



Next Generation Networks – the Technology and its Resource Management

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Abstract— Next Generation Network (NGN) is a generic term that describes the evolution and migration of fixed and mobile network infrastructures from distinct, proprietary networks to converged networks based on IP. It is envisioned to be an interworking environment of heterogeneous networks of wired and wireless access networks, PSTN, satellites, broadcasting, etc. This multilayer structure of transport networks presents a key challenge in network resource management which is a wide subject that has been studied extensively. The operations and management of such interconnected networks and complex service-oriented architectures are the key issues in effective management. They are expected to be much more difficult and important than the traditional network environment. We present an overview of the NGN with its basic architecture, the technologies that can be used for implementation and its need in advanced networking. We also show you the current status towards the management of NGN and discuss challenges in operating and managing it. We also present the operations and management requirements of NGN in accordance with these challenges.

Keywords— Autonomic Computing, Denial of Service attacks (DoS), FCAPS management, IDSs, IPSs, Packet-based Network, PSTN, SLA, Triple and Quadruple-play, xDSL.

I. INTRODUCTION

In 1998, the telecommunication industry started to focus on a "next generation" of network that would replace the current telephone network. Today, Mobile communications play a central role in the voice/data network arena. The future in telecommunication systems goes towards a split between the network provider and the service provider, and a convergence of media distribution and communication networks. Technological innovation, stimulated through digitalization, has been a major factor in driving change in the communications market. This innovation is reducing costs and enhancing the capability of networks to support new services and applications. A key innovation which is expected to bring further significant changes in the communications market is the transformation from circuit-based public switched telecommunication networks to packet-based networks using the Internet Protocol, so-called Next Generation Networks (NGN). The motivation behind the NGN is much more than just switch replacement, it is an answer to the market reality that 'fixed' voice telephony - although a major part of the telecommunications business - is no longer the only feature that the user wants from their phone service provider. Fig. 1 shows the market analysis from 2001 – 2013, where the use of traditional telephone (PSTN) has reduced significantly whereas Cellular Telephony is dominating [1]. Given the demand, it makes sense to build a new infrastructure that primarily designed for data, and that accommodates telephony as one of many data applications.

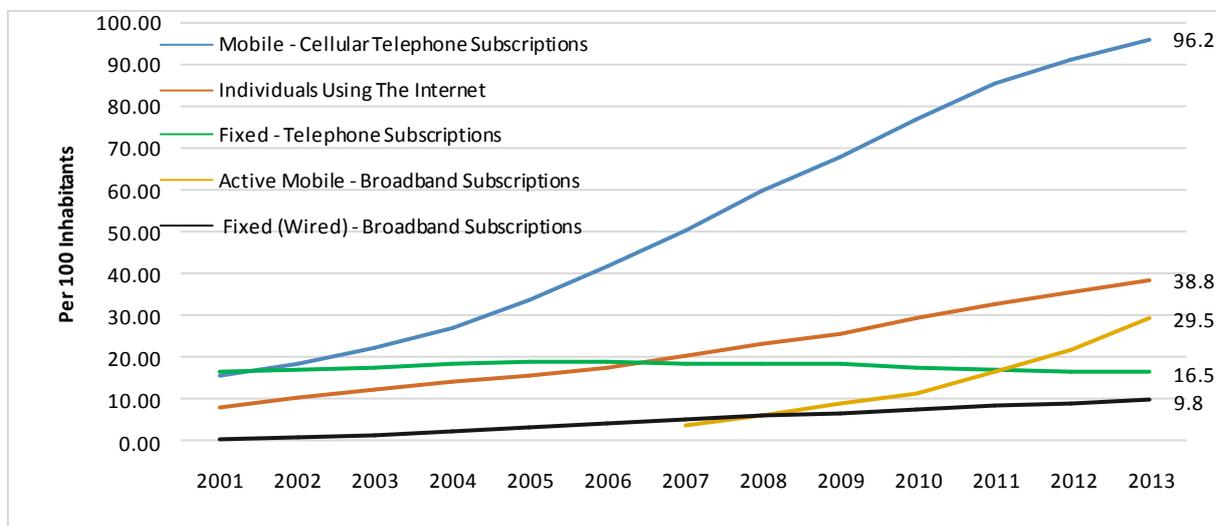


Fig. 1 Market Analysis of Types of Communication

II. IDEA BEHIND NGN

NGN represent a fundamentally fundamental redefinition of the telecommunication industry, a revolution brought up by the merging of voice and data, transmission and computing. The general idea behind the NGN is ubiquity in which one network transports all information and services (voice, data, and all sorts of media such as video) by encapsulating these into packets. A next-generation network (NGN) is a packet based network which can provide services including Telecommunication Services and able to make use of multiple broadband, quality of Service-enabled transport technologies and in which service-related functions are independent [3]. 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. NGN, also defined as “broadband managed IP networks”, includes next generation “core” networks, which evolve towards a converged IP infrastructure capable of carrying a multitude of services by developing high-speed local loop networks that will guarantee the delivery of innovative services. At the end, this new technology may lead to communication companies not even being called "communication companies" any longer, but will lead to their being viewed as a new category of Service Company that hasn't really existed before. The NGN would carry voice and data over the same infrastructure, which would unleash the power of modern computing is on the old communication services [14].

TABLE I
Comparison between Existing Communication Services and NGN

	PSTN / IN	Internet Protocol	NGN
Multimedia service	No	Yes	Yes
QoS – Enabled	Yes (Voice)	No	Yes
Network Intelligence	Yes	No	Yes
Intelligent CPE	No	Yes	Yes
Underlying Transport Network	TDM	Packet	Packet
Service Architecture	Semi-Distinct	Ad-hoc	Distinct
Integrated Control & Management	No	Yes	Yes
Service Reliability	High	Low	High
Service Creation	Complex	Ad-hoc	Systematic
Ease of Use of Services	Medium	High	High
Evolvability / Modularity	Low	Medium	High
Time to Market of Services	Long	Short	Short
Architecture Openness	Low	High	High

III. TECHNOLOGIES IN NETWORKING

A. Narrow Band Internet

- 1) *Speed*: Less than 256 kbps
- 2) *Technology*: Dial-up (ISDN) connections over phone lines; GSM and GPRS data connection in mobile

TABLE III
Types of ISDN

	BRI (Basic Rate Interface)	PRI (Primary Rate Interface)
B Channel for Data	2 x 64 kbps	23 x 64 kbps
D Channel for Signaling	16 kbps	64 kbps
Installation	Ordinary twisted pair copper wires	Ordinary twisted pair copper wires
Bandwidth	112 kbps	64 kbps / may be bonded to provide > 64kbps

B. First generation broadband

- 1) *Speed*: 256 kbps – 50 mbps
- 2) *Technology*: DSL technology over phone lines, its evolutions (ADSL, ADSL2, etc.); EDGE and UMTS/3G technologies in mobile

TABLE III
xDSL Technology

	Maximum Distance (km)	Maximum Rate
HDSL (High Bit DSL)	5	2 Mbit/s
UDSL (Universal DSL)	6	2 Mbit/s
SDSL (Single DSL)	3	2 Mbit/s

ADSL (Asymmetric DSL)	6	- 1 Mbit/s (download) / 16 kbit/s (upload)
	4	- 8 Mbit/s (download)/ 640 kbit/s (upload)
VDSL (Very High DSL)	1.5	- 13 Mbit/s (download) / 1.5 Mbit/s (upload)
	0.3	- 50 Mbit/s (download) / 2.3 Mbit/s (upload)

C. *Future packet based Networks (NGN):*

- 1) *Speed:* More than 50Mbps
- 2) *Technology:* Fiber based fixed solution; Long Term Evolution (LTE) in mobile; IPv4 and IPv6 in networking where IPv4 introduces intelligence in the nodes while IPv6 uses the intelligence of the device connected to it

TABLE IV
Comparison between IPv4 and IPv6

		IPv4	IPv6
QoS	Measurement of service	Type of service field	Traffic class field
	Identification of traffic flows	None	Flow label field
	Recognition of control expedite data	None	Hop-by-Hop extension header
Security	AH header	Optional	Mandated
	ESP header	Optional	Mandated
Mobility	Detection of new networks	-	Yes
	Generation of new addresses	-	Auto configuration
	Mobility headers	-	Mandated
	Option header: destination option, routing, etc.	Optional	Mandated
Packet format	Size of IPv6 header	Variable	Constant
	Optional headers	Optional headers	Extension headers and options
Addressing	Hierarchical Addressing	-	Yes
	Address Renumbering	-	Yes
	Addressing spaces	Lack of address spaces	Large address spaces
	End-to-End communication	No	Yes
	Types of addresses	Unicast, multicast and broadcast	Unicast, multicast and anycast
	Scope of addresses	Local and global	Local and global, link-local
	Address configuration to an interface	A address	Multiple addresses
	Address allocation to an equipment	Multiple interface/addresses	Multiple interface/addresses
	Address auto configuration	Using private addresses	Using public addresses

