Dimensioning and Optimization of Next Generation Networks (NGN)

(DO- NGN)

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Table of Contents

Executive Summary

A key development of telecommunication systems during the past two decades has been the evolution from the circuit-switched network toward the packet-switched network paradigm. Many operators are now migrating their PSTNs from circuit switched networks. This new approach is often called the next-generation network NGN enables network operators to run all services (i.e., voice, data and video) on one network.

This project is to analyze the NGN models and to recommend strategies and methods for its dimensioning/optimization. The analyses will include the following:

- NGN services demand forecasting methods
- NGN networks dimensioning and optimization methods and its implementation

To meet the requirements in development of next generation networks of domestic and international network operators and service providers the following study was conducted:

- Forecast of voice and non-voice service demands and market shares.
- Forecast of voice and non-voice traffic on NGN.
- Access technologies: copper cables, x-DSL, FTTx, power lines, HFC cables & WLAN, WMAN, WLL. 2G/2.5G/3G/4G

There important problems that have to be solved are network structure optimization and network dimensioning & optimization. Therefore, the dimensioning procedures and optimization methods have been modeled in this project based on known dimensions.

The Optimization techniques have been recommended for implementation on PTCL Next Generation Network and complete network diagram is given in the report.

Background

While the terms video and voice are still used to describe services, no operator today can risk calling itself only a voice provider or only a video provider. IP has caused a shift not only in network architecture and operations, but even more fundamentally in the types of services offered to subscribers. The explosion of the Internet and a diverse array of server-based applications have created entire new industries such as Google and Apple's iTunes phenomenon. The amorphous term "information services," which some saw as extensions of bulletin boards and library searches, has morphed in to multibillion-dollar businesses.

Terms used in the mid-1990s are much less useful today. An operator is no longer a telephone provider; it must provide consumers with an array of communication services. While video is still a part of the service mix, entertainment services now include a wide range of opportunities for differentiation. This transformation of services extends beyond traditional voice and data services and even beyond video to an era of integrated information, communication, and entertainment.

Telecos in the Asia–Pacific region are actively planning an IP convergence roadmap for their voice networks. Soaring stock valuations, aggressive debt financing and over-investment during the 'telecoms bubble' have forced these operators to focus more than ever on business fundamentals. Competition has driven down tariffs, often to non-viable levels, while at the same time the operators' networks are ageing. Many incumbent operators have additional problems, having recently been subjected to competition and – for those being privatized – increasing scrutiny from investors.

The Business Development (BD) teams of different Telecos are working in the region to analyze the economic value of their planned investments which includes NGN investment. The teams are also working to evaluate the revenue potential of new applications and to identify and quantify a reduction in operational costs.

Telco's of the region also wants to assess how NGN migration would improve key financial indicators and, in turn, its market valuation. This aspect is especially interesting for operators which are about to be privatized. The analysis of each NGN business case is typically a joint effort with the operator (with confidentiality of client information ensured by a non-disclosure agreement).

For a South-East Asian incumbent, currently running an ageing TDM network, and which still expects traffic growth, NGN migration was shown to offer capex savings in the long run. This is because without NGN, the operator will need to invest in new TDM ports to support traffic growth as well as to replace old TDM equipment reaching the end of its service life.

NGN is a multi-service network able to support voice, data and video:

- A network with a control plane (signaling, control) separated from the transport/switching plane
- A network with open interfaces between transport, control and applications
- A network using packet mode technology to transport of all kind of information
- A network with guaranteed QoS for different traffic types and SLAs

NGN (Next Generation Networks) is a concept for defining and deploying networks, which due to their formal separation into different layers and planes and use of open interfaces, offers service providers and operators a platform which can evolve in a step-by-step manner to create, deploy and manage innovative services.

Network planning is a critical issue to network operators and network service providers in a time of globalization. Unlike the situation before 1990, a current telecommunications market requires flexible and adaptive network planning methodologies. A lot of work has been done for planning and optimization of PSTN but not for the NGN. Recently, the reference manual on “Telecom Network Planning for evolving network architecture” provided by ITU-D is expected to cover these issues but it is still in an initial development stage.

Therefore, during the next five years APT, ITU and other similar organization should play an important role in assisting its Member countries for the smooth migration from existing networks into the NGN by doing research projects on new network planning and optimization issues. This project addresses similar issues. The project also discussed implementation of optimization technique through case study and for this case study PTCL has been considered.

Chapter 1

NGN Overview

1.0 Introduction

NGN is a concept rather than a new technology. The migration to NGN is not an over-night transformation but it is an evaluation that should be first studied carefully and then implemented step by step. The importance of NGN is in the new services that it shall introduce. So NGN is application driven not technology driven.

Next Generation Networking (**NGN**) is a broad term to describe some key architectural evolutions in telecommunication core and access networks that will be deployed over the next 5-10 years. The general idea behind NGN is that one network transports all information and services (voice, data, and all sorts of media such as video) by encapsulating these into packets, like it is on the Internet. NGNs are commonly built around the Internet Protocol, and therefore the term "all-IP" is also sometimes used to describe the transformation towards NGN [6][11].

According to **ITU-T** the definition (Feb 2004) is:

> A Next Generation Network (NGN) is a packet-based network able to provide services including 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 offers unrestricted access by users to different service providers. It supports generalized mobility which will allow consistent and ubiquitous provision of services to users.

ETSI defines NGN as:

> “A concept for defining and deploying networks, which due to their formal separation into different layers and planes and use of open interfaces, offers service providers and operators a platform which can evolve in a step by step manner to create, deploy and manage innovative services”

1.1 History of NGN

International standardization of NGN was started with NGN Workshop held by ITU-T in July 2003. Later on, European Telecommunication Standards Institute (ETSI), Telecoms & Internet converged Services & Protocols for Advanced Network (TISPAN) launched project in July 2003 in Europe. This marked the beginning of studies on a next-generation telecommunications infrastructure applying the IP Multimedia Subsystem (IMS) specified by the 3rd Generation Partnership Project

(3GPP) for high-speed broadband access. The first specification called “NGN Release 1” was completed at the beginning of 2006 [6].

At ITU-T, NGN studies were also intensified by the formation of the Focus Group on Next Generation Networks (FGNGN). The results from FGNGN were passed on to SG13, the lead study group for NGN studies, which initiated a Recommendations procedure in July 2006 and began issuing a sequence of formal ITU Recommendations.

The FGNGN was formally terminated in December 2005, but to carry out centralized study system, NGN Global Standards Initiative (NGN-GSI) was formed that includes study groups such as SG11 (signaling protocols), SG19 (mobile networks), and SG17 (security issues).

1.2 Standards bodies and industry support forums

Various industry forums have emerged to promote as well as standardize the evolving services of next generation networks. These new network services leverage a common IMS core for a horizontal signaling layer [1][6].

- Alliance for Telecommunications Industry Solutions (ATIS)
- IPTV Interoperability Forum (IIF)
- Multiservice Forum (MSF)
- IMS/NGN Forum
- SIP Forum

These forums generally host interoperability events in which multiple vendors show that services based on standards promoted by the forums can actually be deployed. They also publish specifications and interoperability agreements in parallel with standards bodies.

The NGN-related Recommendations issued by ITU-T are listed in **Table below** as of October 2007.

Category	Recommendation	Short title	Publication date
Outline	Y.2001	General overview to NGN	2004/12
	Y.2001	General principal and general reference model of Next Generation Networks	2004/10
Scope of Release 1	Supp 1 to Y-2000 series	NGN release 1scope	2006/07
	Y.2201	NGN release 1 requirements	2007/04
	Y.2211	IMS-based real time conversational services over NGN	2007/10
	Y.2091	Terms and definitions for NEXT Generation Networks	2007/03
Architecture	Y-2012	Functional requirement and architecture of the NGN	2006/09
	Supp 1 to Y-2012	Session/border control (S/BC) functions	2006/07
	Y.2021	IMS for Next Generation Networks	2006/09
	Y.2031	PSTN/ISDN emulation architecture	2006/09
	Y.2013	Converged services framework: functional requirements and architecture	2006/12
Traffic & QoS control	Y.2111	Resource and admission control functions in Next Generation Networks	2006/09
	Y.2112	A QoS control architecture for Ethernet-based IP access network	2006/06
	Y.2171	Admission control priority levels in Next Generation Networks	2006/09

	Y.2172	Services restoration priority levels in Next Generation Networks	2007/06
Evolution from PSTN/ISDN	Y.2261	PSTN/ISDN evolution to NGN	2006/09
	Y.2262	PSTN/ISDN evolution and simulation	2006/12
	Y.2271	Call-sever-based PSTN/ISDN emulation	2006/09
Management	Y.240/M.3060	Principles for the Management of the Next Generation Networks	2006/03
Future packet-based network	Y.2601	Fundamental characteristics and requirements of future packet-based network	2006/12
	Y.2611	High level architecture of future packet-based networks	2006/12
Security	Y.2701	Security requirements for NGN release 1	2007/04
Mobility	Y.2801/Q.1706	Mobility management requirements for NGN	2006/11
	Y.2802?Q.1762	Fixed-mobile convergence general requirements	2006/09
Specifications of OCAF	Y.2901	The carrier grad open environment reference model	2006/12
	Y.2902	Carrier grad open environment reference model	2006/12
Resource control protocol	Q.3301.1	Recourse control protocol- Protocol at the Rs interface	2007/03
	Q.3302.1	Recourse control protocol- Protocol at the Rp interface	2007/03
	Q.3303.0	Protocol at the interface between PD-PE and PE-PE (Rw interface): Overview	2007/4 start
	Q.3303.1	COPS Alternative	2004/08
	Q.3303.2	H.248 Alternative	2006/08
Signaling profile	Q.3401	NGN NNI signaling profile	2004/03

The NGN standardization process adopts a release approach that issues a group of specific functions with an estimated completion date to conform to market demands. The Y.2000 series of Recommendations has been given for NGN requirements and architecture. Now, these recommendations have been easily accessible from the ITU web site.

1.3 Drivers of NGN

With the arrival of NGN, the business has got new dimensions and it has changed the environment. The following table highlights some of the environmental changed:

S. No.	Old Requirements	New Requirements
1	E2E Transparency	Packet Inspection/NATS
2	Peer-to-peer	NATs/Firewalls/Servers
3	Connectionless	MPLS
4	Best Effort	Real-time demand Bandwodth Demand
5	User back-off	QoS guarantee
6	Network Empowerment	User Empowerment
7	No Flow state	Flow state
8	Trust	Hackers everywhere
9	Static Address	DHCP, Mobility

In the current business environment, most operators are faced with the same problem: how to control costs and cap investment in TDM technology, whilst developing new services to attract and retain customers [27]. The operators are facing many problems such as:

- Obsolescence problem, both for the transit level and the access level of the PSTN
- Reduction of revenues coming from voice switched access

- Launch innovative services in order to attract and/or retain customers;
- Generate new revenue streams
    - Telecom Operator and Vendor Interests
    - Improvement in Access Technologies
    - Reduced Vendor Dependency
    - Opening of Global Financial Markets

This evolution in the service providers' networks leads to the so-called NGNs, Next Generation Networks, which pave the way for the adoption of VoIP (Voice over IP) technology both at core network and at subscriber level.

The NGN for PSTN Transformation solution provides valuable benefits to service providers that intend to replace their PSTNs with VoIP technology.

Some of the key benefits are the following:

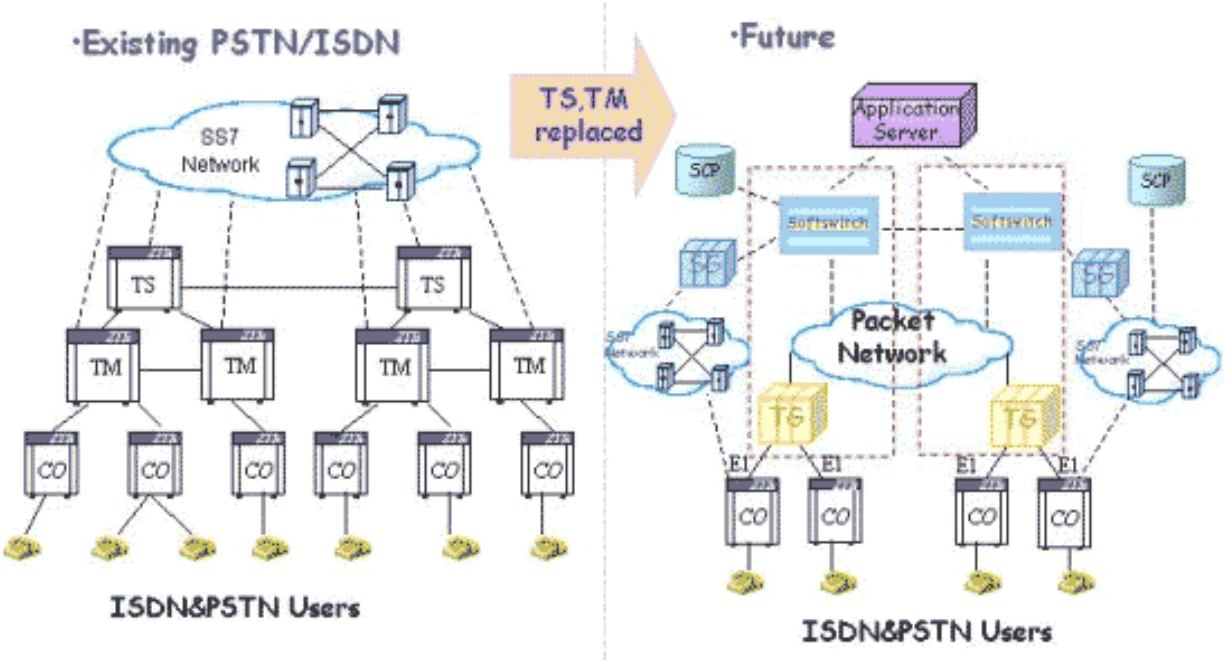
- Significant operational expenditure (OpEx) savings,
    - Replacement of a traditional or obsolescent technology with a new one, with more compact and less consuming equipment which allows reduction in the number of nodes and use of open interfaces, etc.
    - Adoption of IP which allows reduction in transmission and bandwidth requirements and provide easier and more economic network management.
- Capital expenditure (CapEx) savings coming from the capping of investments in TDM switch and network technology, from the reduced cost of IP technology, from the sharing of backbone resources between voice, data, etc.
- Segue to new IP services—The NGN for PSTN Transformation solution can be a foundation for the new networks

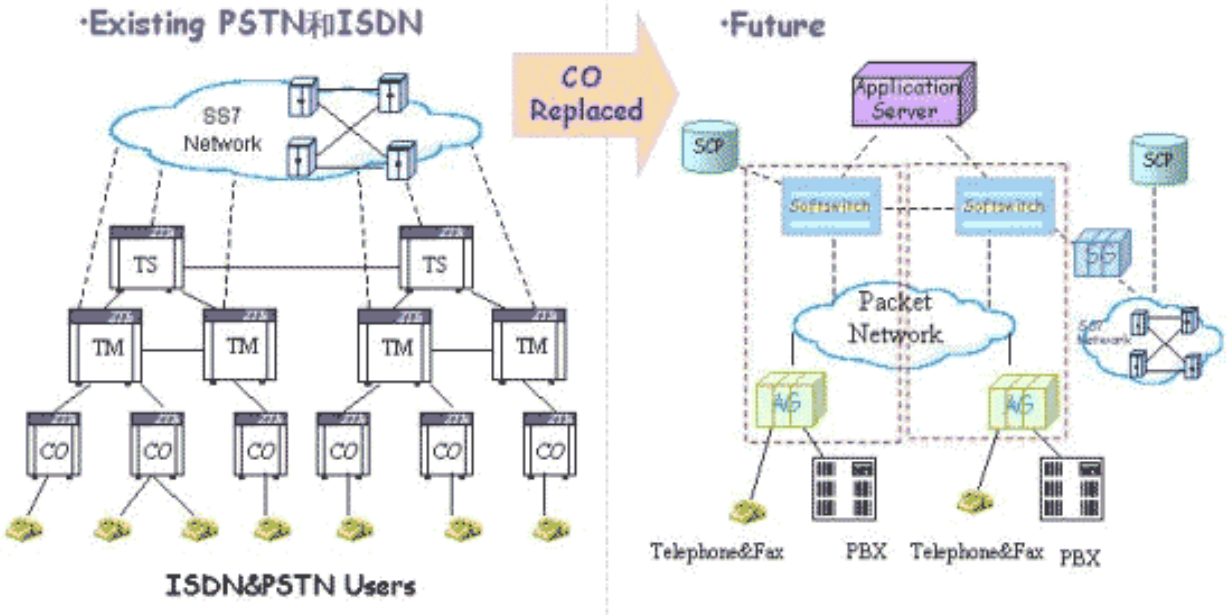
1.4 Characteristics of NGN

A typical NGN has the following characteristics:

- Packet-based transfer
- Separation of control functions among bearer capabilities, call/session, and application/ service
- Decoupling of service provision from network, and provision of open interfaces
- Support for a wide range of services and applications
- Broadband capabilities with end-to-end QoS
- Interworking with legacy networks via open interfaces
- Generalized mobility
- Unrestricted access by users to different service providers
- Converged services between Fixed/Mobile
- Compliant with all Regulatory requirements, for example concerning emergency communications and security/privacy, etc

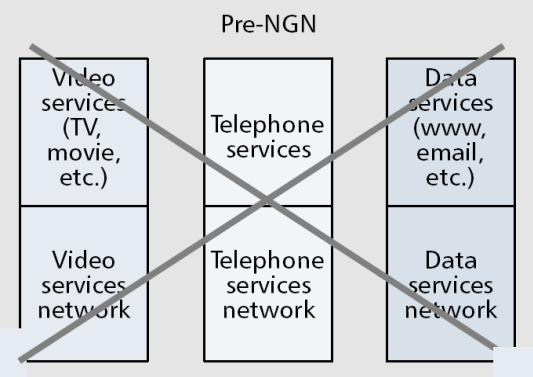
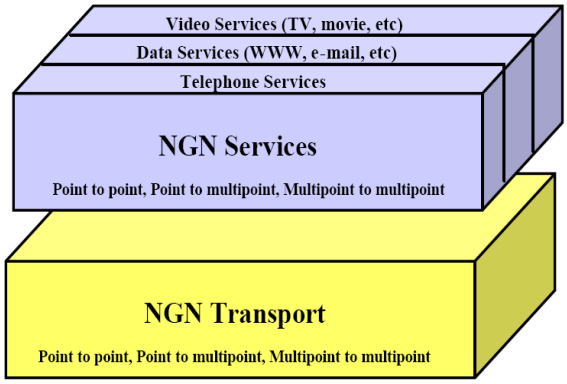
1.5 NGN VS PSTN



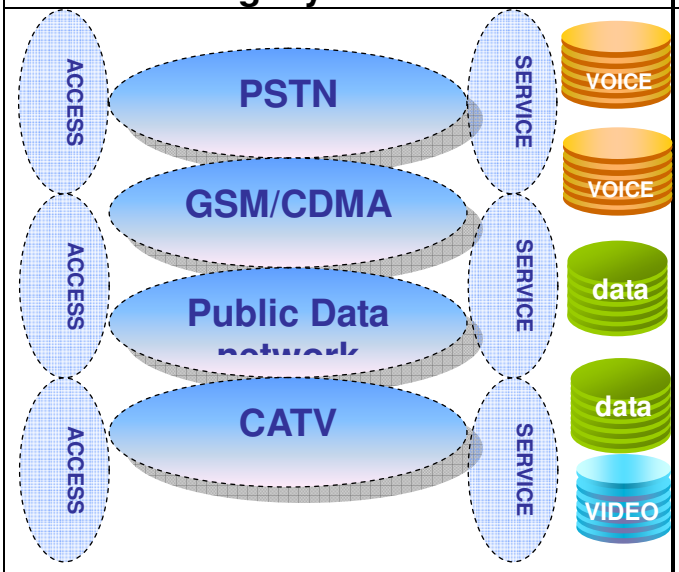
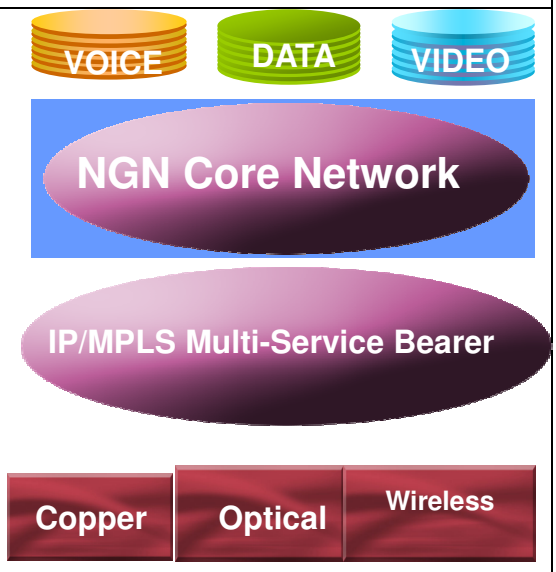


1.6 Pre-NGN Vs NGN

The following figure shows a pre-NGN model Vs NGN model which is horizontally integrated network as compared to previous vertically integrated network.

Pre-NGN	NGN
Vertically-Integrated Networks	Horizontally-integrated Network
	

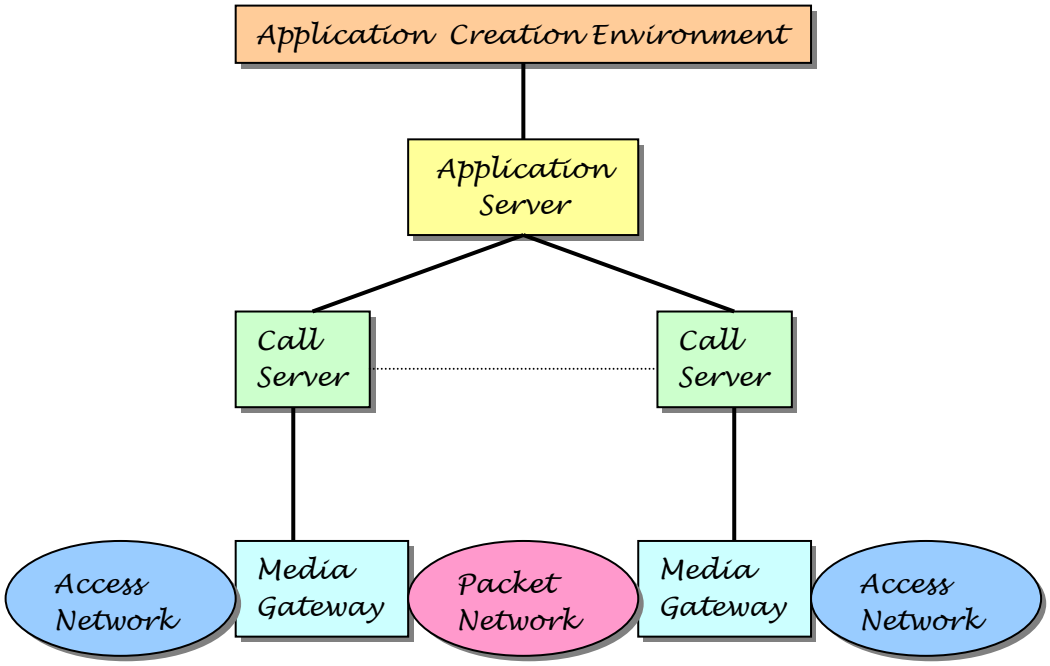
The following table shows another dimension of looking into a legacy network and NGN

Legacy Network	NGN
	
Legacy Networks were dedicated and isolated networks with service specific signaling and routing for service connection	NGN has a common IP core and provide nomadically accessible IP applications regardless of a specific access link or user device
Limited Broadband and Multimedia services	Provide integrated services instead of limited service
High OPEX	Centralized management and simple network structure, reduce OPEX
High Service cost	
Long Service provision time	Realize the fast and cost effective new service deployment.

Inefficient O&M. Too many sites, too many types of nodes	OPEX Saving from reduction of transmission, room space, O&M center, etc.
Outdated and aged Exchanges	Pave the way to all-IP network

1.7 NGN Architecture

Different NGN architecture diagrams are shown below. Each of the diagrams shows different angle of understanding. The last diagram is showing NGN architectural view defined by ITU [11][12].



