New Generation Networks: a Networking Trend

Redes de nueva generación: Una consolidación del networking

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Abstract

This paper offers a comprehensive survey of recent developments in the field of Next Generation Networks (NGN). The traditional concepts associated to NGN are extended by including up-to-date studies and standards and also by sorting future research lines according to the main challenges of such networks, namely architecture, management and mobility. The current trend suggests that certain key aspects are yet to be solved in order to determine who the actual owner of an NGN network is.

Keywords: New Generation Networks,Quality of Service, NGN Mobilite

Resumen

Este trabajo ofrece un estudio exhaustivo de los acontecimientos recientes en el ámbito de las Redes de Próxima Generación (NGN). Los conceptos tradicionales asociados a las NGN se amplían mediante la inclusión de arriba-a-fecha de los estudios y las normas y también por la clasificación futuras líneas de investigación de acuerdo a los principales retos de este tipo de redes, es decir, la arquitectura, la gestión y la movilidad. La tendencia actual sugiere que algunos aspectos clave aún no se han resuelto con el fin de determinar quién es el dueño real de una red NGN.

Palabras Clave: Redes de Nueva Generación, calidad del servicio, las NGN Mobilite.

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Introducción

At present, technological convergence has allowed gradual integration of various types of heterogeneous network infrastructures, which are capable of offering added-value services as well as guaranteeing the Quality of Service (QoS) provided by the transport layer. This type of suitable convergence has been termed *Next Generation Network (NGN)*. However, such a continuous technological shift, makes us wonder about the type of network architecture we are facing, namely about a somewhat unusual architecture in which services play a fundamental role [1]. In the last decade, this service-driven philosophy of network design has promoted the use of *reusable components* so as to efficiently support the sort of uninterrupted services that operate using different types of networks. To this end, a series of high-level *interfaces* have been created in order to guarantee a successful deployment of the so called *Service Oriented Architecture* model (SOA).

Communication networks evolution, from traditional networks to NGN, has relied upon appropriate convergence of applications and services. Within NGN, multimedia services are meant to be safe and accessible from any network using any type of desktop-based or mobile terminal; which is possible through the use of a unified transport network. In order to achieve these aims, there is a consensus about the use of MPLS-based IP routers to carry out tagging processes as well as traffic differentiation. However, some other aspects are still to be considered when attempting to define NGN, namely network architecture, network management and network mobility (which governs current IP networks).

In order to set a complete context that allows a clear understanding of NGN trends, this paper is organized as follows: A concept provided by ITU[1] on New Generation Networks is presented as the starting point is; subsequently, the structural and functional architecture of such networks is explained. Then, a recently adopted approach on management and services is discussed to finally analyze the concept of mobility.

1. ITU: International Telecommunication Union.

Definition and Features of New Generation Networks (NGN)

According to what has been established by ITU regarding NGN, it can be stated that a particular NGN is a *packet-transmission-based network that is capable of offering integrated services (including traditional telephone services) and also capable of fully exploiting the channel's available bandwidth through the use of Quality of service Technology (QoS) so that packet transport is successfully carried out regardless of the network infrastructure. Additionally, this network offers unrestricted access to users from various telephone companies and also supports mobility, allowing user multipoint access* [2][3].

When analyzing the previous definition of NGN, the following fundamental features can be found:

- The transport plane is to be based on IP/MPLS packet switching technology
- There is a separation between services and transport-network technology (Decoupling Access and Services)
- A wide range of services, applications and mechanisms of different nature must be supported, namely real-time, non-real-time, streaming, multimedia services etc.
- End-to-end broadband access, including Quality of Service (QoS), must be guaranteed.
- Traditional networks should migrate, or else provide inter-operation through the use of open interfaces and standard protocols
- Existence of generalized mobility
- Users should be provided with unrestricted access to various service providers
- Users should perceive that the same services share unified features
- Fixed and Mobile Convergence must exist (FMC) in terms of services
- The network must support multiple last-mile technologies as well as various types of access networks
- There must be full compliance with all standard requirements regarding security, privacy, emergency communication, legal interception, etc.

After analyzing the aforementioned concepts and features, and in order to gain a better understanding of the rationale behind the general concept of NGN, it can be observed that the first part of the definition addresses the sort of packet-based information flow that occurs within the Internet regardless of the IP-protocol version. This allows, and to a certain extent compels developers to use the IP protocol for their creations to survive within an Internet-dependent environment, which suggests a recovery for protocol IP in terms of popular awareness.

A second fundamental aspect lies in determining the great variety of equipment that converges on a single network, which makes protocol coexistence necessary and poses traffic management as a decisive factor, since isolated conflicts cause overall network congestion.

Thus, the problems associated to new-service articulation and traditional-network supported service integration divert the concept of QoS onto the aspects that pertain to the transport and data-link layers, specifically onto the principles of encapsulation [4].

In order to achieve reliable connectivity in terms of transport, it was decided that protocol IP be used to guarantee a type of public connectivity that becomes general, ubiquitous and global. Such a protocol can be easily transported over various underlying access technologies and also over various core transport-layer technologies (e.g. xDSL, ATM, MPLS, frame-retransmission, OTN) according to the environment of a particular service provider.[5]

Regarding the previous discussion, it is important to include connectivity aspects that support IPv4, IPv6, real-time communications, one-to-one point connectivity, and one-to-many connectivity. On the other hand, and provided that the main purpose of NGN is to admit services and applications regardless of the access-network technologies, these networks should also support any user network regardless of the configuration complexity level. That is, an NGN is intended to handle the end-user functional starting processes that deal with service access, and address-space management.

By taking advantage of IPv6, it is possible to support not only address-space extensions but also various advanced features that impact on NGN networking functions as well as on the performance of the corresponding functional entities. This contributes to further flexibility when introducing new services/applications by using extension-and-option header combinations.

Within signaling aspects, recommendation H-323 can be highlighted (packet-based multimedia communication systems). This recommendation deals with the way PC telephones or existing conventional telephones can be properly connected (with adapters) to packet networks and so inter-operate with Public Switched Telephone Networks by using gateways. Recommendation H.323 is part of a larger series of standards and regulations intended to facilitate videoconferences over a wide variety of networks. Widely known as H.32X, this series of standards includes recommendations such as H.320 for narrow band ISDN (N-ISDN), H.321 for broadband ISDN (B-ISDN) and H.324 for General Switched Telephone Networks (GSTN). Figure 1 illustrates protocol series H.323 [6][3].

Figure 1. *Series-H.323 protocols*

<table>
<tr><th>Audio</th><th>Video</th><th>Data</th><th colspan="3">Interfaz usuario control de</th></tr>
<tr><td>G.711</td><td>H.261</td><td rowspan="5">T.120</td><td colspan="2" rowspan="2">H.225</td><td rowspan="5">Control H.245</td></tr>
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<tr><td colspan="2">RTP/RTCP</td></tr>
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Provided the preservation and continuity of protocol IP, it is worth mentioning that the current protocol-associated evolution of NGN networking further supports any IPv6-based work. This allows solving particular optimization issues in terms of routing, particularly when using NEMO technologies, which offer increased bandwidth and better scalability of network services. [7]

On the other hand, it is necessary to observe how optical-fiber services increasingly permeate every-day activities and businesses. Such is the case of Japan, where a complete optical-fiber infrastructure is already operating and internet-access home services (FTTH) as well as video distribution services are provided based on technologies such as PON and G-PON. The benefits of having this type infrastructure include lower costs, larger bandwidth availability and further reductions in terms of network maintenance [8].

