International Telecommunication Union

QUESTION 19-1/2

Final Report

ITU-D STUDY GROUP 2 4th STUDY PERIOD (2006-2010)

QUESTION 19-1/2:

Strategy for migration from existing networks to next-generation (NGN) for developing countries

THE STUDY GROUPS OF ITU-D

In accordance with Resolution 2 (Doha, 2006), WTDC-06 maintained two study groups and determined the Questions to be studied by them. The working procedures to be followed by the study groups are defined in Resolution 1 (Doha, 2006) adopted by WTDC-06. For the period 2006-2010, Study Group 1 was entrusted with the study of nine Questions in the field of telecommunication development strategies and policies. Study Group 2 was entrusted with the study of ten Questions in the field of development and management of telecommunication services and networks and ICT applications.

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ABSTRACT

This report is the proposed final outcome of ITU-D SG 2 Question 19-1/2 for study period 2006-2010. It explains the trends of telecommunication that would eventually lead to NGN. Then, it explains the NGN technology and provides guidelines for NGN migration as well as some case examples. The report also provides some considerations regarding the regulatory problems raised by NGN migration.

This report contains annexes. Annex 1 presents Trends of Telecommunication, Annex 2 presents NGN Functional Architecture/QoS/Securiry, Annex 3 presents Examples of Migration Scenarios, Annex 4 presents a questionnaire sent to administrations and sector members about their NGN migration, Annex 5 presents some answers received for this questionnaire. Annex 6 contains the text of Opinion 2 of WTPF-09 on NGN, and finally Annex 7 contains a list of ITU relevant standards pertaining to NGN.

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Guidelines for Migration of Existing Networks to Next-Generation Networks (NGN) for Developing Countries

1 Technology development

1.1 Service aspect of Development

Understanding the service requirements should be the 1st step for all telecommunication developments and in this regard, identify the media characteristics should be the initial phase to identify the services. According to the development of processors enhancing processing powers and semi-conductor technology producing small enough to mount on board lead the requirements to use diverse multimedia in various ways which need broadband connectivity an any cases of fixed or mobile.

Table 1-1 shows high level abstract view of media requirements in terms of bandwidth and QoS aspects. Many of services except normal voice required broadband at least 2 Mb/s with high priority treatment for ensuring QoS requirement. To support these trend of services, it is highly requested networks be equipped with enough capabilities to manage traffics (e.g. sessions, flows etc.) whatever broadband connectivity provided with over provisioning or well managed. NGN provides one of way to meet these requirements in carrier class level but in managed way.

Table 1-1: Media service requirements

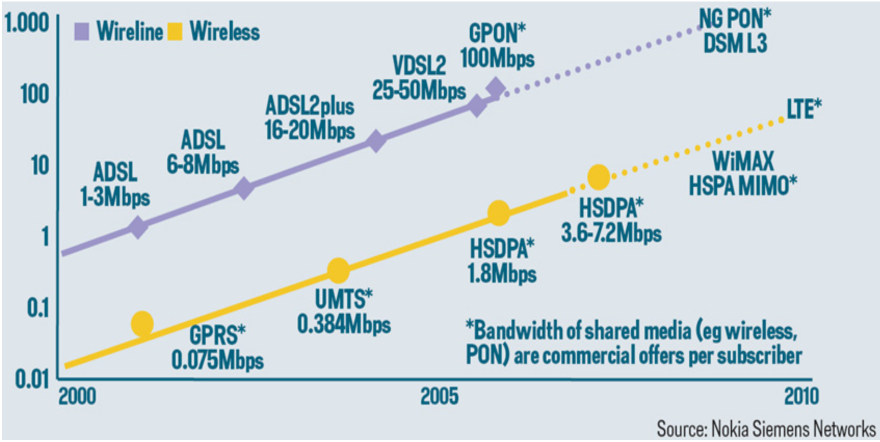
Service	Bandwidth (downstream)	QoS Requirement
Broadcast TV (MPEG-2)	2 to 6 Mb/s	Parameterized
HDTV (MPEG-4)	6 to 12 Mb/s	Parameterized
PPV or NVoD	2 to 6 Mb/s	Prioritized
VoD	2 to 6 Mb/s	Prioritized
Picture in Picture (MPEG-2)	up to 12 Mb/s	Parameterized
PVR	2 to 6 Mb/s	Prioritized
Interactive TV	up to 3 Mb/s	Best effort
High speed Internet	3 to 10 Mb/s	Best effort
Video Conferencing	300 to 750 Kb/s	Prioritized
Voice/Video Telephony	64 to 750 Kb/s	Prioritized

1.2 Access Transport technology

As explained in previous clause 1.1, supporting various types of multimedia is required that networks are equipped with enough bandwidth and traffic management capabilities. Ensuring required bandwidth is the initial point to support these service (and media) requirements. There are two perspectives to provide bandwidth: over fixed and over mobile.

Following Figure 1-1 shows available bandwidth through currently available fixed and mobile accesses.

Figure 1-1: Wireless and wireline data speeds

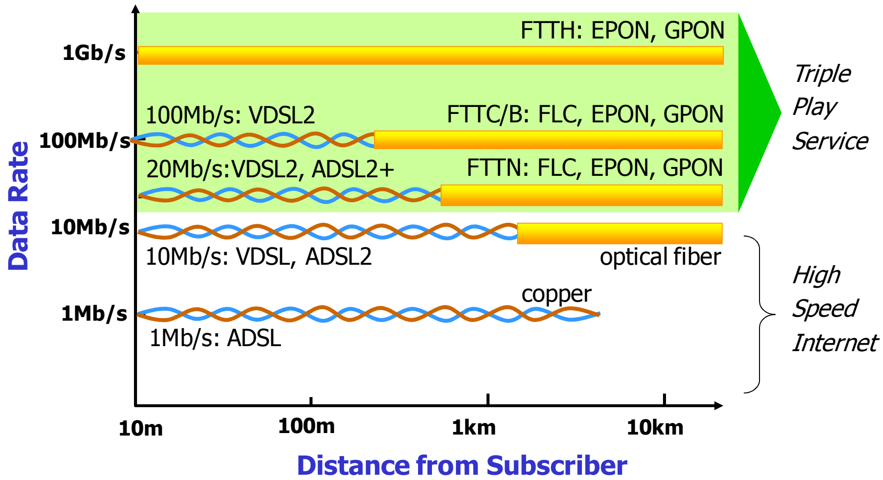


Mobile networks are still on-going of their development. But as see on the Figure 1-1, mobile especially using WiMAX including WiFi also have good capability to support broadband and become very popular access technology. Benefiting the mobility, mobile access is a crucial access for the nomadic users such as business people and students etc., using connectivity wherever they stay or move.

In fixed networks, since provide the xDSL which is very popular broadband access in the world (actually the best technology to build up broadband today) fiber based broadband is becoming deploy now in various countries with FTTC (Fiber to the Curb) and FTTH (Fiber to the Home). With the development of PON (Passive Optical Network) 100 Mb/s is now available to everyone in economic way. Therefore many of developed country cases, business users are being cover by the fiber and some of home also.

As shown Figure 1-2, fiber based technology provide much longer distance than legacy accesses with enough bandwidth. This feature contributes greatly to enlarge providing broadband connectivity including rural areas. Especially combination of fiber with xDSL support economical provision of broadband extending distance to reach end users but keeping broadband capabilities e.g. FTTC with VDSL provide 30 Mb/s to the household.

Figure 1-2: Transmission technology developments

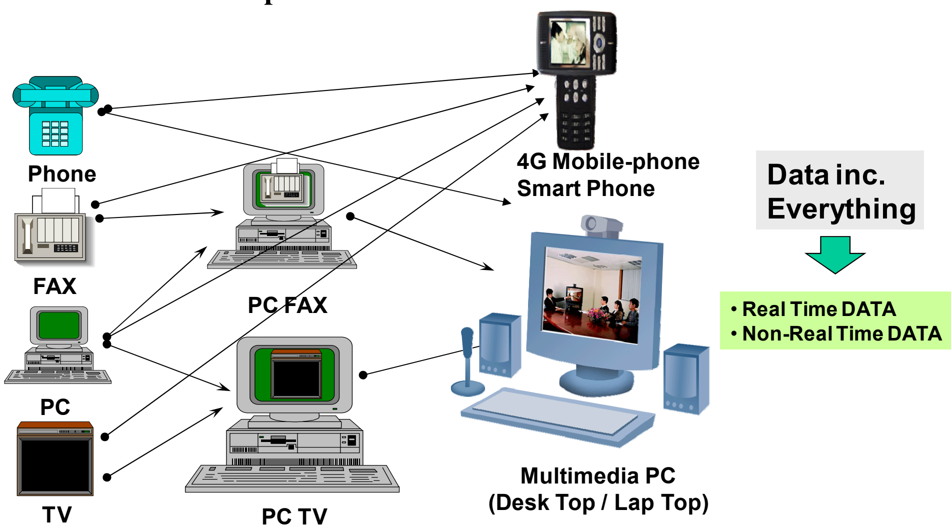


1.3 Terminal device development

Thanks to the processing technology developments, terminal devices have been remarkably developed and are continuing now. During the last decade, terminal devices especially with Lap Top computer and mobile phones including smart phone (e.g. PDA) have been kept the leading role of most of telecommunication services developments. Portable and smart are major key themes in this developments.

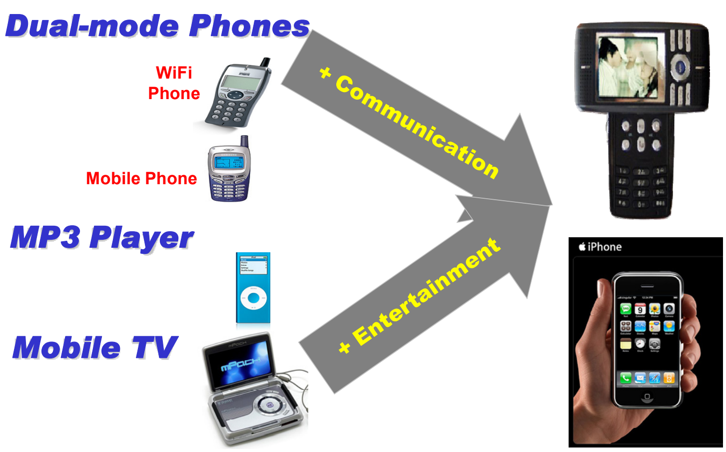
As shown in Figure 1-3, legacy terminal functions for graphic, text and video are integrated into one physical device such as PC based or mobile based. Voice service function also very well developed and integrated into small piece called mobile phone and this function also incorporated into PC consisting integrated multimedia terminal device. With this integration, all traffic types are change to "Data" including voice, so output signal of terminal device should be "Data but with real time or non real time differences." This integration of various functions into Lap Top PC is resulting nomadic life such as moving personal office etc.

Figure 1-3: Terminal device development



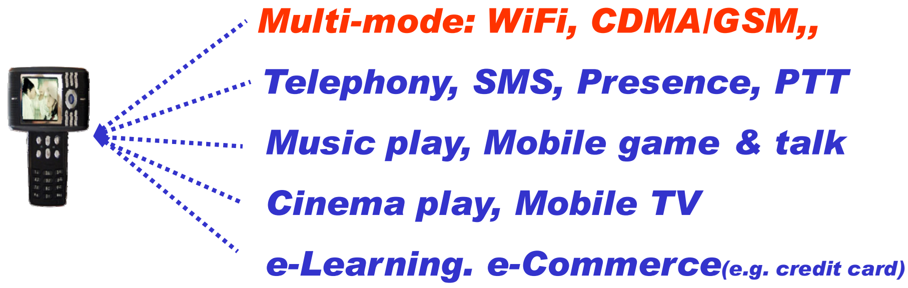
Out of this development, mobile terminal device should be one of the remarkable one to enhancing our ICT life. Mobile phone is not any more only phone, this becomes smart handheld device allowing people to communicate anywhere and anytime including personal entertainments (Figure 1-4)

Figure 1-4: Mobile terminal device development



As a result of his development, end user terminal device, even single device such as a smart mobile phone, is now ready to support most multimedia services as shown in Figure 1-5.

Figure 1-5: Various services over multi-function terminal device

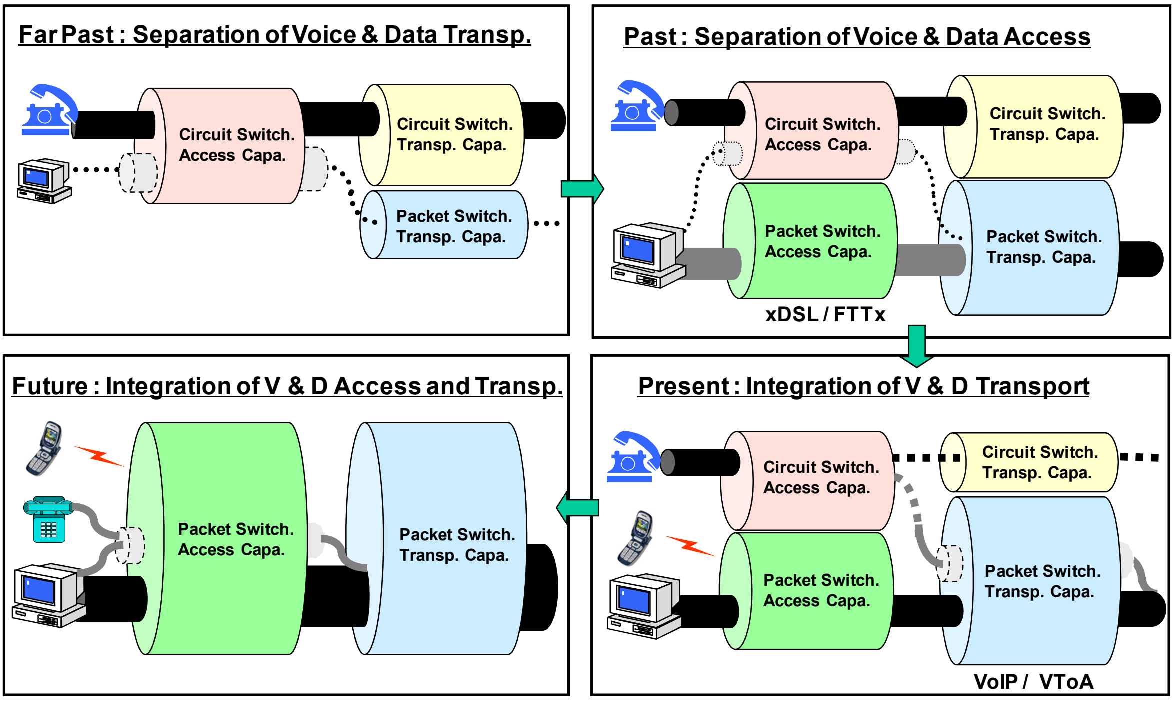


1.4 Telecom networks developments

Many technologies are developed and used in networks not only for mobile but also fixed networks. It is quite hard to analyze such developments in detail like in this short report. Therefore this report tries to analyze big stream to evolve the telecommunication networks today and future.

One of important changes or direction to lead the evolution of telecom networks should be the change from "Circuit" to "Packet." Until the end of 1980s, change to analog to digital was the biggest theme for the telecom network development such as the initiation of ISDN etc. But since the introduction of IP technology in the middle of 1990s, circuit based networks migration to packet based is the most crucial point for the development. Figure 1-5 shows an abstract view of the efforts technology developments did and future direction.

Figure 1-6: Trend of telecom networks developments



* Note V: Voice, D: Data

- Far Past: Telecommunication networks were quite clearly separated based on the services such as voice and data. So PSTN has been developed for voice services including voice-band data such as for facsimile, and PSDN has been developed for data communications. But both networks used circuit technology for access to the networks.
- Past: Packet technologies widely deployed in most of networks not only for core networks similar as far past but also access networks. This has been mainly derived by the IP technology supporting the xDSL and remarkable contribution to build up connected world. There were several data services still used circuit access such as using modem.
- Present: Packet capability is the major capability which provided by the telecom networks whatever voice and data including mobile communications. Benefiting broadband accesses, this packet based infrastructure covers many of multimedia services including voice. But still circuit based networks position as a major network for voice services while some of voice service using circuit access start to transport by the packet core.
- Future: It is expected that packet capabilities to cover all areas of networks such as access and core networks. And this will support not only for multimedia but also voice services over fixed and mobile together with broadband capability.

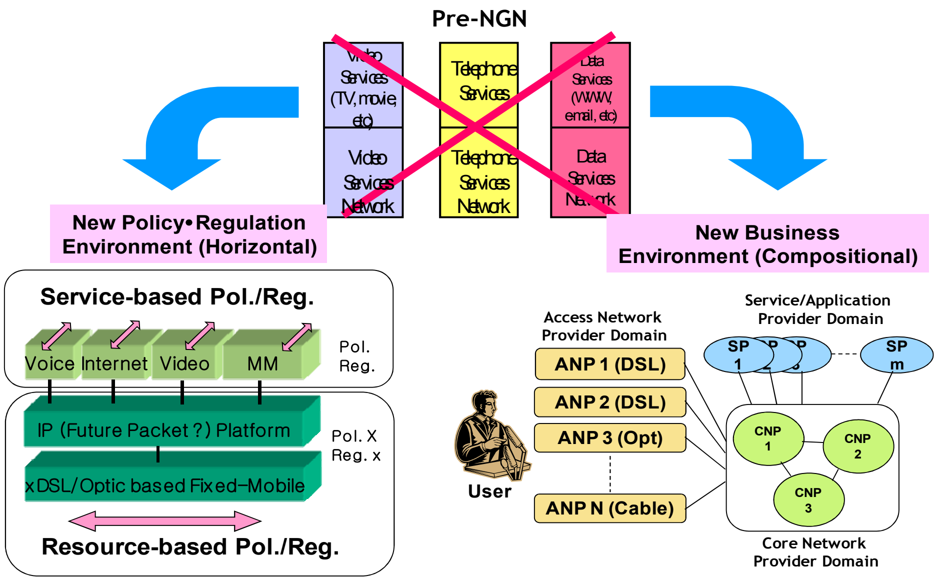
2 NGN as a today's solution

2.1 Benefits of NGN

Legacy network generally build up based on specific services which means PSTN build for supporting voice services and PSDN for data service etc. This resulted so called "Silo Effect" which caused some barriers for further development of services as well as encouraging competition in telecommunication businesses.

Following the NGN development, thanks to NGN, providing services are available over the underline transport networks. Therefore service provisioning will be independent with underline networks as shown in the left part of Figure 2-1 and this will encourage fare competition in service businesses. In addition, NGN also supports various access technologies to attach NGN core networks for delivering their services. This will also allow competition in access networks with diverse choices to the end user according to their service needs. This shows in the right part of Figure 2-1

Figure 2-1: Benefits of NGN



2.2 Consolidated Network

NGN provides many of features not only for solve difficulties from the legacy but also prepare for the future as well. From the technical aspects, NGN provides following key functions:

- Distributed control: To adapt to the distributed processing nature of IP network, eliminate the structural defects of SS7 signalling architecture, and support the location transparency of distributed computing.
- Open control: The network control interface should be open to support the service creation, service update, and service logic by third parties.
- Separate the service provision process from network operation: Encourage the competitive environment of NGN to speed up the provision of diversified value added services.
- Support the services of converged network: generate converged voice/data services that are flexible and easy to use, so as to tap the technical potential and market value of NGN.
- Provide enhanced security and protection: as basic requirement of an open architecture. protect the network infrastructure by ensuring the trustworthiness of the service provider

Using such functions, NGN provides following features which are essential and very useful:

- Location transparency: With distributed computing technology, third party service providers can access from anywhere regardless of the actual physical location of such server.
- Network transparency: The Service Enabler and Server block executes upon third party service request the corresponding control process independent of the type of the specific network of the terminal user. So the server can neglect the technical features of the target network.
- Protocol transparency: This will achieve by providing standardized protocol programming interface tools, realizing independent service control process, shielding complex network technical details to the VAS Enabler & Server block.
- Independent of network providers: Numerous third party service providers on the top layer constitute the separated application service layer, where their functionality, technology, operation and management are all independent of their underlying enabler block and network infrastructure block. With security ensured, it may interface with the users directly and provide personalized services to users.
- Independent of manufacturers: On the bottom layer, network equipment compliant to standard protocols may come from different manufacturers. With the open service environment they can form a multi-vendor application environment in the true sense, providing users with the best service in a competitive environment

Figure 2-2: Use of NGN for consolidation of technologies

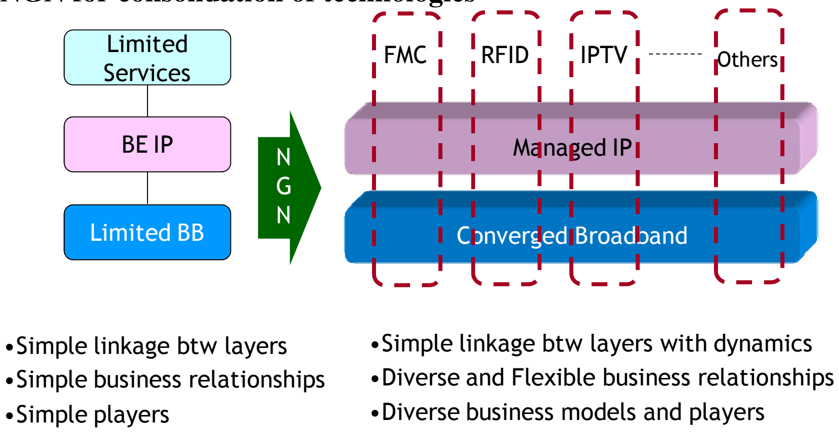
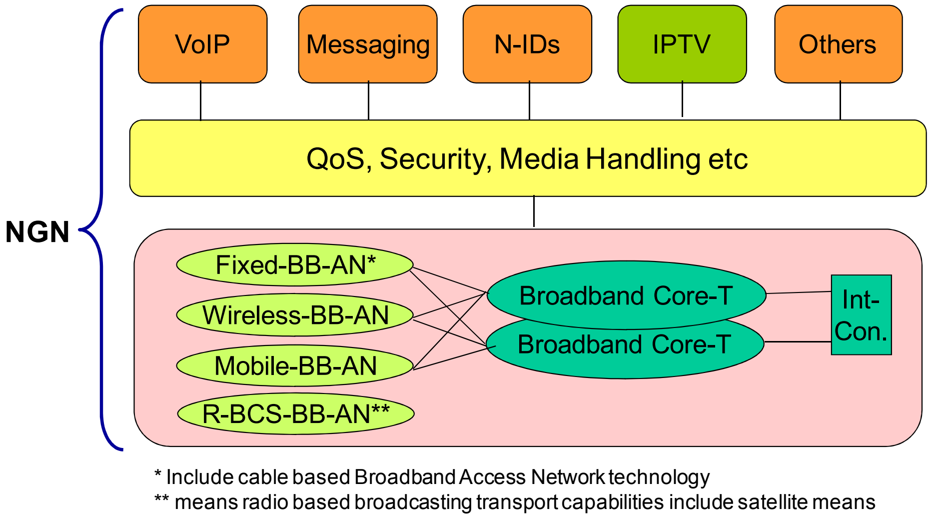


Figure 2-2 shows the result of NGN to consolidated available technologies and will solve relevant difficulties in economic way. Following Figure 2-3 shows an example how NGN consists as a platform to support this.

Figure 2-3: NGN as a consolidated network platform

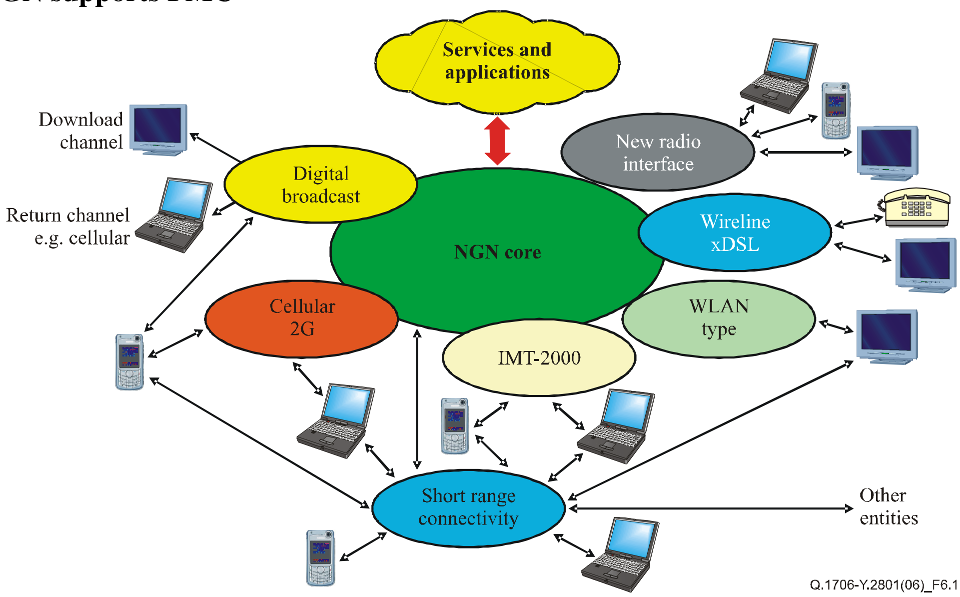


2.3 NGN for convergences

2.3.1 NGN for FMC

FMC is the first occasion to show convergence feature of various telecommunication services between fixed and mobile environments. FMC is the capabilities, in a given network configuration, that provide services and application to the end user regardless of the fixed or mobile access technologies being used and independent of the user's location. Therefore NGN services to end users regardless of the fixed or mobile access technologies being used. Figure 2-4 shows how NGN supports the FMC combining with other different networks.

Figure 2-4: NGN supports FMC



One of the most important features of FMC is a 'Seamless service' operation providing ubiquity of service availability where the end users can enjoy virtually any application, from any location, on any terminal device.

There are two perspectives to look at this, one from end user's view and the other from service provider's view.

From the end user perspective, services are available seamlessly across heterogeneous fixed networks (i.e. PSTN, ISDN, PSDN, WAN/LAN/CATV, etc.) and mobile networks (i.e. GSM, CDMA2000, WiMAX, etc.), while from the service provider's perspective, seamless service provisioned across heterogeneous fixed and mobile networks. Both perspectives have any limitations imposed by the characteristics of the particular access technology being used.

Generalized Mobility is supported in FMC (i.e. terminal device mobility, user mobility and session mobility) and different levels of mobility may be needed according to a given scenario.

The fundamental characteristics of FMC are described as followings:

- Consistency of user experience is provided through the fixed network and the mobile network with supporting the user is able to obtain services in a consistent manner as allowed by the connectivity and terminal device capabilities. For example, an ongoing call could be downgraded for some reasons such as, change of access technology or terminal device capability. A video communication may be downgraded to a voice communication when the user migrates to mobile only coverage where the access technology is not able to support it.
- Subscriptions and service provisioning are access technology agnostic but the service stratum may be aware of both the access and terminal device capabilities involved in a communication instance. Service registration, triggering and execution adapt to network and terminal device capabilities. The user's availability, reachability, and the terminal device's capabilities are perceptible to network functions, and as needed to services and applications. FMC respects the user's privacy, and privacy-sensitive data (e.g., address book, preferences, presence settings, billing/payment settings and other security settings) contained in the user's profile, the user's personal preferences (e.g. availability, reachability) and the terminal's device capabilities.
- FMC's service and application processing may depend on terminal device capabilities. Compatible terminal device capabilities may be selected by end-to-end interaction between terminal devices, or between the terminal device and the FMC service stratum according to the service and application needs.

2.3.2 NGN for IPTV

From NGN point of view, IPTV is defined as multimedia services over broadband IP-based networks, managed to support the required level of quality of service (QoS)/quality of experience (QoE), security, interactivity and reliability, etc. It means that NGN should be the best tool supporting the reliable and secure delivery of multimedia contents including video, which is a very crucial issue for IPTV services. In this regard, NGN should be the best platform to support IPTV with enough capabilities to manage bandwidth and traffics in terms of QoS and QoE at least.

As the IPTV service requires not only the broadband multimedia streaming but also the security and reliability with a certain level of quality, there are certain limitations to support those capabilities in current best effort based IP network such as the Internet. Therefore, NGN with adjustment for IPTV characteristics would be a suitable way to provide new emerging services over heterogeneous networking environment.

In other direction, IPTV will also contribute to accelerate deployment of NGN. With this feature adding to FMC will allow network and service operators will provide "Triple play services" using a consolidated network platform called NGN. Following Figure 2-5 shows how NGN support IPTV and Figure 2-6 explains convergence aspects of IPTV.

Figure 2-5: NGN supports IPTV

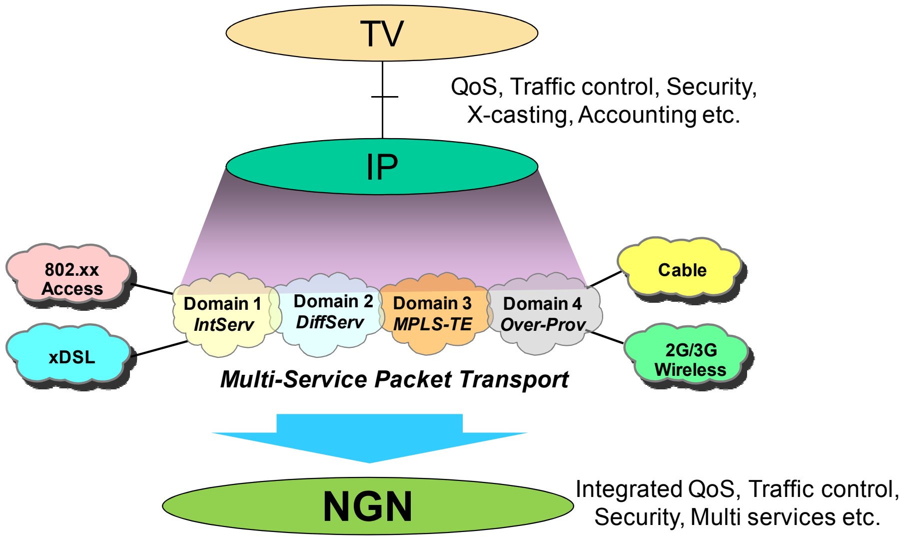
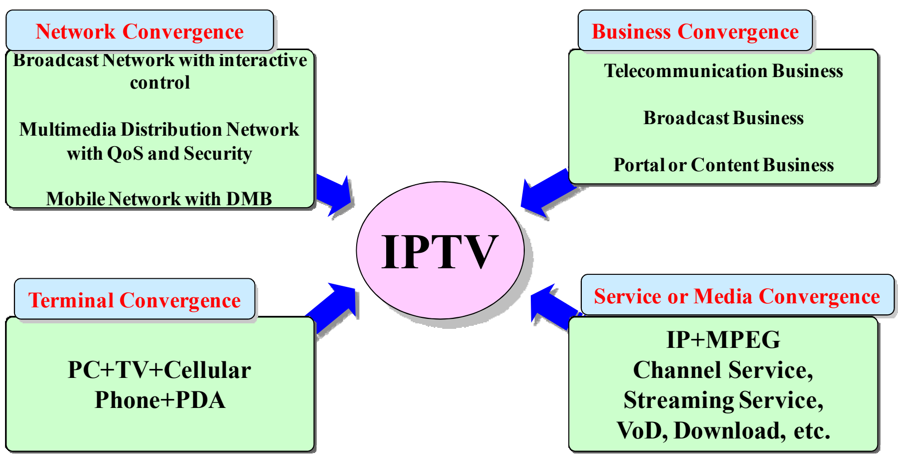


Figure 2-6: IPTV as a result of convergences



3 NGN Technologies

3.1 Introduction

The last 10 years or more have seen an increasingly fast integration of computers and telephony, both equipment and networks. Traditional public network operators have seen a decrease in telephony traffic on their Public Switched Telecommunications Networks, due in part to the increasing popularity of Mobile Telephones and the movement of services from Telephone Networks to the Public Internet.

The concept of a new, integrated broadband network has developed over the last few years and has been labelled "Next Generation Network: NGN".

The basic characteristics of an NGN can be determined from the problems faced by the network operators: the need to provide services over broadband accesses (to increase revenue); the need to merge diverse network services – data (web browsing), voice, telephony, multimedia and emerging "popular" internet services such as Instant Messaging and Presence and broadcast type services; and the desire of customers to be able to access their services from anywhere (inherent mobility). Rather than a network to provide a specific solution (such as the PSTN), what was needed for the next generation was a series of networks that could support a flexible platform for service delivery.

3.2 Definition and features of NGN

ITU-T Recommendation Y.2001 defined NGN as "A packet-based network able to provide telecommunication services and able to make use of multiple broadband, QoS-enabled transport technologies, and in which service-related functions are independent from underlying transport-related technologies. It enables unfettered access for users to networks and to competing service providers and/or services of their choice. It supports generalized mobility which will allow consistent and ubiquitous provision of services to users."

Recommendation Y.2001 further defines the NGN by the following fundamental characteristics:

- packet-based transfer;
- separation of control functions among bearer capabilities, call/session, and application/service;
- decoupling of service provision from transport, and provision of open interfaces;
- support for a wide range of services, applications and mechanisms based on service building blocks (including real time/streaming/non-real time and multimedia services);
- broadband capabilities with end-to-end QoS (Quality of Service);
- inter-working with legacy networks via open interfaces;
- generalized mobility;
- unrestricted access by users to different service providers;
- a variety of identification schemes;
- unified service characteristics for the same service as perceived by the user;
- converged services between fixed/mobile;
- independence of service-related functions from underlying transport technologies;
- support of multiple last mile technologies;
- compliance with all regulatory requirements, for example concerning emergency communications, security, privacy, lawful interception.

Recommendation Y.2001 decomposed the NGN into a number of areas to be studied for requirements and solutions. These areas largely form the basis of standardization activities in ITU-T and other Standards Developing Organizations (SDO):

- General framework and architectural principles.
- Service capabilities and service architecture.
- Interoperability of services and network in NGN.
- Telecommunications capabilities for disaster relief.
- Architecture models for the NGN.
- End-to-end Quality of Service.
- Service platforms.
- Network management.
- Security.
- Generalized mobility.
- Network control architecture(s) and protocols.
- Numbering, naming and addressing.

3.3 Overview of Release 1 Technology

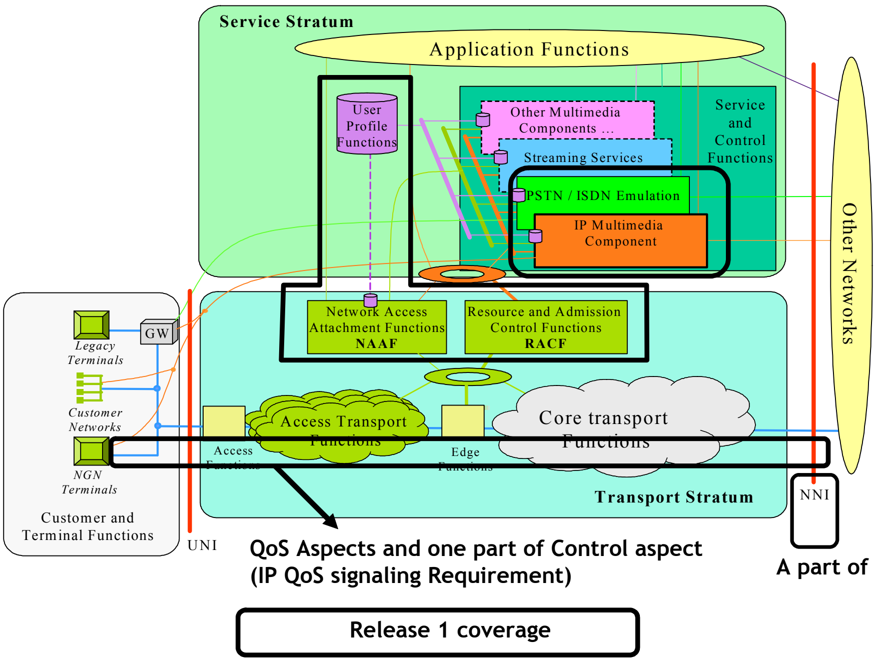
Release 1 is the first step towards a comprehensive framework of services, capabilities and network functions that constitute an NGN, as described in Recommendation Y.2001. Ensuring an architectural flexibility to support future enhancements and releases with minimum impact is an essential characteristic of the NGN framework.

The NGN framework delivers services tailored to both User's and Service Provider's requirements. It is recognized that specific realizations of NGN Release 1 may extend beyond the services and capabilities described in the NGN Release 1 Scope document, as well as Service Provider requirements may drive a particular set of services and capabilities to be supported in a particular network.

The overview of the Release 1 service aspects has formed the basis and overall guidelines for the other subject areas.

A pictorial representation of the NGN was derived in conjunction with ETSI TISPAN and depicts the Release 1 development shown as black colored boxes in Figure 3-1.

Figure 3-1: Coverage of ITU-T NGN Release 1



3.3.1 ITU-T NGN Release 1 Target Environnement

The NGN framework supports advanced architecture objectives for the offer of a comprehensive set of services over a unifying IP layer network. The transport stratum has to support a multiplicity of access networks and a variety of mobile and fixed terminal types. Services are separable from the transport stratum into a service stratum and are not limited to those provided by the "home network", but may be obtained from multiple Service Providers and third parties. In Release 1 all services are carried over IP although IP itself may in turn be carried over a number of underlying technologies, such as ATM, Ethernet, etc. IPv4 or IPv6 networking is assumed at packet interconnection points and packet network interfaces, therefore the focus is on the definition of IP packet interfaces.

As far as the QoS objectives are concerned, QoS coordination across the transport stratum (access and core segments), in cooperation with application resource requirements, lead to an end to end QoS environment for the services offered to end users. Within that perspective, NGN Release 1 provides an initial set of requirements, architectures, mechanisms and guidelines to enable end-to-end QoS, including resource and admission control, coordination between access and core networks and inter-core network aspects.

In an open IP environment, security for the end users and the network itself is a critical aspect. NGN Release 1 contains Security Requirements specification based on the application of the ITU-T Recommendation X.805 to NGN and thus addressing the following dimensions of NGN security: Access Control, Authentication, Non-repudiation, Data Confidentiality, Communication Security, Data Integrity, Availability and Privacy. The specification also addresses the incremental security considerations resulting from the interconnection of existing networks to NGN.

Coordination of all of the various network components within the NGN and across network boundaries is needed to provide a robust, efficient, manageable system. NGN management supports the monitoring and control of the NGN services and service/transport components via the communication of management information across interfaces between NGN components and management systems, between NGN-supportive management systems, and between NGN components and personnel of service providers and network operators. As far as the management objectives of the NGN Release 1 are concerned, the NGN Management Focus Group has been working, in cooperation with ITU-T NGN-GSI (Global Standard Initiative) and Study Group 2, towards the definition of realistic objectives and corresponding solutions. This work includes, for example, provisioning of capabilities for management of NGN service components independently from the underlying NGN transport components, for personalization of end user services and creation of new services from service capabilities, for end user service improvements such as customer self service, for enabling service providers to reduce the time frame for the design, creation and delivery of new services.

Generalized Mobility is a key aspect of the NGN framework. Mobile users require seamless and transparent mechanisms for roaming between network operators and continual access to tailored services from a variety of environments while using a variety of terminals with varying capabilities. In addition, NGN communications and services have to be available to all qualified users requesting those services, regardless of the type of access network technology, as long as the services can be tailored for the specific terminal type and are compatible with the QoS of the access network. In describing the mobility within a NGN network, no major new interfaces for mobility are proposed for Release 1. Existing interfaces should be used, as well as existing signaling capabilities for all types of mobility as currently defined.

Personal Mobility is based on a personal identifier and the capability of the network to provide those services delineated in the user's service profile. For NGN Release 1, personal mobility continues to be used where users can register themselves with the services. Similarly, Terminal Mobility exists within and among networks where the terminal can register to the access network. Nomadism, defined as personal or terminal mobility without maintaining an active service session during mobility, shall be supported between networks and within a network. This does not exclude support for mobility with active service session. Where such continuity exists, such support is expected to also be used for NGN Release 1.

Applications and end user services offered as part of the NGN are designed to be easily created in an open environment for both operators and third parties. A flexible service framework enables implementation of value added services making usage of core network capabilities in an agnostic fashion. These core capabilities are be accessed via published application interfaces and features providing consistent access methods to the capabilities. Application developers will rely on this consistency when designing new applications. NGN Release 1 supports interfaces to the following classes of services (where applicable): Intelligent Network-based services, Session Initiation Protocol (SIP)-based services, and Open Service Environment (OSA/Parlay, OMA etc.)-based services.

Additional open service environment capabilities include the end user support, for compatibility among various services, of subscription from differing service providers and access from different access network environments.

3.3.2 Basic Components

IP Multimedia Component so called IMS positioned within the Service and Control Functions of the NGN architecture, this component is based on the 3GPP/3GPP2 IMS (IP Multimedia Subsystem). It has been a starting point for the definition of NGN Release 1 to leverage the capabilities of the 3GPP/3GPP2 IMS (for SIP-based call/session control of real time conversational communications), with consideration of the appropriate extensions, required for example to support the heterogeneous access network environment of Release 1. Full compatibility with 3GPP/3GPP2 IP connectivity access networks (e.g. IP-CAN) and terminals will be maintained.

All **NGN access network** types are required to offer IP connectivity. NGN supports access networks of diverse technologies and capabilities. The following provides a non-exhaustive set of candidate technologies (the required technologies will be those capable to provide IP connectivity):

- wireline domain: xDSL (ADSL, SDSL and VDSL transport systems and supporting connection/multiplexing technologies), PDH/SDH dedicated bandwidth access, Optical access (point to point, single star and xPON (Passive Optical Network) transport systems, such as BPON, EPON, GPON, GEPON), Cable networks, LAN (Local Area Network) networks, PLC (Power Line Carrier) networks;
- wireless domain: IEEE 802.X Wireless networks [e.g., WLAN, Broadband Wireless Access (BWA)], 3GPP/3GPP2 Packet Switched (PS) domain (Circuit Switched (CS) domain is not supported), Broadcast networks.

As far as the **interconnection between multiple NGN** network administrative domains or between NGN domains and other networks are concerned, the NGN is required to support access to and from other networks that provide communications, services and content. NGN Release 1 provides support for services across multiple NGN network administrative domains. Direct interconnection with the PSTN/ISDN will be supported by means of interworking functions implemented within the NGN. The following lists the Network-to-Network interconnection capabilities supported in NGN (also applicable to Enterprise networks as Private Network-to-Network interconnection):

- Circuit based legacy networks: PSTN/ISDN, PLMN (Public Land Mobile Network)
- other IP based networks: public Internet, Cable networks, Broadcast networks, other multimedia networks (3GPP/3GPP2 IMS)

NGN customers may deploy a variety of network configurations, both wired and wireless, behind the Network Termination function. It is also recognized that many customer and termination functions deploy firewalls and private IP addresses in combination with NAPT (Network Address Port Translation). NGN Release 1 supports simultaneous access to NGN through a single Network Termination function from multiple terminals connected via a customer network. The support for customer and termination functions will be limited to control (part of) the gateway functions between customer owned equipment and the access transport function.

As far as the **NGN end user equipment** are concerned, the NGN shall support a huge variety of end user equipment, from those with intrinsic capability to support a simple service set to others supporting programmable service sets.

User equipment uses its Network Termination function to access services. This function being access network technology specific, the Network Termination function types supported in NGN will be determined by the NGN Access network types. The simultaneous use of multiple access networks by single equipment shall be allowed, however there is no requirement to co-ordinate the communication in such scenarios.

3.4 NGN requirements (Release 1 aspect)

This clause introduces NGN requirements but mainly based on Release 1 concept, because Release 2 aspects are recently finished and will be in the approval process soon.

3.4.1 Services aspects

The following services are examples of the types of services supported by NGN (in terms of Release 1). It has to be noted that compliance of a given network environment to NGN Release 1 does not mean support of all possible combinations of services (as well as capabilities and network configurations).

- Multimedia services: NGN supports both real time conversational communications (beyond voice) and non-real time communications. This includes, but is not limited to, the end to end delivery of communications using more than one media.

Examples include:

- Messaging services (Instant Messaging (IM), Short Messaging Service (SMS), Multimedia. Messaging Service (MMS), etc.).
- Group Messaging.
- Push to talk over NGN.
- Point-to-point interactive multimedia services (e.g., video-telephony, white-boarding), collaborative interactive communication services (multimedia conferencing with file sharing and application sharing, e-learning, gaming).
- Push-based services (e.g., IP multimedia services, MMS, and new services including public safety, government, corporate Information Technology, etc.).
- Content delivery services (Radio and Video streaming, Music/Video on demand, TV channel distribution, financial information distribution, professional and medical image distribution, electronic publishing).
- Broadcast/Multicast services
- Hosted and transit services for enterprises (IP Centrex, etc.).
- Information services (e.g., cinema ticket information, motorway traffic status).
- Presence and General Notification services.
- 3GPP/3GPP2 OSA-based services.

• PSTN/ISDN Emulation services: enabling legacy terminals to continue to use existing telecommunication services while connected to an NGN network. The user should have the identical experience as provided by the legacy PSTN/ISDN services. Not all service capabilities and interfaces have to be present to provide an emulation of a particular PSTN/ISDN network.

• PSTN/ISDN Emulation provides PSTN/ISDN service capabilities and interfaces using adaptation to an IP infrastructure. The supported PSTN/ISDN service set may be only applicable to certain terminal types, i.e. legacy terminals or user equipment behaving like legacy terminals.

• PSTN/ISDN Simulation services: enabling NGN terminals in an NGN network to use telecommunication services similar to legacy PSTN/ISDN services (legacy terminals with terminal adaptations may also use these simulation services). Simulated services may not necessarily have the full functionality as defined for PSTN/ISDN, and may not necessarily use PSTN/ISDN call models or signaling protocols.

  PSTN/ISDN Simulation provides PSTN/ISDN-like service capabilities using session control over IP interfaces and infrastructure.

• Other services: This category primarily addresses various data services common to packet data networks. Examples include Data Retrieval applications, Data Communication services (ex. data file transfer, electronic mailbox and web browsing), Online applications (online sales for consumers, e-commerce, online procurement for commercials), Sensor Network services, Remote Control/Tele-Action services (ex. home applications control, telemetry, alarms), Over-the-Network Device Management.

• Internet access: Deployment of an NGN network shall not inhibit user access to the public Internet through existing mechanisms. Support for Internet access through the NGN core that includes end to end transparency, peer to peer interactions and some other Internet services is in scope of NGN, but not required in Release 1.

• Public Service aspects: These services may be applicable to NGN networks required to support public services. The NGN network should provide these services in compliance with national and regional regulations and international treaties.
  - Lawful Interception.
  - Malicious Call Trace.
  - User Identity Presentation and Privacy.
  - Emergency Telecommunication Services and Telecommunication Disaster Relief.
  - Users with Disabilities.
  - Carrier Selection.
  - Number Portability.

3.4.2 NGN Capabilities

In today's networks, vertical integration is the typical service construct, requiring specific infrastructure components for service delivery. This will not be the usual case within a converged NGN infrastructure. In order to support multiple, innovative and evolving services, allowing flexible service design, creation and development, as well as third-party development and support, the concept of "*capabilities*" as set of basic building blocks for the provisioning of NGN service features is essential. NGN shall provide such a standard set of capabilities.

Examples of network aspects of capabilities include: network management, routing, network authentication and authorization, accounting, traffic class and priority management, media resource management, etc.

Within the set of (more or less service or environment-specific) capabilities to support services, those supporting critical features of NGN Release 1 services include presence, location, group management, message handling, broadcast/multicast, push, session handling, device management. The following provides some details of this subset of capabilities.

- **Presence** concerns information describing the status of each user or device connected to NGN. Presence includes information such as location (longitude and latitude), place (office, home or outside), type of access (dial-up, DSL, fiber or wireless), type of terminal (cellular or PC), availability (busy or free), access condition (congestion or resource availability), and so on. Since the presence information is part of the user's private information, it should be managed in compliance with user privacy and access rules.
- NGN should have mechanisms to determine and report **Location information** of the user's terminal, managing location information as a standard attribute of the terminal. This capability may be used by various services and is particularly important for emergency cases, such as traffic accident, natural disaster, medical emergency, and so on. Location can be specified in various ways: for fixed terminals, the address assigned to the terminal can be used, while for mobile wireless terminals, the geographical position of the base station can be used. Similarly to presence, location information is part of the user's private information and, as such, it should be handled adequately.
- **Group Management** deals with secure and efficient management of groups of network entities. Virtual Private Network (VPN) services provided by network operators constitute a typical case requiring this capability: a closed user group needs to be defined based on a membership list, and communications secured within that group. NGN should be able to manage such groups in a secure and efficient way.
- **Message Handling** deals with management of message-based data streams, which is also called "messaging". Messaging types can be distinguished according to various criteria, including single and multimedia, real-time and non real-time (3GPP has defined immediate, deferred delivery and session-based messaging types). Examples of real-time messaging are Instant Messaging and Chat, Email and SMS are examples of non real-time messaging. NGN should support the various types of messaging.
- **The Broadcast/Multicast capability** enables applications to deliver content to multiple users at the same time using broadcast or multicast type of content delivery mechanisms. In addition to standard point-to-point unicast, broadcast and multicast mechanisms should be supported for efficient network resource usage and scalable content delivery.
- **The Push capability** is used to transmit data from an initiator to a recipient without a previous recipient action. This data transmission may trigger applications on the recipient's terminal. A typical example of push-based service is Push to talk in cellular networks, but the Push capability can be used in various other scenarios, such as message display or announcement generation on terminals like TV, and emergency messaging in natural disaster situations like earthquake or tsunami.
- **Session Handling** deals with end-to-end session setup and termination, and related management coordination, such as finding the destination users, controlling access rights, controlling resource allocation, etc. The session management process increases in complexity when multimedia applications are launched among multiple users. For example, in case of a multimedia conferencing utilizing multiple media types, such as video, voice, instant messaging and whiteboard, the setup of multiple QoS-enabled connections may be required within a single session, as well as the codec

alignment for each media. Multi-party session establishment requires the session handling capability to manage the users' join/leave operations.

- **Device Management** enables network management protocols and other mechanisms for robust management of user terminal devices and their applications over a variety of bearers during the entire life cycle of the terminals and applications. One aspect of this capability is device provisioning, by which a device is initially configured with a minimum of user interaction.

3.5 Enhancements to IMS for NGN applications

The IMS specifications were developed for use with cellular access networks and were based on certain assumptions regarding the access network such as bandwidth available. Inherent differences between the different types of access networks will have concrete consequences on the IMS specifications. Examples of such consequences are:

- To Support xDSL based access networks the IMS may also need to interface to the Network Attachment functions of the IP-CAN, for the purpose of accessing location information. No equivalent interface exists in the base IMS specifications.
- Support of IPv4 has to be taken into account and this leads to a requirement to support NAPT functionalities. There are at least two reasons leading to this:
  - Some operators have (or will have) to face IPv4 addresses shortage.
  - Privacy of IP addresses for media streams cannot rely on RFC 3041 (Privacy Extensions for Stateless Address Auto-configuration in IPv6), as would have been the case for IPv6. NAPT provides an alternative for hiding terminal addresses.

Support of NAPT functionality is covered in the NGN Functional Architecture. Extensions to IMS for working with configurations containing NAPT need to be provided in the IMS specifications.

- Relaxing the constraints on bandwidth scarcity may lead to considerations for the optional support of some features that are currently considered mandatory (e.g.; SIP compression).
- Differences in location management will impact various protocols that convey this information, both on signalling interfaces and charging interfaces.
- Differences in resource reservation procedures in the access network will require changes to the IMS resource authorisation and reservation procedures, as the resource reservation procedures for xDSL access networks will have to be initiated by a network entity (i.e.; the P-CSCF in case of SIP-based services), on behalf of end-user terminals.

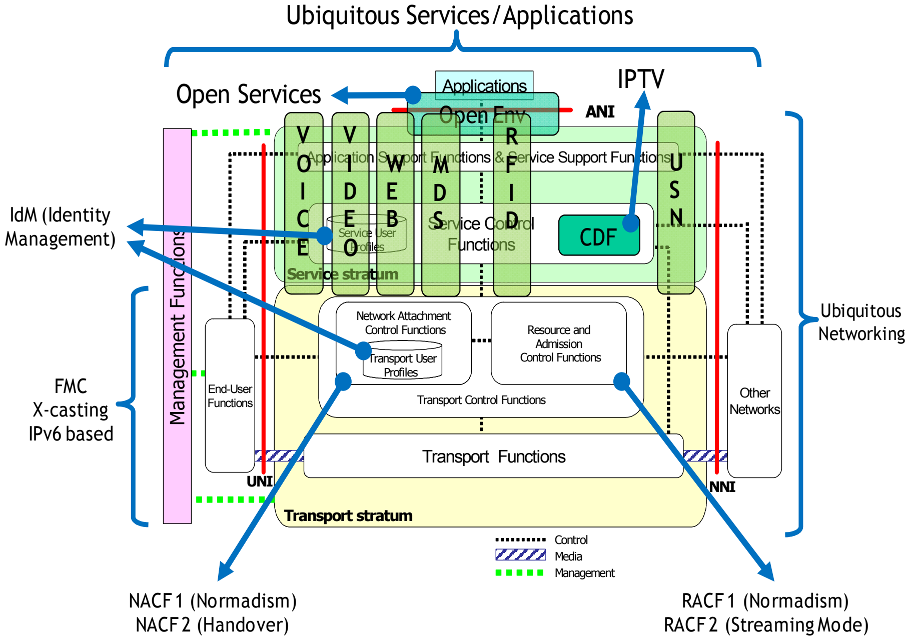
The above mentioned extensions are being examined by various standards bodies to support the use of IMS in NGN.

3.6 Issues for future of NGN

NGN should continuously evolve to build up "Connected World" and someone proposed NGN should support Ubiquitous Networking which will represent the situation of "Connect to Anything" in other words.

Following Figure 3-2 shows an overall view of NGN developments in ITU-T and identify many of areas are quite well developed. Some of functions and capabilities still need further developments especially taking consideration of Identity management and ensuring security and traffic management resolving the QoS/QOE and Security considerations.

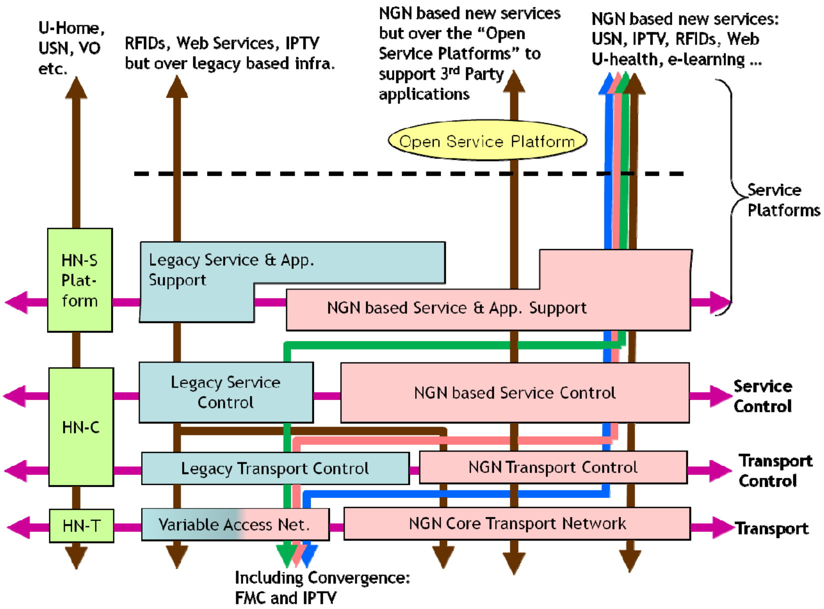
Figure 3-2: Status of NGN developments



Considering this, ITU-T based on the NGN-GSI is continuing of their developments for the NGN will play a crucial role in a future environment as well. For this, as shown in Figure 3-3, ITU-T NGN GSI will focus various technical subjects with higher priority. More service oriented functions and capabilities will developed especially support of USN (Ubiquitous Sensor Networks) and Web based various services over the NGN. And supporting the seamless services over the FMC with mobility management capabilities should developed with the highest priority.

From the functional aspects, extension of various key functions such as NACF and RACF with MMCF should continue for targeting support of above service requirements.

Figure 3-3: Future developments of NGN



4 Migration to NGN

4.1 Why need migration?

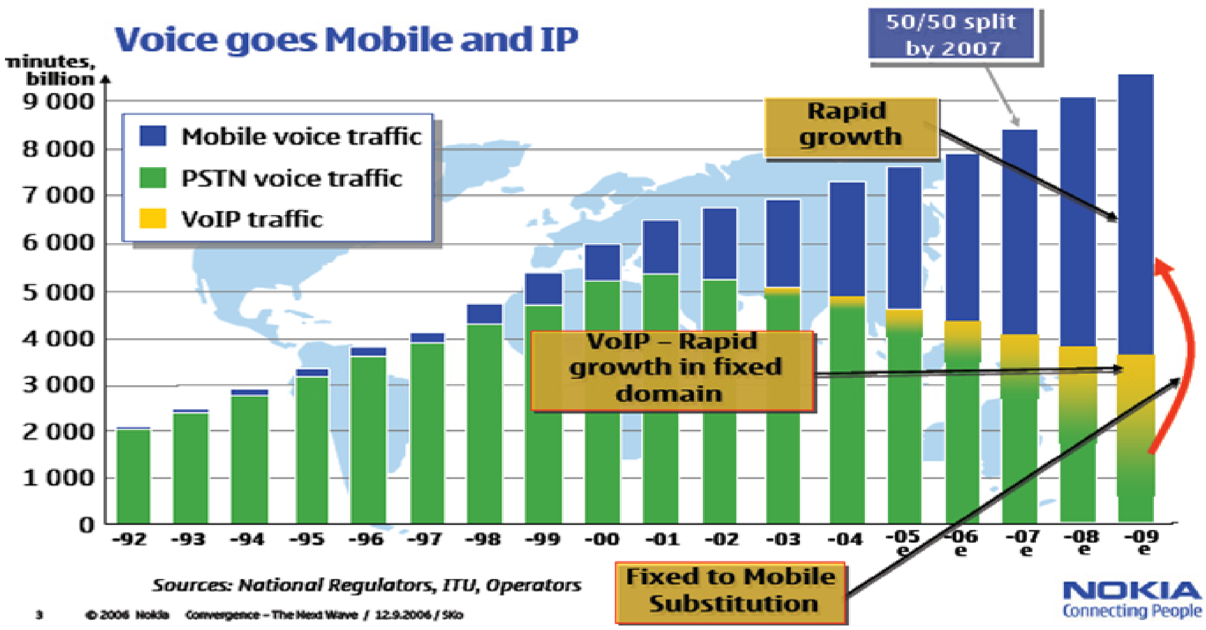
This section describes motivations to migrate from legacy network infrastructure to the new network infrastructure. There are several reasons according to the different viewpoints such as business aspects, technical aspects and etc.

4.1.1 General Motivation for Migration

One of the important factors to consider migration to the new network infrastructure such as NGN is that following the trend caused by the business flows.

One of the critical point of the business flows is the movement of voice services from legacy fixed based (e.g. PSTN and ISDN) to mobile and IP based. As shown in Figure 1 below, this trend is being rapidly progressed since the year 2003. This trend caused two directions: one is for reducing revenue of traditional network operators (e.g. falling down of voice revenue: France Telecom – 10%, Deutsche Telekom – 6% and BT – 5% annually, *Source: Forrester, quoted in The Economist 14 Oct 06*) and the other is requesting more IP based capabilities on their networks which requests additional investment in addition to the legacy network infrastructure.

Figure 4-1: Moving trend of voice services



There are several ways to meet these trends and it could be classified two ways: Compensate reduction of revenue and finding new revenue sources.

For the compensation of revenue reduction, cost reductions by sharing network infrastructure and systems should be the most important point in addition to the reduction of network and service infrastructure deployment cost. Followings are requirements in this sense and are caused to consider migration to NGN:

- Reduced OPEX and enhancing streamline operations.
- Integrated platforms for provisioning of various types services and applications.
- Integrated operation platforms including integrated maintenance and training.
- Centralized Management and Control.

In general, providing commercial multimedia services in economic ways should be the one of strong candidate in the viewpoints of finding new revenue sources. In this regard, followings should be considered as high level requirements when provide multimedia services and will be leaded reasons of migration to NGN:

- Compensate voice revenue reduction and increase Broadband related businesses.
- Providing Service innovation (e.g. VPN).
- Decreased time to market to introduce any new types of services and applications.

4.1.2 Operator's view for Migration

Meeting the business trend is also very serious subject to the operators, because they position in the center of these trends. That is, operators should be prepared, as soon as possible, that their service provisioning and operation will be enough to compensate falling down of their revenue stream. And their new systems and any elements will be enough to provide new revenue timely manner when they introduce those into their infrastructure.

Followings are taking into account when operators are willing to introduce new infrastructures:

- Support of business continuity required to maintain ongoing dominant services and customers that require carrier-grade service.
- Flexibility to incorporate existing new services and react quickly to the ones that appear on real time (well utilize main advantage of IP mode).
- Profitability to allow feasible return on investments and in the best practices market values.
- Survivability to allow service assurance in case of failures and external unexpected events.
- Quality of Service to guarantee the Service Level Agreements for different traffic mixes, conditions and overload.
- Interoperability across networks to allow to carry end to end services for flows in different network domains.

It is generally recognized that NGN should one of the dominant candidate to fulfill those requirements. Therefore many operators have a plan to migrate their legacy infrastructure to NGN and even some of them already start their migration toward NGN.

4.1.3 Technical view for Migration

There are many of technical issues on the today's internet even use of IP technology which is used also in NGN. These technical issues caused certain difficulties to resolve requirements of network operators and service providers. In addition, more technical issues are coming from handling the media effectively such as IPTV. Therefore it is required to develop completely new technology or additional capabilities on top of current IP when IP use.

Key summary of technical issues are shown in Table 1.

Table 1: Technical issue for migration

Technical Area	Issue
Management	Scalability Billing
QoS & security	Higher reliability Higher resiliency Secure systems Robustness Performance Application performance Authentication, Authorization and Accounting
Ubiquity	A ubiquitous network enabling user to be connected – always on, anytime, anywhere, anyhow Presence awareness
Content	Digital Rights Management (DRM) Conditional access
Network optimization	Common services infrastructure Fewer number of network nodes Fewer switching operations Simplified service deployment Higher capacity
Interoperability	Interoperable equipments from all vendors
Multitude of access networks	Fixed, mobile, copper, fibre, wireless… Transparent mobility across wireline & wireless
Shared resources	Shared voice & data resources
Mixing of traditional and internet service	Ability to combine traditional circuit switched communication services and IP services
Interactivity	End-to-end interactivity Personalized interactive multimedia communication Gaming: High performance and low latency User control
Storage	Business continuity Data retention
Standards compliant	Implementing standards compliant devices Standardized protocols and interfaces

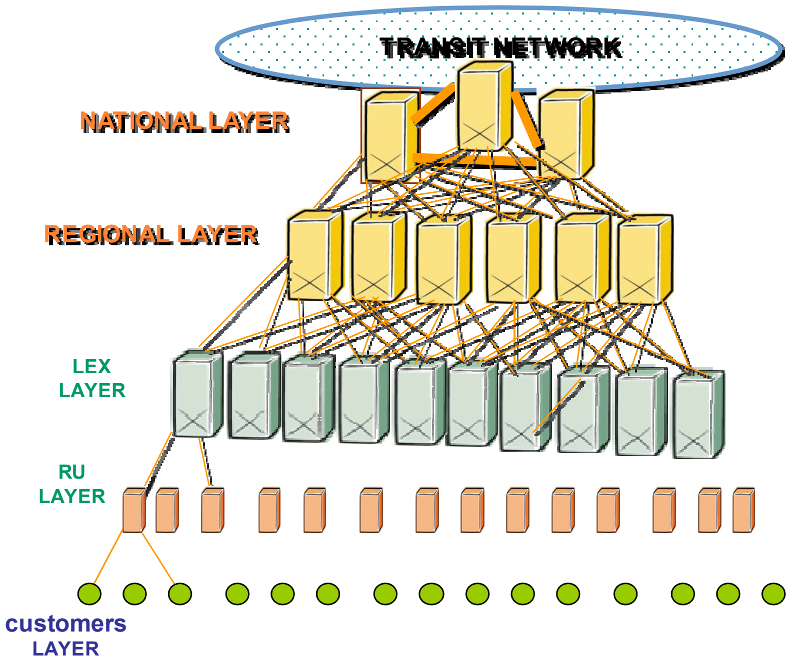
NGN according to its definition given by the ITU-T Recommendation Y.2001 announced as one of the strongest candidate to solve many of these technical issues even not all of them. So most of industries are being developed NGN systems and operators are starting migration of their infrastructure based on NGN.

4.1.4 Architectural considerations

One of tradition in the legacy telecommunication has been constructed with several hierarchies. There are two aspects: one is for technology bases such as physical network, transport network and service network etc., and the other is geometric distribution basis such as Remote access network, access network, regional network and national network etc. These hierarchies are generally very helpful not only for installation and operation but also system developments. And these hierarchies are quite well fitted with traditional telephone based service provision and network operation, that is, E.164 number based.

However these hierarchies are becoming bottleneck, especially properly providing end to end connectivity and handling routing effectively taking consideration of various IP features such as using flat address and dynamic routing. Therefore legacy hierarchies are subject for the preparation of IP based infrastructure. Following Figure X shows an architecture model of traditional telecommunication networks.

Figure 4-2: General Architecture model of traditional telecommunication networks



Followings are summary of key features which traditional architecture model comprised.

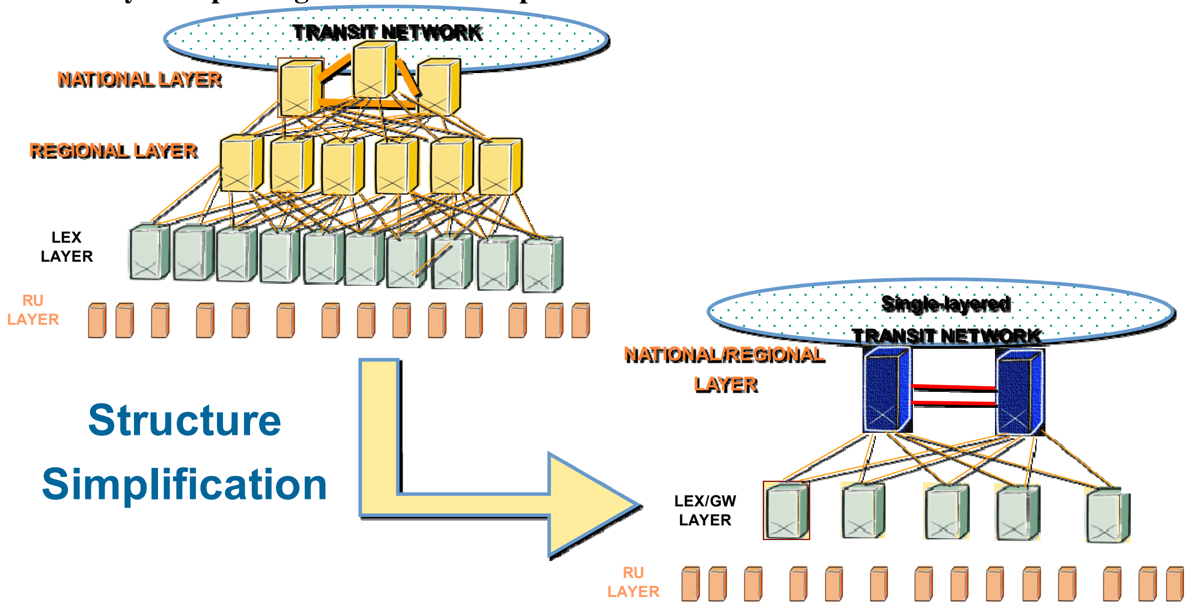
- Hierarchical topology with 4 to 5 layers, connectivity to the upper next layer and within each layer as a function of economical optimization.
- Number of nodes as a function of output data traffic and nodes capacity.
- Service handling for media, signaling and control at all exchange nodes.
- Carrier grade quality with well defined QoS criteria and standardized engineering rules.

While try to keep good features of existing infrastructure, it is required to improve certain features to meet the moving trend. Following aspects should be taken into account in this regard:

- Less network nodes and links due to the higher capacity of systems (one order of magnitude).
- Same capillarity at access level due to identical customer location.
- Topological connectivity higher for high capacity nodes and paths due to security.
- High protection level and diversity paths/sources in all high capacity systems, both at functional and physical levels.

Taking consideration of above rationale, it is anticipated that new infrastructure should be build with simple architecture than existing one. Following Figure 4-3 would be one of example for this anticipation.

Figure 4-3: Way of improving Architectural aspect



Such simpler architecture will give many of benefits in addition to resolve issues which are resided in legacy telecommunication infrastructure. One of important benefits should be addressed in the access networks which are dominated by physical infrastructure cost and deployment time. This benefit is obtained through shorter local loop length than classical networks and pave the way for high bandwidth Multimedia services.

This simpler architecture will allow quick deployment of broadband capabilities by using xDSL and/or Fiber optic closer to customer when implementing new outside plant or renovating existing one. In addition, this will also give flexibility to introduce new Wireless technologies for low density customer. All these enhancement of access networks equipped with fixed and mobile broadband capabilities will provide very flexible ways to provide various multimedia services covering fixed and mobile convergence situation.

4.2 NGN as a migration path

4.2.1 Features of NGN

The full name of NGN is "Next Generation Network" so the name itself does not give enough information to understand the overall pictures. Thanks to ITU-T developed clear definition and various key features to identify NGN in more details including service and functional aspects. ITU-T recommendations Y.2001 and Y.2011 provide us the definition of NGN and its features in the sense of agreed in global consensus.

The ITU-T Recommendation Y.2001 identified the global definition of NGN such as "A packet-based network able to provide telecommunication services and able to make use of multiple broadband, QoS-enabled transport technologies and in which service-related functions are independent from underlying transport-related technologies. It enables unfettered access for users to networks and to competing service providers and/or services of their choice. It supports generalized mobility which will allow consistent and ubiquitous provision of services to users."

In addition, Recommendation Y.2001 identified fundamental characteristics of NGN as following:

- **packet-based transfer**;
- separation of control functions among bearer capabilities, call/session, and application/ service;
- **decoupling of service provision from transport**, and provision of open interfaces;
- support for a wide range of services, applications and mechanisms based on service building blocks (including real time/ streaming/ non-real time and multimedia services);
- **broadband capabilities** with end-to-end QoS (Quality of Service);
- **interworking with legacy networks** via open interfaces;

- generalized mobility (see 3.2 and 8.7);
- **unfettered access** by users to different service providers;
- a variety of identification schemes;
- unified service characteristics for the same service as perceived by the user;
- **converged services between fixed/mobile**;
- **independence of service-related functions from underlying transport technologies**;
- support of multiple last mile technologies;
- compliant with all regulatory requirements, for example concerning emergency communications, security, privacy, lawful interception, etc.

Looking at the definition and characteristics of NGN (especially in bolded underline parts of characteristics), following key features of NGN are derived and these should be a framework to understand and use of NGN.

- Open architecture: open to support service creation, service updating, and incorporation of service logic provision by third parties and also support "Distributed control" as well as enhanced security and protection.
- Independent provisioning: service provision process should be separated from network operation by using distributed, open control mechanism to promote competition.
- Multiplicity: The NGN functional architecture shall offer the configuration flexibility needed to support multiple access technologies.

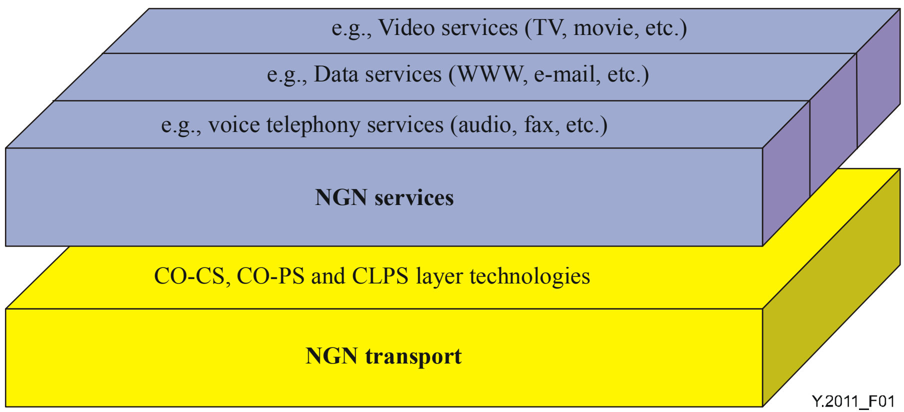
Comparing these key features which derived from the definition and characteristics of the NGN defined by ITU-T, it is recognized those features will provide certain conditions to resolve difficulties which coming from meeting the business trend described in Chapter 1.

4.2.2 Basic of NGN Architecture

One of the beauties and the biggest challenge of the NGN is the separation between services from underline transport technologies. The basic reference model of NGN is shown in Figure 4-4 (ITU-T Recommendation Y.2011) . This diagram shows the figure when services are separated from the underlying transport.

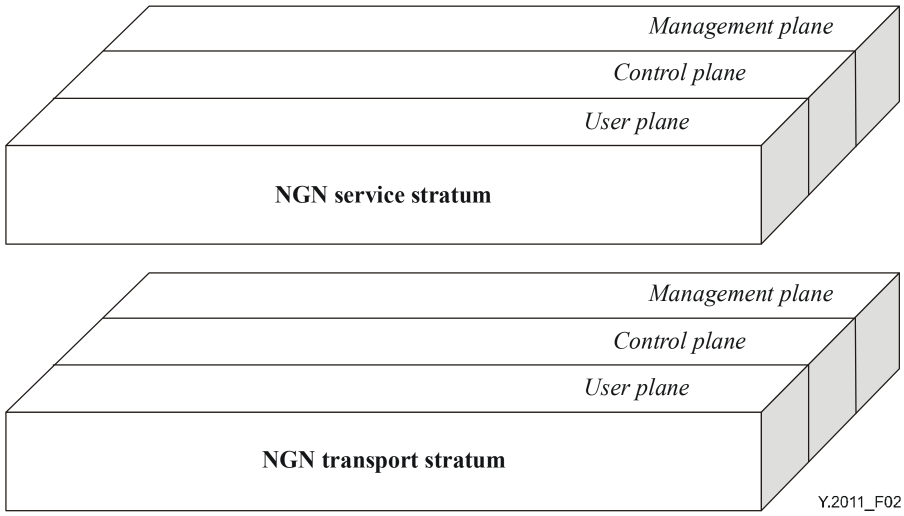
In general, any and all types of network technologies may be deployed in the transport stratum indicated as "NGN transport", including connection-oriented circuit-switched (CO-CS), connection-oriented packet-switched (CO-PS) and connectionless packet-switched (CLPS) layer technologies according to ITU-T Recommendations G.805 and G.809. Until today it is considered that IP is the preferred transport protocol used to support NGN services as well as supporting legacy services. The "NGN services" provide the user services, such as a telephone service, a Web service, etc. Therefore "NGN service" may involve a complex set of geographically distributed services platforms or in the simple case just the service functions in two end-user sites.

Figure 4-4: (Figure 1/Y.2011) Separation of services from transport in NGN



ITU-T Recommendation Y.2011 uses a language to identify these two important aspects with the name of "NGN Service Stratum" and "NGN Transport Stratum" shown in Figure4-5 and provides overall views to understand both two as following:

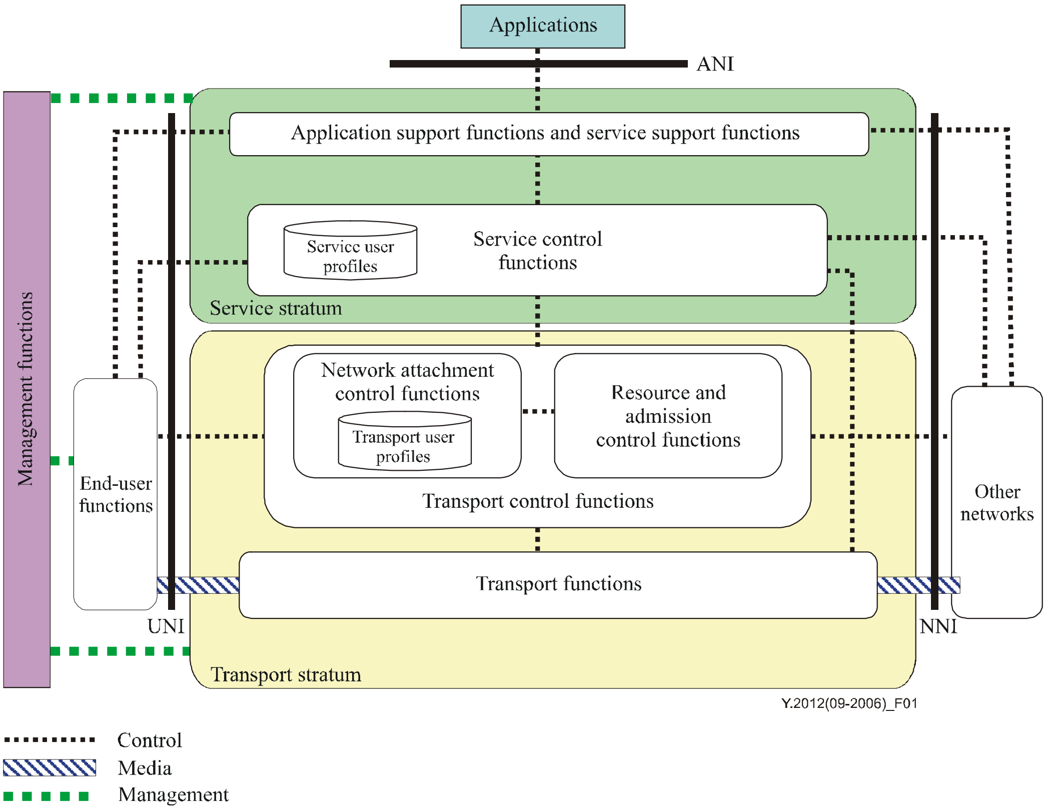
Figure 4-5: (Figure 2/Y.2011) NGN Basic Reference Model (NGN BRM)



- **NGN service stratum**: That part of the NGN which provides the user functions that transfer service-related data and the functions that control and manage service resources and network services to enable user services and applications. User services may be implemented by a recursion of multiple service layers within the service stratum. The NGN service stratum is concerned with the application and its services to be operated between peer entities. For example, services may be related to voice, data or video applications, arranged separately or in some combination in the case of multimedia applications. From an architectural perspective, each layer in the service stratum is considered to have its own user, control and management planes (but see notes below).
- **NGN transport stratum**: That part of the NGN which provides the user functions that transfer data and the functions that control and manage transport resources to carry such data between terminating entities. The data so carried may itself be user, control and/or management information. Dynamic or static associations may be established to control and/or manage the information transfer between such entities. An NGN transport stratum is implemented by a recursion of multiple layer networks as described in ITU-T Recommendations G.805 and G.809. From an architectural perspective, each layer in the transport stratum is considered to have its own user, control and management planes.

Based on the above basics of NGN architecture, ITU-T developed NGN architecture model with detailed functions and published by ITU-T Recommendation Y.2012 as shown in Figure 4-6.

Figure 4-6: (Figure 3/Y.2012) NGN Architecture Overview



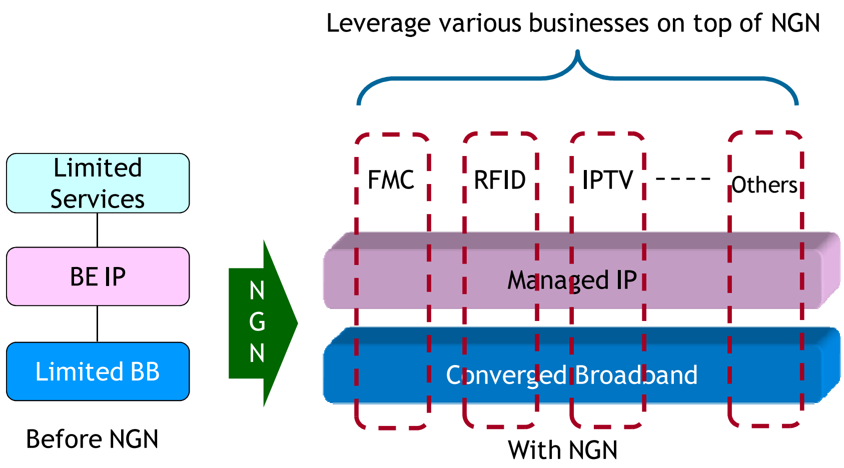
NGN Architecture in ITU-T Recommendation Y.2012 has been developed to incorporate the following principles:

- Support for multiple access technologies: The NGN functional architecture shall offer the configuration flexibility needed to support multiple access technologies.
- Distributed control: This will enable adaptation to the distributed processing nature of packet-based networks and support location transparency for distributed computing.
- Open control: The network control interface should be open to support service creation, service updating, and incorporation of service logic provision by third parties.
- Independent service provisioning: The service provisioning process should be separated from transport network operation by using the above-mentioned distributed, open control mechanism. This is intended to promote a competitive environment for NGN development in order to speed up the provision of diversified NGN services.
- Support for services in a converged network: This is needed to generate flexible, easy-to-use multimedia services, by tapping the technical potential of the converged, fixed-mobile functional architecture of the NGN.
- Enhanced security and protection: This is the basic principle of an open architecture. It is imperative to protect the network infrastructure by providing mechanisms for security and survivability in the relevant layers.
- Functional entity characteristics: Functional entities should incorporate the following principles:
  - Functional entities may not be distributed over multiple physical units but may have multiple instances.
  - Functional entities have no direct relationship with the layered architecture. However, similar entities may be located in different logical layers.

4.2.3 Benefits from NGN Architecture

One of the greatest benefits of NGN architecture is support a way to provide various services over common transport platform. And various broadband technologies over fixed and mobile access network domains will give more opportunity to leverage this benefit such as providing various broadband and convergence services over fixed and mobile converged transport networks. Following Figure 4-7 shows how NGN architecture will support various services.

Figure 4-7: Benefit of NGN Architecture



One of the advantages of using IP is providing the simple linkage between Layer 3 and Layer 4 which is the critical point of separation , in general, between service and transport. Before the NGN (shown in the left side of the figure), IP only provide one type of capability called "Best Effort" which could not support enough quality and security considerations. In addition, underlying transport has been relying on the very limited broadband capabilities provided by xDSL causing certain limitation to meet such business trend. This situation could not provide enough platforms to leverage convergence services and businesses.

After the NGN, enlarged capabilities in IP (called "Managed IP") and underline transport with converged broadband capabilities will provide a way to support various services (e.g. IPTV, RFIDs, FMC etc) over the common transport while keeping the simple linkage between Layer 3 and Layer 4. Consequently this will lead diverse business models and players to encourage diverse and flexible business relationships.

4.3 Ways for migration to NGN

4.3.1 Consideration for Migration to NGN

Many of views and consideration would be carefully examined during the set up of migration plan for the new infrastructure because this will impact so many aspects to the related entities as well as communities. Migration of legacy network infrastructure such as PSTN/ISDN to NGN also will have huge impacts to whole of communication infrastructure. Taking consideration of this, ITU-T recommendation Y.2261 gives guidance when operator will build up a migration plan.

For migration of PSTN/ISDN to NGN, aspects identified in the followings are to be considered.

4.3.1.1 Signaling and control

PSTN/ISDN uses signaling systems such as analogue line signaling, channel associated signaling (CAS) like signaling systems R1 [Q.310-Q.332], R2 [Q.400-Q.490], and common channel signaling (CCS), like SS7 or DSS1 [Q.931]. All these signaling systems are for the circuit switched networks. Since NGN transport is packet-based (and call and bearer are decoupled), other suitable types of signaling (e.g., BICC, SIP-I [Q.1912.5], etc.) may be required. Also, the signaling function and call control function may reside in more than one NGN element.

Since the NGN has to work with the PSTN/ISDN and other networks, interworking between NGN signaling systems and the legacy network signaling systems is required. Signaling aspects within the next generation corporate network shall remain independent from NGN access or core network signaling.

It is further anticipated that signaling aspects for access and core networks be independent in order to provide the possibility for a step-wise approach for migration to NGN.

4.3.1.2 Management

An NGN management system is comprised of three planes, namely the network management plane, the network control plane and the service management plane. Each of the three planes implements corresponding management functions to each layer in the NGN layered model.

Migration of PSTN/ISDN management (i.e., operations, administration and management) systems requires the ability to support the transition of PSTN/ISDN through intermediate stages towards NGN.

4.3.1.3 Services

PSTN/ISDN services which are traditionally provided by PSTN/ISDN exchanges may be provided by application servers (ASs) in NGN. It is expected that some or all of the legacy services will be provided by NGN. However, there is no guarantee that all services will be provided when PSTN/ISDN is simulated.

Use of legacy terminals via adaptation to the NGN is expected in order to support existing services.

- Bearer services: While evolving from PSTN/ISDN to NGN, continuity of bearer services should be provided. Use of NGN to connect PSTNs/ISDNs shall be transparent for all bearer services. NGN should provide same or better QoS for PSTN/ISDN bearer services.
  - PSTN/ISDN simulation provides functionality that is similar but not identical to existing N-ISDN bearer services.
  - PSTN/ISDN emulation shall be capable of providing all bearer services offered by PSTN/ISDN. However, there is no requirement for NGN to support all N-ISDN bearer services identified in the ITU-T I.230-series Recommendations.
- Supplementary services: While evolving from PSTN/ISDN to NGN, continuity of supplementary services should be provided to the extent practical. PSTN/ISDN emulation shall provide support for all supplementary services offered by PSTN/ISDN while PSTN/ISDN simulation provides functionality that is similar but not identical to existing PSTN/ISDN services. The NGN need not support all ISDN supplementary services identified in I.250 series of ITU-T Recommendations. NGN shall appear transparent when used to connect supplementary services between PSTNs/ISDNs.
- Operation, administration and maintenance (OAM): OAM functionality is used to verify network performance, and to reduce operational expenses by minimizing service interruptions, service degradation and operational downtimes. As a minimum, when performing PSTN/ISDN migration to NGN, the ability to detect faults, defects and failures such as lost, errored or mis-inserted packets, should be provided. Additionally, there should be mechanisms to indicate connectivity status and provide support for performance monitoring.
- Naming, numbering and addressing: The NGN naming, numbering and addressing schemes, in accordance with ITU-T Recommendation Y.2001 shall be able to interwork with the existing E.164 numbering scheme. During PSTN/ISDN migration to NGN process, it should be ensured that the sovereignty of ITU Member States, with regard to country code numbering, naming, addressing and identification plans, is fully maintained. Also, as a minimum, support should exist for Internet IP addressing schemes including E.164 Telephone uniform resource identifiers (TEL URIs), e.g., tel: +98 765 4321 and/or SIP Uniform Resource Identifiers (SIP URIs), e.g., sip:my.name@company.org.
- Accounting, charging and billing: During the transition period, maintaining the existing accounting, charging and billing procedures, to the extent practical, may be required. Migration from existing

networks to NGN will also imply replacement of the existing sources of the accounting data generation. The NGN shall support both offline and online charging.

- Interworking: Interworking is used to express interactions between networks, between end-systems, or between parts thereof, with the aim of providing a functional entity capable of supporting an end-to-end telecommunication. PSTN/ISDN migration to NGN should take the following into consideration:
  - Ability to interwork with IMS-based or non-IMS-based networks such as other PSTN/ISDN, public IP networks (e.g., NGN, Internet);
  - Ability for inter-domain, inter-area or internetwork interworking;
  - Support for authentication and authorization;
  - Ability to perform call admission control;
  - Capability to support network performance parameters as defined in [Y.1541];
  - Support for accounting, charging and billing.
- Call routing: When an NGN coexists with PSTN/ISDN, the routing scheme should allow the carriers to control where their traffic enters and leaves the NGN. This will make it possible for the carrier to optimize use of their network resources and to avoid multiple points of interworking between NGN and PSTN/ISDN along the media path.
- Service requirements by national regulatory bodies: Following requirements are required by national/regional regulation or law, an NGN service provider shall provide which means in the case of interworking:
  - the basic telephone service with the same or better quality and availability as the existing PSTN/ISDN;
  - the capability for accurate charging and accounting;
  - capabilities to support number portability;
  - the availability of a directory inquiry service for PSTN/ISDN and the NGN users;
  - support of emergency telecommunications;
  - support for all users, including the disabled. Support should provide at least the same capabilities as the existing PSTN/ISDN. NGN offers the opportunity for more advanced support, e.g., network capabilities for text to speech;
  - mechanisms to support lawful interception and monitoring of various media types of telecommunications such as voice, data, video, e-mail, messaging, etc. Such a mechanism may be required of a network provider for providing access to content of telecommunication (CT) and intercept-related information (IRI) by law enforcement agencies (LEA), to satisfy the requirements of administrations and international treaties;
  - interoperability between an NGN and other networks e.g., PSTN/ISDN and PLMN.

4.3.2 Generic Migration Procedure

Migration from one to other is not an easy or simple task because many of things are involved with various perspectives. Especially migration of network infrastructure need very careful plan and examine various aspects. As a conclusion, there is no single way or the best way for the migration to NGN, because migration should be based on each country situation as well as each operator given condition.

It is recommended to consider following procedure for building migration plan of legacy network infrastructure to NGN:

1 Provision of new communication services to broadband users in addition to existing network.

2 A significant portion of users switches to those services. Reduction of true PSTN/ISDN usage visible.

3 Cost of maintaining both systems in parallel becomes a factor. **Decision to begin replacement of infrastructure**.

4 Replacement of part of the infrastructure (e.g. local switch) by new infrastructure, **without forcing all users to migrate**.

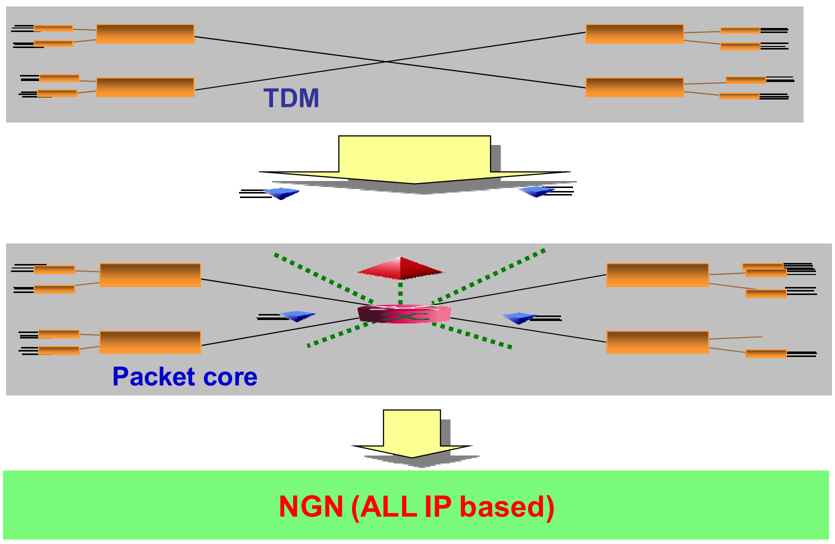
5 Full change to new infrastructure.

6 Migrate remaining users to NGN.

4.3.3 Generic way for Migration

Result of migration should be became "All IP environment" which is a key technology of the NGN, so from the technical viewpoints migration should be explained as change from "TDM based" to "IP based." Taking consideration of possession portions between "Access Network domain" and "Core Network domain" of each country, migration procedure should be applied to one of such domains first. It is general understanding that it is easier to set up migration plan for "Core Network domain" to. Core migration will have less impact on the service provision rather than "Access Network domain." migration. Figure 4-8 shows generic view of Core Network migration to NGN.

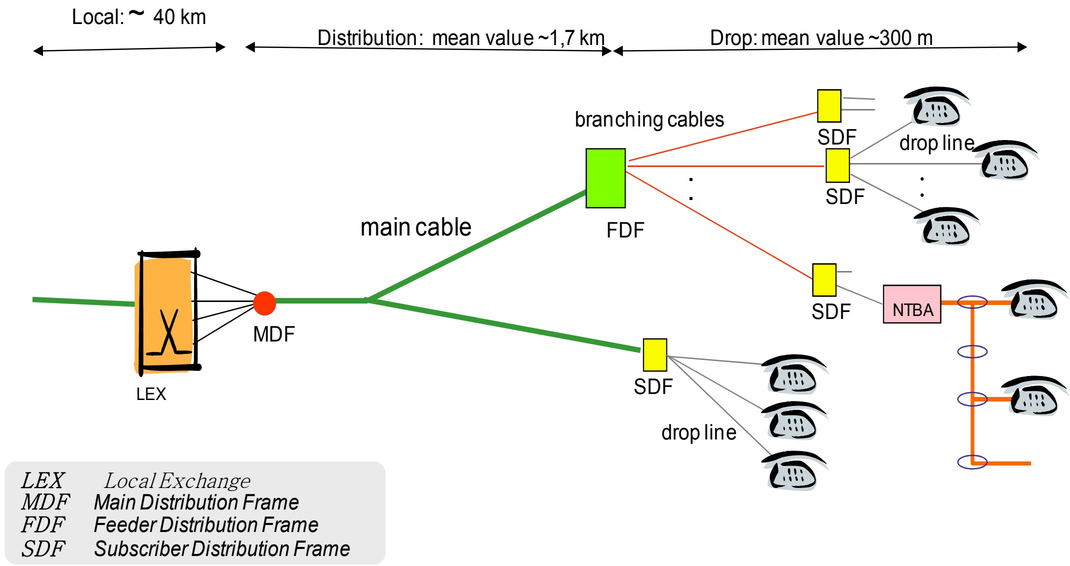
Figure 4-8: Generic view of Core Network migration to NGN



In the case of Access Network Domain which has quite complicated situations not only for technical aspects but also geographical differences, it is not recommended to choose one specific technology to replace any legacy access network systems. It is rather recommended to consider harmonization among different technologies to cover customer requests in more flexible and economical way. Many of different access technologies are developed using fixed and mobile with supporting broadband connectivity. And most of technology also provides IP connectivity which is the critical technical feature to meet NGN requirements (e.g. Packet based transfer).

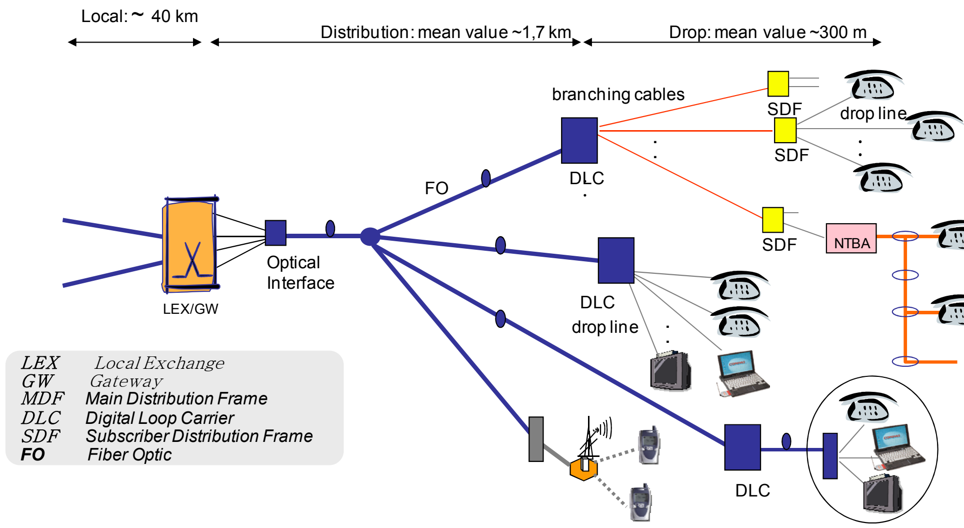
In case of fixed based access networks, xDSL technology is mainly used to provide broadband today. The final goal in the fixed network will be to deploy fiber based infrastructure. xDSL gives the possibility to utilize existing copper based access infrastructure as much as possible for deploying broadband infrastructure in economic way, but with limited capacity (below 10 Mbps). Fiber optics is a kind of target technology in the area of fixed networks with its unlimited capacity not only for core networks but also access networks including home network as well. Only concerns are related to the cost and construction difficulties. Both concerns will be faced by the quick development of the technology. Therefore it is recommended to use both xDSL and Fiber together in the access network as a preparation of migration to NGN including preparation of enough broadband capability. Following Figure 4-9 shows an example how access networks constructed taking consideration of geographical distances.

Figure 4-9: Generic view of Access Network (Fixed) migration to NGN



Another important area should be utilize mobile (including wireless such as WiFi and WiMAX) to provide broadband connectivity. This aspect is also very important because many of people, especially in developing regions, uses mobile phone for their life communication and mobile will provide mobility to the people. There are many technologies to provide broadband capability in mobile access networks including IP connectivity but still has certain limits on the providing bandwidth (around 10 Mbps). Standard organizations are working hard to develop technologies for better bandwidth but will take a time. Following Figure 4-10 shows an example diagram how different mobile technologies are used in the access networks.

Figure 4-10: Generic view of Access Network (Mixed) migration to NGN



4.3.4 NGN Technology for support migration

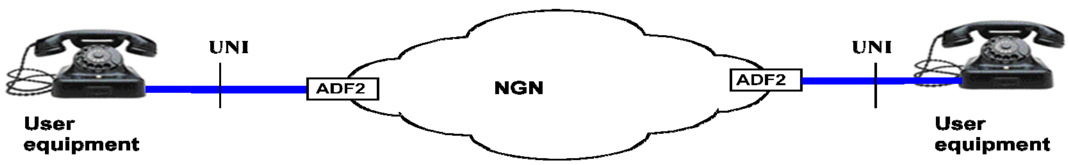
To help migration of legacy networks to NGN at least voice based services, NGN provides two capabilities. One of this is "Emulation" which supports provision of PSTN/ISDN service capabilities and interfaces using adaptation to an NGN infrastructure using IP. The other is "Simulation" which supports provision of PSTN/ISDN-like service capabilities using session control over IP interfaces and infrastructure.

4.3.4.1 Emulation Scenario

Following Figure4-11 shows a high level view of emulation scenario. Using NGN Emulation capability which provides "Adaptation Function (ADF)" legacy terminal devices such as black phone connects to the NGN and uses their services with following aspects:

- An encapsulation process.
- All services available to PSTN/ISDN users.
- User experience not changed by the network transformation.

Figure 4-11: NGN Emulation of PSTN/ISDN



4.3.4.2 Simulation Scenario

Simulation is for providing PSTN/ISDN like service to the NGN users. So NGN users will communicate with PSTN/ISDN users using this simulation capability. Key features of NGN Simulation summarizes following:

- PSTN/ISDN-like services available.
- Availability of possible new services.
- User experience is changed by the network transformation.

Figure 4-12: NGN Simulation Scenario-1 of PSTN/ISDN

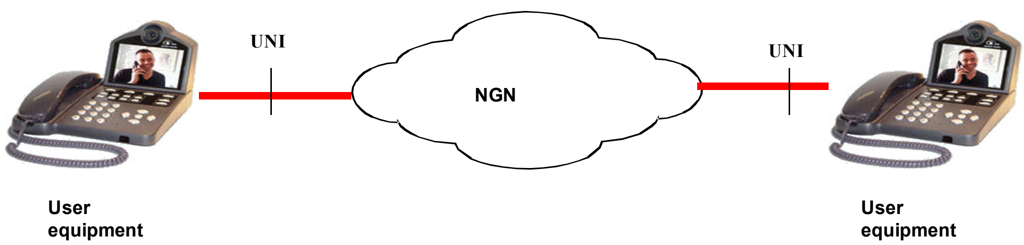
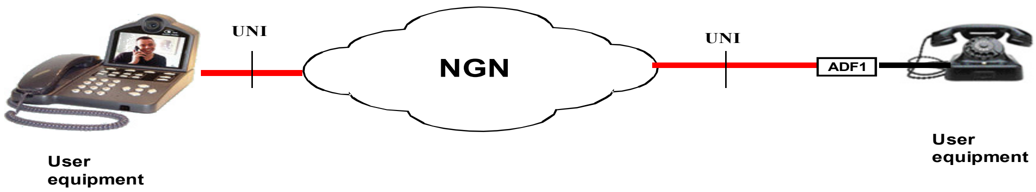


Figure: 4-13 NGN Simulation Scenario-2 of PSTN/ISDN



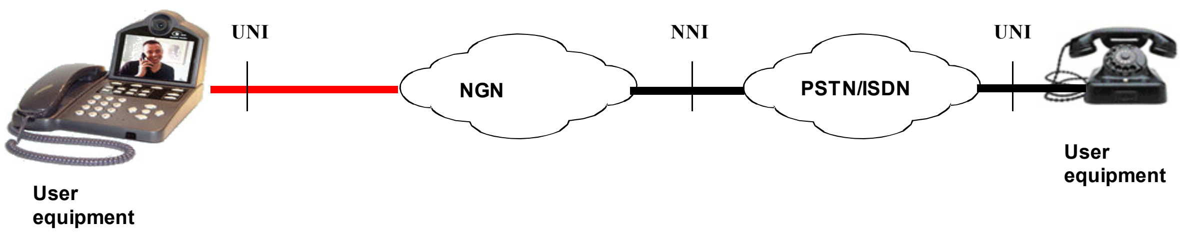
4.3.4.3 Interworking using Emulation and Simulation

Taking into consideration the importance of voice services, NGN voice oriented services should be linked with voice services in PSTN/ISDN environment. To support of this requirement, emulation and simulation jointly are used for interworking between NGN and legacy networks such as PSTN/ISDN. It will be decided according to the interworking situation which technology would be used in which area.

Figure 4-14 shows an example of interworking between NGN and legacy PSTN/ISDN. Simulation is used in NGN side while interworking with legacy side is using emulation. Service features in this case are characterized as following:

- Service interworking between NGN and PSTN/ISDN is required
- Only PSTN/ISDN-like services available
- Legacy terminal user experience cannot be fulfilled for end-to-end connection

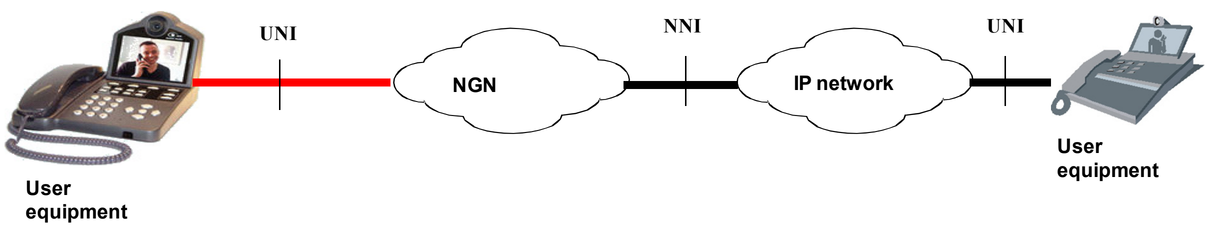
Figure 4-14: Interworking-1 between NGN Emulation and Simulation



Following Figure 4-15 shows another example of interworking between NGN and legacy IP based network which support voice service (e.g. VoIP). Simulation is used in NGN side while interworking with legacy side is using emulation. Service features in this case are characterized as following:

- Service interworking between NGN and IP network is required.
- Both the NGN and IP network user experiences may not be fulfilled for end-to-end connection.

Figure 4-15: Interworking-2 between NGN Emulation and Simulation

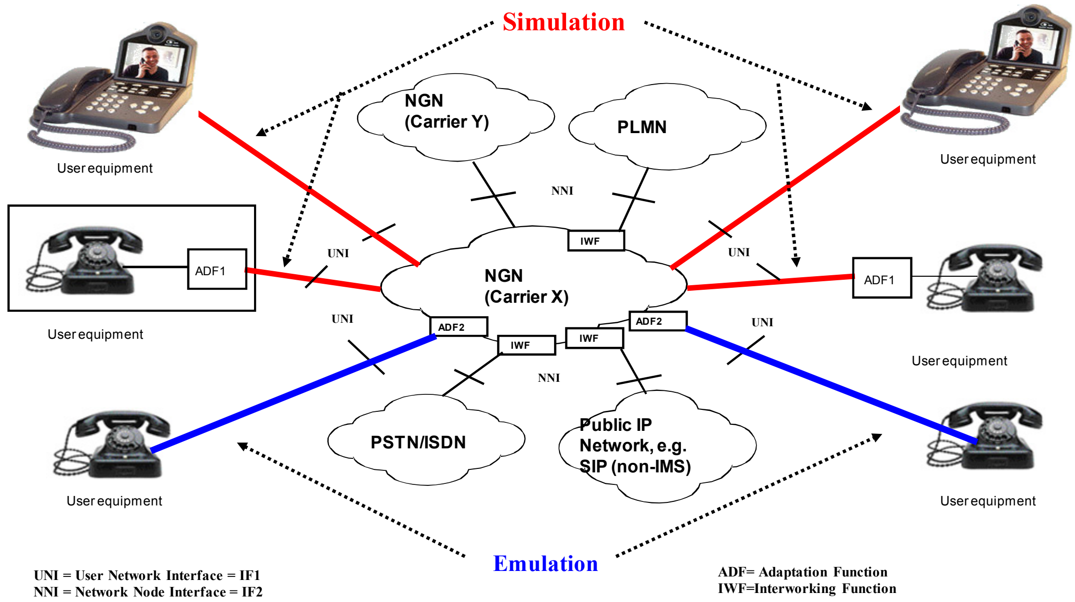


4.3.4.4 Overall configuration of using Emulation and Simulation

Key requirement of Emulation and Simulation technology is supporting voice oriented services. PSTN/ISDN is a major network infrastructure today to support voice services including various supplement services especially in case of ISDN. In addition, there are continuously increasing end users of using voice services over legacy IP environment.

Therefore NGN should support its voice related capabilities such as emulation and simulation to cover PSTN/ISDN and legacy IP based networks. So combination of these capabilities with proper interworking scenarios will help to support end user voice service requirements in the cases of end user device connected to fixed, mobile and legacy IP based to cover voice services wherever end user places. Following Figure 4-16 shows overall configuration model of using emulation and simulation with indicating interworking situation combined.

Figure 4-16: Overall view of using NGN Emulation and Simulation



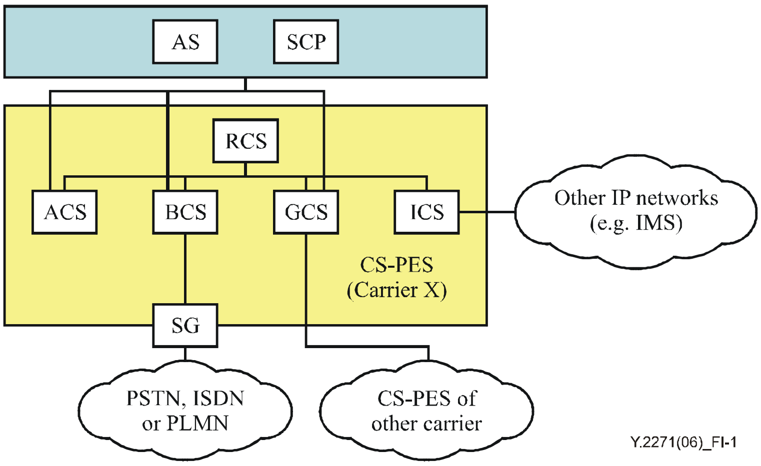
4.3.4.5 Call Server supporting migration to NGN

The Call Server is the core element for PSTN/ISDN emulation which is responsible for call control, gateway control, media resource control, routing, user profile and subscriber authentication, authorization and accounting. The call server may provide PSTN/ISDN basic service and supplementary services, and may provide value-added services through service interaction with an external service control point (SCP) and/or Application Server in the service/application layer.

A call server may function in one or more of the following roles as identified in ITU-T Recommendation Y.2271 and Figure 4-17 shows an example of the deployment:

- Access call server (ACS) – to implement access gateway control and media resource control functions, thus providing PSTN/ISDN basic service and supplementary services;
- Breakout call server (BCS) – to implement interworking functions to enable interconnection with PSTN/ISDN networks;
- IMS call server (ICS) – to provide interoperability between PSTN/ISDN emulation components and IP multimedia components within a single NGN domain;
- Gateway call server (GCS) – to provide interoperability between different NGN domains from different service providers;
- Routing call server (RCS) – to provide the routing function between call servers.

Figure 4-17: (Figure 1/Y.2271) Call Server Deployment Example



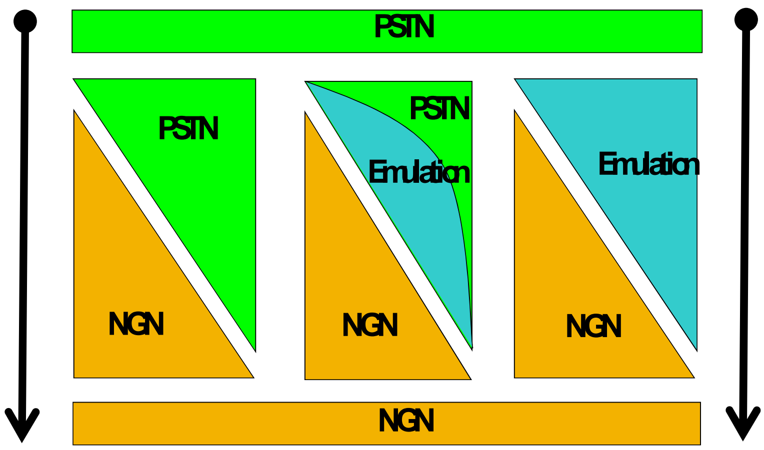
* AS: Application Server, SCP: Service Control Point, SG: Signaling Gateway, PES: PSTN Emulation Service Component

4.4 Migration Scenarios

Using emulation and/or simulation of NGN, there are various ways of migration from legacy network to NGN. This should be decided according to the each country or provider situation. In this report, three different types of migration scenarios are introduced as a framework consideration but other possibility should not be limited.

Following Figure4-18 shows a pictorial explanation of these three types of migration from PSTN/ISDN to NGN. Three scenarios are following:

Figure 4-18: Overall migration scenarios



- Overlay Scenario (Left Side of Figure 4-18): NGN will be deployed and operate jointly with PSTN/ISDN. NGN will occupy more portions while PSTN/ISDN will continuously decrease and finally migration to NGN.

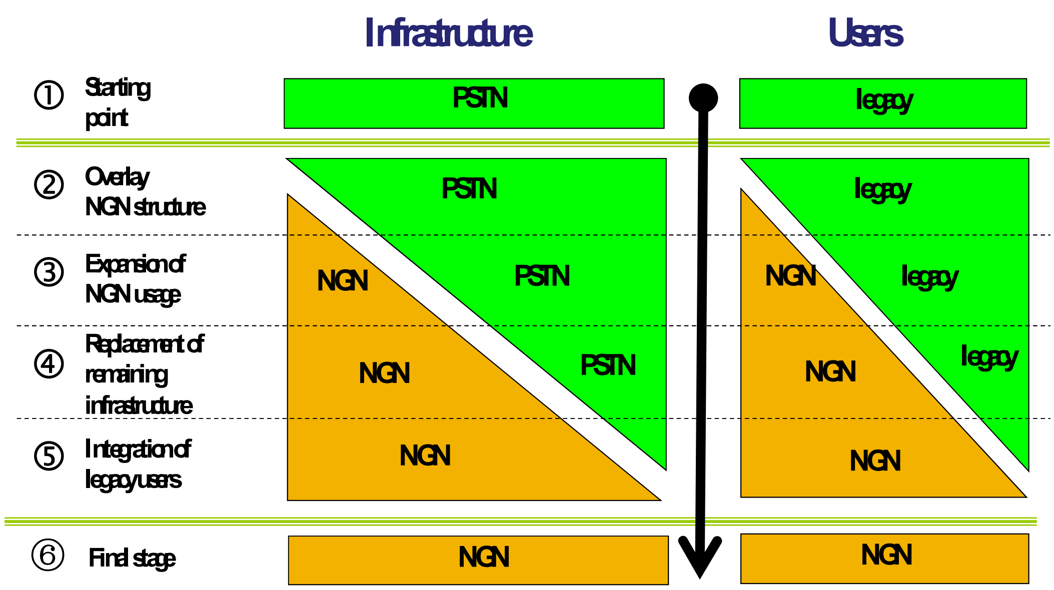
- Replace Scenario (Right Side of Figure 4-18): NGN emulation will widely use to support voice oriented services but keeping the legacy terminal such as black phone. So end user could not recognize the change of technology behind their terminal.
- Mixed Scenario (Middle of Figure 4-18): This is a scenario to use both overlay and emulation, so at the beginning some of PSTN user connection will replace by NGN emulation while other PSTB users will keep their PSTN connections. And according to the increase of NGN deployment, Emulation and PSTN users will replaced by NGN users.

4.4.1 Overlay Scenario

This Overlay Scenario will be useful in the case of country or operator who have well stable or new PSTN/ISDN infrastructure. In this case, it is hard to justify replace all PSTN/ISDN equipments to NGN because this legacy infrastructure could not yet return value to compensate all their investment. And the status of infrastructure is quite good stage and will use next several years without any serious amount of operation, administration and maintenance including fault management.

Through this scenario, operator will be gradually preparing enough resources for the next investment while keeping their customers in a good situation. In addition to this, operator will also meet users' requirements which use advanced capabilities through newly deployed NGN. According to the increasing of users who wish to use advanced capabilities, then operator will expand the coverage of NGN and consequently will decrease customers in legacy networks. Finally someday will fully deployed of NGN and cover all users. In this case, NGN users will communicate with PSTN/ISDN users using their simulation but through interworking between NGN and PSTN/ISDN networks. Following Figure 4-19 shows the steps of this scenario.

Figure 4-19: An overlay migration scenario

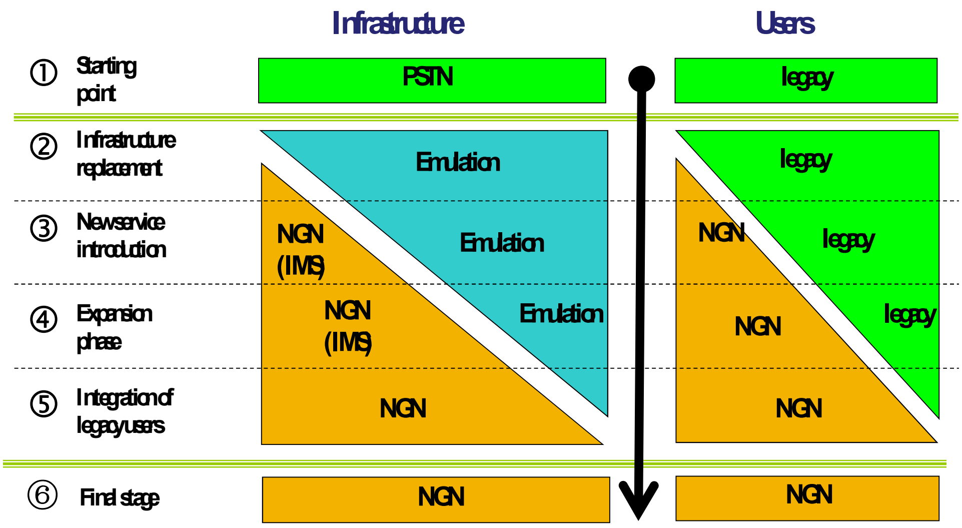


4.4.2 Infrastructure Replacement Scenario

This scenario will be useful in the case of country or operator who does not have enough PSTN/ISDN infrastructures, where there is already lack of connectivity to support voice services. In this case, it is hard to continue the deployment of PSTN/ISDN equipments because this will also need new investment while investment for NGN will be also necessary. But in this case, current users even using PSTN/ISDN will be continuously supported without any change of their terminal if possible.

Through this scenario, operator will stop their deployment of PSTN/ISDN but replaced investment to NGN. Then operator will provide ADF (Adaptation Function) to the current PSTN/ISDN users to provide continuous usage of voice services which means expansion of NGN emulation capabilities as shown in Figure 4-3. And according to the increasing of users who wish to use advanced capabilities, then operator will expand the coverage of NGN and consequently will decrease customers who using emulation services. Finally someday all users will be fully covered by NGN capabilities. Following Figure 4-3 shows the steps of this scenario.

Figure 4-20: An Infrastructure replacement migration scenario

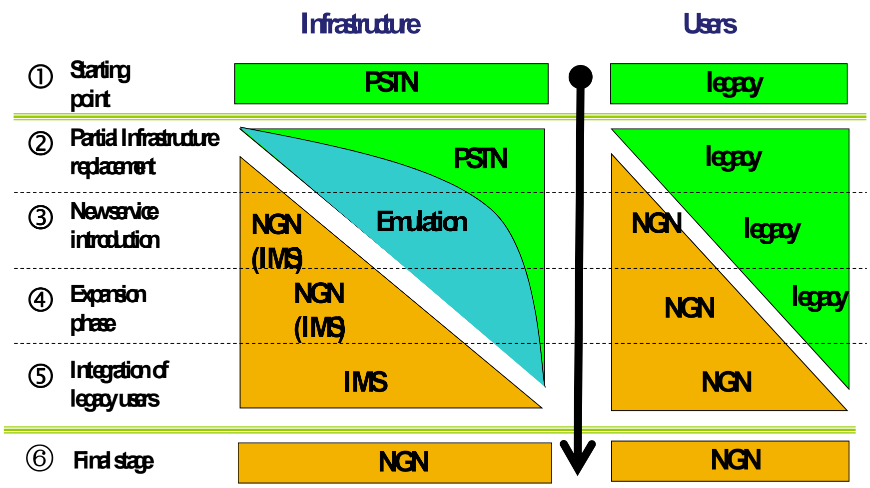


4.4.3 Mixed Scenario

This scenario will be useful in the case of country or operator who is placed in the middle stage, i.e. some parts of PSTN/ISDN need to be replaced but other parts of PSTN/ISDN are still in good and stable status using new PSTN/ISDN infrastructure. In this case, considerations from both overlay and replacement scenarios should be taken into account. That is, operator should keep PSTN/ISDN networks with relevant customers until the time of returning their investment or the status of PSTN/ISDN will request serious amount of operation, administration and maintenance including fault management which means time to replacement. In other direction, operator will start to deploy NGN infrastructure replacing other parts of PSTN/ISDN which reach to time to replacement. Figure 4-21 shows the steps of this scenario.

Through this scenario, operator will be gradually preparing enough resources for the next new investment while keeping their customers in PSTN/ISDN situation. In addition to this, operator will also meet users' requirements which use advanced capabilities through newly deployed NGN. According to the increasing number of users who wish to use advanced capabilities, operator will expand the coverage of NGN and consequently will decrease the number of customers in legacy networks. The final solution will be to fully deploy of NGN for covering all users.

Figure 4-21: Mixed migration scenario



5 Review from NGN Deployment

5.1 Objectives for NGN Deployment

Scenarios and plan for Migration should be decided according to each country or operator situation. In general there are two high level views to be considered when migration is requested.

First one is the considering migration to NGN as a way to improve infrastructure. In this case, migration plan should be focused on replacement of legacy telecommunications by so called "All IP" including expansion of deployment of "Broadband."

The other is the considering migration to NGN as an enabler of their society such as encouraging e-Society. In this case, migration plan should be focused to support convergences such as Fixed Mobile convergence as well as supporting various applications (e.g. e-health, USN etc).

It is recommended that both views should be combined with balance which will be different according to each country or operator situation.

5.2 Learning from prior experiences

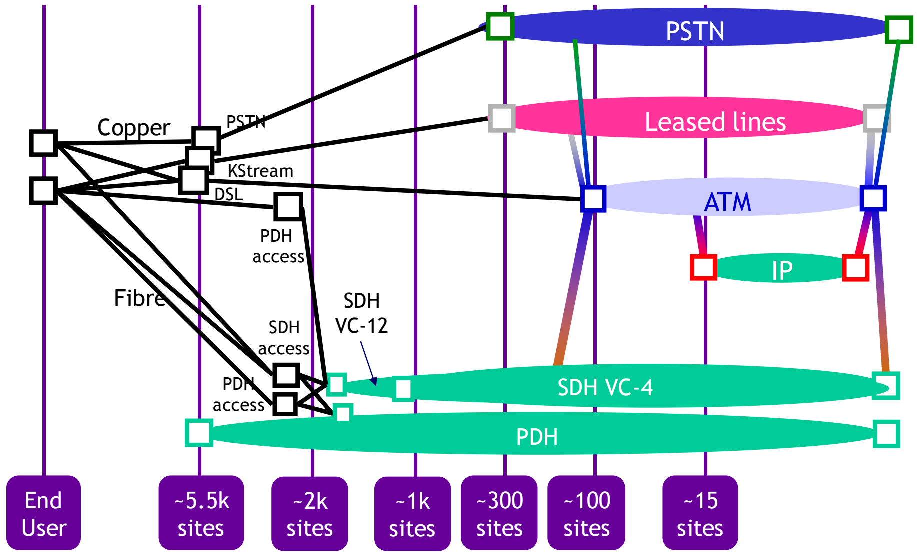
5.2.1 Improve Infrastructure

One of the advanced experiences on migration to NGN has been announced by the BT with the name of "21C Network" which will take a key role of BT networks for 21C businesses. One of interesting things to find from BT's 21C network plan is that comparing their current network structure and 21C network's. This gives us very important message what are benefits of implementing NGN especially for the network operators.

Following Figure 5-1 shows network structures of current BT's network comprising with various transmission networks and various different nodes which have different roles according to their responsible services and geographical position. In the case of core network, there are also different networks supporting different routings according to the service specific features.

This service oriented structure and network configuration cause duplication of infrastructural elements such as transmission nodes or routing nodes. In addition it also requests complicated operation of services and networks because different systems involved for specific services. These aspects need more investments which might cause duplication of provisioning and might require additional resources for operation and maintenance causing more expense of human and financial resources.

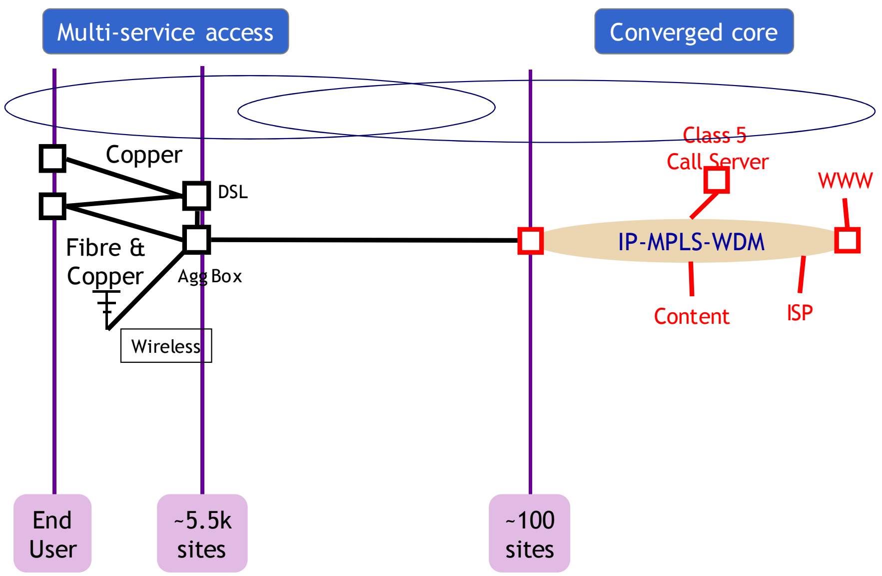
Figure 5-1: Legacy Network structures of BT with number of odes



In contrast of the current BT's network configuration, 21C network shows a rather simple structure but more powerful capabilities not only for voice services but also broadband services as well. Figure 5-2 is a simple configuration model of 21C network. Figure 5-1 is showing simplicity of structure and especially remarkable reduction of number of nodes while keeping full coverage of customers. This structure has been advantaged from "All IP" features to make simple configuration in core networks, so all services should be routed by the IP core networks with different flows which have different treatment from the traffic management and service provisioning aspects but using same systems.

One more advantage of this structure is to shorten and to extend the contacting points of the customers allowing the network to cover customers more closely. This is the reason this structure keeps most number of the nodes located in the customer sides while removing other nodes from the previous structure.

Figure 5-2: 21C Network structures of BT with number of odes



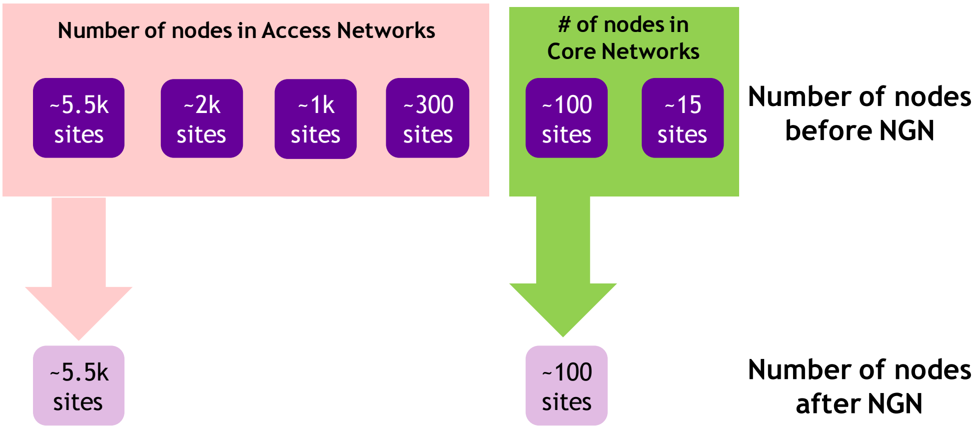
Adoption of NGN in BT's network by the name of "21C Network" shows how infrastructure be improved to meet future business trends and users/operators' requirements. It is required to look at carefully BT's implementation of NGN and will get more learning from improvement of infrastructure aspects.

One of report tells us this new structure will give benefit to reduce 30~40% reduction of Green House Gas emission which is now becomes serious subject for the world. Simple calculations are support this report as following:

- Reduction of Access Nodes: from 8.8 K sites to 5.5 sites (37.5 % reduction).
- Reduction of Core Nodes: from 115 sites to 100 sites (14 % reduction).

This report does not try to evaluate this result from cost aspects, but this is generally assumes huge amount of cost savings if including costs of operating each site.

Figure 5-3: BT Benefits from 21C networks



5.2.2 Enhancing Society

The other types of migration to NGN is providing infrastructure for building up new society such as e-Society. This approach has been announced from the Rep. of Korea by their name of "BcN: Broadband Convergence Networks" and is being deploy now in Rep. of Korea.

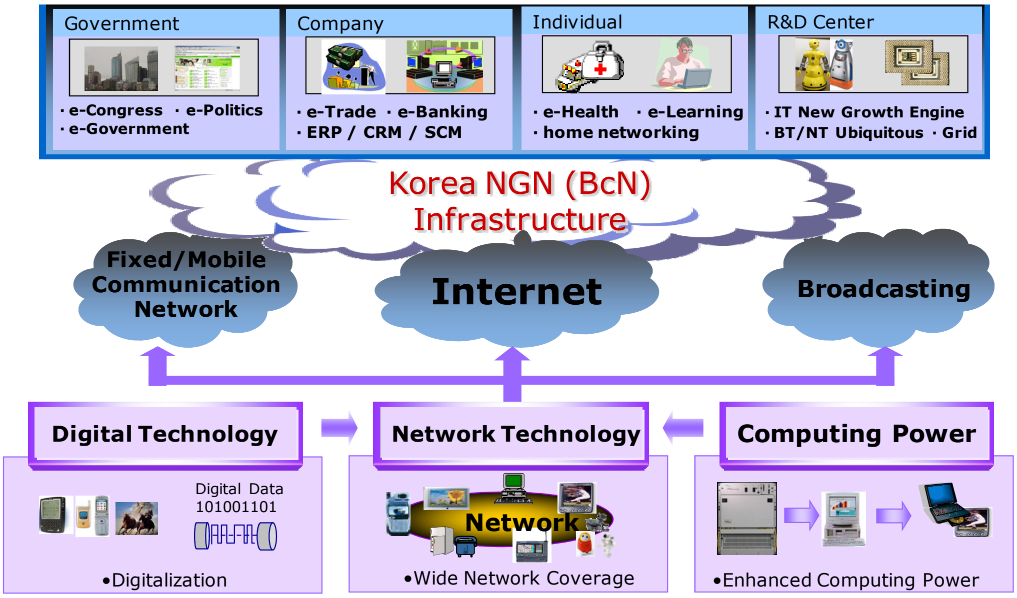
One difference of Korean case is that they initiate this project at the almost end stage of their broadband deployment. Therefore their vision on the BcN has been quite different from BT's case study. The main points are the following:

- Build a state of the art information infrastructure in the world.
- Create an environment to use high-quality multimedia services.
- Prepare the core plan according to the IT Industry market growth.

As shown these vision statements, Korea rather focuses to build up their new social infrastructure while BT focuses to improve their infrastructure. So Korea uses kind of role sharing model which each sector took different roles. According to this, government took a role to encourage development of new services and application which will use for building up e-Society such as e-learning, e-health, USN etc. Network operators, are rather focusing to upgrade their infrastructure for supporting convergence services such as FMC and IPTV while continuing improving access network capabilities to provide more bandwidth to the customer.

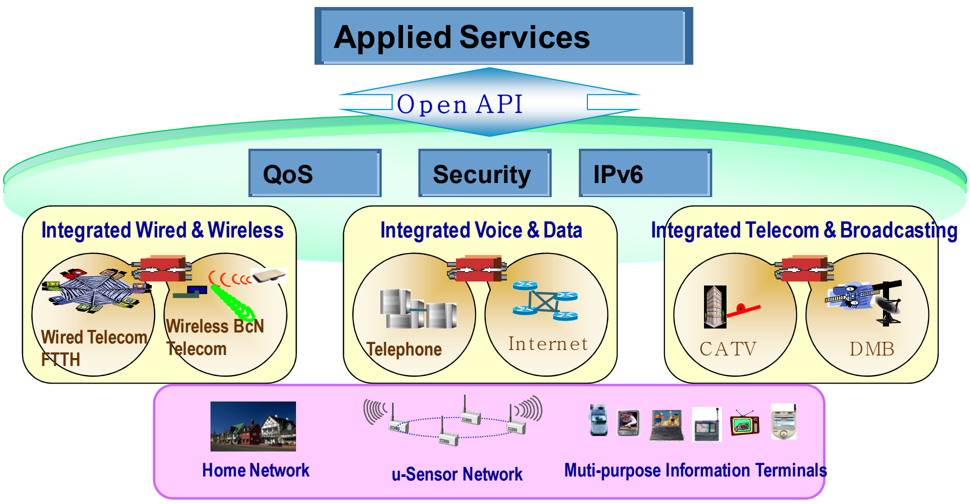
Figure 5-4 shows an overall vision of Korea BcN. Korea BcN provides network infrastructure to the whole new society such as e-Society for government, company, R&D centers and individual. BcN also takes a crucial role to integrate various different infrastructure using different technologies such as FMC converging networks, Internet and broadcasting networks as well with supporting digital, network and computing technologies.

Figure 5-4: Overall vision of Korea BcN



Following Figure 5-5 shows an overview of Korea BcN model. It is easily find key features are assigned to develop integration of differences such as between wired and wireless (FMC), between voice and data and between Telecom and Broadcasting (IPTV) including network capabilities for QoS, Security and expansion of using IPv6 which will be important technology to implement USN.

Figure 5-5: Overview of Korea BcN



6 Regulatory challenges raised by NGN migration

NGN raises regulatory challenges that can be linked, in one way or another, to the convergence process at the service provision and network access levels. This section discusses a number of NGN-related regulatory challenges from a technical perspective. These challenges include open access, market definition, QoS and interconnection.

In this discussion, it is important to remember that NGN will inherit some of the same regulatory obligations imposed on the PSTN like lawful interception and access to emergency services. The need for access to emergency services has been taken into account by both 3GPP and TISPAN. However, the first introduction of emergency services within 3GPP IMS architecture is only planned for Release 7 onwards, while the first two IMS releases, R5 and R6, only allows access to emergency services through the circuit-switched domain, the legacy GSM core infrastructure used for voice calls.

Lawful interception for packet mode services is already enabled by GPRS in 2G mobile networks. GPRS has the capability to send a duplicate of all packets exchanged by a user over a PDP context as well as the address of the entity accessed through this context. Lawful interception was introduced from the first 3GPP IMS R5 specification.

6.1 Open access

There are a number of difficulties associated with new fibre deployments. Long-term civil engineering costs that involve passive infrastructure renovation in the public domain, such as trench digging and duct installation, and drop-cable connectivity in the private domain, such as indoor and residential cabling, are significant. They also involve significant negotiating complexity that would be prohibitive for any individual service provider to assume alone. For these reasons, requiring passive infrastructure sharing is one solution regulators are exploring. The European Regulators Group (ERG), for example, launched a public consultation in May 2007 proposing, among other measures, duct sharing for FTTx deployments.[1] The ERG was expected to finalize its recommendations to the European Commission in September 2007, in time for the European Commission to recommend changes to the European Union regulatory framework in October 2007.

Another key issue for promoting competition, while encouraging investment in NGN access networks, is the question of local loop unbundling in a fibre environment. Today's local loop unbundling regulations focuses on the last mile. But the move to FTTH, FTTB and FTTC means the focus is on the last quarter mile or less. Given the costs and other resources involved, the LLU model appropriate for legacy copper may have to be adapted for fibre or different remedies identified. Some European regulators have also expressed concerns about the difficulty of unbundling point-to-multipoint fibre technology. These concerns are discussed in Chapter 1 of this publication. Where regulators mandate LLU one option could be a bit-stream offer at the Central Office level, where the nature of the access network is totally transparent. Other options could include requiring collocation at the street cabinet level and backhaul from the cabinet to the operator's node, as proposed by the ERG in its May 2007 public consultation. However, backhaul could be difficult for competitive operators to provide for themselves unless duct-sharing is available. As discussed in Chapter 9, some regulators, including in the United States and Hong Kong, China, have decided to forbear from regulating NGN access.

Another issue raised by FTTx is related with the removal of Main Distribution Frames (MDF) by the incumbent operator thereby making obsolete the "old" scheme of LLU for copper (see box 3.1) at least in its full unbundling and line sharing options, since LLU takes place at the MDF under traditional LLU scenarios. Where points of interconnection are withdrawn, it will be important for competitive operators both that they not face additional costs as part of the NGN migration process, and that they remain able to continue their current service offerings, and not face the problem of "stranded investments". The Netherlands's incumbent operator, KPN, for instance[2] announced that it would remove all of its MDFs as part of its NGN migration, to

1 See http://www.erg.eu.int/doc/publications/consult_regprinc_nga/erg_cons_doc_on_reg_princ_of_nga.pdf

2 See http://erg.eu.int/doc/whatsnew/kpn_van_den_beukel_erg_17_apr_07.pdf

consolidate its network into a reduced number of switching nodes and shift DSLAMs only within street cabinets. KPN hopes, by selling the buildings that house its MDFs, to raise EUR 1 billion which it can then use to finance its FTTx rollout. KPN and the Dutch national regulatory authority, OPTA, are discussing KPN's plans for MDF removal, which could include phase-out conditions for the withdrawal of MDF access, as well as KPN's proposal to provide "sub loop unbundling (SLU)" for street cabinets and a "Wholesale Broadband Access (WBA)" offer at local, regional or national switching levels. Regulators in other countries may wish to follow the regulatory developments in Europe and elsewhere as operators continue to roll out their NGN access networks.

6.2 Market Definition

The identification and definition of relevant markets are the basis of competition analysis used for the establishment of *ex ante* regulation in many countries, particularly in the EU. With NGN this task will become much more complex due to the blurring of the boundaries between technologies and services. This complexity could be at the source of disputes between regulatory authorities and market players.

The case of Deutsche Telekom's NGN deployment and its dispute with the regulator regarding its obligation to provide access to its network to competitors is a good example of the new regulatory challenges raised by NGN. While this case is discussed in more detail in Chapter 9 – Enabling Environment for NGN, it is worthwhile highlighting its technical aspects. At the heart of the dispute between Deutsche Telekom and the regulator lies a difference of interpretation as to the qualitative differences between fibre access and DSL access. In Deutsche Telekom's view, the extra bandwidth provided by fibre will qualitatively change the service, through for instance the provision of High-Definition TV, making it a different market from the DSL one in which it is currently designated as having SMP. However, the regulator views the project mainly as an upgrade of Deutsche Telekom's DSL service with the intention of retaining its current DSL subscribers.

The results of such disputes could be dramatic if incumbents threaten to freeze their investment. However, given the potential returns, European regulators seemed confident that operators would continue to invest in similar projects.

6.3 Quality of Service

NGN's unified transport of services raises issues related to the connection-less nature of IP transport, especially for real-time interactive voice or multimedia communication streams that are sensitive to packet loss, delay or jitter. However, many technologies that ensure QoS over an IP network already exist. These can be broadly split into technological approaches based on over-dimensioning that is associated with relative priorities or on explicit end-to-end resource reservation.

It must be noted that the bulk of the Internet uses the "best-effort" model with no QoS guarantees. Many applications on the Internet use the Transmission Control Protocol (TCP) that reduces user traffic in the case of congestion. TCP, however, is not suitable for real-time applications like video streaming, voice or multimedia communications that cannot limit the rate of packet sending in case of congestion. Fortunately, real-time applications such as voice telephony or video streaming do not represent, as yet, a significant amount of Internet core traffic. Today a reasonably over-dimensioned core network, as is the case of many Internet backbones, manages to handle this traffic.

A next-generation network, however, is different from the Internet even though they share the same IP transport technology. NGN relies on explicit guarantees provided by the network to its end-user for quality sensitive applications, such as IPTV and guaranteed VoIP. Such applications are expected to constitute a large portion of NGN traffic.

A next-generation network, however, is a managed and closed network. As such, many of the QoS techniques involving differentiated priorities and resource reservations that are not widely applied in the Internet because of scalability and cost issues can be applied within next-generation networks. Furthermore, in NGN architecture the transport domain is under the control of a service domain which guarantees that proper resources are allocated by the transport domain for the duration of a given service provision by the network. This is something that does not exist in the Internet since the "control" is end-to-end and not within the network.

The critical issue that remains is the need to ensure the coordination between different next-generation networks in order to provide end-to-end QoS. There is a general misconception that in the PSTN end-to-end QoS is associated with the reservation of a TDM circuit of 64 Kbit/s all along the traversed networks. While this is true, end-to-end PSTN QoS also depends on proper end-to-end signaling through ITU Signaling System N°7 (SS7). The same principle of end-to-end signaling could be applied over any packet transport bearer, the possibility of which was demonstrated by ITU's specification of the Bearer Independent Call Control (BICC) protocol which is an adaptation of SS7.

By definition and design, IMS architecture uses the SIP protocol for call (session) signaling. SIP is essentially an Internet end-to-end protocol; however 3GPP and ETSI TISPAN have extended it to make it usable for network control functions in NGN voice and multimedia calls. This occurs in a manner similar to call and service control functions in legacy SS7-based intelligent network architecture. ITU is developing NGN signaling protocols for resource reservation on a call-by-call basis that will be applicable within networks, especially at network interconnection points. This work is being advanced in close cooperation with 3GPP and ETSI TISPAN. ITU has already produced some Recommendations on NGN signaling protocols for resource reservation while further work is being undertaken by ITU-T SG11.

It is, of course, not the regulator's duty to enter into the detailed technicalities of QoS provision within NGN. However, to support essential services, such as interactive voice, regulators could contribute to the definition of the basic requirements needed at interconnection points, in a similar way to what occurs today between telephony networks.

6.4 Interconnection

The need for interconnection between telecommunication networks stems generally from the over-arching necessity of service completion. NGN is no exception; in fact it introduces even more interconnection requirements than legacy telephony networks as a consequence of the ubiquity of access to services it introduces.

In addition to the legacy interconnection requirements for service completion among different next-generation networks and between a next-generation network and other voice networks, it must allow subscribers the ability to:

- Connect from any other network and get their service profile from their home network in order to be served according to it, which is similar to the concept of mobile roaming, but applied to all types of broadband packet access;
- Access the services of their own network in preference to those of the visited network, which is a feature currently present in mobile networks through the Customized Application for Mobile network Enhanced Logic (CAMEL) IN interface that allows roaming subscribers to receive, for instance, network information messages and access value-added service in their own language; and
- Access value-added services from a third-party service provider, which is a concept that is currently available for some 2.5 and 3G content services such as access to alternative Wireless Application Protocol (WAP) portals, or I-mode services.

NGN interconnection requirements necessitate a common definition of what constitutes a multimedia call. Such an issue may be critical in the selection of either a calling party pays (CPP) or a bill-and-keep regime. While this topic will be discussed in detail in Chapter 5 – Interconnection in an IP-based NGN Environment, it is important to clarify a misconception that links the CPP regime with circuit-switched transport. A CPP regime owes more to a service completion agreement for a given call between two network domains rather than on actual resource reservation for a given call. The fact that in legacy voice telephony this implies a reservation of a dedicated circuit is only a technical detail that will evolve as networks move towards packet transport. In NGN, such a service completion guarantee would be meaningful for individual multimedia calls only if a signaling interaction exists, or is deemed necessary, between respective control entities at network domain boundaries. For this signaling to exist, a common definition of the requirements of these multimedia calls must exist, similar to what already exists for voice calls.

It is likely that the roaming issue will be even more complex with NGN. Today, the mobile industry has agreed on mutual roaming agreements without the necessity of regulatory intervention. Regulators have only intervened on the topic of roaming tariffs. With NGN, regulators will have to consider whether it will be necessary to mandate roaming. For example, should an NGN mobile access operator be required to allow clients of any NGN fibre access operator to roam on its access network and vice-versa?

The issue of access to third-party services is also important. In the past, mobile operators have attempted to lock-in their customers to their own service provision platform. Fortunately, such practices are no longer in place even if, in practice, most third-party service provision is done though operator portals. In a similar way, regulators should closely monitor third-party access to services in a NGN environment. Even if, on paper, IMS architecture enshrines third party access to service provider platforms, its actual implementation will be quite complex, perhaps allowing room for uncompetitive behavior veiled behind technical arguments.

7 Status of NGN Migration and further work

During the study period 2006-2010 of this question, a questionnaire on NGN migration was sent to administration and sector member of ITU. Quite few responses were received as a result (only 9). The questionnaire and a summary of the results received are presented in respectively annex 1 and 2 of this document.

The synthesis of the questionnaire cannot thus be considered as statistically meaningful. However, during the study period, some contributions were made from developing countries during the Question meeting as well as other ITU workshops as regard the status of their migration process to NGN.

These contributions as well as the questionnaire lead us to draw the following observations regarding the migration to NGN in developing countries as of mid-2009:

- A vast majority of developing countries are aware of NGN migration and the challenge it raises;
- Many countries already introduced some components of NGN architecture within their networks like VoIP with soft switches or the introduction of national IP backbones; some have even migrated a significant part of their legacy voice architecture to NGN;
- Still, what characterizes many developing countries is the lack of Broadband access – especially in its wireline form (DSL, Fiber, …) – with respect to developed countries;
- Lack of Broadband access result in marginal if inexistent use of new NGN services – like IPTV and multimedia communication – in many developing countries;
- Many developing countries also view the new NGN architecture as being complex with competing standard bodies (3GPP, TISPAN, ITU, …) and fear that this architecture would have a heavy cost in terms of investments and expertise with no clear returns.

The above observations provide a mixed feeling of positive and negative news. On the positive side one can say with a certain level of assurance that NGN is beginning its rollout in developing countries but on the negative side the lack of Broadband access in many developing countries results in a uncertain situation in many countries especially in light of the heavy investments that are needed for a full-fledged NGN migration.

It is thus foreseen that the work of this question should be continued in the next study period with a particular focus on **Broadband access** as a lever for NGN migration in developing countries. The necessary conditions for this Broadband access take-up and the resulting advent of NGN were already outlined in Opinion 2 of the last ITU World Telecommunication Policy Forum (WTPF) of Lisbon that took place in April 2009. This opinion could be found in Annex 3 of this document.

After the tremendous growth of Mobile telephony in developing countries, one can say that the digital divide has shifted from voice to Broadband access and the associated NGN services. It is thus up of ITU-D – in line with the follow-up of Opinion 2 of WTPF – to devise a continuation of this question during the next study period that focus on the particular challenge of Broadband access as an essential pre-requisite for NGN migration in developing countries.

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