The following network diagrams represent how the architectural model may be instantiated (**PSTN to IP network interface scenario**)

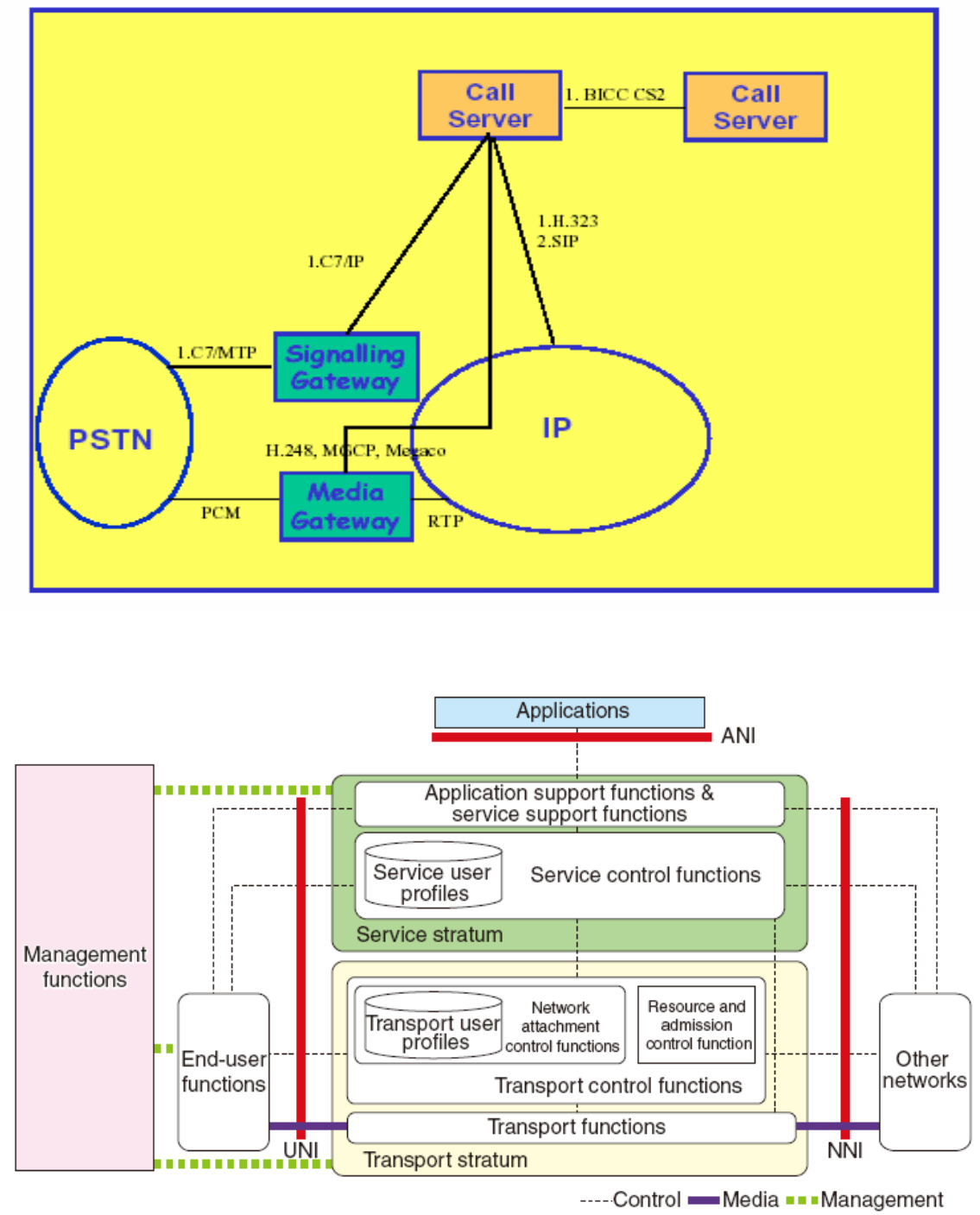


Figure: NGN architecture overview at ITU-T

1.8 NGN Layers

The conceptual model of NGN architecture consists of four layers [4][9][12]:

1. Access/Media layer
2. Core Transport layer
3. Control layer
4. Service/Application layer.

Their functions are different and functions of each layer are explained in the following section.

1.8.1 Access/Media Layer

It is the lowest layer in the model and provides the infrastructure for access of end user devices, like wireless or standard telephones, mobile or desktop computer etc to transport network and vice versa. Therefore, this layer provides a connection between Core Packet Transport layer and various existing communication networks.

This includes different media gateways, DSLAM, MSAN and so on that support connection to and from the access network with the core network. This is also called Access gateways and does the following functions:

a. Allows the connection of subscriber lines to the packet network
b. Converts the traffic flows of analogue access (Pots) or 2 Mb/s access devices into packets
c. Provides subscriber access to NGN network and services.
d. Provides access of various communication terminals such as analog phone, SIP Phone, PC Phone visual terminal and intelligent terminals to the Core Packet Transport layer via various access gateways

1.8.2 Core Transport Layer

The transport layer provides transport between network nodes to which the access networks are connected. It is a packet switching network composed of backbone transmission equipments such as IP router or broadband ATM switch as the bearer basis of the softswitch system. The network handling converged services on IP. It is made of IP backbone and consisting from one or from multiple high-speed backbone packet switched networks.

1.8.3 Control Layer

This layer is responsible for the control of communication sessions, e.g. establishing or disconnecting voice etc. The call server that provides call control functions and also provides the control of the Media gateway. It includes **Soft switch, Media Gateway, MRS, and SHLR**. It Provide the following functions:

a. provides the “service delivery control” within the network

b. in charge of Call Control and handling of Media Gateways control (Access and/or Trunking) via H.248 protocol
c. performs signaling gateway functionality or uses a signaling gateway for interworking with PSTN N7 signaling network
d. provides connection to Intelligent Network /applications servers to offer the same services as those available to TDM subscribers
e. The control Layer combines the equipment that manages signaling and call control progress.
f. The control handles the call setup and controls the media gateways.
g. Major components at this layer are the soft-switches.

1.8.4 Application/Service Layer

It is common to call this layer a service layer, because it merger so called application servers and a media servers (platforms to disseminate content). It is also IT platform that plays the role of an IN-SCE (Intelligent Network Service Creation Environment) extending their functionality in order to cover the new network scenarios. This includes **NMS, ENIP** and **APP** servers and so on

The service layer offers elementary service functions that can be used by service providers to build more complex or comprehensive network. This layer provides basic blocks of services, from which operators can make their more complex and more usable service.

1.9 NGN Components

The components of NGN Architecture are important part of NGN platform that makes it possible for entity universal communication network, witch integrate voice and data services. This component can be software or hardware guise. Example, appertain to here Central control element design as Media Gateway Controller (Call Agent), Media Gateways, Softswitch, Signaling Gateways etc..

1.9.1 Media Gateway Controller/Softswitch

Softswitch is the next generation voice and multimedia switch based on the IP technologies. It is design to replace the Class 5 and Class 4 switches based on the circuit switching technologies.

The advantages of the Softswitch vs. the traditional circuit switch are:

- New services and revenue stream for service providers
- Flexibility in deployment and operation
- Unified messaging

- Easy integration of dissimilar networks and components
- Lower cost of solution deployment and total ownership

Soft switch technology enables connectivity between the Internet, wireless networks, cable networks and traditional wireline telephony network, which results a converged network.

1.9.2 Application Server

A unit that supports service execution, e.g. to control Call Servers and NGN special resources (e.g. media server, message server).

1.9.3 Packet Network

Trend is to use IP based networks over various transport possibilities (ATM, SDH,WDM…). These IP based networks must offer guarantees of Quality of Service (QoS) regarding the real time characteristics of voice, video and multimedia

1.9.4 Trunking Gateways

Trunking gateways allows interworking between classical TDM telephony network and Packet-based NGN networks, It also converts TDM circuits/ trunks (64kbps) flows into data packets, and vice versa

1.9.5 Access Networks/Gateways

This network allows the connection of subscriber lines to the packet network and converts the traffic flows of analogue access (Pots) or 2 Mb/s access devices into Packets. It also provides subscriber access to NGN network and services.

1.10 NGN Protocols

Next Generation Networks requires new protocols to support converged networks. The requirement is that it should have support for the following:

- legacy PSTN interworking,
- Migration Plan from legacy to NGN,
- High availability,
- Lifeline services and Scalability

One of the main principles of NGN architecture is its division of management functions from connection hardware. In traditional telephony, connection functions of transport layer and functions of management layer were supported by one device - exchange. In NGN, elements MGW/SGW are used as connection and routing function of exchange (switching network, interface and signaling). Servers for

controlling of calling (Soft switch) are replacing controlling functions of exchange (processors and memories). This division with use of packet network, primarily for data transfers, is used also for voice and multimedia communication in real time. This is demanding a new management protocols.

While VoIP-Voice over Internet Protocol comes in many forms, the four major standards-based systems are:

- H.323
- SIP(Session Initiation Protocol)
- H.248 / MEGACO-MEdia GAteway and COntrol
- SIGTRAN

H.323 and H.248 are ITU [6] standards. IETF-Internet Engineering Task Force [30] originated SIP as an internet technology based on PC-Personal Computers and other intelligent devices. H.248 originated from the PSTN-Public Switched Telephone network using SS7-Signaling System 7 with dumb devices.

These protocols we can divide into three groups:

- Signaling protocols for call control, which allows establishment, controlling, and termination of session. (SIP protocol and recommendation H.323).
- Protocols for MGW/SGW management, with use of soft switches. Mainly it is protocols type of Master/Slave H.248/MEGACO and MGCP.
- Signaling protocols between soft switches. There is debate about protocols SIP-T (protocol SIP for telephony) and SIGTRAN.

The following table shows some features of these protocols:

	H.323	**SIP**	**MGCP/H.248/Megaco**
Standard Body	ITU	IETF	MGCP/Megaco-IETF/H.248
Architecture	Distributed	Distributed	Centralized
Call Control	Gatekeeper	Proxy/Re-direct Server	Call Agent/MGC
End Points	Gateway, Terminals	User agent	Media Gateway
Signaling Transport	TCP or UDP	TCP or UDP	MGCP-UDP, Megaco/H.248-Both
Multimedia Capable	Yes	Yes	Yes
Supplemental Services	Provided by endpoints or call control	Provided by endpoints or call control	Provided by call agent

1.10.1 H.323

H323 is defined as “an ITU standard that provides specification for computers, equipment, and services for multimedia communication over packet based networks that defines how real-time audio, video and data information is transmitted.”

H.323 is an ITU VOIP protocol. It was created at about the same time as SIP, but was more widely adopted and deployed earlier. Today, most of the world's VoIP traffic is carried over H.323 networks, with billions of minutes of traffic being carried every month. H.323's strengths lie in its ability to serve in a variety of roles, including multimedia communication (voice, video, and data conferencing), as well as applications where interworking with the PSTN is vital. H.323 was designed while keeping in view multimedia communications over IP networks, making it the perfect solution for real-time multimedia communication over packet-based networks.

This standard is based on the Internet Engineering Task Force (IETF) Real-Time Protocol (RTP) and Real-Time Control Protocol (RTCP), with additional protocols for call signaling, and data and audiovisual communications.”

H.323, which describes how multimedia communications occur between terminals, network equipment and services, is part of a larger group of ITU recommendations for multi-media interoperability called H.3x. The latest of these recommendations, H.248, is a recommendation to provide a single standard for the control of gateway devices in multi-media packet transmissions to allow calls to connect from a LAN to a Public Switched Telephone Network (PSTN), as well as to other standards-based terminals.

H.323 networks consist of Call Processing servers, MG-Media Gateways and GateKeepers. Call Processing servers provide routing and communications (connections) to MG and end-user devices (phones called terminals). MG or Gateways provide H.323 call termination and interface with non-H.323 networks such as PSTN-Public Switched Telephone Network (circuit-switched long distance networks). Used in larger networks, optional GK-GateKeepers or Gatekeepers provide central call administration and control, bandwidth administration and signaling.

1.10.2 SIGTRAN:

SIGnaling TRANsport (SIGTRAN) protocol[30] is used to carry SS7 signals over the Internet. PSTN’s signals are being carried over IP network after converting from SS7 to IP signals. SCTP (Signaling Control transmission Protocol) is used as underlying transport vehicle to carry SS7 over IP. PSTN signals SS7 are transmitted to SG (Signaling Gateway) which in turns converts SS7 into SIGTRAN signals. SIGTRAN signals are sent to a SoftSwitch or to next Signaling Gateway SG..

Basic function of SIGTRAN:

- To transport PSTN (SS7) signals over IP keeping the functions &

requirements of PSTN

- Idea is to transport ISDN(Q.931, ISUP, SCCP etc) messages between IP nodes (SG, MGC, MGW) or to an IP-based database
- To provide signaling capability for Call Management and to provide media paths for IP real-time traffic
- Real-time traffic can be Voice, Music, video which needs instant transportation

1.10.3 H.248 Protocol

H.248 [36] is an ITU standard also known as MEGACO-Media Gateway Control. It is used for signaling and session management needed during a communication between a media gateway, and the media gateway controller managing it. H.248/MEGACO allows setting up, keeping, and terminating calls between multiple endpoints as between telephone subscribers using the TDM

1.10.4 SIP

Session Initiation Protocol (SIP) [35] is an application-Layer protocol used to handle call establishment, maintenance and termination of multimedia sessions (conferences) e.g. Internet telephony calls. SIP can also INVITE participants to already existing sessions, such as multicast conferences. Media can be added to (and removed from) an existing session.

SIP-Session Initiation Protocol is an IETF-Internet Engineering Task Force signaling protocol for internet conferencing, telephony, presence, events notification (emergency calling) and instant messaging. Designed around internet applications such as HTTP-HyperText Transfer Protocol, SIP is more multi-media focused than just for voice applications.

SIP can support five aspects of establishing and terminating multimedia communications:

1. **User location**: determination of the end system to be used for communication;

2. **User availability**: determination of the willingness of the called party to engage in communications;

3. **User capabilities**: determination of the media and media parameters to be used;

4. **Session setup**: "ringing", establishment of session parameters at both called and calling party;

5. **Session management**: including transfer and termination of sessions, modifying session parameters, and invoking services.

SIP can be used with other IETF protocols to build a complete multimedia architecture. These architectures will include protocols such as:

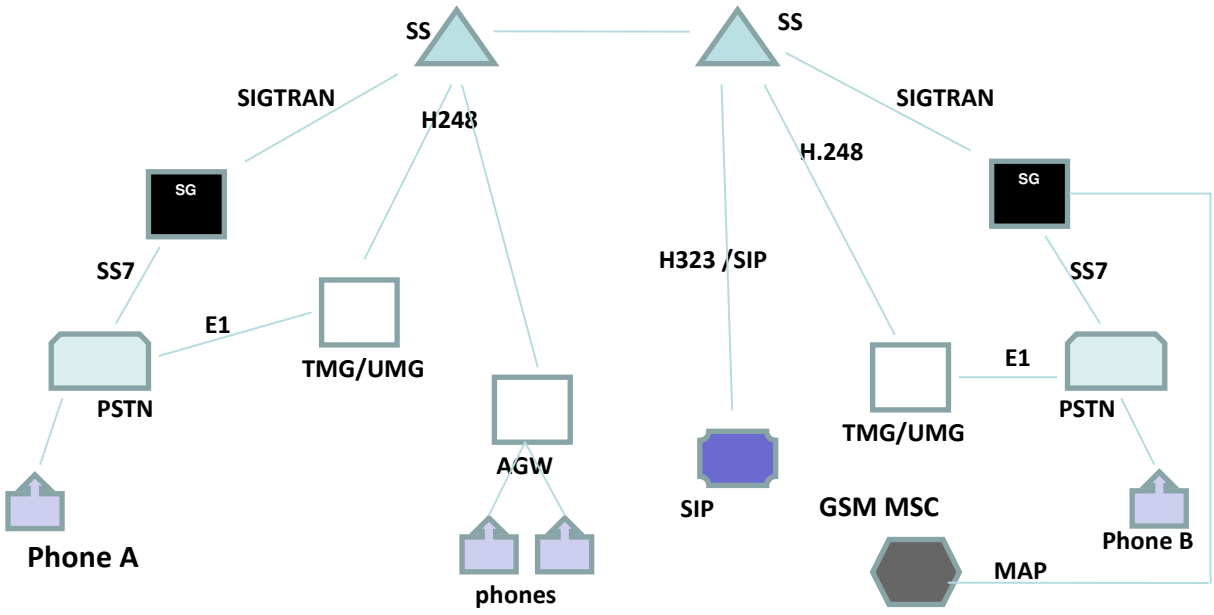
- Real-time Transport Protocol (RTP) [31] for transporting real-time data and providing QoS feedback.

- Real-Time streaming protocol (RTSP) [32] for controlling delivery of streaming media.

- MediaGateway Control Protocol (MEGACO) [33] for controlling gateways to the Public Switched Telephone Network (PSTN).

- Session Description Protocol (SDP) [34] for describing multimedia sessions.

Therefore, SIP should be used in conjunction with other protocols in order to provide complete services to the users. However, the basic functionality and operation of SIP does not depend on any of these protocols.



1.11 NGN Services

The Convergence of the three types of networks into a seamless network may not be the target but the new generation of services is the aim. The success of the migration of NGN depends on these services and the way of introducing them.

Several services [24][27] that will be important drivers in the NGN environment are:

1. Voice Telephony: e.g. Call Waiting, Call Forwarding, 3-Way Calling
2. Voice Portal: provide callers with anywhere, anytime access to information like news, weather, stock quotes, and account balances using simple voice commands and any telephone.
3. Data services: bandwidth-on-demand, connection reliability/resilient.
4. Multimedia services: This allows customers to converse with each other while displaying visual information.
5. Virtual Private Networks: allow large, geographically dispersed organizations to combine their existing private networks with portions of the PSTN, thus providing subscribers with uniform dialing capabilities.
6. Public Network Computing: Provides public network-based computing services for businesses and consumers (e.g, to host a web page, store/maintain/backup data files, or run a computing application).
7. Unified Messaging: Supports the delivery of voice mail, email, fax mail, and pages through common interfaces .
8. Information Brokering: Involves advertising, finding, and providing information to match consumers with providers.
9. E-Commerce: Allows consumers to purchase goods and services electronically over the network.
10. Call Center Services: A subscriber could place a call to a call center agent by clicking on a Web page.
11. Interactive gaming: Offers consumers a way to meet online and establish interactive gaming sessions.
12. Distributed Virtual Reality: Refers to technologically generated representations of real-word events, people, places, experiences, etc., in which the participants in and providers of the virtual experience are physically distributed.
13. Home Manager: These services could monitor and control home security systems, energy systems, home entertainment systems, and other home appliances.

Some future services include the following:

- IP services
- VoIP/ IP telephony
- UMS
- IP centrex
- Multimedia conferencing.
- VoD
- Content delivery
- IP offload

- Long distance Bypass

1.12 NGN Service Creation

For NGN Infrastructure we need to create new services. These services can be created [17] in cooperation with various industries which include the following:

- Broadcasting
- Financial
- Medical
- Education
- Advertising
- Business industries
- Internet services etc.

Creation of new services and values with open and collaborative works will add value to NGN services. The Next-Generation Services Joint-Development Forum is also set to support the rapid development and commercialization of new services. This forum initiate Joint-Development with business from various industries, creating new business models that take advantage of NGN features.

1.13 Challenges for NGN

Some challenges that are faced by the Telecos for migration towards NGN are as follows:

- Large Scale Capital Expenditure
- Operational Challenges
- Integration of Multiple Private Networks and Application into the Larger Public Networks
- Quality of Service (QoS)
- National Security and Competitive Policies

1.14 Conclusion

NGN shall provide the capabilities (infrastructure, protocols, etc.) to make the creation, deployment and management of all kinds of **services** (known or not yet known) possible. This comprises of services using different kinds of media (audio, visual, audiovisual), with all kinds of encoding schemes and data services, conversational, unicast, multicast and broadcast, messaging, simple data transfer services, real-time and non-real-time, delay-sensitive and delay-tolerant services. Services with different bandwidth demands from a few kbit/s to hundreds of Mbit/s, guaranteed or not, should be supported within the capabilities of the transport technologies.

Chapter 2
Access Technologies Overview

2.1. Introduction

The increasing usage of the Internet around the world leads to a massive growth in traffic volume and dynamics to be handled by the network backbones. There are number of different technologies which are trying to secure a growing customer base in this economic environment. Four major fixed line technologies are:

- Optical networks,
- Hybrid-fiber coax (HFC),
- Digital subscriber line (DSL) and
- Power line Communication (PLC)

These technologies [13][14][15] are the being deployed to deliver the triple play (voice, video and high-speed data). Similarly, there are many wireless technologies that can be deployed for broadband services and applications. Some of these technologies are as under:

- Microwave links
- MMDS (Multi-channel Multipoint Distribution Service)
- LMDS (Local Multipoint Distribution Service)
- FSO (Free Space Optics)
- WiFi (Wireless Fidelity)
- WiMax (Worldwide Interoperability for Microwave Access)
- Satellite
- 3G (Third Generation Mobile Networks)

But which of these technologies is best positioned to deliver these services today and into even the near-term future?

Residential bandwidth growth is the main driver of these technologies**.** Telco / ISPs needs to invest in their network infrastructure to enable broadband for their end customers. Huge upgrades may be necessary on the core / backbone network for example, in order to support heavy load of aggregation links connecting the Point Of Presence (PoP), no matter what the access technology is used.

There are many applications to handle broadband traffic that leads to different architecture like:

- Application convergence: web2.0, unified messaging, web client-oriented applications.

- Service convergence: Broadband access, Video (IPTV, VoD), VoIP
- Network convergence: Mobile / PSTN / broadband / FTTH etc.

Broadband access [2][3] has revealed new drivers, combined in the “Triple Play” offers:

- High speed Internet: creates new capabilities like emerging “Web2.0” applications: videos, photos, flash animations have never easier to upload and release on video streaming website (youtube, dailymotion) social networking web sites
- VoIP: one of the most valuable service that data networks bring to end-user

- IPTV and VoD: broadband access now allows TV channels to be broadcasted over data
  network, supporting both Simple Definition and High Definition standard.

- VoD: another growing service which enables to choose the content in a large video repository, and watch the content whenever the end user want it.

- Security: this is the area, where ISP can make money by proposing remote tools such as security scanners, outsourced Firewall engines. Parental control can be managed by broadband provider as well.

2.2. Comparison Factors

There are different factors [37] that are considered while choosing the access technology for a network. However, the factors for a wire line and wireless technologies may be different. The following factors will be considered in this report:

- Capacity
- Capacity sharing
- Symmetry
- Max Range
- Strengths
- Weaknesses
- Bandwidth allocation
- Maximum bandwidth per subscriber
- Increasing Bandwidth
- Simplicity of deployment:
- Spectrum Usage
- Cost of CPE
- Cost of Network Technology
- Network rollout cost
- Prioritizing services

- Delay, jitter
- Impact of faults in the access node
- Effect of malfunctioning
- Space requirement
- Energy Consumption
- Level of maintenance
- Level of difficulty in identifying and eradicating malfunctions

The above mentioned factors are considered for each of the fixed line and wireless technologies. Each factor is given points as 1 for poor performance, 2 for medium and 3 for good performance of technology. However, there are some factors which are not much affecting the selection of the technology are given same points. In this way, we analyze that which technology is best suitable for broadband access.

2.3. Fixed Line Technologies

2.3.1 Optical Networks

The optical access network [8][37] is that part of the access network implemented using optical fiber. Optical access offers the promise of greatly increased access-network bandwidth by up to several gigabits per second (Gbps)—and most likely more, as technology advances.

Fibre to the home (FTTH) is a form of fibre-optic communication delivery in which an optical fibre is run directly onto the customers' home. This contrasts with other fibre-optic communication delivery strategies such as fibre to the node (FTTN), fibre to the curb (FTTC), or hybrid fibre-coaxial (HFC), all of which depend upon more traditional methods such as copper wires or coaxial cable for "last mile" delivery.

2.3.1.1 Parameters Studied

Capacity: It offers high capacity of bandwidth and can support up to 1 Gbps /channel /fibre: Points: 3

Capacity sharing: Offers Capacity sharing in PON and does not offer in PTP networks. Points: 1
Symmetry: Symmetric, Points: 3
Max Range: It offers Maximum range and support up to 20 Km. Points: 3
Strengths: Gives high Bandwidth, Points: 3
Weaknesses: Expensive Deployment of Network, Points: 1
Bandwidth allocation: The amount allocated to the subscriber is governed by the interface type, or traffic shaping on the access node: Easy, Points: 3
Maximum bandwidth per subscriber: Good, Points: 3
Increasing Bandwidth: subscriber interfaces can be upgraded to include more bandwidth. Easy, Points: 3

Simplicity of deployment: Difficult. Requires new fibre access network overlay, Points: 1
Spectrum Usage: T Hz, Points: 3
Cost of CPE. The cost of CPE for optical networks is very high and in the years to come it will reduce as more people will be employing this technology. Points: 1
Cost of Network Technology: High, Points: 1
Network rollout cost: High, points: 1
Prioritizing services: Simple, Points: 3
Delay, jitter: Low, Points: 3
Impact of faults in the access node: Low, Points: 3
Effect of malfunctioning: Low, Points: 3
Space requirement: High, Points: 1
Energy Consumption: High energy consumption. Points: 1
Level of maintenance: Fiber optic cables and Equipment costs much less to maintain. Points: 3
Level of difficulty in identifying and eradicating malfunctions: Easy, Points: 3

2.3.2. HFC

The cable video HFC network [8][37] is a tree and- branch architecture that uses optical fiber to feed nodes and then coax to feed the subscribers. In this architecture, the bandwidth is shared among all subscribers on a node.

2.3.2.1 Parameters Studied

Capacity: It offers capacity of 3 to 100 Mbps depending on the type of technology used in different regions. Points: 2
Capacity sharing: yes. Points: 3
Symmetry: Asymmetric, Points: 1
Max Range: Up to 100 Km using amplifiers, Points: 2
Strengths: Uses Existing Cable Network, Points: 3
Weaknesses: Expensive Deployment of Network, Points: 1
Bandwidth allocation: The amount allocated to the subscriber is governed by the interface type, or traffic shaping on the access node: Difficult, Points: 1
Maximum bandwidth per subscriber: Medium, Points: 2
Increasing Bandwidth: subscriber interfaces can be upgraded to include more bandwidth. Medium, Points: 2
Simplicity of deployment: Easy if Cable network available, Points: 3
Spectrum Usage: 5-1000 MHz, 6-8 MHz/channel, Points: 3
Cost of CPE. The cost of CPE of HFC networks is very high and in the years to come it will reduce as more people will be employing this technology. Points: 1
Cost of Network Technology: High, Points: 1
Network rollout cost: High, points: 1
Prioritizing services: Difficult, Points: 1
Delay, jitter: Medium, Points: 2

Impact of faults in the access node: Medium, Points: 2
Effect of malfunctioning: Medium, Points: 2
Space requirement: High, Points: 1
Energy Consumption: High energy consumption. Points: 1
Level of maintenance: Medium. Points: 2
Level of difficulty in identifying and eradicating malfunctions: Medium, Points: 2

2.3.3. DSL

The DSL network [8] uses twisted-pair copper to feed subscribers from a central office or a remote "local point of presence" terminal. In this architecture, the bandwidth is dedicated to a single user, but shared among the three services (voice, data and video). Many different types of digital subscriber line (DSL) exist, with asymmetrical digital subscriber line (ADSL) being the most commonly deployed. The length of the copper loop affects the data rates that can be delivered to the individual subscriber [18][19].

2.3.3.1 Parameters Studied

Capacity: It offers capacity of 1.5 to 52 Mbps depending on the type of DSL technology used. Points: 2
Capacity sharing: low. Points: 1
Symmetry: Asymmetric, Points: 1
Max Range: 1 to 5 Km depending on the type of technology used and is medium. Points: 2
Strengths: Uses Existing POTS Network, Points: 3
Bandwidth allocation: The amount allocated to the subscriber is governed by the interface type, or traffic shaping on the access node: Difficult, Points: 1
Maximum bandwidth per subscriber: low, Points: 1
Increasing Bandwidth: subscriber interfaces can be upgraded to include more bandwidth. Medium, Points: 2
Simplicity of deployment: Simple. Points: 3
Spectrum Usage: up to 2.2 MHz, Points: 3
Cost of CPE. Low. Points: 3
Cost of Network Technology: Low, Points: 3
Network rollout cost: low, points: 3
Prioritizing services: Difficult, Points: 1
Delay, jitter: High, Points: 1
Impact of faults in the access node: High, Points:1
Effect of malfunctioning: High, Points: 1
Space requirement: High, Points: 1
Energy Consumption: Medium energy consumption. Points: 2
Level of maintenance: Low. Points : 3
Level of difficulty in identifying and eradicating malfunctions: difficult Points: 1

2.3.4. Power Line Communication (PLC)

Power line communication [8] or power line carrier (PLC), also known as Power line Digital Subscriber Line (PDSL), is a system for carrying data on a conductor also used for electric power transmission. Broadband over Power Lines (BPL) uses PLC by sending and receiving information bearing signals over power lines to provide access to the Internet.

Electrical power is transmitted over high voltage transmission lines, distributed over medium voltage, and used inside buildings at lower voltages. Power line communications can be applied at each stage.

All power line communications systems operate by impressing a modulated carrier signal on the wiring system. Different types of power line communications use different frequency bands, depending on the signal transmission characteristics of the power wiring used. Since the power wiring system was originally intended for transmission of AC power, in conventional use, the power wire circuits have only a limited ability to carry higher frequencies.

Data rates over a power line communication system vary widely. Low-frequency (about 100-200 kHz) carriers impressed on high-voltage transmission lines may carry one or two analog voice circuits, or telemetry and control circuits with an equivalent data rate of a few hundred bits per second; however, these circuits may be many miles long.

2.3.4.1 Parameters Studied

Capacity: It offers capacity of 2 to 4 Mbps per user, Points: 1
Capacity sharing: yes. Points: 3
Symmetry: Asymmetric, Points: 1
Max Range: Up to 3 Km in medium voltage and is low. Points: 1
Strengths: Uses existing power grid Network, Points: 3
Bandwidth allocation: The amount allocated to the subscriber is governed by the interface type, or traffic shaping on the access node: Difficult, Points: 1
Maximum bandwidth per subscriber: Low, Points: 1
Increasing Bandwidth: subscriber interfaces can be upgraded to include more bandwidth. Low, Points: 1
Simplicity of deployment: Easy. Points: 3
Spectrum Usage: 1-30 MHz, Points: 3
Cost of CPE. Cheap, Points: 1
Cost of Network Technology: Low, Points: 3
Network rollout cost: High, points: 1
Prioritizing services: Difficult, Points: 1
Delay, jitter: High, Points: 1
Impact of faults in the access node: High, Points: 1

Effect of malfunctioning: High, Points: 1
Space requirement: Low, Points: 3
Energy Consumption: Low energy consumption. Points: 3
Level of maintenance: Medium. Points: 2
Level of difficulty in identifying and eradicating malfunctions: Difficult, Points: 1

2.3.5. Comparative analysis of Fixed-line Technologies

The table given below shows which technology can offer maximum facilities for broad band access. All the points given to each parameter has been added here and result has been concluded.

Characteristics/ Technology	**Optical network**	**HFC**	**DSL**	**PLC**
Capacity	3	2	2	1
Capacity sharing	1	3	1	3
Symmetry	3	1	1	1
Max Range	3	2	2	1
Strengths	3	3	3	3
Bandwidth allocation	3	1	1	1
Maximum bandwidth per subscriber	3	2	1	1
Increasing Bandwidth	3	2	2	1
Simplicity of deployment	1	3	3	3
Spectrum Usage	3	3	3	3
Cost of CPE	1	1	3	1
Cost of Network Technology	1	1	3	3
Network rollout cost	1	1	3	1
Prioritizing services	3	1	1	1
Delay, jitter	3	2	1	1
Impact of faults in the access node	3	2	1	1
Effect of malfunctioning	3	2	1	1
Space requirement	1	1	1	3
Energy Consumption	1	1	2	3
Level of maintenance	3	2	3	2
Level of difficulty in identifying & eradicating malfunctions	3	2	1	1
TOTAL POINTS	49	38	38	36

From the table above, it is clear that Optical fibre technology is the best fixed line technology which can be used for broad band access. Though DSL technology is the technology of today and is used very commonly but keeping in view the future demand for bandwidth it is becoming less preferred among the broad band users.

2.4 Wireless Technologies

Broadband wireless communications have gained increased interest during the last few years [16]. The broadband wireless access approach to the “last-mile” access segment is becoming increasingly attractive to network operators and service providers since it offers a flexible and cost-effective solution to enable delivery of even broadband services to end customers. Eight wireless technologies have been considered for comparison on different characteristics. Some of these characteristics are different from fixed line technologies.

1. Microwave
2. MMDS (Multi-channel Multipoint Distribution Service)
3. LMDS (Local Multipoint Distribution Service)
4. FSO (Free Space Optics)
5. WiFi (Wireless Fidelity)
6. WiMax (Worldwide Interoperability for Microwave Access)
7. Satellite Technology
8. Third Generation (3 G) Mobile Networks

2.4.1 Microwave links

A **microwave link** [8] is a communications system that uses radio waves in the microwave frequency range to transmit video, audio, or data between two locations, which can be from just a few feet or meters to several miles or kilometers apart. Microwave links are commonly used by television broadcasters to transmit programmes across a country, for instance, or from an outside broadcast back to a studio. Bandwidth allocations of 50MHz in the carrier range 300MHz to 1GHz are typical. Involve line of sight (LOS) communication technology. Affected greatly by environmental constraints, including rain fade

A typical microwave radio consists of three basic components: a digital modem for interfacing with digital terminal equipment, a radio frequency (RF) unit for converting a carrier signal from the modem to a microwave signal, and an antenna to transmit and receive the signal. The combination of these three components is referred to as a radio terminal. Two terminals are required to establish a microwave communications link, commonly referred to as a microwave hop.

2.4.1.1 Parameter Studied

Data Rate (Throughput): up to 155 Mbps/Link, Points: 3
Typical Range: 5 Km, Points: 1
Spectrum Usage: 2, 4, 6, 21.3-23.6 GHz, > 40 GHz, Points: 3
Symmetry: Symmetric, Points: 1
Standardization: Yes, Points: 3
Licensed Required: Yes, Points: 1

Flexible bandwidth allocations: No, Points: 1
Higher number of user support: Medium, Points: 2
Attenuation: Low, Points: 3
Simplicity of deployment: Difficult, LOS needed, Points: 1
Space requirement: High, Points: 1
Energy Consumption: High, Points:1
Cost of CPE: High, Points: 1
Network rollout cost: High, Points: 1

2.4.2 MMDS (Multi-channel Multipoint Distribution Service)

Multichannel Multipoint Distribution Service (MMDS) [8], also known as **Wireless Cable and was previously called as Business Radio Service** (BRS), is a wireless technology, used for general-purpose broadband networking. It is most commonly used in sparsely populated rural areas, where laying cables is not economically viable, although some companies may also offer MMDS services in urban areas.

MMDS uses microwave frequencies from 2 GHz to 3 GHz in range. Reception of BRS-delivered television signals is done with a special rooftop microwave antenna and a set-top box for the television receiving the signals. The antenna usually has an integrated down-converter to transmit the signals at frequencies compatible with terrestrial TV tuners down on the coax (much like on satellite dishes where the signals are converted down to frequencies more compatible with standard TV coaxial cabling), some larger antennas use an external down-converter. The receiver box is very similar in appearance to an analogue cable television receiver box.

The MMDS band was separated into eleven "channels" which are auctioned off like other bands. The idea was that entities could own several channels and multiplex several television and radio channels onto each channel using digital technology. Each "channel" was capable of 10 Mbit/s, exclusive of any forward error correction technology that is required for this type of technology.

Parameter Studied

Data Rate (Higher throughput): up to 10 Mbps, Points: 2
Typical Range: 100 Km, Points: 3
Spectrum Usage: 21-27 GHz, Points: 3
Symmetry: Symmetric, Points: 1
Standardization: No, Points: 1
Licensed Required: Yes, Points: 1
Flexible bandwidth allocations: Yes, Points: 3
Higher number of user support: High, Points: 3
Low attenuation: Low, Points: 3
Simplicity of deployment: Difficult, Points: 1
Space requirement: Medium, Points: 2
Energy Consumption: Low, Points: 3
Cost of CPE: Medium, Points: 2
Network rollout cost: Medium, Points: 2

2.4.3 LMDS (Local Multipoint Distribution Service)

LMDS [8] is a broadband wireless access technology governed by the IEEE and is outlined by the 802 LAN/MAN Standards Committee through the efforts of the IEEE 802.16.1 Task Group. The technology is also named as "WiBAS" (Wireless Broadband Access System)

LMDS commonly operates on microwave frequencies across the 26 GHz and 29 GHz bands. In the United States, frequencies from 31.0 through 31.3 GHz are also considered LMDS frequencies. LMDS was conceived as a broadband, fixed wireless, point-to-multipoint technology for utilization in the last mile.

Throughput capacity and reliable distance of the link depends on common radio link constraints and the modulation method used - either phase-shift keying or amplitude modulation. In general deployment links of up to 5 miles (8 km) from the base station are possible, but distance is typically limited to about 1.5 miles (2.4 km) due to rain fading attenuation constraints. Some point-to-point systems also use the LMDS frequencies and can reach slightly farther distances due to increased antenna gain.

Parameter Studied

Data Rate (Higher throughput): Up to 155 Mbps/link, Points: 3
Typical Range: 4 Km, Points: 2
Spectrum Usage: 28-31 GHz, Points: 3
Symmetry: Symmetric, Points: 1
Standardization: No, Points: 1
License Required: Yes, Points: 1
Flexible bandwidth allocations: Yes, Points: 2
Higher number of user support: Yes, Points: 3
Low attenuation: Low, Points: 3
Simplicity of deployment: Difficult, Points: 1
Space requirement: Medium, Points: 2
Energy Consumption: Medium, Points: 2
Cost of CPE: Medium, Points: 2
Network rollout cost: Medium, Points: 2

2.4.4 FSO (Free Space Optics)

Free-space optics (FSO) [8] is a technology that offers full-duplex Gigabit Ethernet throughput and can be installed license-free worldwide. FSO offers fast, high ROI and an easy method for installation.

FSO is a line-of-sight technology that uses invisible beams of light to provide optical bandwidth connections that can send and receive voice, video, and data information. Today, FSO technology has enabled the development of a new category of outdoor wireless products that can transmit voice, data, and video at bandwidths up to 1.25 Gbps. This optical connectivity doesn't require expensive fiber-optic cable or securing spectrum licenses for radio frequency (RF) solutions. FSO technology requires light. The use of light is a simple concept similar to optical transmissions using fiber-optic cables; the only difference is the medium. Light travels through air faster than it does through glass, so it is fair to classify FSO technology as optical communications at the speed of light.

Parameter Studied

Data Rate (Higher throughput): Up to 2.5 Gbps: Points: 3
Typical Range: 4 Km: Points: 2
Spectrum Usage: THz (infra-red), Points: 3
Symmetry: Symmetric, Points: 1
Standardization: No, Points: 1
License Required: No, Points: 3
Flexible bandwidth allocations: Yes, Points: 3
Higher number of user support: Yes. Points: 3
Low attenuation: Yes, Points: 3
Simplicity of deployment: Difficult, Points: 1
Space requirement: Low, Points: 3
Energy Consumption: Low, Points: 3
Cost of CPE: Medium, Points: 2
Network rollout cost : Medium, Points: 2

2.4.5 WiFi (Wireless Fidelity)

Wi-Fi is wireless local area network based on the IEEE 802.11 standards [14][15]. Wi-Fi works with no physical wired connection between sender and receiver by using (RF signals, a frequency within the electromagnetic spectrum associated with radio wave propagation. When an RF current is supplied to an antenna, an electromagnetic field is created that then is able to propagate through space.

Wi-Fi is popular wireless networking technology that uses radio waves to provide wireless high-speed Internet and network connections. The Wi-Fi Alliance, the organization that owns the Wi-Fi (registered trademark) term specifically defines Wi-Fi as any "wireless local area network (WLAN) products that are based on the Institute of Electrical and Electronics Engineers' (IEEE) 802.11 standards."

Initially, Wi-Fi was used in place of only the 2.4GHz 802.11b standard, however the Wi-Fi Alliance has expanded the generic use of the Wi-Fi term to include any type of network or WLAN product based on any of the 802.11 standards, including 802.11b, 802.11a, dual-band, and so on. Wi-Fi uses both single-carrier direct-sequence spread spectrum radio technology (part of the larger family of spread spectrum systems) and multi-carrier orthogonal frequency-division multiplexing (OFDM) radio technology.

As of 2009 Wi-Fi technology had spread widely within business and industrial sites. In business environments, just like other environments, increasing the number of Wi-Fi access-points provides redundancy, support for fast roaming and increased overall network-capacity by using more channels or by defining smaller cells.

Parameter Studied

Data Rate (Higher throughput): 2, 11, 54 Mbps (Depending on standard), Points: 2
Typical Range: 100 meter: Points: 1
Spectrum Usage: 2.4, 5.7 GHz, Points: 3
Symmetry: Symmetric, Points: 3
Standardization: Yes, Points: 3
License Required: No, Points: 3
Flexible bandwidth allocations: yes, Points: 3
Higher number of user support: Yes, Points: 3
Low attenuation: low, Points: 2
Simplicity of deployment: Easy, Points: 3
Space requirement: Medium, Points: 2
Energy Consumption: Medium, Points: 2
Cost of CPE: Medium, Points: 2
Network rollout cost: Medium, Points: 2

2.4.6 WiMax (Worldwide Interoperability for Microwave Access)

WiMAX [8] stands for Worldwide Interoperability for Microwave Access and it is based on IEEE 802.16 standards. It works same as Wi-Fi does but it is more improved and efficient then WiFi and it can route data to Wi-Fi that is Wi-Fi devices can take advantage of **WiMAX connection** [15]. **WiMAX technology** provides higher speed connection up to 70 Mbps over the area of 30 miles. There is no need for line of sight connection between subscriber terminals and the base station in **WiMAX technology** and it can support hundreds if not thousands of subscribers from a single base station. It is also specified in **802.16** standards that it will supports low latency applications such as voice, video, and Internet access at the same time.

WiMAX is a wireless digital communications system, also known as IEEE 802.16 that is intended for wireless "metropolitan area networks". WiMAX can provide broadband wireless access up to 30 miles (50 km) for fixed stations, and 3 - 10 miles (5 - 15 km) for mobile stations. With WiMAX, WiFi-like data rates are easily supported, but the issue of interference is lessened. WiMAX operates on both licensed and non-licensed frequencies, providing a regulated environment and viable economic model for wireless carriers.

WiMAX can be used for wireless networking in much the same way as the more common WiFi protocol. WiMAX is a second-generation protocol that allows for more efficient bandwidth use, interference avoidance, and is intended to allow higher data rates over longer distances.

Parameter Studied

Data Rate (Higher throughput): Up to 70 Mbps, Points: 2
Typical Range: Up to 50 Km, Points: 2
Spectrum Usage: 2-11 GHz (Licensed), 10-66 GHz (unlicensed), Points: 3
Symmetry: Symmetric, Points: 1
Standardization: No, Points: 1
License: Yes, Points: 1
Flexible bandwidth allocations: Yes, Points: 2
Higher number of user support: Yes, Points: 3
Low attenuation: Yes, Points: 2
Simplicity of deployment: Easy, Points: 3
Space requirement: Medium, Points: 2
Energy Consumption: Medium, Points: 2
Cost of CPE: Medium, Points: 2
Network rollout cost: Medium, Points: 2

2.4.7 Satellite Technology

A **communications satellite** [8] is an artificial satellite stationed in space for the purpose of telecommunications. For fixed (point-to-point) services, communications satellites provide a microwave radio relay technology. They are also used for mobile applications such as communications to ships, vehicles, planes and hand-held terminals, and for TV and radio broadcasting. Satellite Technology is based on space satellite (relay) and ground receivers. A commonly used receiver is VSAT (Very Small Aperture Terminal).

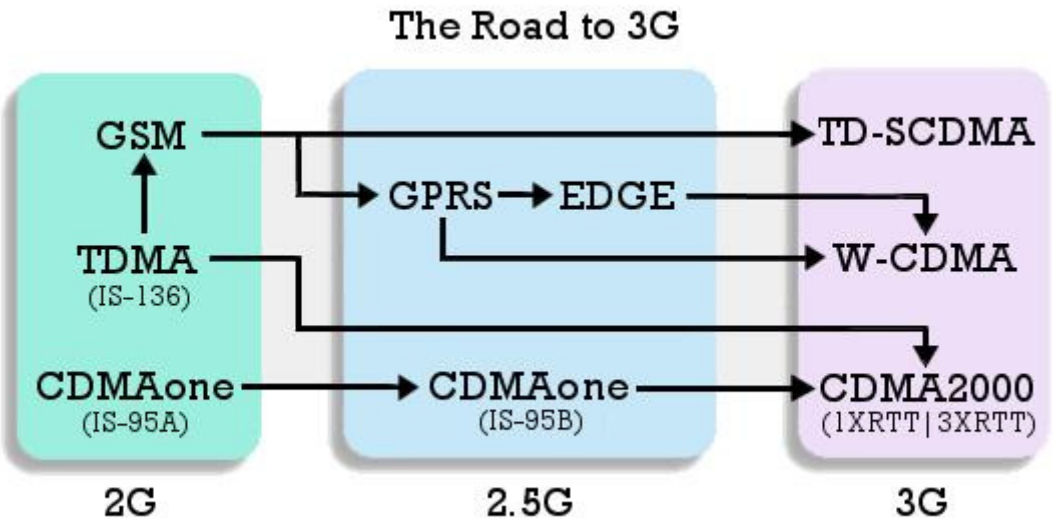
It has unique advantage is that it can cover the entire globe. The main disadvantages are its low speed, higher installation cost and monthly charges as compared with other access technologies.

Parameter Studied

Data Rate (Higher throughput): Up to 155 Mbps (down link), Points: 3
Typical Range: 1000-30,000 Km, Points: 3
Spectrum Usage: 11.7-17.8, 20-30 GHz (Licensed), Points: 3
Symmetry: Asymmetric, Points: 3
Standardization: Yes, Points: 3
Licensed: Yes, Points: 1
Flexible bandwidth allocations: Yes, Points: 3
Higher number of user support: Yes, Points: 3
Low attenuation: Low, Points: 2
Simplicity of deployment: Medium, Points: 2
Space requirement High, Points: 1
Energy Consumption: High, Points: 1
Cost of CPE: High, Points: 1
Network rollout cost: High, Points: 1

2.4.8 Third Generation (3 G) Mobile Networks

Until recently user need for mobile communication were focused for voice, which can be easily transmitted. However nowadays, a diverse range of media which includes images and videos started to gave new dimensions to our life. Now users would like to share to share images, video, music and this kind of data is much more demanding (in terms of the data rate). Moreover from a business perspective, the possibility to have higher data rates and therefore to send bigger files would allow better efficiency and mobility. This is where 3G and 4G enter the game**.** These technologies, with 3G already in early stages of deployment, will allow users to transmit data with stable connections and better data rates**.**



3G technology has been developed and is ready, already deployed in some cases. The International Telecommunication Union (ITU) tried to develop a unique global 3G standard. The main standards under that name are:

- W-CDMA (Wideband Code Division Multiple Access), it uses the GSM infrastructure but with a CDMA air interface, it is used by UMTS (Universal Mobile Telecommunications System**,** the European standard, data rate up to 384 Kbps), FOMA (Freedom of Mobile Multimedia Access, it is the Japanese standard) and HSPA (High Speed Packet Access, it is an enhancement of UMTS, practical data rate up to 7.2 Mbps)
- CDMA-2000 (data rate up to 3.1 Mbps), the evolution of CDMA-one (it includes EV-DO, Evolution Data Optimized)
- TD-CDMA/TD-SCDMA, both are mixing TDMA and CDMA, the difference is that TD-SCDMA is developed by China so they can avoid the cost of using the proprietary technology

In Asia**,** Japan and South Korea are the most advanced country in mobile phone technology**.** NTT DoCoMo in Japan has deployed 3G four years ago and has 20 million 3G customers. The firm is currently pushing to develop 4G capacity and expects to begin 4G services by 2010.

Parameter Studied

Data Rate (Higher throughput): Up to 2 Mbps / Mobile, Points: 2
Typical Range: 3-5 Km (depends on coverage area), Points: 2
Spectrum Usage: 1.92- 1.98 GHz, 2.11-2.17 GHz, Points: 3
Symmetry: Symmetric, Points: 1
Standardization: Yes, Points: 3
License: Yes, Points: 1

Flexible bandwidth allocations: Yes, Points: 3
Higher number of user support: Yes, Points: 3
Low attenuation: Low, Points: 3
Simplicity of deployment: Easy, Points: 3
Space requirement: Low, Points: 3
Energy Consumption: Low, Points: 3
Cost of CPE: Low, Points: 3
Network rollout cost: High, Points: 1

2.4.9 Comparative analysis of wireless Technologies

All the points for the above technologies have been consolidated in the table below:

Parameter/Tech	Microwave	MMDS	LMDS	FSO	WiFi	WiMax	Sat	3G
Data Rate (Higher throughput)	3	2	3	3	2	2	3	2
Typical Range	1	3	2	2	1	2	3	2
Spectrum Usage	3	3	3	3	3	3	3	3
Symmetry	1	1	1	1	3	1	3	1
Standardization	3	1	1	1	3	1	3	3
License	1	1	1	3	3	1	1	1
Flexible bandwidth allocations	1	3	2	3	3	2	3	3
Higher number of user support	2	3	3	3	3	3	3	3
Low attenuation	3	3	3	3	2	2	2	3
Simplicity of deployment	1	1	1	1	3	3	2	3
Space requirement	1	2	2	3	2	2	1	3
Energy Consumption	1	3	2	3	2	2	1	3
Cost of CPE	1	2	2	2	2	2	1	3
Network rollout cost	1	2	2	2	2	2	1	1
Total	**23**	**30**	**28**	**33**	**34**	**28**	**30**	**34**

From the analysis given in the table above, it is evident that WiFi and 3G are the most promising wireless access technologies for NGN as both the technologies got 34 points. FSO is also a technology of the future where it can support high bandwidth but there are some constraints of this technology during fogy and misty weather.

2.5. Recommendations for NGN

It is necessary to consider that a generic comparison of technologies, such as this one, cannot always apply in all cases. The balance can easily shift from one side or the other depending on statutory, commercial or structural constraints.

As Optical networks are on the increase, it is likely that some of the disadvantages of optical network listed here will gradually be eliminated. However some of the inherent features of optical network will remain. But one thing is almost certain, the fibre optic based access network, and therefore end customer products too, will constantly be upgraded to handle more than 50 Mbps.

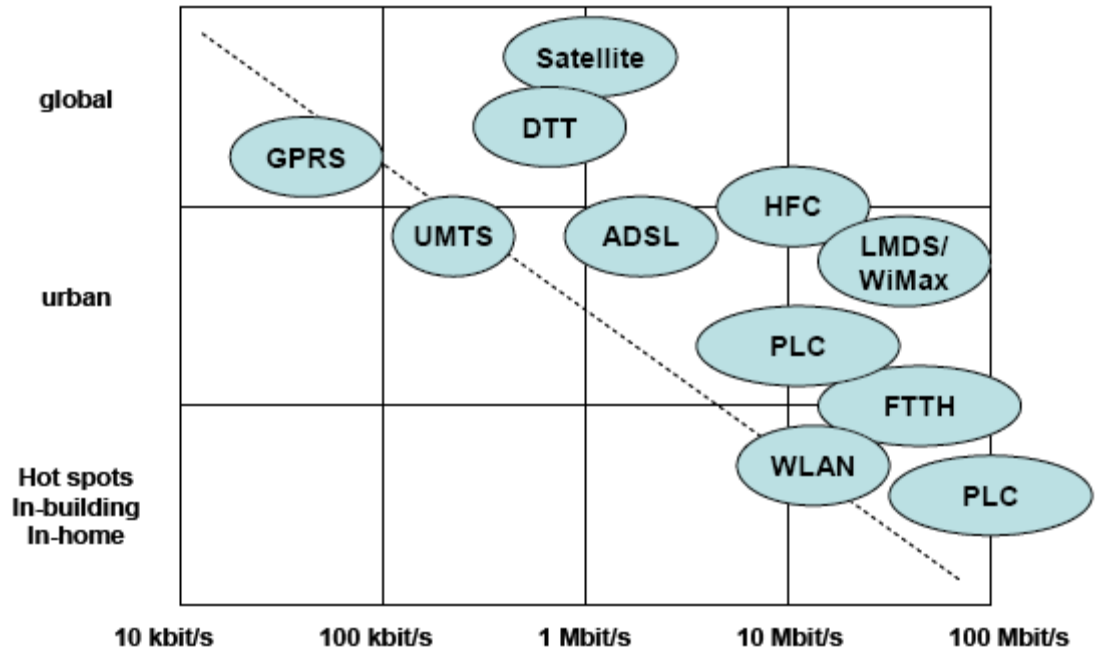


Figure: Coverage versus bit rate analysis for access technologies

Similarly, from the figure above in can be observed that LMDS and WiMax are the wireless technologies that are proving to be best for broad band access and providing better bandwidth for multimedia application in future NGN environment.

It is evident that the wireless growth engine is data i.e. text messaging, instant messaging (IM), video, games, social networking, and more. Data applications are exciting and more popular among younger subscribers, but rising data ARPU (average revenue per user) has not contributed into rising total ARPU. There is increasing demand that Carriers need to push the technology envelope to translate data ARPU into increased total ARPU. There is rapid technology evolution and spectrum is becoming more costly. Just a year ago, the industry was talking about 3G technologies; now plans for 4G are under way.

Media-driven entertainment companies are expected to play a major role in the development and dissemination of next-generation entertainment. Digital media is moving to the Internet, and this migration represents a unique way to connect content creators to consumers in a customizable fashion. As stated above, video takes a tremendous amount of bandwidth. Networks will have to work together to handle the huge volume of traffic, which increases the value proposition of telecom companies that can provide adequate bandwidth.

The wireless broadband sector continues to evolve as worldwide demand for wireless connectivity increases. Although wireless broadband is still in the stage of developments but in 2008 it has become apparent that WiMAX and Long-term evolution are emerging as the most likely technologies for the Next Generation Mobile Networks. However attitudes towards the two technologies are divided, differing at a regional level and also between the types of service providers. While LTE it is still in the development process, WiMAX is beginning to be launched after standardization three years ago. LTE is also gaining industry support particularly from the mobile operators, as it offers a migration path to 4G from existing 3G/HSPA technologies.

Chapter 3
NGN Structure in NTT Japan

3.1 Introduction

Japan has been relatively late in joining the broadband revolution, but started to show rapid growth in 2001. A major reason for the delay has been the slow liberalisation of the telecommunications market, which has allowed the incumbent NTT (Nippon Telegraph and Telephone) to control the market in many ways [28].

Liberalisation began in 1999, when NTT was re-organized into a holding company with five major businesses, namely NTT East, NTT West (local telephone companies), NTT Communications (long distance), NTT DoCoMo (mobile), and NTT Data (information services). Following liberalisation, broadband growth picked up rapidly and by the end of June 2009 Japan was the third largest broadband nation in the world after the USA and China.

Japan telecommunication services market witnessed the rapid infiltration of fiber to the home (FTTH) in 2007 [10]. While IP WAN services continued to grow, the debut of low-cost services caused service prices to fall and widened the lower-end of the market. To promote the creation of new next-generation network (NGN) markets, it is important for carriers to strengthen communications and build win-win relationships with providers of upper-layer services [40].

Major trends in Japan's telecommunications industry in 2008 were [28][29]:

- Rapid penetration of FTTH
- Start of NGN service
- Development of FMC

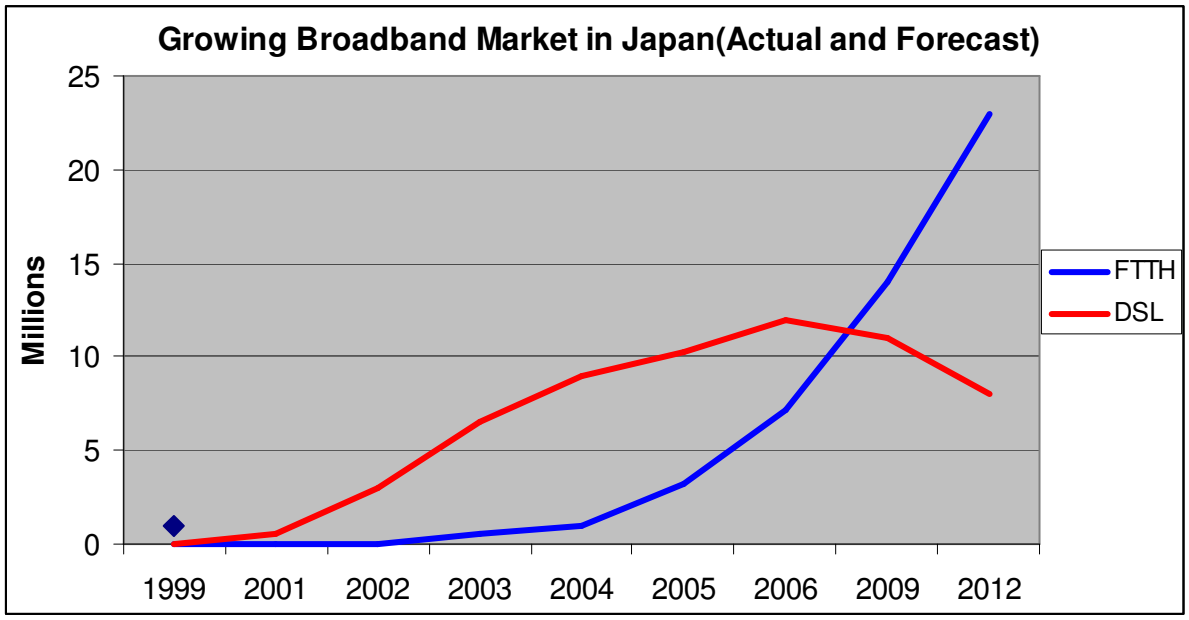
Fiber-to-the-Home (FTTH) According to the Ministry of Internal Affairs and Communications (MIC) announcement in June 2008, the number of FTTH subscribers (13.1 million) surpassed the number of DSL subscribers (12.3 million) for the first time. Total broadband service subscriber number is 29.3 million, an 8% increase from the previous year.

General description of NGN is that one network transports all information and services (voice, data, and all sorts of media such as video). NGN is commonly built around the Internet Protocol (IP) and is also the necessary network service to realize

Fixed-Mobile Convergence (FMC). Nippon Telegraph and Telephone (NTT), Japan's largest telecommunication service provider, started NGN service in March 2008.

3.2 Broadband in Japan

As of November 2008, the total volume of traffic downloaded by Japan's broadband users was estimated at an average of 990 Gbps, showing an increase of 21.6 per cent year on year. In March 2009, broadband household penetration stood at 63 per cent and 1 Gbps download speeds was quite common. But the government has an even more ambitious target, to provide 100 per cent broadband coverage and 90 per cent ultra high speed FTTH coverage by mid-2010. This goal has been backed by the consistently heavy investment over the last decade, with JPY 865 billion invested in 2008 alone [38].



Growing Broadband Market in Japan

At the end of December 2008, there were 58.76 million fixed lines in Japan. The combined share of NTT East and NTT West was 85.1 per cent. Fixed line market is shrinking due to the increasing popularity of VoIP and mobile communications including 3G, and by the end of December 2008 there were 19.59 million VoIP subscribers. NTT is doing well in this market too – while the shares of Softbank BB and NTT Communications Corp dropped to 21.4 per cent and 15.5 per cent respectively, the share of NTT East and NTT West continued to increase and reached 37.4 per cent (up 7.9 per cent year on year).

NTT East and NTT West introduced ADSL over a decade ago. Market liberalization resulted in the entry of new broadband access providers and over the last few years broadband access prices fell dramatically while ADSL speeds reached 50 Mbps. DSL subscriber numbers peaked in 2006. Since then it started falling, with an increasing number of customers choosing high speed FTTx services. In June 2009, the number of FTTx subscribers for the first time exceeded that of DSL customers [28]. The price/speed comparison of different broadband services (ISDN, ADSL, and FTTx) is shown in figure below.

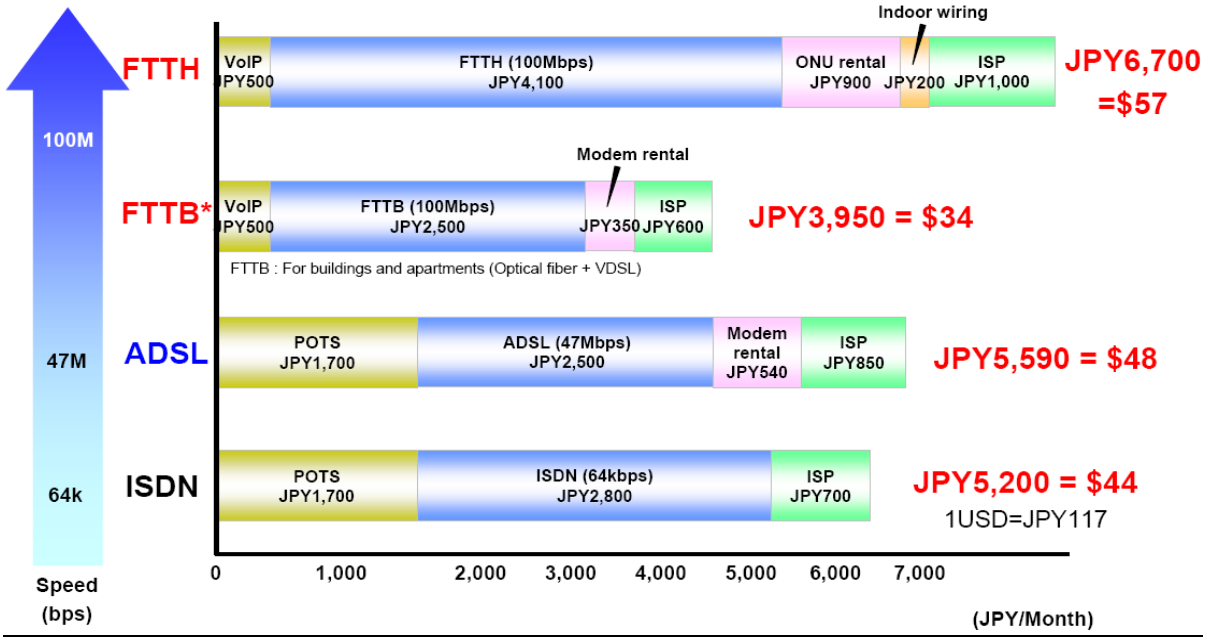


Figure: Monthly charges of broadband services in Japan

Despite liberalisation, the government still owns over 30 per cent of NTT. As a result, the operator faced less pressure from capital markets for short-term profits and was less nervous to invest in fibre network deployment. Also, NTT used profits from its mobile division, NTT DoCoMo, to invest in FTTH, and today NTT has the largest FTTH network in the world in terms of homes passed. In densely populated areas GE-PON is the most popular fibre access technology used mainly by NTT East, NTT West, and KDDI. In most cases the operators use FTTB, combining GE-PON with 100 Mbps VDSL.

As of April 2009, there were 107.84 million mobile subscribers in Japan resulting in the penetration rate of over 80 per cent. The NTT DoCoMo and KDDI shares fell slightly to 49.1 per cent and 27.7 per cent respectively, while the share of Softbank Mobile (ex Vodafone Japan) increased slightly to 18.1 per cent. A recent entrant,

eMobile (a subsidiary of eAccess), continued its network expansion and by early 2009 had signed up over 1.2 million subscribers [39].

At the end of 2008, there were 92.72 million mobile broadband subscribers. Japan does not stop there however – it has plans to move to 4G in the next few years. DoCoMo is a leader when it comes to developing the fourth generation LTE (Long Term Evolution) standard. The operator plans to invest JPY 300-400 billion in LTE during the next five years and to cover 50 per cent of the population with the new network by 2014. Commercial LTE services are expected to be launched in mid of 2010.

IDC Japan attributes the FTTH expansion to aggressive sales by service providers and lowered subscription fees, and analyzes that the FTTH market will dominate. ADSL users, are forced to switch to high-speed FTTH as more and more housing complexes are fitted with FTTH connectivity. From 2005 to 2009, the compound annual growth rate of the FTTH market is about 40%, while that of the ADSL market 5.5%, which is about 13 million FTTH users and 17 million ADSL users by 2009.

ADSL users who do not feel compelled move on FTTH may continue to use to the current service, and entry-type ADSL service has also been introduced at an affordable price, allowing the ADSL market to be kept substantially large. IDC Japan forecasts that, although FTTH will definitely expand, ADSL will continue to keep more than a 50% share until 2009 as subscribers to narrowband services are likely to upgrade to ADSL.

3.3 IPTV in Japan

Japanese telecoms company NTT has adopted its IPTV service 'Hikari-TV' running on IPv6, the next-generation Internet network protocol. Hikari-TV has been running commercially across NTT's IPv6-based, fibre-to-the-home (FTTH) network since March 2008, and first large-scale, commercially successful application of an IPTV service that runs over an IPv6 network. There are similar product offerings like IPTV in other parts of the world, but this one is using a network built from the ground up for IPv6.

It delivers both live and on-demand content to "hundreds of thousands" of subscribers in Japan for prices ranging from US$ 26-36 per month. The service is operated by subsidiary NTT Plala, and offers high-definition content and over 10,000 VOD titles, as well as more than 13,000 karaoke titles.

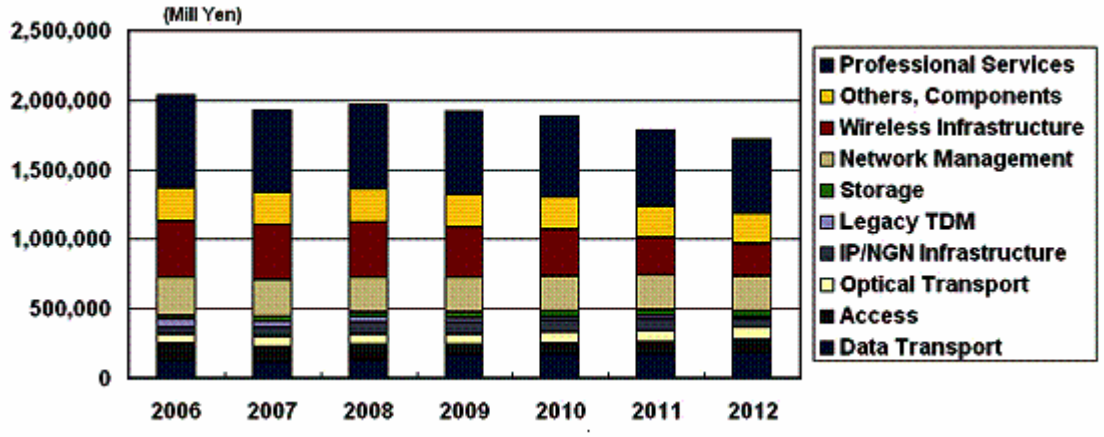
IPv6 is deemed necessary as the Internet's main communications protocol, IPv4, uses 32-bit addresses and can support approximately 4.3bn individually addressed

devices on the Internet - a total expected to be filled up by 2012. IPv6 on the other hand uses 128-bit addresses and can support many, many more devices.

NTT reports [10] that it is releasing details about its IPv6-based IPTV service in the hope of encouraging more organisations to adopt IPv6. NTT Plala is reportedly putting a number of features of IPv6 to the test with Hikari-TV, with features performing well so far including the abundant address space offered, the ability to deliver multicast broadcast streams and the Quality of Service (QoS) features which enable the preservation of bandwidth for IPTV, VoIP and data transmission.

3.4 FTTH in Japan

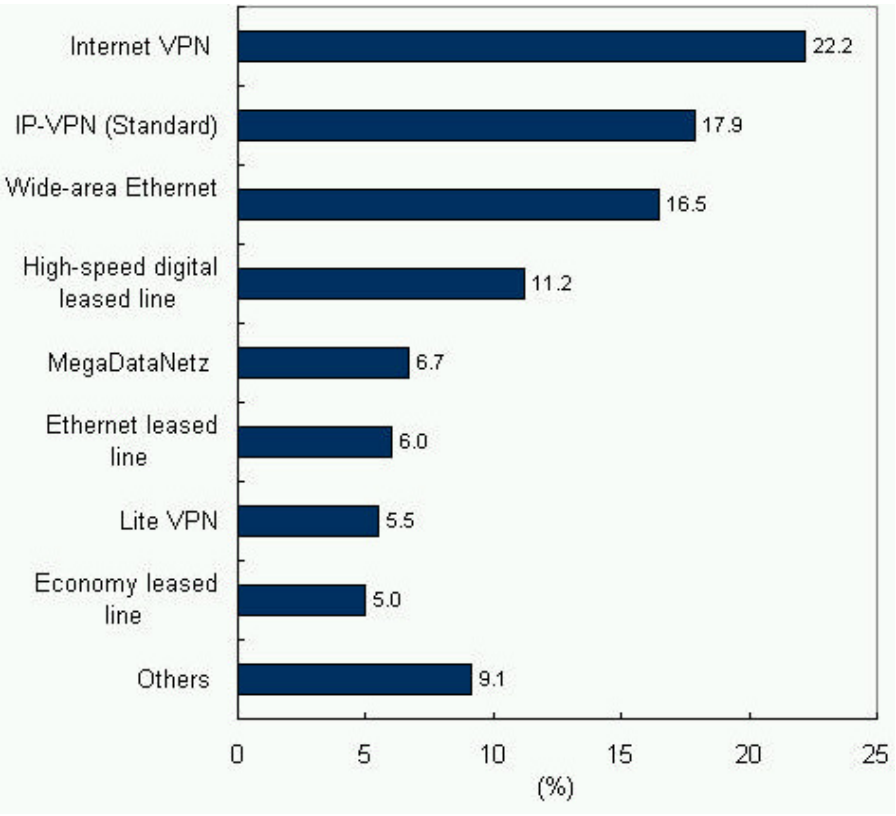
About 10.5 million of FttH's 15 million subscribers are in Japan where carriers are still adding as many as 300,000 new customers each month. In Japan, DSL uptake started to decline in early 2006 and the technology now loses about 300,000 customers per quarter, mainly to FttH architectures which are growing by nearly 900,000 customers per quarter [38].



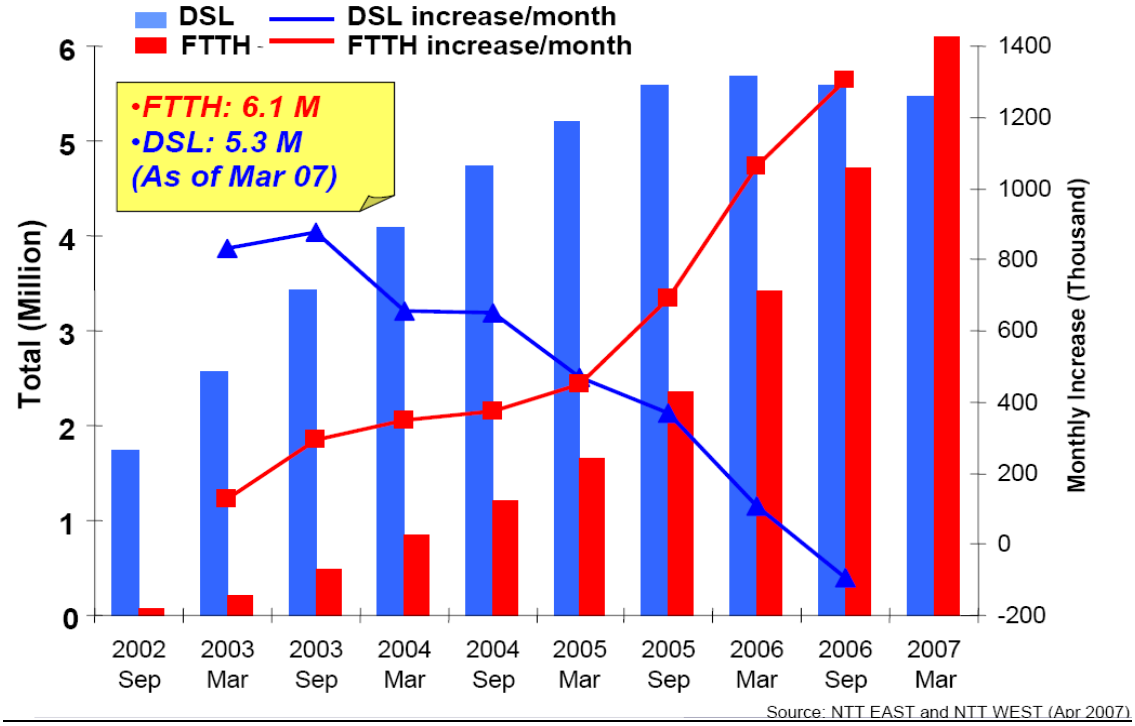
Japan Carrier Capex Market Forecast, 2006-2012: (Source: IDC)

Japan's Ministry of Internal Affairs and Communications began urging domestic Telecommunications operators in 2005 to have Next Generation Networks in place by 2007. This was designed to enable Japan to have working standards sorted out one year before the ITU international NGN standards were determined, giving Japan an international competitive advantage in NGN equipment manufacture.

The city of Osaka became a battleground for FttH in 2003. NTT West and K-Opticom ran promotional campaigns for their FttH services, resulting in strong price competition. One impact of this explosion in FttH services on Japan's broadband market has been for the copper wire-based broadband providers to increase the speed of their offerings. Two key broadband wholesalers – NTT and eAccess – have pushed their DSL services into the 40Mb/s range [39].



% age Spread of Technologies used in Japan



Broadband subscribers of NTT

3.5 Conclusion

Optic fiber dominates Japan's broadband market. According to June 2008 survey by the Japanese Ministry of Internal Affairs and Communications (MIC), the number of fiber-to-the home (FTTH) subscribers has surpassed the number of DSL subscribers for the first time. Also, NTT started NGN (Next Generation Network) service in March 2008, which will lead to Fixed-Mobile convergence (FMC) service. The schedule of the roll out of NGN in Japan is given in the following table:

2008	2009	2010	2011	2012
Launch of NGN services commercialization (March 2008)	1. Reinforce and enhance NGN & 3G network services 2. Create services through partnership with application providers etc.	Deployment of both fixed and mobile full-IP network infrastructure (Establishment of the service convergence infrastructure)	Progress full-fledged service convergence	Full-scale rollout of broadband and ubiquitous services

Adding to fixed broadband, wireless broadband is emerging. Next generation broadband wireless communication service using 2.5GHz band will start in this year.

The broadband penetration will likely reach 50% and a shift to data rates of 24 Mb/s to 100 Mb/s has begun. By 2010, 75% broadband penetration is likely, with 10% to 20% of households subscribing to very high-speed-broadband. Broadband will eventually be adopted by most households as websites become increasingly designed for broadband, e-mail attachments (e.g., photo collections) grow large, and new services such as VoIP become widely adopted.

Bandwidth increases reflect the general tendency for demand to increase along with computing power and memory. They will also reflect the demand for specific services such as IP video that require more bandwidth. TFI forecasts IP video penetration of 40% in 2010, with high definition IP video penetration of 20%. A shift to much higher data rates in the range of 24 Mb/s to 100 Mb/s has already begun. So far, only a few places have access at these rates, notably Japan.

Chapter 4
Dimensioning & Optimization of NGN (DO-NGN)

4.1 Introduction

The performance of network services depends on a variety of interacting elements and control functions in a multi-layered environment. NGN consist of a large number of stochastic layers and components, with unpredictable behavior such as links, routers, topology, routing protocols, transmission protocols and traffic characteristics. These components impact in a complex and integrated manner the overall network performance and, as a consequence, they impact the overall network QoS as users perceive it. Dimensioning of NGN as multi-layered complex systems supports the engineering task to design and manage networks which provide a whole spectrum of services, each with its QoS requirements.

Basic understanding of all network components is required for efficient planning, operations and resource management in multi-service IP networks. This includes the modeling of different traffic classes in multi-service environments. For dimensioning of network different models, one needs to be studied for various traffic types, and resource allocation like bandwidth, etc affect in performance evaluation.

The quality of service delivered to end users is a result of many factors, including the 'end-to-end' bandwidth availability and not just sufficient capacity in the final access network. The speed and reliability with which data are delivered are dependent on at least four groups of the network:

- Speed and capacity of the source (servers and interconnect links into the public internet of the web site)
- Throughput of the core network(s) of the carriers through which the information travels from the website to the ISP of the specific user;
- Capacity of the ISP network.
- Speed and capacity in the 'last mile'.

At present, video services represent a challenge for the core and backhaul parts of the network, rather than the last mile.

Network dimensioning and optimization are two key components to provide multi-service QoS guarantees without overprovision. Network dimensioning makes the networks not to work with overburden always. Network optimization provide QoS guaranteeing for important applications or real-time applications in case network is congested or in overburden. Network engineering has to resolve the trade-off between capacity and QoS requirements [2]. Traffic theory currently plays a very minor role in the design of the Internet. Network dimensioning is generally based on simple rules of thumb while considerable effort is spent on the design of variety network optimizing mechanisms. Jim W. Roberts argued that traffic theory, an

essential component in the design of traditional telecommunications networks, should be increasingly applied in the development of the multi-service Internet [3].

4.2 Dimensioning Criteria

It is important for a Telco's to know how much busy-hour traffic its Networks are handling. In particular, it needs to know when a network is becoming overloaded and additional routes shall be offered to the traffic. Thus, the traffic should be measured regularly and records kept. On the basis of these records future traffic can be forecasted. In order for the forecast to be as accurate as possible, it should be derived from figures for the present traffic which are as accurate as possible. Comparing and analyzing the transmission bandwidth demand and resource presently available is the best way for Dimensioning of Network. Bandwidth demand forecast and network resource present conditions are not the only requirements for network design, a lot of factors are involved in network planning, for example service characteristics, requirements, services developing trend, transmission technology ever development are also factors not to be excluded.

For the analysis, we need to create a traffic model to predict the bandwidth needs of the subscriber up to 2012. The method used to calculate the bandwidth needs was based on two factors:

1. Bandwidth per application
2. Number of digital streams required by the user.

The number of digital streams delivered to the subscriber is also increasing. Three streams that are commonly used are data, voice and video. There are other factors that can increase the amount of streams. Some of the factors include:

- Number of available TVs (SDTV & HDTV)
- Number of TVs with "picture-in picture" capabilities
- Number of phones
- Number of computers with broadband Internet connection
- Number of digital video recorders

Digital video recorders create an additional requirement for a digital stream as someone can be watching one channel and recording another one at the same time. In this case, two digital streams of video are being sent to the subscriber at the same time. For example, in 2005 the data was calculated as follows:

- 1 high-speed data stream at 4 Mbps
- 3 voice streams at 0.064 Mbps
- 1 video on demand at 4 Mbps
- 1 standard TV at 4 Mbps
- 1 HDTV at 13 Mbps

- A DVR factor of less than 1 extra stream at 4 Mbps

Multiplying and adding, one can assess that in 2005, the maximum amount of bandwidth required for a residential subscriber is almost 26 Mbps. Improvements in compression were taken into account, but the analysis shows that by 2012 the "power user" will require close to 100 Mbps of bandwidth and the "average user" will require over 40 Mbps of bandwidth even with compression.

Bandwidth requirement depends on the type and number of applications a customer will use over the Internet. Applications such as Web pages, video, music, software downloads and pictures will drive the need for greater bandwidth. For example, digital photos had an average file size of 44 Kb in 2003 but with the advent of new digital cameras like 5+ megapixel, this type of file size has gone up to 1-5 MB per picture.

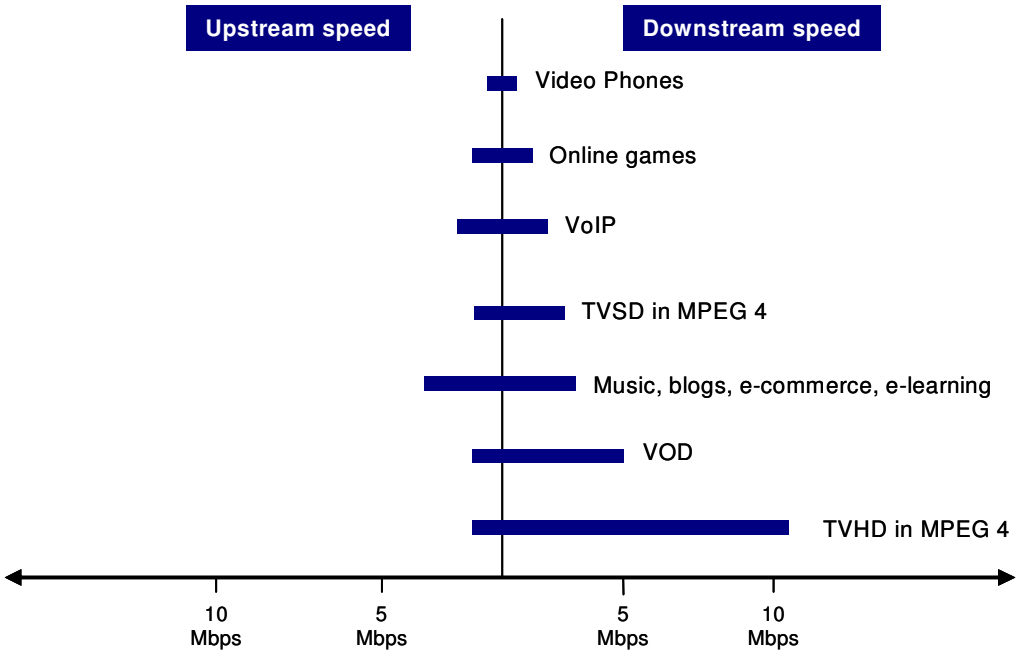
Video will be an important application for the residential subscriber. Standard television (SDTV) and high-definition television (HDTV) all require video compression to reduce the size of the data stream so they can be deployed over an access infrastructure.

Some of the standards used to deliver digital television are:

- MPEG2
- MPEG4
- ITU-T rec. H.263
- ITU-T rec. H.264/AVC

Motion Pictures Expert Group (MPEG) and the ITU-T's recommendation H.263 are the standards used for delivery of digital video. All these methods use different compression techniques to reduce the size of the video stream. Compression technologies enable standard digital TV (SDTV) to be compressed to 4 Mbps, and with improvements in technology (MPEG4) this could possibly get reduced to 2 Mbps. HDTV can be delivered at 10-16 Mbps today. With MPEG4 technology improvements, this may be reduced to 6-8 Mbps in the future. Digital pictures and video are just two of the many applications that are driving the need for more residential bandwidth.

The following figure shows the minimum bandwidth requirement for upstream and downstream.



Minimum bandwidth requirements

4.3 Bandwidth Requirements

Bandwidth requirements for digital video may encounter a strong surge as more households adopt these technologies in three to five years. Presently there are more than 1.2 billion TV households world wide. Transmission speeds needed to support HDTV depend on the compression technology. With MPEG-2 compression, an HDTV signal will require 15 Mbps to 20 Mbps but with MPEG-4 streaming HDTV over digital channels ranged from 5 Mbps to 10 Mbps.

Channel	Bit rate(Mbps)
Internet (Average User)	5
Internet (High user)	10
Telephony	0.1
SDTV Uncompressed	210
SDTV with MPEG-2	3
SDTV with MPEG-4	1.5
HDTV Uncompressed	800+
HDTV with MPEG-2	12-16
HDTV with MPEG-4	6-8

Source: ITU CRU

Table: Bandwidth requirement for user

In the table above, Internet speeds are reported as the downstream bit rate. Upstream has a lower bit rate in many carriers' offerings. High

users require higher-speed Internet for video editing, video conferencing, large-file downloads, high-end gaming, etc. The 10 Mbps proposed for high user requirements may be conservative. High-end offerings from some carriers extend to 30 Mbps or 50 Mbps. Operators in Japan offer 100 Mbps services, and higher speeds are still under development.

In summary, the near-term bandwidth requirement for all-digital triple-play might range from 16 Mbps to 48 Mbps per household. Some triple-play systems use less because they are not transmitting all the video applications in the digital bit stream.

IPTV is practical only because of compression techniques with modern video codec, which can compress more than 100:1 using the latest MPEG-4 (H.264) codec. A single hour of IPTV requires five Gigabytes, the same as 1,000 hours of voice and more than the annual amount of email a consumer will receive and send.

4.4 Drivers for NGN in Pakistan

Besides other drivers mentioned in the previous sections, the major driver that played an active role for the migration towards NGN is telecom growth in Pakistan. There was an astonishing growth in telecom sector and the Telecom tariff for broadband usage is decreasing due to market competition.

Most of the South Asia region has shown tremendous growth in telecom sector; but in Pakistan infrastructure and subscriber growth patterns seem unrivalled with the telecoms sector experiencing unusually high growth. Total tele-density of Pakistan's telecoms sector is about 61% in May 2009 (PTA), which is well ahead of many other countries of this region.

The mobile market of Pakistan is very dominating and is driving the market. Although in year 2007 it raised the levels of competition and investment and offered low tariffs but presently the mobile market in Pakistan is in the stage of survival because of low tariff and strong competition. Till May 2009, there are about 60 million mobile subscribers in Pakistan, and this figure is likely to increase to 120 million by the end of 2012. It is expected that about 82% of the population will have access to a mobile handset in three to four years time.

The fixed-line operators in Pakistan have seen less growth opportunities but still their survival is with the deployment of WLL. The internet usage is also becoming more popular through dial up connection as broadband services remain costly. Recently some packages have been introduced by **Pakistan Telecommunication Company Limited** (PTCL) which has shown some growth of internet market in Pakistan.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Fixed	2.18	2.28	2.49	2.7	2.95	3.43	3.39	3.04	2.7	2.2
WLL	-	-	-	-	-	.17	.66	1.08	1.4	1.6
Total Fixed	2.18	2.28	2.49	2.7	2.95	3.60	4.05	4.12	4.1	3.8
Mobile	.22	.52	1.16	1.61	3.29	8.30	22.21	39.94	54.6	57.4

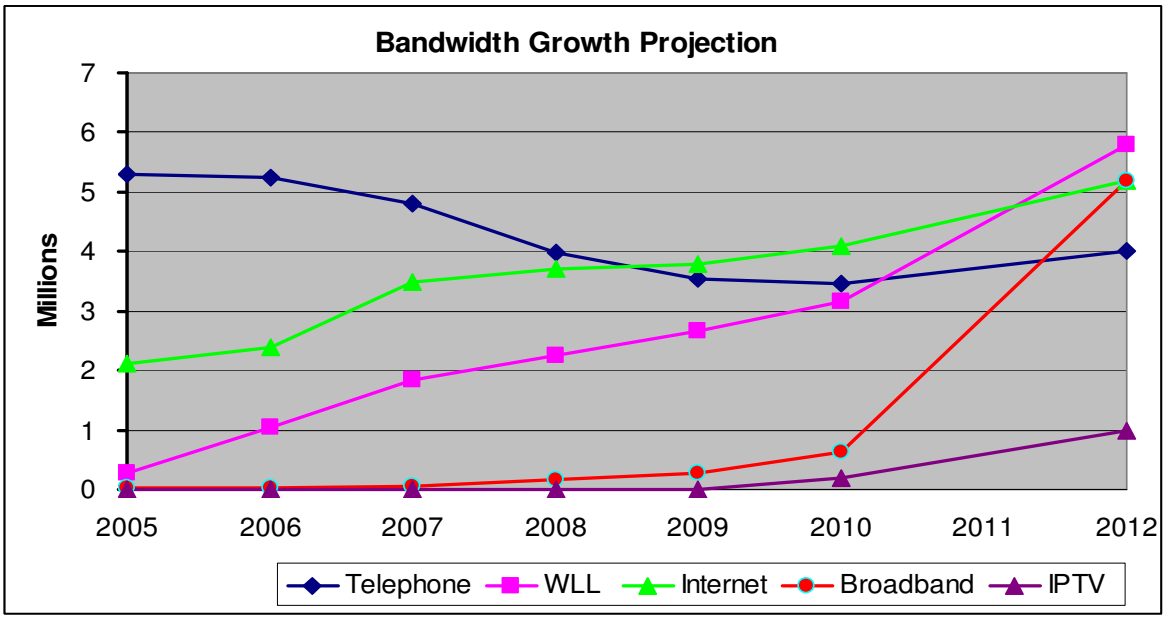
Table: Telephone Users Density (million)

PTA has announced a new policy in May 2009 for purchase of Internet bandwidth. Previously, both internet service providers (ISPs) and DSL operators were purchasing bandwidth from single operator i.e. PTCL.

Demand for broadband has doubled over 2008. The total number of subscribers reached 267,180, up from 127,000, but still only reflecting a penetration rate of 0.2%. Cost remains the single largest barrier to growth. Greater competition in the bandwidth sector should bring overall tariffs down. On average broadband prices stand at US$16, twice that charged in India. In addition, the cost of PCs/laptops is a further burden, meaning that for the most part, the internet is accessed in educational institutions, organizations and internet cafes.

DSL remains the most widely available broadband platform and about 60 % of the total is using DSL through available fixed-line infrastructure. As around two-thirds of Pakistanis live in remote and rural areas, operators are now investing heavily into developing WiMAX technology, which can offer broadband services wirelessly. WiMAX is now the second most widely accessed form of broadband technology after DSL, having beaten Hybrid Fibre Coaxial (HFC).

The broadband market is expanding beyond expectations. It is estimated that the subscribers will reach total of 627,000 at the end of 2009, accounting for 0.4% of the population. By 2012, it is forecasted that the total subscriber base will reach to 6 million plus and in 2013 it may reach to about 15 million.



Bandwidth Growth forecast

The fixed-line market on the other hand noted a significant decline in 2008, down by 12.8% to reach a total of 6.074 M. Fixed-line is quickly being neglected in favour of mobile services. This is due to their increasing affordability, while also offering better network coverage thanks to aggressive investments.

4.5 Network Diagram for NGN

To construct a cost-effective and orient-future NGN network, the advanced technology and smooth evolution are the general principles. Based on the PTCL's requirements, the NGN Network equipments are being deployed in 4 regions: North (6 cities), Central-I (10 cities), Central-II (1 city) and South (2 cities).

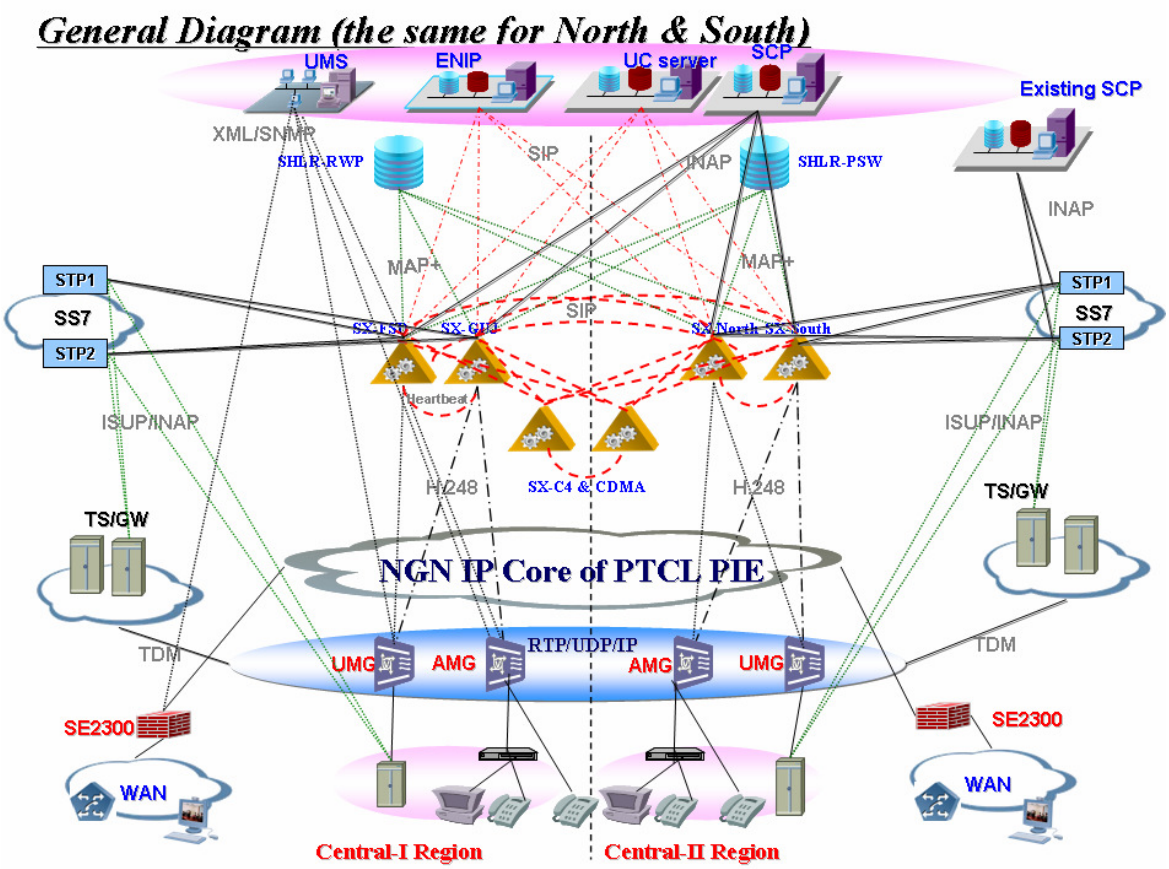


Figure: Overall Network Diagram

Totally 8 SoftX3000 are being deployed in 4 regions, each region has 2, and SoftX3000 acts as MGC which control UMG8900, also acts as SSP which triggers IN service(UC/CRBT/WEB800). SoftX3000 communicate with UMG8900/UA5000 with H.248 protocol, communicate with ENIP with SIP protocol, and communicate with SHLR with MAP+ protocol, communicate with SCP with INAP protocol. NGN network can communicate with the existing PSTN network based on No.7 through STP. New IN service like UC, WEB800 and CRBT will be deployed; LIG will also be deployed to provide lawful interception services.

4.5.1 Interconnect with other networks

4.5.1.1 Interconnect with PSTN

In the interconnecting with PSTN, the trunk gateway (TMG) converts voice media into IP packets. The UMG8900 performs coding/decoding, assembly/disassembly, and delay variation filtration between TDM and VOIP, and connect to the bearer network via standard 100M/1000M Ethernet interfaces. The circuit side interfaces of the UMG8900 are E1 interface, SDH155H optical and electrical interfaces.

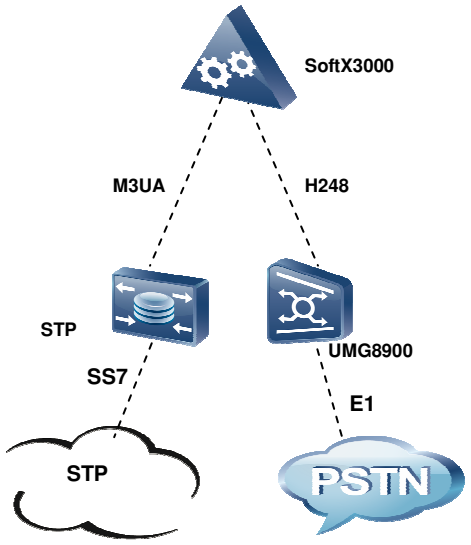


Figure: Interconnecting with PSTN scenario

4.5.1.2 Interconnect with CDMA WLL

SoftX3000 of C5 can interconnect with the CDMA WLL network via SIP-T protocol, and the UMG8900s can communicate each other based on RTP/UDP/IP protocol for media. The C5 network will use private IP for signaling & media, and CDMA is also using private IP for them, PIE will provide route for the signaling & media.

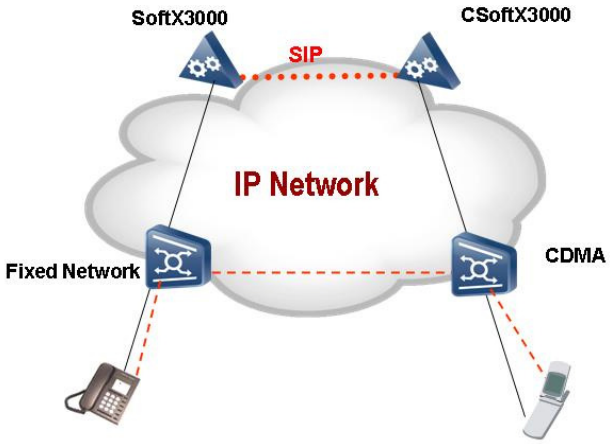


Figure: Interconnecting with CDMA WLL

4.5.1.3 Interconnect with IGW C4 Network

When Signaling & Media IP of PTCL C4 Network is migrated to Private IP, SoftX3000 of C5 can interconnect with the IGW C4 network via SIP-T protocol for signaling, and the UMG8900s can communicate each other based on RTP/UDP/IP protocol for media. The C5 network will use private IP for signaling & media, and IGW C4 is also using private IP for them, PIE will provide route for the signaling & media.

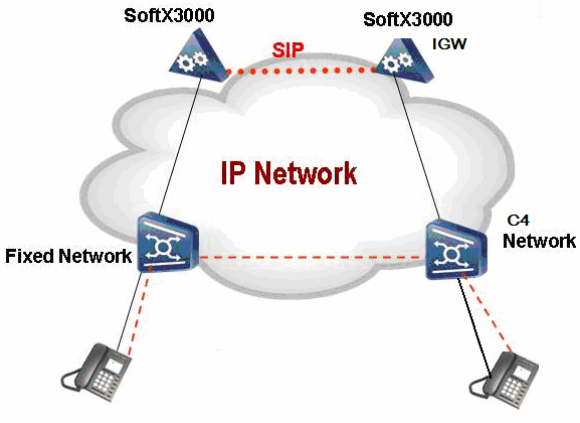


Figure: Interconnecting with IGW C4

4.5.1.4 Interconnect with Intelligent Network

A Soft Switch interconnects with an intelligent network via new USAU (Universal Signaling Adaptation Unit).

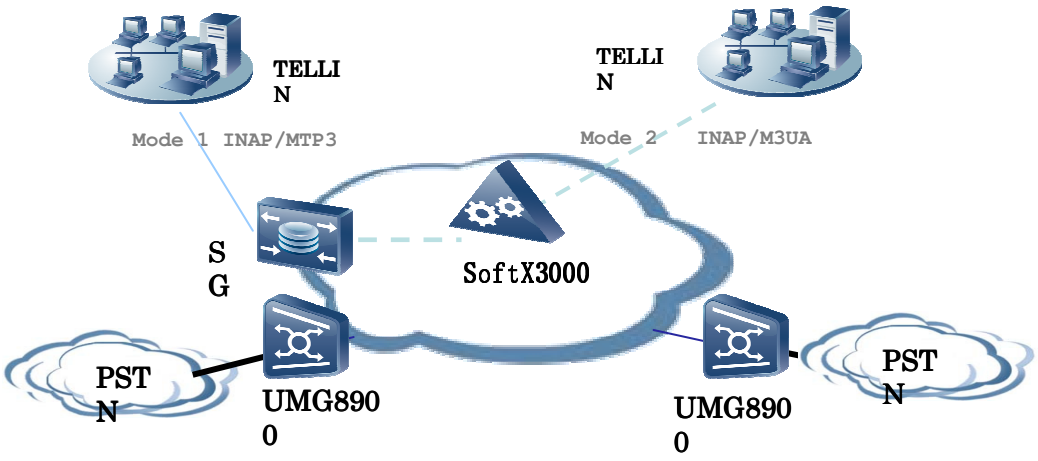


Figure: Interconnecting with IN network scenario

The soft switch interconnects with the intelligent network via INAP/TCAP/SCCP/M3UA/SCTP/IP protocol.

In Pakistan, we have successfully launched PPS, PPT, UBP and other services base on TELLIN system for PTCL PSTN subscriber. Considering PTCL's NGN expansion requirements, the existing TELLIN system is being upgrade to serve for NGN subscriber also, which will provide cost effective IN service solution for PTCL.

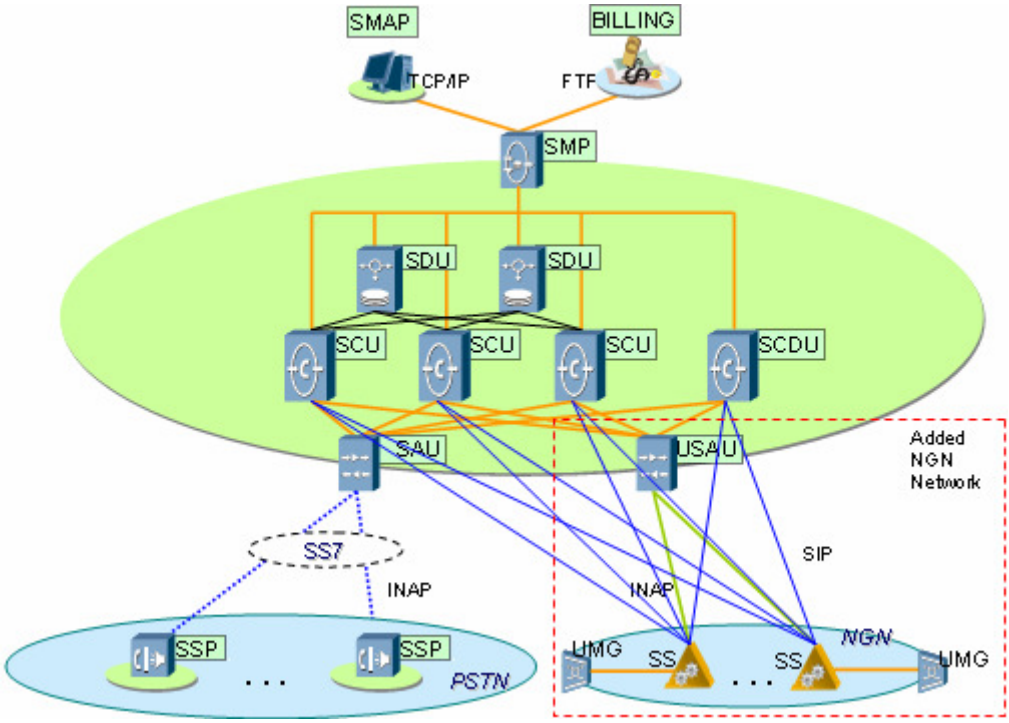


Figure : Proposed interconnecting with existing IN network

As showing in figure, the TELLIN platform will serve for PSTN network and NGN network simultaneously. For this solution USAU for NGN signal link, Soft Switch will interconnect with USAU base on IANP protocol will be used.

The proposed solution will allow NGN subscriber using the existing services, such as PPS, PPT, UBP, and PRM etc. This solution also provides the way to realize the evolution smoothly from PSTN network to NGN network.

4.5.1.5 Interconnect with STP Network

The signaling interconnecting between NGN and the PSTN can be divided into two levels.

1. Level 1

The first level is at the application layer where the soft switch supports ISUP, TUP, ISDN PRI, R2 Signaling, and No.5 (which serves as an international signaling system and is in full compliance with ITU-T Q.140-Q.164).

2. Level 2

The second level is at the transport layer where a signaling gateway is used for interconnecting between the soft switch in NGN and the PSTN. The SG is divided into two forms according to actual requirements.

Stand-alone SG

The SG in this mode supports SIGTRAN protocol family and is suited for connecting quasi-associated signaling links. It is primarily used in interconnecting with large capacity PSTN and with intelligent networks.

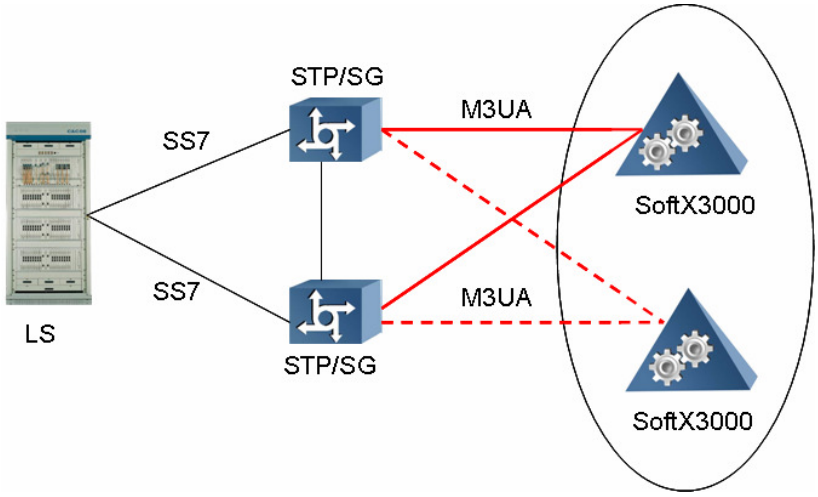


Figure: Inter-working with signaling network via M3UA

4.5.1.6 Interconnect with H.323 Network

The Soft Switch may interconnect with the H.323 network via H.323 protocol.

The soft switch sends RAS message to the opposite GK and exchanges Q.931 signaling with the opposite GK or GW, performing call control, setting up H.245 channels, and negotiating media capabilities and media channels. The soft switch supports routes signaling via GK or directly via gateway. When a GK is used for routing signaling, all signaling interactions are performed between the soft switch and the opposite GK.

Otherwise, when a gateway is used for routing signaling, except for the RAS sent to GK from the Soft Switch, all of the H.323 signaling could be directly exchanged between the Soft Switch and the opposite H.323 GW.

When an operator interconnects with his own H.323 VoIP network, he may avoid complex IP address translation by adopting unified IP address planning. If the assigned IP addresses of the VOIP network and the Soft Switch network are in different address spaces, an NAT can be used for address translation between them. The call part of H.323 protocol family includes H.225.0 and H.245. The NAT is required to perform interconnecting between signaling stream and media stream of VOIP. Residing at the application layer, H.225.0 and H.245 contain the IP addresses and port numbers of the called and calling gateways, therefore, to accomplish NAT of H.225.0 and H.245,

analysis on the application layer is needed, i.e. the NAT should have H.323 application layer gateway (ALG) functionality.

4.6 DO-NGN in Pakistan

The Total optimization of Next Generation Network at Pakistan can be divided in to the following two steps:

- Access Network Optimization
- Backbone (Core) Network Optimization

As recommended in previous chapter, access network optimization includes step by step replacement of Access technologies from DSL to Optical fibre access. As suggested Optical fibre is more compromising technology and can offer high bandwidth especially to bandwidth hungry applications. For wireless access technology WiMAX is more supportive for high bandwidth demand. It is however felt that in future technologies like LMDS and WiMax will dominate the market.

For backbone network optimization Dual homing technique is recommended. Dual homing is a disaster recovery and network optimizing mechanism based on Soft switch (SoftX3000). The Soft switch is the core of NGN. It has the following features:

- Capacity is large.
- Highly centralized.
- Bears multiple services.

If the Soft switch is faulty entirely, the services on the entire NGN will be disrupted. Thus, if a network overloaded, dual homing is used for the optimization and recovery of the network. In this case, the slave Soft Switch is used to bear the services of the master Soft Switch.

4.6.1 Network Optimization (Dual-Homing) Mode

Core Network optimization based on dual homing have the following three modes of operation:

1. Cold backup mode: The master/slave switchover of Soft Switch is realized through plugging the network cable of master Soft Switch. The hardware configuration of slave Soft Switch is the same as that of master software. This mode is not used at present.
2. Hot backup master/slave mode: A master Soft Switch and a slave Soft Switch are used. Through heartbeat messages, a Soft Switch gets to know the state of the other Soft Switch. Usually the slave Soft Switch does not bear service. When the master Soft Switch is faulty, the slave Soft Switch is activated to take over the services of master Soft Switch.

3. Hot backup load sharing mode: Two Soft Switches share the loading of services. They are master and slave Soft Switches mutually. If a Soft Switch is overloaded, the other Soft Switch bears all the services. Logically, you can consider them as two pairs of master/slave Soft Switches.

This project recommends Load sharing mode for optimization of network and the network diagram is as follows:

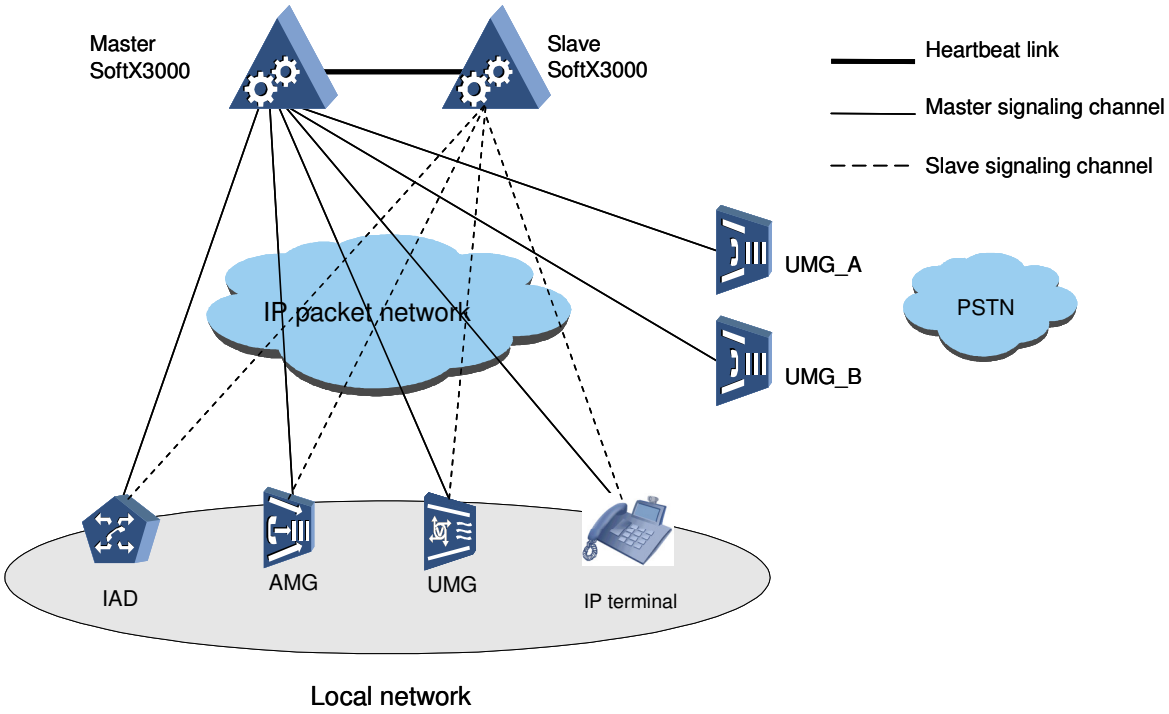


Figure: Networking when master/slave mode is used

In master/slave optimization mode, the SoftX3000 uses the “1 + 1” backup mode. One SoftX3000 functions as the master SoftX3000. It bears services, and the IP address is IP1. The remaining SoftX3000 functions as the slave SoftX3000. Usually it does not bear services, and the IP address is IP2. Normally, the MG registers at the master SoftX3000. The real line in Figure above indicates the master signaling link. When the master SoftX3000 has an over load or global fault, the master SoftX3000 is manually or automatically switched to the slave SoftX3000. After that, the slave SoftX3000 bears all the services. And the MG switches the registration path. The dashed line in Figure above shows that the MG registers at the slave SoftX3000. The slave SoftX3000 receives the registration request and restores all the services. The salient features of this recommended topology are:

- The topology is simple and the reliability is high;
- The data configuration of 2 SoftX3000 are regular, data configuration and maintenance is easy;
- It supports manually and automatically switchover, and it’s fasted when automatically switchover;

4.6.2 AMG/UMG allocation

If 1+1 backup optimization mode is adopted, the allocation is as following table, and the E1s/subs number means the workload on the master MGC.

1+1 backup optimization mode				
Region	**Product**	**Master MGC**	**Slave MGC**	**E1s/Subs Sub-total**
North	UMG	SX-RWP	SX-PSW	400
	MSAN	SX-RWP	SX-PSW	47900
Central-I	UMG	SX-FSD	SX-GUJ	724
	MSAN	SX-FSD	SX-GUJ	97500
Central-II	UMG	SX-LHR-N	SX-LHR-N	1312
	MSAN	SX-LHR-N	SX-LHR-N	275800
South	UMG	SX-KHI	SX-HYD	224

According to recommendations, the load share dual-homing is adopted for this project and the allocation is as following table. They are allocated according to trunk/subs number and location, the trunk/subs number means the workload on the master MGC.

Load share Optimization Mode						
Region	**Product**	**SITE NAME**	**No.**	**Master MGC**	**Slave MGC**	**Total**
UMG distribution						
North	UMG R6	Rawalpindi Sattelite town	0	SX-RWP	SX-PSW	256
	UMG R3R5	Islamabad F-5	256	SX-RWP	SX-PSW	
	UMG R3R5	Peshawar Charsadda Road	64	SX-PSW	SX-RWP	144
	UMG R3R5	Jhelum-II	64	SX-PSW	SX-RWP	
	UMG Mini	Wah Taxila Cantt	16	SX-PSW	SX-RWP	
Central_I	UMG R6	Faislabad Central Exchange	0	SX-FSD	SX-GUJ	352
	UMG R3R5	Faislabad Central Exchange	64	SX-FSD	SX-GUJ	
	UMG R3R5	Sialkot CANTT	96	SX-FSD	SX-GUJ	
	UMG R3R5	Sargodha New S.Town	64	SX-FSD	SX-GUJ	

	UMG R3R5	Gujrat	64	SX-FSD	SX-GUJ	
	UMG R3R5	Bahawalpur	64	SX-FSD	SX-GUJ	
	UMG R3R5	Gujranwala P.Colony	128	SX-GUJ	SX-FSD	372
	UMG R3R5	Multan Central	160	SX-GUJ	SX-FSD	
	UMG Mini	Jhang	40	SX-GUJ	SX-FSD	
	UMG Mini	Qila Sheikhupra-II	24	SX-GUJ	SX-FSD	
	UMG Mini	OKARA-II	24	SX-GUJ	SX-FSD	
Central_II	UMG R6	LHR C.T.H-III	0	SX-LHR-N	SX-LHR-S	608
	UMG R3R5	LHR C.T.H-III	608	SX-LHR-N	SX-LHR-S	
	UMG R3R5	LHR Garden Town 4	704	SX-LHR-S	SX-LHR-N	704
South	UMG R6	Karachi HCTE/PECHS	0	SX-KHI	SX-HYD	224
	UMG R3R5	Karachi HCTE/PECHS	224	SX-KHI	SX-HYD	
MSAN distribution						
	MSAN	Rawalpindi CITY -II	11000	SX-RWP	SX-PSW	23900
	MSAN	Wah Taxila Cantt Ascom	2200	SX-RWP	SX-PSW	
	MSAN	Jhelum-II	5500	SX-RWP	SX-PSW	
	MSAN	Peshawar Charsadda Road-II	5200	SX-RWP	SX-PSW	
	MSAN	Rawalpindi CANTT-I-	14500	SX-PSW	SX-RWP	24000
	MSAN	Chacklala	4300	SX-RWP	SX-PSW	
	MSAN	Peshawar G.T Road	5200	SX-PSW	SX-RWP	
Central_I	MSAN	OKARA-II	5200	SX-FSD	SX-GUJ	48600
	MSAN	Gujranwala P.Colony-	5000	SX-FSD	SX-GUJ	
	MSAN	Gujrat-	8000	SX-FSD	SX-GUJ	
	MSAN	Multan Central-	10000	SX-FSD	SX-GUJ	
	MSAN	Multan Mumtazabad	5000	SX-FSD	SX-GUJ	
	MSAN	Multan New Multan	5000	SX-FSD	SX-GUJ	
	MSAN	Jhang	5200	SX-FSD	SX-GUJ	

	MSAN	Qila Sheikhupra-II	5200	SX-FSD	SX-GUJ	
	MSAN	Gujranwala CTX-III-	10000	SX-GUJ	SX-FSD	48900
	MSAN	Sialkot CANTT	15200	SX-GUJ	SX-FSD	
	MSAN	Sargodha New S.Town	8200	SX-GUJ	SX-FSD	
	MSAN	Multan Gulgashat-	5000	SX-GUJ	SX-FSD	
	MSAN	Bahawalpur	10500	SX-GUJ	SX-FSD	
Central_II	MSAN	Lahore BADAMIBAGH-II	12000	SX-LHR-N	SX-LHR-S	137800
	MSAN	Lahore BAGHBANPURA-IV	18000	SX-LHR-N	SX-LHR-S	
	MSAN	Lahore SHAHALAMI-1	34500	SX-LHR-N	SX-LHR-S	
	MSAN	Lahore MULTAN ROAD	4200	SX-LHR-N	SX-LHR-S	
	MSAN	Lahore MUSTAFA TOWN	18500	SX-LHR-N	SX-LHR-S	
	MSAN	Lahore SAMANABAD	46500	SX-LHR-N	SX-LHR-S	
	MSAN	Lahore Ali Raza Abad	4100	SX-LHR-N	SX-LHR-S	
	MSAN	Lahore C.T.H-II	21000	SX-LHR-S	SX-LHR-N	138000
	MSAN	Lahore C.T.H-III	11500	SX-LHR-S	SX-LHR-N	
	MSAN	Lahore MISRI SHAH-I	26500	SX-LHR-S	SX-LHR-N	
	MSAN	Lahore SHAHDARA-II & III	14500	SX-LHR-S	SX-LHR-N	
	MSAN	Lahore EGERTON ROAD	6500	SX-LHR-S	SX-LHR-N	
	MSAN	Lahore FEROZPUR ROAD	8000	SX-LHR-S	SX-LHR-N	
	MSAN	Lahore GULBERG	15500	SX-LHR-S	SX-LHR-N	
	MSAN	Lahore GULSHAN RAVI	10500	SX-LHR-S	SX-LHR-N	
	MSAN	Lahore CANTT	7500	SX-LHR-S	SX-LHR-N	
	MSAN	Lahore TOWN SHIP	16500	SX-LHR-S	SX-LHR-N	

4.6.3 Naming rule for new network

This naming rule has been suggested and it contains the NE, Route, Link, and some other entities of NGN network, the name contains such information like the region, city, ID, master or slave, and it will be revised by PTCL.