This recently developed evolution undergone by big networks whose physical layer used to rely on copper, and now rely on optical fiber, allows proper migration of IP networks from circuit-switching based to packet-switching based. This results in end users (either home or business) requiring larger bandwidths, especially in rural or suburban areas, which entails architecture improvements within an NGN at the access level as well as better organization of telecommunication service providers.[9]

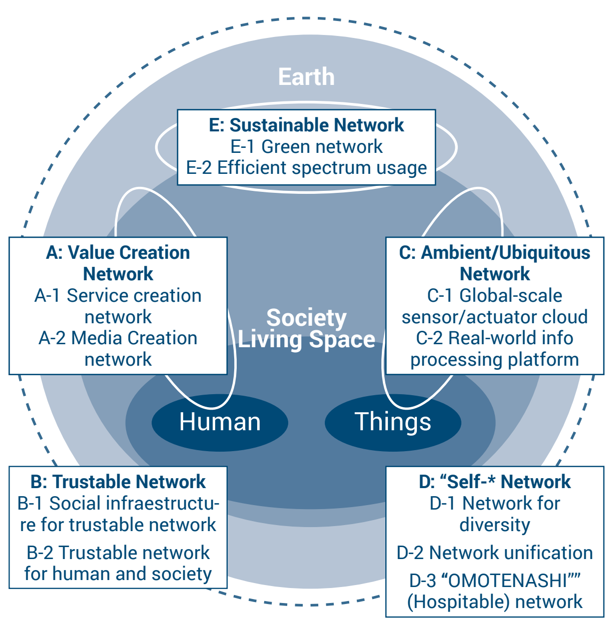
Similar to the way copper-to-fiber evolution is to be considered, careful attention should also be paid to wireless networks. These networks are now widely implemented and play a major role within the whole concept of NGN mobility. Thus it is necessary to provide high transmission rates with small convergence areas and low cost. This issue has been addressed and managed by implementing mobile communications 4G standards, where a solution is to be provided for the various convergent technologies. Solutions also address support for existing services. A summary of these aspects and their associated features can be found in [10]

When having a close look at what has been termed web 2.0 and also at the so called SOA, the characteristic elements associated to NGN can be easily found. Such elements are mainly intended to solve user needs and to ease knowledge exchange (more than mere object-reference information exchange). Within these fundamental purposes, social communities represent the most compelling feature for internet service providers, promoting a paradigm shift in terms of service demand, and extending to other aspects such as adaptability, contextualization and service customization; these elements can only be integrated with ease within an actual NGN. [11][12].

It is also important to mention the aspects associated to the migration process from traditional networks to IP networks, as stated in [13], where some of the most relevant factors include traditional-network maintenance costs, VoIP development and the current multimedia-service market. Three alternatives are introduced to be implemented, either in a mutually-exclusive fashion or as a combination of strategies depending on the scale of financial investment of service providers. The alternatives are as follows: i) complete replacement of traditional networks with IP-based NGN, ii) an overlap of NGN over previous networks considering gateway problems that may occur, and iii) a gradual migration that depends on existing infrastructure at the access level, taking advantage of switches and also of Time Division Multiplexing (TDM).

However, not having accomplished a full development of both the concepts and technologies that allow a solid definition of NGN, in [14] a new term is already put forward, namely NWGN. The proposal covers five major parts and, overall, gathers a series of conditions that allow better planning and design for recently developed networks as well as for upcoming networks (Figure 2).

Figure 2. *NWGN Parts*

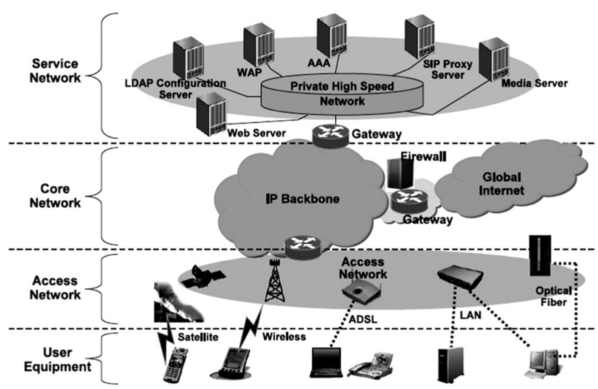


New Generation Networks Architecture

Figure 3 shows the typical components of New Generations Networks, where four main levels can be observed [2], namely:

Network Services: This level deals with providing users with services and applications. The level consists of a series of servers to guarantee that the network actually offers the type of solutions expected by end users, e.g. web servers, authorization (AAA) and control servers, Proxy Servers, LDAP Configuration Servers, and authentication g-servers (WAP Server).

Figure 3. *Components of NGN*

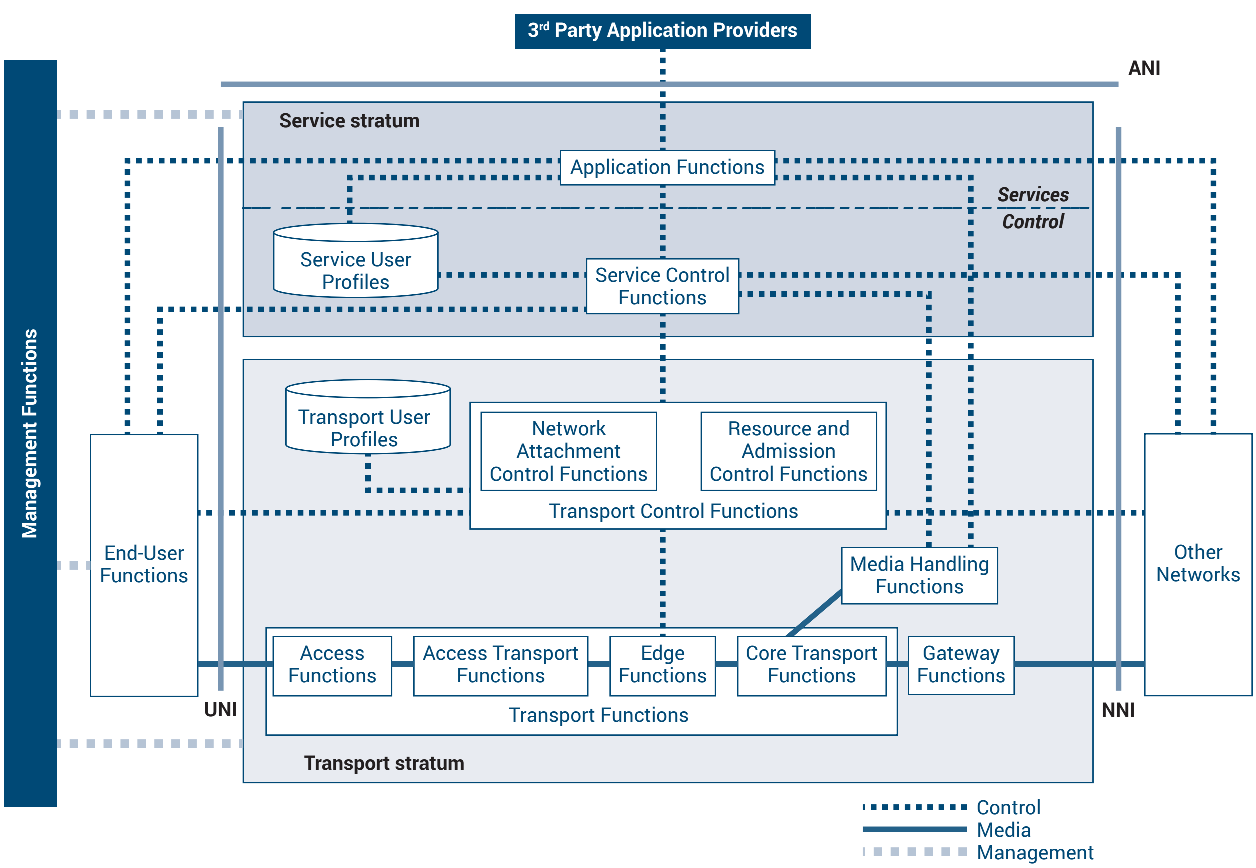


Core Network: Mainly represented by the network's backbone associated to traditional networks and of those networks that emerge from technological advances, this level concentrates all information transport that may exist among the various network entities. The level is basically in charge of packet transfer and also of management and control functions.

Access Network: The importance of this level lies in the need to connect to different access technologies. The level allows coexistence of various technological means and separates the network core from user equipment.

User Equipment: This level consists of all the equipment employed by users to access the network. The level supports a wide variety of protocols and technologies intended to receive services and/or applications from the network.

Figure 4. *Functional Structure of NGN*



On the other hand, Figure 4 shows the functional structure of NGN as stated in various official documents issued by ITU-T, namely ITU-T X (where X refers to each of the documents that established the necessary NGN operation conditions). In this sense, the architecture associated to NGN requires flexible configurations that allow accessing from multiple technologies; likewise, such an architecture must support distribution and control mechanisms, providing proper separation between the services it provides (through information transport) and the various bit rates that pertain to NGN services [5] [15] [16]

The functions of this architecture are separated into two big layers, namely Service and Transport. The functions of the Service Layer offer support for session-based and non-session services. These functions include further support for subscriptions and notifications; likewise, they offer message exchange methods. The characteristics of management and administration functions within a particular NGN are included in the Transport Layer; this layer guarantees proper configuration, authentication and security of end-user equipment, either desktop-based or mobile.[3]

Management and Services

This section introduces a series of relevant services that allow determining the importance of NGN developments in the dynamics of supply and demand for telecommunication service providers nowadays.

In recent years, NGN networks have gradually replaced traditional networks (SDH, PDH) and up to a certain extent NGN has become a solid foundation for data transport over IP/Ethernet; as a consequence, the type of traffic that converges in these new networks also brings its own difficulties, such as synchronization issues at a data level and also at a network level. In order to address these issues, it is necessary to study new measurement techniques intended for time-frequency distributions using packets. New methods have been developed to deal with clock synchronization over packet-based networks, namely Network Time Protocol (NTP) and Precise Time Protocol (PTP), which guarantee convergence and network service [17].

NGN embraces new capabilities and supports a wide range of emerging services, including those services that offer advanced and complex functionalities. Resulting from a third-party provider initiative for applications and services, the main purpose is to develop new applications and capabilities to be accessed by using open, normalized interfaces. This initiative is motivated by the ever-greater need for cooperation among service-and-network providers when developing normalized application network interfaces (ANI). As a result, NGN networks are meant to support software reuse and software portability as well as the use of commercial software, thus achieving a profitable development.

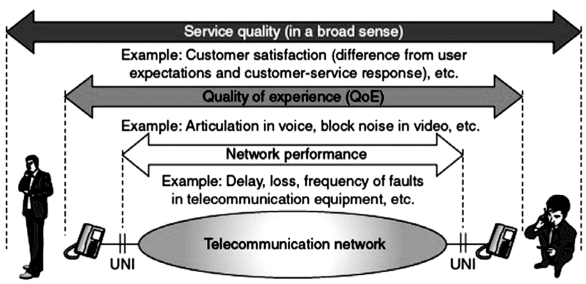
NGN also provides the necessary capacity to establish, manage and end end-to-end service sessions intended to cover, for instance, various parts, a set of end points associated to those parts, and a description of the multimedia connections between end points. These network capabilities are available for fixed-network environments and also for mobile networks in order to meet the service requirements and make use of adequate application servers for proper service performance.

NGN offers application support through the web, which facilitates improvements in the exploitation of devices maximum capacity as well as of the network's characteristics; this is particularly suitable for the case of web-based applications. Support capabilities of this sort of applications allow users to have a web-based environment that is coherent and that can cover different network environments (e.g. local, office-based and/or mobile) as well as various types of devices (e.g. portable, mobile telephones, personal computers, tablets). In this sense, various needs are successfully satisfied, namely interoperability between wired and wireless networks, safe access to applications, efficient use of bandwidth, etc.[18]

Quality is an important concept in the construction of NGN. However, the term "quality" may be associated to various meanings. For instance, quality can be used to refer to voice quality in a telephone call, or the term can be used to talk about image quality in video-delivery services. Quality can also be associated to communication services when describing the extent (and time span) to which communication equipment works with no failure and also to refer to client request response times whenever customers require a specific service or maintenance assistance from service providers [6] [17].

By observing Figure 5, it is possible to determine four levels/types of telecommunication service quality. The parameters that help to specify each type of Quality of Service are as follows: IP packets, transfer delay, IP packet transfer, delay variation and IP-packet-loss rates between UNI, NNI, and some SNI reference points. Specific Quality of Service between reference points is provided by the NGN in terms of network performance. For a particular NGN, the type of QoS required by certain service (e.g. IP telephone calls, video streaming, or data communication) can be negotiated between the network and the corresponding terminal/server.

Figure 5. *Types of QoS in NGN*



An NGN supports end-to-end QoS through various networks that use diverse infrastructure technologies offered by various service providers in order to guarantee a particular level of service required by users or by applications [19].

NGNs accept various levels of QoS that can be negotiated between users and providers, and/or among providers. This involves the use of various strategies such as resource-control and resource-admission mechanisms, class of traffic differentiation, precedence management, QoS signaling mechanisms, operation-quality management measurements that guarantee quality, and congestion (overload) control.[6]

NGNs include capabilities for user identification, which allows network operators and service providers to identify particular users of certain NGN services and so use such information for specific purposes (e.g. authentication and authorization procedures).

NGNs offer further capabilities for users to identify NGN providers NGN (on every layer) whenever direct relations exist. In this sense, these networks support authentication and authorization functionalities on both layers, namely transport and service. For authentication purposes on the transport layer, it is required that the network identifies a particular user before the user actually accesses the network and its privilege functions. A single authentication function may become important when attempting to prevent unauthorized use of networks, e.g. to avoid large-volume non-requested data communications taking place. Due to the authorization function, an authority emerges to control access to network resources, and so this contributes to counteracting access violations [19] [20].

Mobility

Some of the most relevant characteristics of NGNs include the concept of generalized mobility, that is, the capability of users or of other mobile entities o communicate with others and have access to services regardless of location changes or of any changes in the technical environment [1] [11]. The concept of wireless-network mobility is extended and applied to single entities that can communicate independent of the place and service. The degree of service availability may depend on factors such as access-network capacity (where bottle-neck phenomena is usually observed) and the type of service-level agreement between the user's own network and the networks of various providers.

Nowadays, it is important to consider that smart-phones have played an important role in popularizing mobile internet access for millions of people, which is an ever-growing trend. In terms of technology, mobility has become a requirement, thus the telecommunication industry is compelled to continue promoting and enhancing such wireless access for years to come; allowing for reliability and data rates that compare with those of wired connections [21].

Users may be offered the possibility of using a wider variety of access technologies, which permits mobility between wired public-access points and wireless access points of various technologies. This means that mobility is not to interrupt an ongoing application or service in use. To this end, the following goals must be attained:

- Possibility to use various access technologies from different locations

- Ever-more seamless broadband communications between wired and wireless networks
- Continuity when crossing the borders of existing networks; this should entail no interruptions of applications or of client services (proper roaming agreements)

Mobility management includes the ability of mobile entities (e.g. user, terminals and local networks) to move form one network to another (itinerants), either towards an NGN or towards conventional networks. NGNs deal with two types of mobility, namely personal mobility and terminal mobility (UIT-T Q.1706).

In an NGN, personal mobility exists whenever users employ registration mechanisms to associate themselves to a terminal that may also be associated (by the network) to the users. When there are interfaces intended for user registration between users and terminals and also between users and networks, such interfaces are to be used. Likewise, in this version of NGN, both intra-network and inter-network terminal mobility is allowed when using registration mechanisms to associate a particular terminal to a network, having terminal mobility support with service continuity [22].

Conclusions

Although it is evident that the recent advances in terms of network infrastructure, interconnection, and services are significant; to date, it is still somewhat pretentious to claim that there is a true integration within the service and transport layers that constitute telecommunication networks.

There is no doubt that improvements in terms of transport are considerable and the range of services to be offered grows on a continuous basis. However, while complete regions in some parts of the world are very close to attaining the goals embraced by NGN concepts, some other regions are being left with scarce or no access to internet services, which makes us reflect on how utterly distant we are from living in an actual worldwide community driven by telecommunications.

Telecommunication service providers have understood that it is necessary to integrate their services and also to share their resources in order to meet an ever-growing user demand that entails covering particular needs, which represent an almost impossible challenge for a single provider to cope.

Nevertheless, it is important to highlight that the protocol IP is still the bedrock upon which telecommunication decisions are taken regardless of the protocol's version.

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