IV. NGN ARCHITECTURE

The Next Generation Network (NGN) is body of key architectural changes in telecommunication core and access networks. NGN is expected to completely reshape the present structure of communication system. The present structure of vertically independent, although interconnected, networks may be transformed into a horizontal structure of networks based on Internet Protocol [2]. The architecture for the NGN is prescribed in ITU - T Recommendation Y.2012 "Functional requirements and architecture of the NGN". The NGN consists of four function groups and two types of user profiles. Transport functions transfer multimedia streams over the IP network. Transport control functions allocate IP addresses, perform authentication tasks, and enable control functions such as resource admission for guaranteeing IP-layer QoS to be used from service components [3]. Service control functions (such as IMS) and application support functions & service support functions provide support functions such as presence management.

Two types of user profiles are specified based on how user information used by the service control function group and

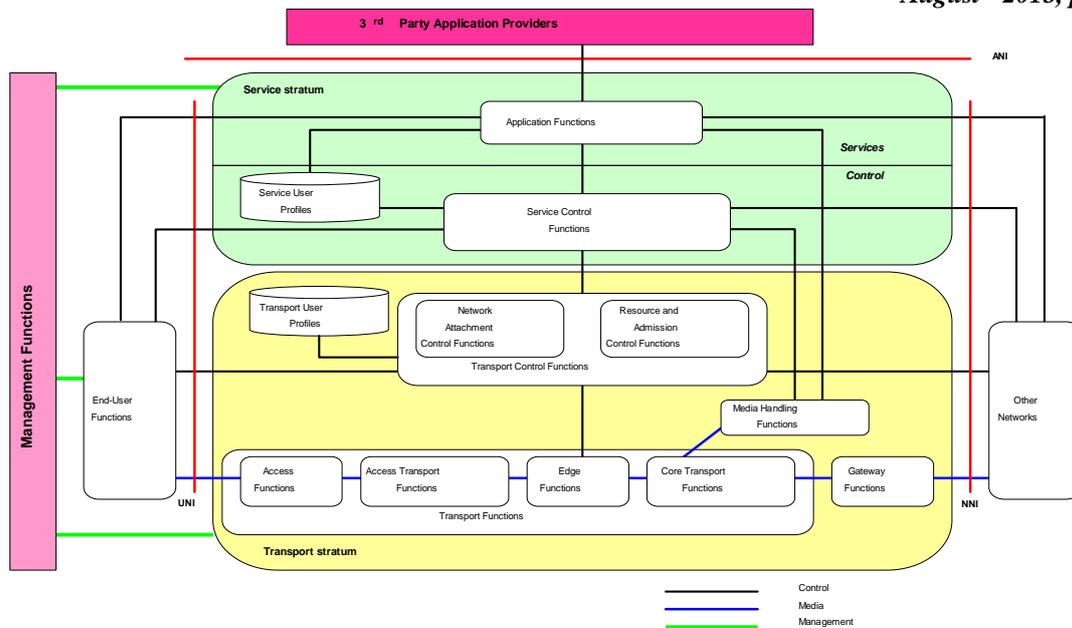


Fig. 2 NGN Architecture

transport control function group is applied and how it relates to the functions. One of these is the transport user profile, which is referred to by the transport control function group. This profile includes information such as user authentication data and the bandwidth that the user may obtain when connecting to the access network. The other is the service user profile used by the service control function group. This profile includes information such as what services the user is allowed to use and how many simultaneous connections may be made.

ITU-T Recommendation Y.2012 calls for three types of interfaces:

- A. The user-network interface (UNI), which is the connection point with end-user functions;
- B. The network-network interface (NNI), which is the connection point with other networks; and
- C. The application-network interface (ANI), which is the connection point with application functions [1].

V. NEED OF NGN

The developments in new communication structures and the impetus they are expected to give to the present process of convergence in networks, services and terminals are expected to lead also to new policy challenges. The movement is driven by the following:

A. Economic Drivers

Recently, the revenues from fixed line voice call have reduced drastically due to emerging new market segments, moreover, mobile telephone services has reached saturation. Competitive pressure from new entrants in high margin sector of markets has led to the “ladder of investment” for NGN.

B. Technological Drivers

Obsolescence of legacy networks and, cost and complexity of managing multiple of them has forced to switch from PSTN voice services to IP based networks which are cheaper and have wider range of services. It also allows bundling of multiple services (triple and quadruple play).

C. Social Drivers

Demand for innovative, high bandwidth services for evolved and more flexible form of communications including instant messaging and video conferencing has given scope for NGN. Also, Business demand for integrated services, in particular in case of multinational structures which needs to be linked to different national branches, guaranteeing a flexible and secure access to centralize resources and intelligence has further increased the need of NGN.

But, before we reap the benefits of the NGN transition and its resources, it has to face many challenges and manage them [1].

VI. CHALLENGES FOR NGN MANAGEMENT

In the NGN environment, we envision and assume the coexistence of old and new networks and inter-working of heterogeneous networks provided through the cooperation of service providers around the world. This is a very ambitious goal and there are many challenges that must be overcome before this vision can be realized. In this section, we examine these challenges.

A. Network Discovery and Selection

Since NGN consists of interconnected heterogeneous networks using heterogeneous user terminals, NGN should provide a seamless capability, independent of access method and network, and NGN also should address the identifying mechanisms. That is, each terminal can use more than one type of network and possibly access multiple networks simultaneously for different applications (e.g., one for voice and another for receiving streaming media). In such an environment, a terminal must be able to discover what networks are available for use [4]. One of the proposed solutions

for network discovery is to use software-defined radio devices that can scan the available networks. After scanning, they will load the required software and reconfigure themselves for the selected network. The software can be downloaded from the media such as a server, smart card, memory card or over the air.

B. Generalized Mobility

At present, mobility is used in a limited sense such as movement of user and terminal and with or without service continuity to similar public accessed networks (such as WLAN, GSM, UMTS, etc.). This means the horizontal handoff, which involves a terminal device to change cells within the same type of network to maintain service continuity. In the future, mobility will be offered in a broader sense where users may have the ability to use more access technologies, allowing movements between public wired access points and public wireless access points of various technologies. That is, in NGN environment, in addition to the horizontal handoff, the vertical handoff must also be supported. The vertical handoff mechanism allows a terminal device to change networks between different types of networks (e.g. between 3G and 4G networks) in a way that is completely transparent to end user applications [2]. Thus, the challenge is to allow vertical handoffs between pairs of different types of networks in the presence of 2G, 3G, WLAN, WMAN, satellite and 4G networks. The greater challenge lies when the vertical handoffs must take place with a certain set of QoS requirements still satisfied.

In NGN, all three types of roaming should be supported to roam through different network types, operating in different cities and countries. For true global roaming, roaming agreements must be set up among service providers among countries [5]. Today, only a few service providers in different countries provide global roaming. The challenge is to provide more roaming agreements among the service providers in different countries. The greater challenge would be to provide inter-standard roaming in different countries.

C. QoS Support

Over the past decade, much research has been conducted in the area of QoS, and many protocols and methods have been proposed. However, the predominant method to support QoS by the Internet service providers (ISPs) today is overprovisioning. That is, instead of implementing complex QoS algorithms and methods, ISPs typically provide enough bandwidth in their backbone trunks so that their networks are hardly overloaded and thus there exists very little delay and few packets are lost in transit. This is quite feasible since a lot of fiber trunks have been installed over the past decade and the bandwidth cost of wired Internet trunks is very cheap. In the ISP's views, it is much simpler and cheaper to provide overprovisioned networks than implementing and managing complex QoS mechanisms [6].

Although NGN is supposed to provide higher bandwidth and more cost-effective channels than its predecessor networks, the bandwidth cost in NGN wireless networks will remain higher than wired networks. Thus, overprovisioning in NGN will not be feasible and QoS support mechanisms will definitely be needed. Providing QoS support in NGN will be a major challenge thus much work is needed [7].

D. Charging and Billing

Internet access is widely available from ISPs by using a number of access technologies including xDSL, cable modem, FTTH, satellite, and leased lines. The charging models for these traditional Internet access networks are already established and are in use around the world. These established charging models are now being applied with limited success to the new and evolving Internet access networks including WLAN and mobile telecommunication networks offering 2G and 3G services.

In the NGN environment, multiple service providers will typically be involved during a session (e.g., a phone call and data access), which may roam from one service provider network to one or more other service provider networks. Thus, in some cases, a single session may incur number of charges, each of which may be for a different service provider. Moreover, different charging schemes may be used for different types of services (e.g., charging can be based on data, time, or content) [4]. One challenge is to keep track of charges per each segment of a session's use of its network, service or content. More charging agreements between the service providers are needed in order to allow roaming during a session in order to obtain a continued service as far as a customer is concerned.

E. Security

Over the past few years, the Internet and enterprise networks have been plagued by denial of service attacks (DoS), worms and viruses, which have caused millions of computer systems to be shut down or infected and the stored data to be lost, ultimately causing billions of dollars in loss.

The first mobile phone virus, Cabir, has surfaced in June 2004 on Bluetooth-enabled Nokia mobile phones running the Symbian OS. The CommWarrior virus in March 2005 was a Symbian virus spread by multimedia messaging services (MMS) and Bluetooth which destroyed content on the handset. Once infected, the handset would no longer boot [8]. Since the first virus came out, more worms and the strains of viruses in the mobile telecommunication networks are continually discovered.

In the NGN environment, we will likely see more open platforms on terminal devices and servers providing various downloadable contents, some of which may carry worms and viruses. More interconnectivity and inter-working will make the vulnerability even greater. Monitoring, detecting, analyzing and preventing worms and viruses on wired networks are very difficult tasks, but the same tasks on wired, wireless, and mobile networks combined would be even more difficult and challenging [2].

VII. NGN MANAGEMENT

NGN management (NGNM) provides management functions for NGN resources and services, and offers communications between the management planes and the NGN resources or services and other management planes. FCAPS (Fault, Configuration, Accounting, Performance and Security) management areas are sufficient to cover most, if

not all, of the issues related to the operations and management of the wired networks in NGN. With the introduction of wireless and mobile networks, a few additional areas, which could not be easily covered by FCAPS, had to be added. They are mobility management, customer management, and terminal management. In this section, we propose the requirements of NGNM based on the ITU-T specification and the challenges presented above.

A. Fault Management

The NGN environment will consist of numerous network devices such as base stations (BSs), access points (APs) gateways (GWs), routers, and servers to be monitored and controlled. Due to the increased number of devices to cover more geographic areas and users, along with the increased number of types of devices, scalable fault management solutions are desirable. Devices are likely to generate more event (including problem) reports as they will be involved in handoffs, roaming, charging, etc., and thus there will be a lot more event reports to be processed than in the traditional networks. Logging and auditing of events will be a challenging task but will need to be provided. Hence, traditional ways of conducting fault management will not likely scale well in the NGN environment. One possible solution is to apply the concept of 'autonomic computing', where devices will be more self-managed. The research in this area has recently begun and the results can hopefully be applied to the NGN environment [9].

B. Accounting Management

Accounting management largely entails Authentication, Authorization and Accounting (AAA), Charging, and Billing. Accounting management in the NGN environment is also very important and robust, thus precise and inter-working accounting systems are required. Users wishing to use one or more services provided by the service providers must be authenticated (i.e., validate who the user is) and authorized (i.e., validate whether the users allowed to use the service or not). Then, the user can enjoy the service and be charged accordingly. One of the most difficult challenges in the NGN is in providing authentication and authorization service in real time so that when roaming is required, the user can be authenticated and authorized to change the network on the fly. It becomes even more challenging when the roaming combined with vertical handoff and QoS requirement satisfaction checking is required on the fly [4]. IETF (Internet Engineering Task Force) AAA Working Group has standardized AAA based on RADIUS and is currently working on AAA based on DIAMETER. It will be interesting to see whether DIAMETER will be sufficient for AAA in the NGN environment or not. A single user session may involve one or more service providers' networks in the NGN. Also, within the same service provider, a session may involve multiple types of networks which may have different charging schemes. Billing needs to consider various ratings due to service bundling (e.g., mobile phone, Internet access, satellite TV, etc.) A session manager would keep track of the user's activities during a session. A charging system needs to exist in each service provider's network that keeps track of the individual customer's usage. Service providers in turn would periodically settle charges with other service providers based on the settlement agreements' setup between the service providers. A billing system keeps track of customers' charges and generates monthly bills. It also keeps track of overdue payments, credits, etc.

C. Performance Management

Performance management is another essential management area for the NGN environment. This is especially true as most of the service providers today consider performance assurance as a key part of SLA that they make with the customers when they subscribe. At lower level, network performance monitoring is required while at an upper level, service quality management is required [10].

For network performance monitoring, an active monitoring method is typically used, where packets are sent in to the network to obtain performance metrics such as delay, jitter, packet loss, and throughput. These performance figures are either provided to the customers as requested (or via a network weather website), or used for service quality management to verify that their networks are performing according to the agreements they made with the customers via SLAs. SLA is a formal negotiated agreement between a service provider and a customer. The service quality management is the integrated management of all functionalities in the SLA life cycle. When a customer orders a service from a service provider, an SLA is negotiated and then a contract is made. In the SLA contract, QoS parameters that specify the service quality that the service provider will guarantee are included. The service provider must perform SLA monitoring to verify whether the offered service meets the QoS parameters specified in the SLA or not. In order for the service quality management system to verify whether the specified QoS parameters are being met or not, the system must gather performance data from the underlying network performance monitoring system and map such data to the QoS parameters [7], [11].

D. Security Management

In addition to the AAA requirement described above, information security and network security are two important aspects of security in the NGN environment. Both aspects are important to the integrity of the communication or data being transferred and for the health of the network resources including the networks and servers providing the services [2]. Cryptography can be used to encrypt and decrypt packet data while in transit to provide secure communication. A lot of research has been done in this area with results such as AES. A disadvantage of using cryptography is the degradation in the performance. Secure communication may not always be necessary. Thus, service providers must determine where cryptic communication would be necessary and may apply only when and where needed. Firewalls, intrusion detection systems (IDSs), and intrusion prevention systems (IPSs) will be needed in key places in the network to protect resources from potential hackers and worms. Anti-virus software must also be installed in key servers in order to detect and cure viruses. It is always a good idea to constantly keep them up to date and replace to new systems when patching and updating will no longer be effective. Again, these protective measures may degrade the performance of networks and servers but it is well advised to invest and deploy those measures wherever necessary [8], [12].

E. Mobility Management

Mobility management in the NGN entails horizontal and vertical handoffs, and roaming [13]. As explained in Challenges for NGN Management, both horizontal and vertical handoff functionalities must be provided in the NGN and a mobility management system is required to support them. A key challenge will be when changing a network for a session with certain QoS requirements. If the QoS requirement can be satisfied in the new network, then there will be no problem. The problem arises if the new network cannot satisfy the QoS requirement. Should we terminate the session or continue it with lower quality? Although the latter will likely be chosen by most users, such decision can be preset by the user in his or her personal profile.

Mobility agreements must exist in advance between the service providers in order to provide service continuity. The goal of mobility is to have a customer receive the same service (or as close to it) when traveling in an area supported by another network as the customer receives when in their home service provider's area. Authentication of the user in the home network and registration in the session manager must be done on a fly. Otherwise, the transition from one network to another will not be smooth and may lose a connection or experience a short outage in communication [11].

VIII. CONCLUSIONS

As we draw our conclusion, challenges are, in essence, what motivates research. The Next Generation Networks, in that respect, will be a great motivator. There is no need to repeat a stepwise development from telegraphy to telephony, then to internet and finally to the NGN. Let's jump immediately in the future. This paper presented an overview of NGN and the limitations of the current control and management infrastructures in pre-NGN networks, and various classes of service that NGN will have to support are elaborated on [14]. Standardization and research activities on NGN and its management have been taking place quite actively in the past several years but much more work is needed before NGN can be fully realized.

In the above context (VI and VII) we came across so many challenges and requirement that has to be taken into consideration before ubiquitous networking can come into reality. Although there are so many challenges, we require NGN to fulfill today's generation's demands and requirement of advanced networking as it provides:

- A. Mobility of a cellular networks round the globe
- B. Concept richness of internet and packet based data transmission
- C. Bandwidth of optical networks
- D. Security of private networks
- E. Flexibility of Ethernet
- F. Video delivery of cable and television

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