Table: Naming Rule for NGN entities

This is recommended naming rule for NGN entities				
No	Entity	Name	Example	Remarks
1	Network Integrated Card of BAM	NIC0:Maintenance NIC1:plane 0 (172.20.200.0) NIC2:plane 1 (172.30.200.0) NIC3:Backup	NIC0:Maintenance NIC1:plane 0（172.20.200.0）NIC2:plane 1（172.30.200.0）NIC3:Backup	There're 4 NIC in BAM, IGWB, etc.
2	Network Integrated Card IGWB	NIC0:Maintenance NIC1:plane 0（172.20.200.1）NIC2:plane 1（172.30.200.1）NIC3:Billing Center	NIC0:Maintenance NIC1:plane 0（172.20.200.1）NIC2:plane 1（172.30.200.1）NIC3:Billing Center	
3	Working Station(WS)	Region Name-City Short Name-Site Short Name +ID	1st WS in Multan Road Site of Lahore: C-LHR-MulRd-1	The ID of WS is unique in the same site.
4	Network Equipment	Region Name -City Short Name -NE Logical Name+ID -Vender -Office type (Max length 32)	HW SoftX3000 of C5 in Lahore Center: C-LHR-SS1-HW-C5	SS means SoftSwtich; The ID of the same NE is unique in the same city.
5	Local Prefix Set(LDNSET)	LAC -NE Logical Name+ID -Region Name -Area Name (Max length 60)	LDNSET of ISB which is master in RWP Soft Switch: 051-SS1-N-ISB	
6	Call Source	In every LDNSET, we have a Call Source named 'normal'; others are named by their function: S-KHI (Max length 16)	In every LDNSET, we have a Call Source named 'normal'; others are named by their function: S-KHI	

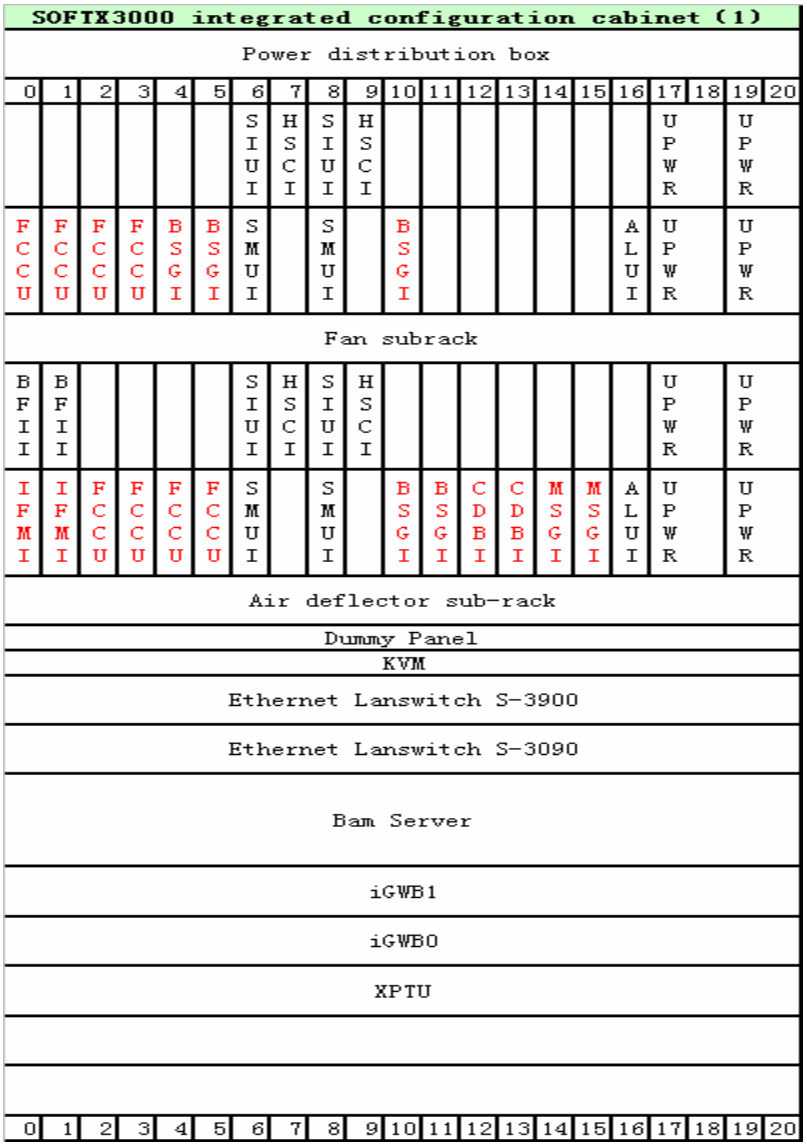
7	Gateway	Region Name-City Short Name -Site name -Gateway Logical Name+ID -Vender – Operator name (Max length 64)	2nd AMG in LHR city Multan Road Site: C-LHR-MulRd-AG02-HW-PTCL	The ID of GW is unique in the same city.
8	Office, Trunk Group(TG)	Region Name-City Short Name-Destination Office Logical Name- (Max length 16)	The first SIP Trunk from RWP SS to FSD SS: C-FSD-SS	
9	Route, Sub-Route(SRT),	RT: (Max length 16) Region Name-City Short Name-type of switch SRT: (Max length 16) Region Name-City Short Name-type of switch - Destination Office Logical Name (Max length 16)	RT: C-FSD-DEC SRT: C-FSD-DEC-NEC	
10	Link, LinkSet, Signaling Route	Region Name-City Short Name-Destination Office Logical Name-Link/Linkset ID-(M/S) (Max length 16)	The 3rd M3UA link from RWP SS to Texila UMG: N-TEX-UMG-3-M; The 4th H248 link from Lahore SS1 to 2nd AMG in Lahore: C-LHR-AG2-4-M	Including SS7,M2UA, M3UA, H248, etc; if necessary we can plus M/S

4.6.4 Core Network Design

4.6.4.1 Board layout

Here we take RWP-Satellite SoftX3000 as example, there're 1 XPTU(X Protocol Transform Unit, for Lawful Interception), 2 IGWB(1+1 backup, for billing), 1 BAM for background administration, and 3 Frames including 1 main control frame(Frame No.0) and 2 service frames.

Each SoftX3000 has 1 pair of MRCA (Media Resource Control Adapter) boards, they're working in load share, and 1 board has the announce capacity of 240 channels, so each SoftX3000 has a announcement capacity of 480 channels as to board layout, shown in figure below:



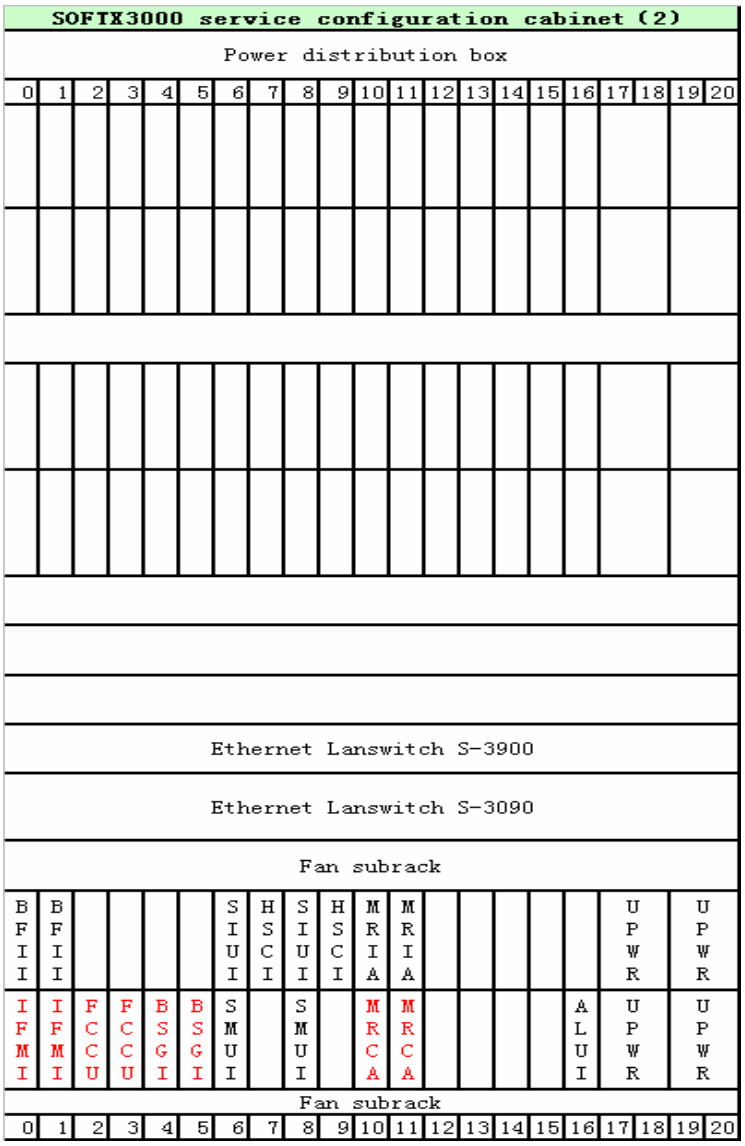


Figure: RWP-SoftX3000 Board layouts

4.6.4.2 Cable connection

The following figure is Rawalpindi Satellite Town site-wise diagram, the signaling is using 10.A.8.0/24 IP segment, Media is using 10.B.8.0/24 IP segment, O&M/LI/Billing is using 10.C.8.0/24 IP segment, A, B, C will be specified by PTCL. O&M/LI/Billing interfaces will be converged in 2 Level-3 LAN Switch, and then connect with PIE router, meanwhile, media & signaling interfaces will directly connect with PIE routers.

The type of interface, cable can be seen from the figure:

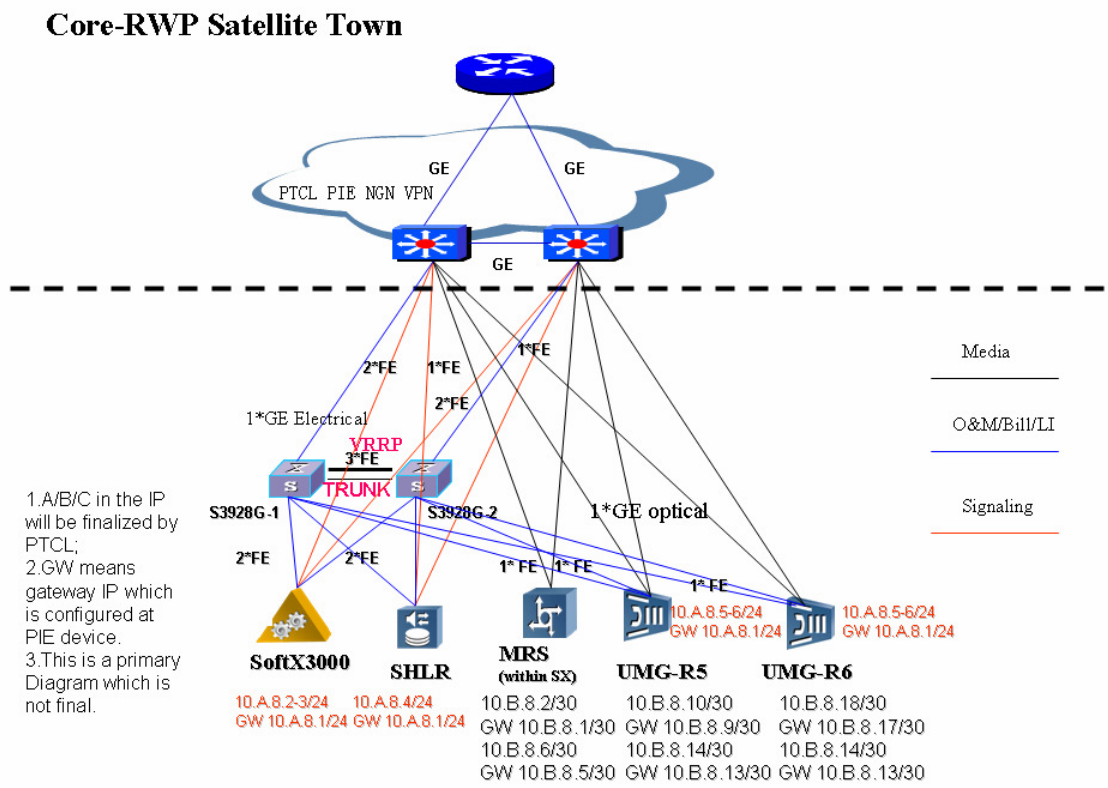


Figure: Site-wise data com connection

The following figure is SoftX3000 Internal Connection

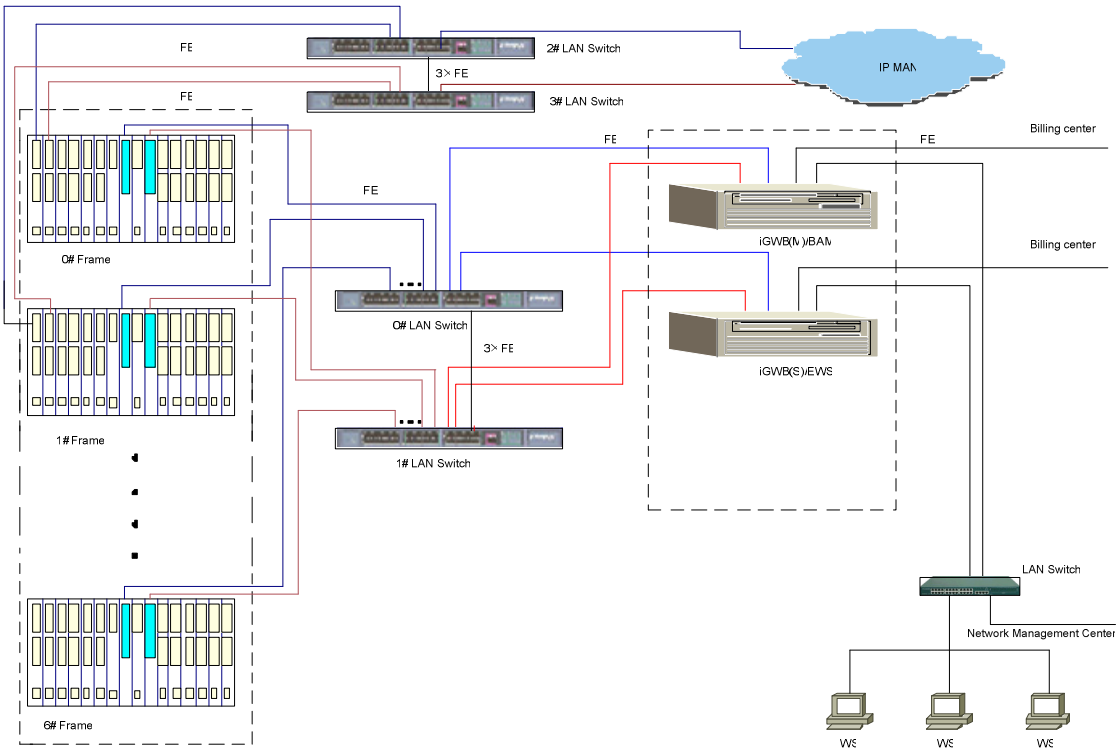


Figure: SoftX3000 Internal Connection

The following diagram is UMG's Connection with ODF/DDF/Data com:

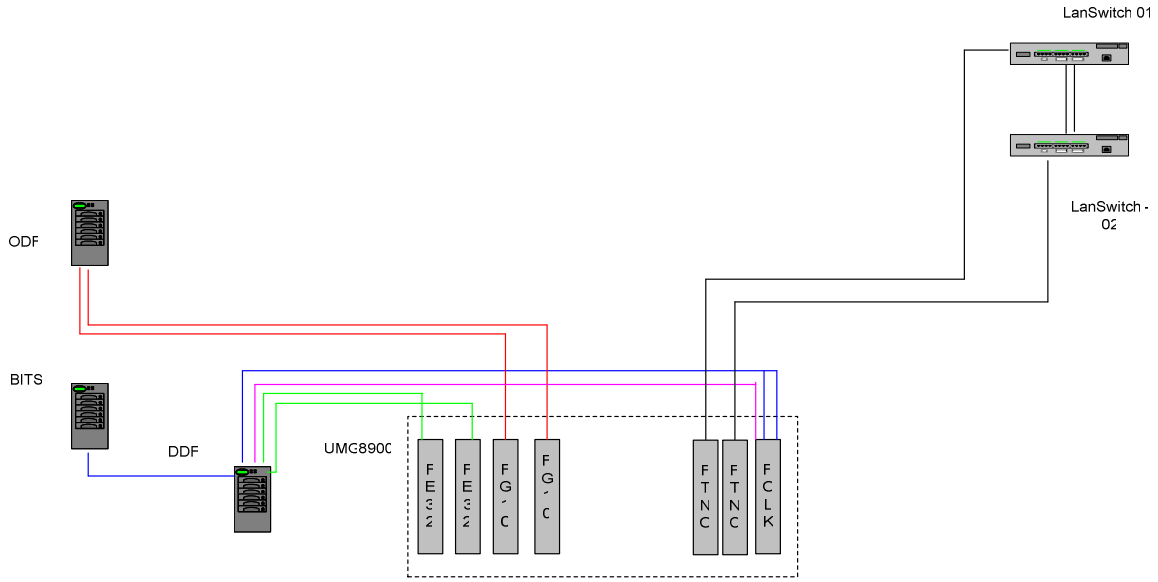
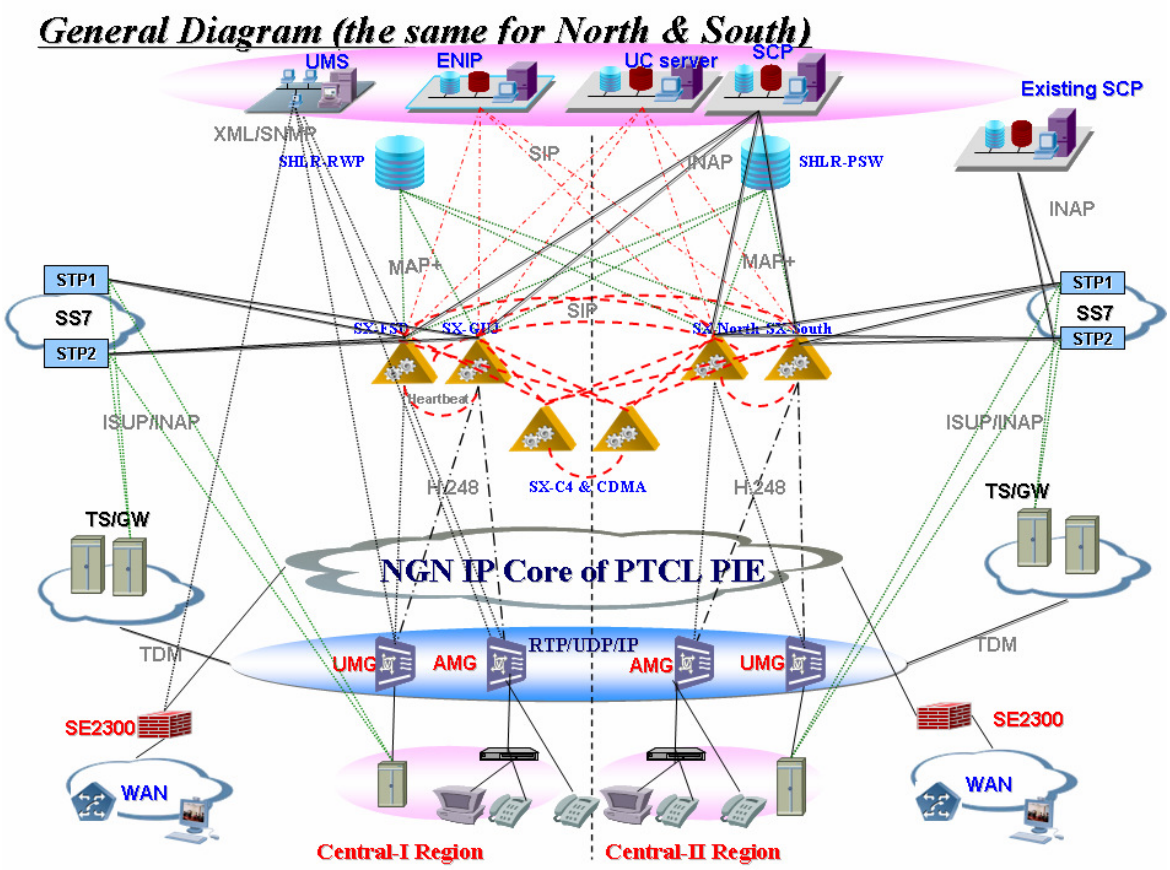


Figure: UMG's Connection with ODF/DDF/Data com

4.7 Signaling Design

4.7.1 Signaling Diagram

From the Figure above**,** we can also know the signaling diagram, the existing STP acts as the adaptation between PSTN (narrow-band) & NGN (broad-band signal), inside NGN, all the signaling are based on IP.



4.7.2 Signaling Point Code

The following table shows how many SPC are required and what's their network indication.

Table: Signaling Point Code

No.	Network Equipment	Network Indication	Use Description
1	SS-RWP	National	Connect with PSTN/SHLR, etc.
2	SS-PSW	National	Connect with PSTN/SHLR, etc.
3	SS-FSD	National	Connect with PSTN/SHLR, etc.
4	SS-GUJ	National	Connect with PSTN/SHLR, etc.
5	SS-LHR-N	National	Connect with PSTN/SHLR, etc.
6	SS-LHR-S	National	Connect with PSTN/SHLR, etc.
7	SS-KHI	National	Connect with PSTN/SHLR, etc.
8	SS-HYD	National	Connect with PSTN/SHLR, etc.
9	SHLR-RWP	National	Connect with SoftX3000, etc.
10	SHLR-PSW	National	Connect with SoftX3000, etc.
12	CRBT	National	Connect with SSP/NGIN
14	USAU	National	Connect with NGN

4.7.3 Signaling Protocol

The protocol interconnecting SoftX3000 & UMG and other NEs as the following Table Interconnection Protocol:

Table: Signaling Protocol

Source Node	Destination Node	Via	Protocol
SoftX3000	SoftX3000 in IGW/C5/CDMA	directly	SIP-T/UDP/IP
	UMG8900	directly	H248
	MSAN	directly	H248
	STP	directly	M3UA/SCTP/IP
	SHLR	directly	MAP/TCAP/SCCP/M3UA
	Legacy SCP	UASU	INAP/TCAP/SCCP/M3UA
	New SCP	UASU	INAP/TCAP/SCCP/M3UA
	ENIP	directly	SIP
	CRBT	directly	ISUP/M3UA
	Local Exchange	STP	ISUP/M3UA
	LIG	XPTU	HI1&HI2 or X1&X2
	UMS	directly	XML/SNMP
UMG8900	SoftX3000	directly	H248
	UMG8900	directly	RTP/UDP/IP
	MC	directly	HI3 or X3

The recommendation on the Access Network and Core network is given above. With step by step migration from DSL to FTTx and WiMax for access Network will definitely impact the NGN in optimization. For Core network load sharing (dual homing) mode will provide resilience and tolerance to the network and in case heavy load the soft switch will provide an optimized solution.

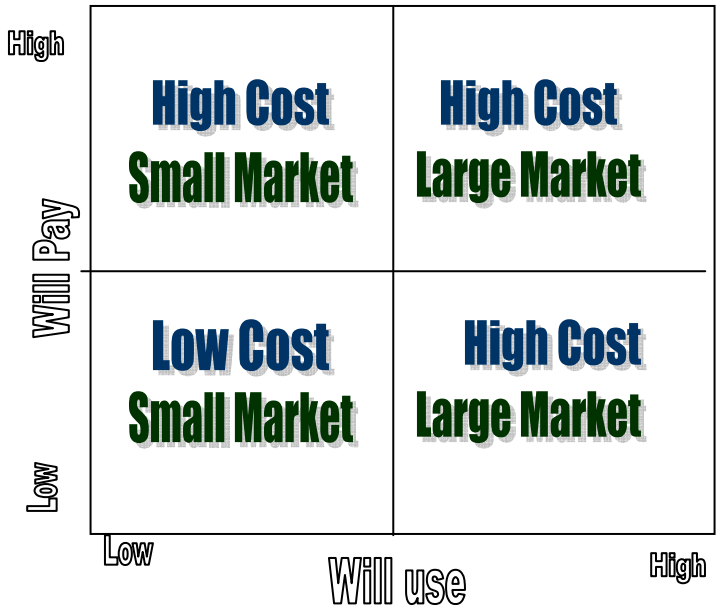
4.8 Services Forecasting

To successfully deploy a new NGN service [5][23], we need to segment and target customers. This can be done through behavior analysis of customers (include enterprise customers) where potential services can be identified based on selected customer groups and related requirements. The following steps are recommended to be adopted:

1. Choose target customers
2. Choose services according to customer activities. The Services provided by NGN during a day to a user as given in the table below.
3. Choose the most profitable service among the listed potential services to identify service development priority.

Time	*Activity*	*Services Required*
0600	On Bed	Alarm
0630	Get up	News/Radio/Traffic Info
0700	On the way	Traffic Info/ Game/ Chatting/ Newspaper
0800 - 1700	At work	Communication/ Information retrival/ Communication/ Shopping/ Education/ Other info
1730	On the way	Traffic Info/ Game/ Chatting/ Newspaper
1900	Dinner	News/ Restaurant info
2000	Leisure Time	Movies/ TV/ Party/ Reading/ Education
2300	On Bed	

After initial step of identification, these identified potential services can be analyzed for market volume, trend and lifecycle, and evaluation of all these potential services according to consumers purchase willing and pay willing as shown in figure below. Finally, among all those evaluated services, services with large market volume and high price can be chosen to increase operators' ARPU and revenue.



Services with high demand and low price shall be identified first and then the services with high price and low demand afterward. It is therefore recommended that Operator's NGN service provision strategy shall depend on the model given in the figure above. Use high-value-added services to attract business high end customers

4.8.1 Service Categorization

The IPCP Framework has categorized traffic types, or services into three main categories:

1. **Type A: Real-Time Services** – which have strict latency requirements e.g. voice;
2. **Type B: Interactive Data and Streaming Services** – which can tolerate a limited amount of delay, but where transmission speed is still a key user requirement e.g. web browsing;
3. **Type C: Delay-Tolerant Services** – which can tolerate more significant delays, without materially affecting the Quality of Service (QoS) perceived by the customer e.g. e-mail, file transfer.

This categorization is designed to indicate major differences in the way the various services make demands on the network. This service categorization is broadly similar to the QoS classes defined by the ITU for IP communication. The ITU identifies four service categories as follows:

a. Real Time
b. Interactive
c. Non-Interactive
d. Unspecified.

Although, with interactive data traffic, immediate transmission is no longer required, but the user's willingness-to-pay will still depend on the time taken for a document (e.g. a web page) to be downloaded. Streaming services are considered in the same category as interactive data, because their capacity requirements can be modeled using the same basic approach. Delay-tolerant services can accept more uncertainty about the transmission time, and significantly slower delivery.

There are about 70 forecast services for NGN which are identified by [7][24] and [25]. Some of these services are being offered through presently available NGN infrastructure while other demand for other mentioned services will soon arise. Different analysis methods have been used to forecast the services [20]. Here each of these services has been analyzed for the type of service in which it falls i.e. Type A: **Real-Time Services**, Type B: **Interactive Data and Streaming Services**, Type C: **Delay-Tolerant Services.**

Table: Services with type of traffic being used

S. No	Forecast Services	Type of Traffic
1	**Web-based computing**. Also called Internet computing.	C
2	**Meta-information management**. Representing and providing unambiguous information about data. For exchange of data in an open and heterogeneous computing environment.	C
3	**Mobile video and game platforms for business services**.	B
4	**Multimedia cross-platform meeting systems**. Enable employees on different platforms to meet and share multimedia content.	C
5	**Collaboration tools based on social networking and Web 2.0.**	C
6	**Anywhere-playback of media files**. Access to convert and play MM files on a portable device on Internet from anywhere.	C
7	**Field mobile computing**. Out of office access through mobiles or handheld devices.	B
8	Real-time tracking of goods.	B
9	Real-time quality control e.g. for ensuring food safety.	B
10	**Secure communication over open networks**. To guarantee secure transmission of commercial communication and transactions over open networks.	C
11	**Prioritized communication in open networks**. To guarantee a certain bit rate level or response time for commercial communication and transactions over open networks.	A
12	**Online reporting of security management**. Customers to verify agreed security standards.	B
13	**Online reporting of service quality**. Customers to verify agreed service levels.	B
14	**Unified communication**. Integrated solutions for use of multiple communication channels and collaborative modes.	A

15	**Mobile broadband**. Provide Internet through portable devices.	B
16	**Internet by satellites**.	B
17	**Voice over IP**.	A
18	**Communication based on Internet Packet Exchange (IPX).**	B
19	**Open operator-neutral fiber networks**. A network access model based on fiber where the infrastructure (platform) is owned by a network access company and services are provided by separate companies.	A
20	**Fixed-mobile telephony convergence**.	B
21	**Remote control of home functions and properties**	A
22	**Intelligent buyer agent**. A software agent participating in electronic markets, both in business and private domains. In the private domain this agent can be connected to refrigerator, freezer and a recipe database.	B
23	**Remote meter readings**.	B
24	**Environmental surveillance on Internet**. Like temperature, humidity and pollution.	B
25	**Online ordering and payment of groceries and goods.**	C
26	**Online banking services**.	B
27	**Online form-filling for public services**	B
28	**Online access to advanced public services**.	B
29	**Online ordering of additional output to existing products**. —Chip-tuned over the air.‖ Requires flexible service levels and pricing models.	B
30	**24/7 self-service**. Firms are providing portals for customer self-service. Examples may be: ordering, changing subscriptions, controlling consumption and expenditures, etc.	C
31	**Near field communication services I**. Ticketing and payment from mobile devices.	C
32	**Near field communication services II**. Advertising and information services to mobile devices.	C
33	**3D virtual trial booths**. Web site for virtually trying out products, e.g., clothes.	B
34	**Home care services for elderly people via a mobile device**. For example, various alarm functions, telemedicine and other support services that make it easier for elderly people to live at home as long as they can.	B
35	**Virtual private networks for sharing of media content within defined groups of users**. May include a server for storing and managing media content.	C
36	**E-learning**.	B
37	**Electronic paper**. Like e-books, e-magazines, electronic pricing labels, timetables at transport stations and billboards.	B
38	**Information about individual's presence and activity on the Internet**.	B
39	**Position-based services**. Two categories of applications relate to location: push of information and advertisements, and control with objects and people.	A
40	**Context-dependent services**. Applications that are context aware and that provide services related to specific situations	B

	and needs. Customer lock-in.	
41	**Personalized services**. Services related to a person and personal characteristics such as personification, health and behavior	C
42	**Family media center**. Centrally located media server reachable by the household's PCs, mobile devices, media streamers, etc., irrespective of location.	B
43	**Advanced setup box**. For recording, VoD, video conferences and other time-shifting-based services.	A
44	**Remote control of set-top box via mobile and Internet**. A service that enables remote handling of set-top box.	A
45	**Thin client solutions for personal use**. Solutions that shift the load of processing, storage, management and security to a server.	B
46	**Entertainment machines with sense and feel attributes**. Increases the user's adventure in the game.	B
47	**User-generated content**. Production and distribution of user-generated content across all types of terminal devices (PC, mobile, video, GPS) and across all types of media (video, film, text).	B
48	**Life log**. The logging of all personal media activities.	B
49	**Net-based socialization**. Using services such as Facebook, MySpace, Yahoo, etc., for creating, recreating and maintaining social conventions online.	C
50	**Adventures in virtual worlds**. A virtual world where users socialize in the forms of animated characters (e.g., Second life).	B
51	**Online ordering and renting of games, music and video**. Games, music and video are offered over a network, notably the Internet, to individuals or communities.	B
52	**Real-time distribution of events in HD on 3-D**. The video format resolution is at least 720 vertical lines or more, presenting three-dimensional objects on the device.	A
53	**Interactive TV with personal video recorder (PVR)**.	A
54	**Triple play**	A
55	**Multiplay**. Provide 3-play services added with mobile and a sensor-based network services (smart home surveillance services, etc.).	A
56	**Peer-to-peer network services**. A distributed system that provides file sharing without any centralized control or hierarchical organization, and where the software running at each node is equivalent in functionality.	B
57	**Flat-rate pricing models**. Unlimited use within a fixed time period to a fixed price.	B
58	High-definition TV, 3-D TV,	A
59	TV on mobile.	A
60	**Internet on handheld devices**. Provide Internet browser on the mobile phone, (Internet in pocket).	C
61	**Internet on TV sets**. Using TV sets as terminals with access to Internet.	C
62	**Web TV**. Streaming video continuously downloaded from the	C

	Internet	
63	**Channel-independent access to content**. Access files by any channel (fixed line, wireless etc.).	B
64	**Hologram on TV.** enables images to change as the position and orientation of the viewing system changes in exactly the same way as if the object was still present, thus making the recorded image appear three-dimensional.	A
65	**TV channels à la carte**. Buying one TV channel at a time, rather than dealing in preset bundles.	A
66	**Global "broadcasters".** Streaming TV or on-demand TV distributed by peer-to-peer (P2P) networks.	B
67	**Call Centre Services**	A
68	**E-Commerce**	B
69	**Information Broker.** Involves advertising, finding, and providing information to match consumers with providers	B
70	**Unified Messaging.** Delivery of voice mail, email, fax mail, and pages through common interfaces	C

After analysis, it has been observed that out of 70 mentioned services, 17 services are of type A and type C each, while there are 36 services which are of type B. This concludes that in future there will be more service of type B.

The world wide trends of the services that are being used are shown in figure below. This figure also predicts that there are more Interactive Data and Streaming Services are being used and will be used world wide in the near future.

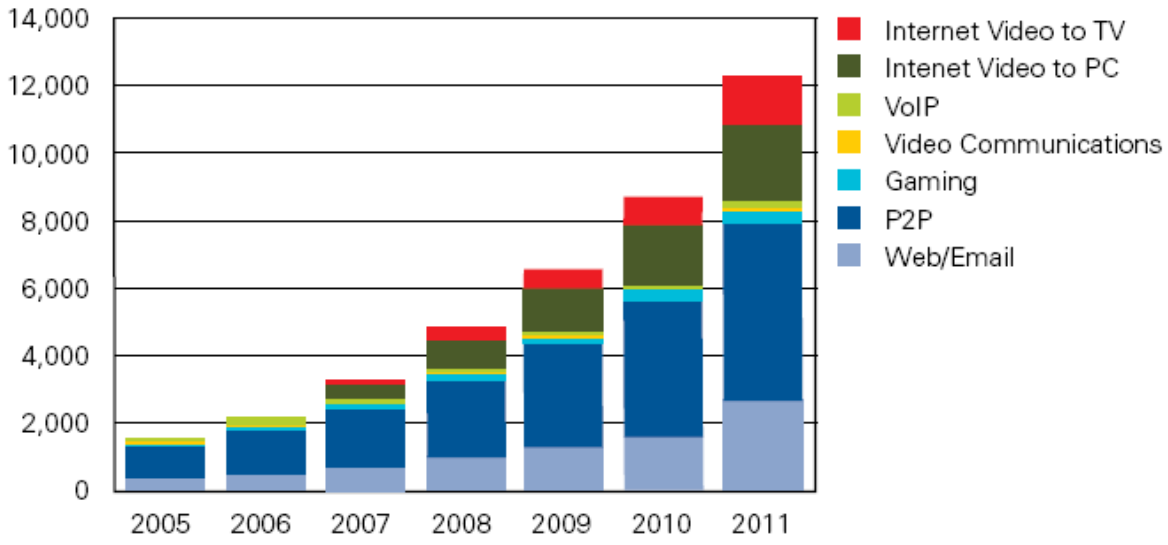


Figure: Actual and forecast demand for bandwidth by content type

4.9 QoS in NGN

Another important factor is QoS while delivering these services which can not be ignored. The quality of service delivered to end users is a function of many factors, including the 'end-to-end' capacity available and not just sufficient capacity in the final access link. The speed and reliability with which data are delivered are dependent on at least four groups of sub-systems:

- Speed and capacity of the source (servers and interconnect links into the public internet of the web site);
- Throughput of the core network(s)
- Capacity of the ISP network including its backhaul; and
- Speed and capacity in the 'last mile'.

The designer of NGN while planning for a network will take care of all the above factors. Presently available NGN structure in Japan does not have any of these issues mentioned above.

5.0 Conclusion

The speed capability of an NGN infrastructure investment will in general be dependant on the access technology. The access speed of the copper local loop can be increased by replacing copper circuits to the cabinet with fibre to the cabinet, which shortens the local loops. The sunk cost of incumbent telecommunication operators in existing networks and the budget for investment in NGN is so large that the transition from the PSTN to an NGN will be evolutionary rather than revolutionary. Significant investment is required in all parts of the network. For example:

- Access network will be progressively replaced with optical fibre cable;
- ATM based aggregation network will be progressively replaced with higher capacity intelligent DSLAMs and Ethernet based optical fibre networks;
- Network of IP switches using MPLS technology;
- Many new service nodes will be established.

The NGN related infrastructure includes:

- DSL enabled copper access loops;
- DSLAM or ISAM;
- fibre to the node (FTTN) cabinets;
- base IP infrastructure for NGN services;
- home gateway i.e. set top box,
- data backhaul from DSL aggregation to the core network.

Different services to be offered on next generation networks in a time span of five to ten years have been studied. As there is a shift from a telecommunication world characterized by single-service networks towards an information service world characterized by multi-service networks, it is expected that the converging technology will drive all information services towards a common infrastructure i.e. Next Generation Network (NGN). The NGN is anticipated to utilize a wide range of current and future heterogeneous access networks and provide end-users with seamless services across these networks [22][26]. The key principle of the NGN is the decoupling of services and networks, allowing them to be offered separately.

Service creation is fundamental to the promises of NGN, but there is still significant uncertainty as to what the service market of NGN will look like in the future. The purpose of this paper is to reduce this uncertainty. Different services have been forecasted that will be offered on the future NGN.

The emergence of the new infrastructures that NGN brings will reshape the tele-communication as well as the media landscape. Deregulation is expected to introduce many more suppliers than in the past, and the NGN represents a real opportunity to service providers for growth and revenue creation. It is also expected that the future NGN will support a greater number and variety of services and applications [21].

Telecoms revenues rose dramatically in Pakistan during fiscal year 2007 (by 21% yo-y) on the back of an increase in traffic in the country's mobile and WLL market. The revenues have been increased by 100% in 2006-2007 compared with 2003-2004. The mobile market alone responsible for growth in the last year of 57% and over the last four years, wireless revenues have grown by a staggering 378%.

Despite substantial growth in Pakistan's internet market over the past three years, the user baser of 2.4mn in 2006 represented a penetration rate of just 1.5%, among the lowest in the world. There are around 110 ISPs in Pakistan, of which 70 are operational. However, the overwhelming majority of customers subscribe to services offered by PTCL. Total bandwidth in the country has also increased dramatically, from just 10 megabytes (MB) in 2000 to 230MB in 2002.

References

1. Kurokawa and I. Higashi, “Standardization Trends of the Next Generation Network in ETSI TISPAN,” NTT Technical Review, Vol. 4, No. 6, pp. 53–57, 2006.

2. Xilinx, Inc. “White Paper WP130: Broadband Access”, 2000

3. Corning Incorporated. “Broadband Technology Overview”. June 2006.

4. M. Carugi, B. Hirschman, and A. Narita, “Introduction to the ITU-T NGN Focus Group Release 1: Target Environment, Services, and Capabilities,” IEEE Communications Magazine, vol. 43, Oct. 2005, pp. 42 – 48.

5. Crimi, J.C. Next Generation Network (NGN) Services, White Paper, Telcordia Technologies, http://www.mobilein.com/NGN_Svcs_WP.pdf. 2009.

6. http://www.itu.int/rec/T-REC/e

7. Digital Britain (2009). *The Interim Report*. January 2009.

8. www.en.wikipedia.org/wiki

9. K. Knightson, N. Morita, and T. Towle, “NGN Architecture: Generic Principles, Functional Architecture, and Implementation,” IEEE Communications Magazine, vol. 43, Oct. 2005, pp. 49 – 56.

10. NGN Services Roll out, NTT Report, 2007.

11. ITU-T (2004). Next Generation Networks – Frameworks and functional architecture models, ITU-T Recommendation Y. 2001.

12. ITU-T (2003). The Evolution of the Core and Access Networks. Presentation on Workshop on Next Generation Networks: What, When & How? ITU-T 9-10 July.

13. IEC. “Internet Access”. October 2002

14. IEEE 802.16 Standard - Local and Metropolitan Area Networks – Part 16, IEEE Std 802.16a-2003.

15. "Understanding Wi-Fi and WiMAX as Metro-Access Solutions", Intel White Paper, 2004.

16. Anders Henten, Morten Falch and Reza Tadayoni: New Trends in Telecommunication Innovation, EuroCPR, Barcelona March 2004.

17. Kocan, K.F., Montgomery, W.A., Siegel, S.A., Thornberry, R. J., & Zenner, G.J.: Service creation for next generation networks. *Bell Labs Technical Journal*, 7 (1), 63-79. 2002

18. OECD: Households with broadband access. http://www.oecd.org/document/23/0,3343,en_2649_34449_33987543_1_1_1_1,00.html. 2004

19. Ofcom: Delivering super-fast broadband in UK, setting the right policy framework. *Ofcom Consultation Report*, September 23, UK. SNF Report No 12/09 31. 2008

20. Okoli, C. & Pawlowski, S.D: The Delphi method as a research tool. *Information & Management*, 42, 15-29. 2004.

21. Richman, S. & Pant, H. (2008). Reliability Concerns for next generation networks. *Bell Labs Technical Journal*, 12 (4), 103-108.

22. Tachikawa, K: A perspective on the evolution of mobile communications. *Communications Magazine,* 41(10), 66-73. 2003

23. Global Insights on Broadband**,** Analyses, forecasts and comments on the Broadband market, Published by telecoms marketresearch.com in association with Buddecomm, January 2009.

24. *J. C. Crimi* : Next Generation Network (NGN) Services A Telcordia Technologies White Paper, *Telcordia Technologies*

25. Jon Iden Leif B. Methlie: IDENTIFYING AND RANKING NEXT GENERATION NETWORK SERVICES, INSTITUTE FOR RESEARCH IN ECONOMICS AND BUSINESS ADMINISTRATION, BERGEN, JUNE 2009

26. Hui, S.Y. and Yeung, K.H: Challenges in the migration to 4G mobile systems. *IEEE Communications Magazine*, 41 (12): 54-59, 2003.

27. NGN Services – The Myth & Inter-Operability Challenges 3rd AIC Conference - Jakarta (21- 25 Nov 2005).

28. CSR Report, NTT, Japan, 2007

29. The Emerging Power to Innovate, NTT Data Corporation, Annual Report 2009.

30. www.ietf.org

31. RFC 1889

32. RFC 2326

33. RFC 3015

34. RFC 2327

35. RFC 3261

36. RFC 3525

37. Comparison of Access Technologies, White Paper, Opera, 2007.

38. Osamu Kamatani: Current Telecom Market in Japan and NTT's NGN (Next Generation Network), NTT Service Integration Laboratories, TISPAN Workshop, Beijing, China, May 2008.

39. BMI Report, Asia Pacific Telecommunications Insight, 2009.

40. IDC Japan Report, 2009.

Some Pictures during Project:

Research Group at Osaka University

Outside and Inside Picture of NTT R & D Centre at Tokyo

NTT Research Group at R & D Centre Tokyo

Research Group and Research Lab. at Osaka University

Glossary of Terms

100baseT: The 100/10 megabits/second Ethernet standard that uses twisted pair wires with RJ-45 connectors.
3G: Third Generation Mobile Phone Networks
ADSL: Asymmetric Digital Subscriber Line
Access Tandem: Switch interconnects with CO switches and other access tandem switches to form the PSTN network. Usually called a “class 4” switch.
Application Server: Computer that implements applications, such as prepaid calling, “class 5” services and interfaces with a softswitch.
Bandwidth: Capacity of a physical circuit or piece of equipment to transport or switch information and is often expressed in terms of bits per second.
Bearer Circuits: Circuits that carry only voice and are never used to carry data messages for call signaling, such as the ISDN or SS7 data links.
BER: Bit Error Rate
BPL: Broadband Power Line
CAPEX: Capital Expenditure
CDMA : Code Division Multiple Access
CLEC: Competitive Local Exchange Carrier
CO: Central Office refers to the type of PSTN switch It is often called a “class 5” switch.
CPE: Customer Premise Equipment
DHCP: Dynamic Host Configuration Protocol
DSLAM: Digital Subscriber Line Access Multiplexer
DTMF: Dual-Tone Multi-Frequency is a set of 16 tones used for in-band signaling between PSTN switches and telephones.
DVB Digital Video Broadcasting
E1 Interface: Transmission link consists of 32 transmission channels (0-31), each of which is 64 Kbits/sec. The overall transmission rate is 2.048 Mbits/sec.
EMC: Electromagnetic Compatibility
ETI: European Telecommunications Institute
ETSI :European Telecommunications Standards Institute
EU: European Union
FM: Frequency modulation
FSO: Free Space Optics
FTTB: Fibre to the Building
FTTH: Fibre to the Home
FTTC: Fibre to the Curb
FWA: Fixed Wireless Access
G.711: This Voice coder is used in the PSTN, and is commonly called PCM (Pulse Code Modulation).
G.723: Standard used in VoIP gateways and is the vocoder in Microsoft’s NetMeeting software. It is called the Multi-rate Coder and has two bit rates, 5.3 and 6.4 Kbits/second.

G.726: This standard is commonly called ADPCM (Adaptive Differential Pulse Code Modulation), is used in the NACT IPAX gateway for the playback of voice messages such as authorization code and destination number prompts.
G.727: This vocoder, commonly called Variable-Rate ADPCM, is available in the NACT IPAX VoIP vocoder suite.
G.728: This standard sometimes known by the abbreviation LD-CELP (Low-Delay Code Excited Linear Prediction), is used in some VoIP gateways.
Gatekeeper: Device or computer that controls one or more gateways within a "zone".
GHz: Gigahertz
GSM: Global systems for mobiles
H.248: The ITU-T protocol recommendation for the control of media gateways by media gateway controllers. See Megaco.
H.323: An ITU-T standard for handling video, data and voice call information.
HDSL: High Speed Digital Subscriber Line
HE: Head-End
HFC: Hybrid Fibre Coax
IETF: Internet Engineering Task Force .
In-band Signaling: The use of tones to convey addressing information (ANI, destination number and information integer digits) in conjunction with changes in the state of the circuit (T1 "A" and "B" bits, E&M E-lead and M-lead, etc.)
ILEC: An Incumbent Local Exchange Carrier is the local telephone company originally granted a monopoly by the government. See CLEC.
ICT: Information and communications technology
IEEE: Institute of Electrical and Electronics Engineers
Interoperability: Ability of a piece of equipment to interoperate with other equipment from different vendors.
IP: Internet Protocol. TCP, UDP, RTP and SCTP all operate on top of IP and use it as their transport protocol.
IP Network: Internet Protocol network is a packet-oriented network
IRED: IR-Emitting Diodes
ISC: International Softswitch Consortium: an organization of companies and other organizations that work on a set of open standards for voice call control by softswitches.
ISDN: Integrated Services Digital Network is a point-to-point signaling protocol designed to interface PBX equipment with central office switches.
ISP: Internet Service Provider
ISUP: ISDN User Part is the network signaling protocol that sets up and tears down calls in the PSTN network using messages transmitted between switches over the SS7 data network.
ITU: International Telecommunications Union—the international standards organization for all types of radio and telephony telecommunications.
ITU-T: International Telecommunications Union—Telecommunications sector.
IXC: An Interexchange Carrier is normally a long distance telephone company in the United States. It interconnects ILEC, CLEC and other IXC switches to form the PSTN.

Kbps: kilobits per second
LAN: Local Area Network
LED: Light-Emitting Diodes
LMDS: Local Multipoint Distribution Service
M3UA: It is the MTP3 User Adaptation Layer protocol that adapts SS7 MTP3 messages for transport over an IP network using the SCTP protocol.
Media Gateway: A device that converts one form of media into another form, for example, PSTN voice into VoIP, and has very little intelligence.
Media Gateway Controller(MGC): A device that controls one or more media gateways and has enough intelligence.
Megaco: Megaco is the IETF name for the ITU-T H.248 protocol standard recommendation for controlling a media gateway when connecting telephone calls between a LAN and the PSTN.
MGCP: Media Gateway Control Protocol is a protocol designed to control various devices that can handle different types of media, e.g., voice, video, data, etc.
MHz: Megahertz
MMDS: Multichannel Multipoint Distribution Service
MPEG: Moving Pictures Experts Group
OFDM: Orthogonal Frequency Division Multiplex
OLT: Optical Line Terminal
OPERA: Open PLC European Research Alliance
OPEX: Operating Expenditure
PCM: Pulse Code
PLC: Power Line Communications
PON: Passive Optical Network
POP: Point of Presence
POTS: Plain Old Telephone Service
PPPoE: Point-to-Point Protocol over Ethernet
PRI: Primary Rate Interface. It refers to a digital circuit, such as a T1 or E1, which carries multiple calls and uses the ISDN signaling protocol.
PSTN: The Public Switched Telephone Network is the public, wire-line, switched network
PTT: The PTT network is a term used to refer to the PSTN network of other countries.
QAM: Quadrature amplitude modulation
QoS: Quality of Service
RF: Radio Frequency
ROI : Return of Investment
RTCP: Real-time Transport Control Protocol is used to report on the performance of a particular RTP transport session.
RTP: Real-time Transport Protocol: a protocol that is used to transport real-time data, such as voice or video.
SCCP: Signaling Connection Control Part: protocol used to deliver transaction messages.
SCTP: Stream Control Transmission Protocol created for transmitting SS7 messages over the IP network.

Signaling Gateway: A signaling gateway (SG) is a device or computer that interfaces a softswitch with a signaling system such as SS7.
SIP: Session Initiation Protocol
SME: Small and Medium Enterprises
SOHO: Small Office and Home Office
Softswitch: Softswitch is a device or computer that controls the setup and teardown of calls in media gateways.
SS7: Signaling System 7
SS7 Network: Signaling System 7 network is a data network that transmits messages between switches and other computers used in the PSTN.
Tandem Switch: A tandem switch interconnects with other PSTN switches. It is often called a “class 4” switch,
TCP: Transmission Control
TDM: Time Division
TDMA: Time Division Multiple Access
UDP: User Datagram
VDSL: Very High Speed Digital Subscriber Line
VLAN: Virtual Local Area Network
Vocoder: Vocoder is an acronym for voice coder/decoder.
VoD: Video on Demand
VoIP: Voice over the IP network:
WAN: Wide Area Network
WiFi: Wireless Fidelity
WIMAX: Worldwide Interoperability for Microwave Access
WLL: Wireless Local Loop
xDSL: Digital Subscriber Line