Realization of the Next-Generation Network

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ABSTRACT

This article provides some insight into the history, definition, requirements, and future trends of next-generation network standards. It concentrates on a high-level overview to provide a strategic direction of standards toward a complete NGN providing fixed-mobile convergence, telebroadcasting, and all aspects of 21st century communications.

INTRODUCTION

The last 10 years or more have seen an increasingly fast integration of computers and telephony, both equipment and networks. Traditional public network operators (PNOs) have seen a decrease in telephony traffic on their public switched telecommunications networks (PSTNs), due in part to the increasing popularity of mobile telephones and the movement of services from telephone networks to the public Internet.

Telephone network customers' demands have moved away from the all-embracing "one-stop shop" for communications provided by their network provider, preferring the unregulated but huge content and communications possibilities offered by the public Internet. The so-called "fixed" network operators' response has been to meet that demand by deploying broadband. While this solution satisfies the customer demands, it has done little to ensure the continued development of global communications networks, as the network operator is left merely providing access to the public Internet (or worse, access to an Internet service provider, ISP) while content and services are provided without any association with networking costs. Customers buy services and not technology, so it is the ability to offer services that can take advantage of broadband which is important from the network operators' point of view.

The concept of a new, integrated broadband network has developed over the last few years and has been labeled next-generation network (NGN).

The basic characteristics of an NGN can be determined from the problems faced by the network operators: the need to provide services over broadband accesses (to increase revenue); the need to merge diverse network services, such as data (Web browsing), voice, telephony, multimedia, and emerging "popular" Internet services such as instant messaging and presence and broadcast type services; and the desire of customers to be able to access their services from anywhere (inherent mobility). Rather than a network to provide a specific solution (e.g., the PSTN), what was needed for the 21st century was a series of networks that could support a flexible platform for service delivery.

One of the most important features of IP is the independence of protocol layers (upper or lower). This feature has greatly impacted global connectivity networks, which provide connections independent of any kind of sublayer networks such as PSTN, asynchronous transfer mode (ATM), and frame relay. Broadband access, such as asymmetrical digital subscriber line (ADSL), has enabled global connectivity coupled with various online applications, making a huge impact and creating a kind of online global village.

An NGN therefore aims to combine the best of both worlds from the PSTN and the Internet.

REQUIREMENTS FOR A NEXT-GENERATION NETWORK

An NGN has been discussed in standards since at least 2003, and the commonest question asked has been "What is an NGN?" The commercial needs, as outlined in the introduction of this article, provided the starting point in determining the requirements to answer the question.

International Telecommunication Union — Telecommunication Standardization Sector (ITU-T) Study Group 13 defined an NGN in Recommendation Y.2001 [1] as "A packet-based network able to provide telecommunication services and able to make use of multiple broadband, QoS-enabled transport technologies, and in which service-related functions are independent from underlying transport-related technologies. It enables unfettered access for users to networks and to competing service providers and/or services of their choice. It supports generalized mobility which will allow consistent and ubiquitous provision of services to users."

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

- Packet-based transfer
- Separation of control functions among bearer capabilities, call/session, and application/service
- Decoupling of service provision from transport, and provision of open interfaces
- Support for a wide range of services, applications, and mechanisms based on service building blocks (including real-time/streaming/non-real-time and multimedia services)
- Broadband capabilities with end-to-end quality of service (QoS)
- Interworking with legacy networks via open interfaces
- Generalized mobility
- Unrestricted access by users to different service providers
- A variety of identification schemes
- Unified service characteristics for the same service as perceived by the user
- Converged services between fixed/mobile
- Independence of service-related functions from underlying transport technologies
- Support of multiple last mile technologies
- Compliance with all regulatory requirements, for example, concerning emergency communications, security, privacy, and lawful interception

Recommendation Y.2001 decomposed the NGN into a number of areas to be studied for requirements and solutions. These areas still largely form the basis of standardization activities in ITU-T and other standards development organizations (SDOs):

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

This article addresses the first two items in the list, general framework and architectural principles, and service capabilities and service architecture, although the other areas are briefly overviewed.

The requirements are still developing, mostly because NGN covers such a large area. Delivery of voice services leads the complexity of PSTN control and management; generalized mobility introduces fixed-mobile convergence (FMC) and the decoupling of service provision from transport, while provision of open interfaces adds the complexity of adapting public Internet approaches to provide the same safe, secure, and reliable networking as does the PSTN.

A further commercial need from some PNOs was to use the NGN to replace their aging PSTN (in whole or in part). This requirement was rather more than interworking and interoperation with legacy networks and terminals. An NGN used to replace a PSTN must provide all of the services the individual operator's PSTN provides — and in an exactly equivalent manner, from the customers' point of view. This is because a customer with legacy equipment that chooses not to take up the new services an NGN offers does not have a new contract with a service provider (SP) and therefore should not be affected by any changes to the network or its technology.

The overall requirements for an NGN can be derived from the needs and characterization in this section. This was clearly a large task, and the demanding timescales required cooperation between standards bodies and the organizations attending them. Two fundamental principles dominated the organization of the work.

ACTIONS IN STANDARDS

In July 2003, ITU-T organized the NGN workshop with the title "Next Generation Networks: What, When and How?" at its headquarters in Geneva, Switzerland. The workshop participants covered most of the telecommunications area, with regulators, industries, carriers, and user groups all represented. One of the difficulties during the workshop was that people used the same term for the future network, NGN, but in somewhat different ways, causing some confusion. Nevertheless, the necessity for NGN global standards was clearly expressed, and was sufficient to make ITU-T members take serious note of these needs. In considering the results of this workshop, ITU-T SG13 launched an NGN Joint Rapporteur Group (JRG) initiative almost immediately in 2003. The NGN-JRG was mandated to identify key issues and develop fundamental standards for building the frameworks of an NGN, including a definition within an ITU-T context, and continued until June 2004. Recommendations Y.2001 [1] and Y.2011 [2] are the results, and are now the basis for NGN studies in ITU-T.

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ETSI TISPAN

In parallel with the ITU-T initiatives, a European initiative began in the regional standards body, the European Telecommunications Standards Institute (ETSI). Two existing committees within ETSI were combined in the summer of 2003. ETSI TIPHON had been investigating the requirements for interconnecting voice over IP (VoIP) and PSTN networks with some success. ETSI Signaling Protocols and Networks (SPAN) had a long history of providing the European flavor of telecommunications standards. Combining these two provided a Technical Body (TB) with a focus on Internet protocols, reuse of services, and skill in developing well used standards. Although ETSI is a European regional SDO, it drew membership from beyond Europe and is probably best known for developing the second-generation (2G) Global Systems for Mobile Communications (GSM).

To develop access network independence, and to promote Fixed-Mobile Convergence, TISPAN chose to support existing fixed broadband access networks and required the IP-CAN (IP Connectivity Access Network) to be supported.

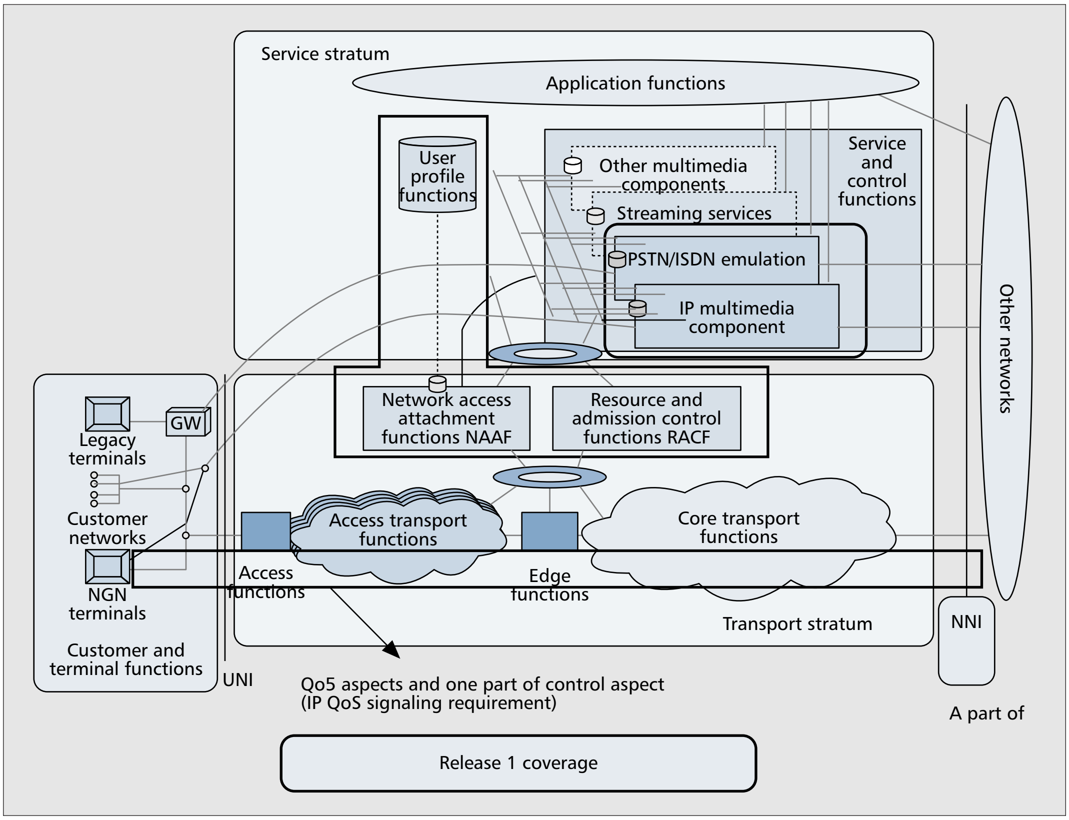

Figure 1. *Current coverage of FGNGN Release 1.*

TISPAN started slowly, but after much discussion and vital strategic input from a small number of network operators, it derived a simple plan to meet the immediate needs of the market:

- To provide all of the services enabled by the Third Generation Partnership Project (3GPP) Internet multimedia subsystem (IMS) to broadband customers, and selected IMS services to PSTN/ISDN customers connected to an NGN.
- Providing most of a network operator's existing PSTN/ISDN services to legacy equipment and interfaces to support PSTN/ISDN replacement scenarios.
- Extending the 3GPP IMS to cover those regulatory areas 3GPP may not have covered: specifically, emergency calling and lawful intercept (LI), possibly malicious call indication (MCI). TISPAN was also required to show that the regulatory requirements for privacy can be met (a calling line identification presentation/restriction, CLIP/CLIR-like, service) and overruled when necessary (emergency calling, LI, and MCI, at least).

The 3GPP IMS was selected as it provided several of the fundamental characteristics of an NGN. The IMS is predicated on packet-based transfer; it supports the separation of control functions among bearer capabilities, call/session, and application/ service; it decouples service provision from transport; provides open interfaces; and supports a wide range of services, applications, and mechanisms based on service building blocks. The IMS incorporates generalized mobility since it was defined in a mobile-based SDO.

PSTN replacement, as has been shown, was a key factor for some network operators, but not all. Those that did not have this requirement were more interested in providing PSTN-like services over broadband accesses (e.g., ADSL). This led to the definition of two types of PSTN services: emulation and simulation. These similar terms were meant to differentiate between the need to support customers' legacy equipment and interfaces in an identical manner to the PSTN, and the need to supply similar types of services over broadband accesses to new or enhanced customer equipment.

The elements of the TISPAN NGN were therefore derived to be:

- A service control plane supporting differing service subsystems (initially PSTN emulation and an adapted IMS)
- A separate applications plane
- A core transport plane based on IP technology
- Integration with existing (diverse) broadband access networks
- Security, QoS, and network management

For the purposes of TISPAN, an access network was regarded as the network component between the customer equipment and the first network element to support service control interactions. To develop access network independence and promote FMC, TISPAN chose to support existing fixed broadband access networks and required the IP connectivity access network (IP-CAN) to be supported. This would also reduce the temptation to change the 3GPP IMS except by addition for FMC.

TISPAN could not provide a set of global, only regional, standards, and therefore needed somewhere to globalize its results, and the ITU-T was the obvious place to start.

ITU-T

As several standards organizations initiated their plans for NGN standards at the beginning of 2004, industry and carriers expressed concerns about possible overlaps, delays, and incompatibilities among future NGN standards if they were produced by different organizations with different contexts. These concerns were discussed among regional standards bodies from Europe, North America. and Asia, and resulted in setting up one special group in ITU-T to initiate a single coordinated NGN standards activity. This would also bridge the gap between study periods. The ITU-T is organized into four-year study periods, and the period between 2000–2004 and 2005–2008 was potentially extremely disruptive as considerable reorganization of the ITU-T was proposed by a number of organizations and members. After consulting ETSI, the Alliance for Telecommunications Industry Solutions (ATIS), China Communications Standards Association (CCSA), Telecommunication Technology Association (TTA), and Telecommunication Technology Committee (TTC), and also receiving some high-level consultation from the ninthth Global Standard Collaboration (GSC), ITU-T launched its Focus Group on NGN (FGNGN) under the responsibility of the ITU-T Director in June 2004. This Focus Group was required to coordinate all aspects of NGN studies and specifically included a requirement to provide the globalization of ETSI TISPAN results.

ITU-T Focus Group on Next-Generation Networks

One of the urgent issues at the beginning of the FGNGN was to define its terms of reference (ToR), because of its position as a special group with a specific timeframe inside the ITU-T. The ToR on the FGNGN group were developed based on ITU-T Recommendation A.7 [3], which specifies focus group activities.

After consultation, including with many ITU-T Study Group chairpeople, and serious discussion during the ninth GSC meeting at May 2004, mandates were given to the FGNGN to create its deliverables within 12 months based on ITU-T Recommendation Y.2001 [1] and Y.2011 [2], and specifically concerning the following topics:

- NGN functional architecture (e.g., based on 3GPP/3GPP2 IMS, but including support for broadband, e.g., xDSL access)
- Generalized mobility
- QoS
- NGN control and signaling
- Security capabilities, including authentication capabilities
- Evolution from existing networks to NGN

The firstst meeting of FGNGN was held at the ITU premises in Geneva, June 2004 to approve the proposed ToR, and set up management teams and working groups to meet the missions. The structure and work scope of seven working groups are:

- WG 1 for Service Requirements: Development of scope, service requirements, and capabilities to release plan
- WG 2 for Functional Architecture and Mobility: Development of functional architecture in general and specific instance views including mobility aspects
- WG 3 for Quality of Service: Development of end-to-end QoS related deliverables including network performance aspects
- WG 4 for Control and Signaling: Development of control related deliverables and support of QoS, including resource admission and control aspects
- WG 5 for Security Capability: Development of a security framework within the NGN environment
- WG 6 for Evolution: Development of deliverables for the evolution of the PSTN/ISDN into an NGN
- WG 7 for Future Packet-Based Bearer Networks: Identify problem status of current packet-based network and develop requirements for future packet-based networks

Since the first meeting, the FGNGN has met every two to three months. The sixth FGNGN meeting was collocated with an ITU-T Study Group 13 (SG13) meeting. ITU-T SG13 were assigned as the parent group of FGNGN by the World Telecommunication Standard Assembly (WTSA) toward the end of 2004. SG13 were also designated the formal lead for NGN studies in ITU-T. Details of deliverables are provided later.

Following the instruction from WTSA 2004, the future of the FGNGN group was decided during the SG13 meeting. The FGNGN was tasked to finish its work, especially Release 1, and close by the end of 2005. All relevant results and ongoing work are to be transferred to SG13 in time for its January 2006 meeting, and some deliverables will be transferred to other appropriate Study Groups in ITU-T.

Service types	Capabilities
• PSTN/ISDN emulation services • PSTN/ISDN simulation services • Internet access • Other services (data services, etc.) • Public service aspects (LI, ETS/TDR[1], etc.)	• Basic capabilities • Multimedia services

[1] LI: lawful interception; ETS: emergency telecommunication services; TDR: telecommunication for disaster relief

Table 1. *Summary of Release 1 service and capabilities.*

FGNGN Release Plan and Future

ITU-T FGNGN works on a release basis with clear objectives and a target date. A release is a method of prioritizing by identifying a set of services to be addressed in a specific timeframe.

1) List of release-independent deliverables						
WG	**Deliverable title**	**Current draft**	**Target date**	**Cat.**	**Stat**	**Target SG***
1	NGN release-independent requirements	(none)	4Q05	0/1/1	P	13
1	NGN general services and capabilities (release independent)	(none)	4Q05	0/1/1	P	13
2	Customer manageable IP network	FGNGN-OD-00149	2Q05	0/2/1	S	13
3	General aspects of QoS and network performance in NGN (TR-NGN.QoS)	FGNGN-OD-00129	3Q05	0/1/1	D	13/12
3	Network performance of nonhomogeneous networks in NGN (TR-NGN.NHNperf.).	FGNGN-OD-00130	3Q05	0/1/1	D	13/1
2) List of Release 1 deliverables						
WG	**Deliverable title**	**Current draft**	**Target date**	**Cat.**	**Stat**	**Target SG***
1	NGN Release 1 scope	FGNGN-OD-00141	2Q05	1/1/1	S	13
1	NGN Release 1 requirements	FGNGN-OD-00142	3Q05	1/1/1	D	13
2	Requirements and architecture for NGN (FRA)	FGNGN-OD-00146	3Q05	1/2/1	D	13
2	Functional requirements for NGN mobility (FRMOB)	FGNGN-OD-00147	3Q05	1/2/1	D	13/19
2	Customer manageable IP Network	FGNGN-OD-00149 2Q05	2Q05	1/2/1	D	13
2	IMS for Next-Generation Networks (IFN)	FGNGN-OD-00148	2Q05	1/2/1	D	13
3	A QoS control architecture for Ethernet-based IP access networks (TR-123.qos)	Approved	Mar. 2005	1/2/1	A	13
3	Multi-service-provider NNI for IP QoS (TR-msnniqos)	FGNGN-OD-00107	3Q05	1/2/1	D	13
3	Requirements and framework for end-to-end QoS in NGN (TRe2eqos.1)	FGNGN-OD-00127	4Q05	1/2/1	D	13
3	A QoS architecture for Ethernet networks (TR-enet)	FGNGN-OD-00131	4Q05	1/2/2	D	13
3	Resource and admission control subsystem (TR-racs)	FGNGN-OD-00128	3Q05	1/2/2	D	13
3	A QoS framework for IP-based access networks (TR-ipaqos)	FGNGN-OD-00113	4Q05	1/2/1	D	13
3	Performance measurement and management for NGN (TR-pmm)	FGNGN-OD-00126	3Q05	1/2/1	D	12
3	Algorithms for achieving end-to-end performance objectives (TRapo)	FGNGN-OD-00135	4Q05	1/2/2	D	12
4	Signaling requirements for IP QoS TRQ.IP QoS.SIG.CS1	Q Series Supplement 51	Dec. 2004	1/2/2	A	11
5	Security requirements for R1	FGNGN-OD-00132	1Q05	1/2/1	S	17
6	Evolution of networks to NGN	FGNGN-OD-00138	3Q05	1/2/1	D	13
6	PSTN/ISDN evolution to NGN	FGNGN-OD-00139	3Q05	1/2/1	D	13
6	PSTN/ISDN emulation and simulation	FGNGN-OD-00140	3Q05	1/2/1	D	13

Table 2 continued on next page...

Table 2. *ITU-T FGNGN deliverables.*

3) List of deliverables beyond Release 1						
WG	Deliverable title	Current draft	Target Date	Cat.	Stat	Target SG*
2	Functional requirement for soft router	FGNGN-OD-00145	TBD	2/2/1	D	13
2	Digital multimedia broadcast	FGNGN-OD-00144	TBD	2/2/1	P	13
2	Converged services framework	FGNGN-OD-00150	TBD	2/2/1	P	13
5	Guidelines for NGN security	FGNGN-OD-00133	2Q05	TBD	D	17
7	Problem statement	FGNGN-OD-00158	Apr. 2005	2/1/1	A	13
7	Requirements	FGNGN-OD-00153	3Q05	2/1/1	S	13
7	High-level architecture	FGNGN-OD-00154	4Q05	2/2/1	D	13
7	Candidate technologies	TBD	4Q05	2	P	13

Table 2. *ITU-T FGNGN deliverables (continued).*

The FGNGN is progressing the work to define the service requirements, and the capabilities needed to realize those services as well as to define other associated capabilities to facilitate an NGN in its first release.

Components of the FGNGN Release

To use this release concept as a method of prioritizing the work, various harmonized components cooperating to provide key features were needed. The FGNGN uses the following two component groups.

Functional components: These are technical components that represent the configuration of NGN from both vertical and horizontal perspectives:
- Vertical perspective: covering transport stratum and service stratum or layers 1–7 of the open systems interconnection (OSI) model
- Horizontal perspective: end to end (user terminal to user terminal, including all network and service platforms)

Structural components: These are operational components useful in managing the development of each release. The following parameters were used in ITU-T during the development of important telecommunications infrastructure, such as ISDN (based on ITU-T Rec. I.130 [4]).
- Timing (release) : Dates for publication of deliverables
- Stages: 1–3[1] based on Recommendation I.130 [4]
- Depth: level of descriptions

Status of FGNGN "Release 1" Development

The ITU-T FGNGN is developing its deliverables based on the seven working groups outlined earlier. An overview of the Release 1 service aspects has formed the basis and overall guidelines for other Working Groups' activities.

A pictorial representation of the NGN was derived in conjunction with ETSI TISPAN and depicts the Release 1 development (Fig. 1).

This figure shows several key aspects of the release 1 approach to NGN. Horizontally across the figure the NGN is broken down into three sections: customer equipment, network equipment, and interconnection with other networks (including other peer NGNs). