzalez Soto, mail oscar.gonzalez - soto@ties.itu.int Mob: +34607757510**	
	Telecom, Market and Demand related data		**Reference year (last)**	**% variation from previous year (s)**	**Projected for future if available**	**Additional descriptions and comments**	
T1	**Population and grow rate**						
T2	**GNP per capita and grow rate**						
T3	**Population with income per capita > survival threshold**						
T4	**Population with literacy (%)**						
T5	**Population with 3rd education degree (%)**						
T6	**Population distribution per Metro/Urban/Suburban/Rural scenario**						
T7	**IDI: ICT Development index and main components**						
T8	**PC penetration rate and grow**						
T9	**Fixed lines penetration rate and grow**						
T10	**Fixed lines penetration rate in Dhaka and grow**						
T11	**Mobile lines penetration rate and grow**						
T12	**Total Internet penetration rate and grow**						
T13	**BB penetration rate and grow (> 256 kbps)**						
T14	**BB penetration rate in Dhaka and grow (> 256 kbps)**						
T15a	**Distribution speeds and prices for BB access: Operator 1**						
T15b	**Distribution speeds and prices for BB access: Operator 2**						
T15c	**Distribution speeds and prices for BB access: Operator 3**						
T15d	**Distribution speeds and prices for BB access: Operator 4**						
T16	**List of top 6 data services and penetration (ie: VPN-IP, VPN-MPLS, VoIP, IPTV, etc.)**						

Tool template 2: Network related inputs additional to the ones available for infrastructure and PSTN

	Network related generic inputs per main operator				
	Bangladesh				
	Guide: Fill template with available data for the most complete "reference year" at December end (desirable 2009) and attach as annexes documents with related information				For questions or doubts contact: Oscar Gonzalez Soto, mail oscar.gonzalez -soto@ties.itu.int Mob: +34607757510
	Network structure and elements	**Total reference year (last)**	**Variation since previous year (s)**	**Projected for future if any**	**Additional descriptions and comments**
N16	Number of xDSL lines				
N17	Number of co-located DSLAMS				
N18	Average size of co-located DSLAM				
N19	Number of remote DSLAMS				
N20	Average size remote DSLAM				
N23	Local Loop distribution per distance (% of loops at < 0.5, <2, <3. 5, <5, > 5 Km)				
N24	LL age (< 5, <10,<15,< 20, > 20 years)				
N26	Total number of 2G base stations				
N27	Total number of 3G base stations				
N28	Network Diagrams for topology				
N29	Top 3 challenges for network modernization found currently				
N30	Top 3 success facts for network modernization up to now				
N31	... other relevant country data for the network infrastructure				

Tool template 3: Techno-economic inputs for business modeling

	Tecno-economic Inputs Bangladesh					
	Urban Scenario					
		All cost units in dollars				
	Network Elements		Capacity	Capex Cost (nominal)	Operation	Maintenance
T1	CPE-Tf	Telephone terminal existing and associated loop				
T2	CPE-data	Modem existing				
T3	CPEVD	New CPEVD (VoIP and data)				
T4	CPE-video	New CPEVD (video)				
T5	CPE-multiservice	New CPE- for VoIP, data and video				
T6	AN voice- existing	Acces Node for voice in existing PSTN (lines)				
T7	AN data (ATM) -existing	AN for in data-existing data net (lines)				
T8	AN multiservice IP ADSL2+ at LE	AN for new multiservice capability at LE				
	AN multiservice IP remote ADSL2+	AN for new multiservice capab. at remote sites				
T9	Local transmission: Circuits	Circuit transmission in existing PSTN (circuits)				
T10	Local transmission data	Data transmission in existing net				
T11	Local transmission Eth. Link	Multiservice transmission ethernet				
T12	Local node PSTN	Local node PSTN in existing net (circuits)				
T13	Local node Data (Mbs)	Local node Data in existing net (Mbs)				
T14	Local node router (Mbs)	Local node router at IP mode (Mbs)				
T15	Node NGN-IMS	Local node NGN-SSW at new network (lines)				
T16	LD circuit NET	Long Distance circuit mode NET (circuits)				
T17	LD data NET	Long Distance data Network existing (Mbs)				
T18	LD NGN NET	Long Distance new NGN Network(Mbs)				
T19	Cable primary	Fiber optic cable at primary per size and type				
T20	Cable secondary	Coper cable at secondary per size and type				
T21	Civil primary	Civil invest.(ducts, manholes, etc,) at primary access				
T22	Civil secondary	Civil invest.(ducts, manholes, etc,) at secondary access				
T23	Primary enhancement	Enhancement of cable and civil at primary access				
T24	Secondary enhancement	Enhancement of cable and civil at secondary access				
T25	Customer Service existing	Customer Service for existing network (lines)				
T26	Conditioning existing	Conditioning for connec. of ADSL in existing net (data lines)				
T27	Interconnection existing	Interconnection for external data traffic in existing net(Mbs)				
T28	Customer Service new	Customer Service for new lines (lines)				
T29	Conditioning new	Conditioning for ADSL in new lines (data lines)				
T30	Interconnection new	Interconnection for external data traffic in new net(Mbs)				
T31	Applic. servers VoIP	Application servers for VoIP (Mbs)				
T32	Applic. servers IPTV	Application servers for IPTV (Mbs)				
T33	Planning, design and eng. project	Planning, design and enginering to start the Network Migration project				
T34	Network and OSS migration project	Instalation, migration and cutover for Network and OSS				

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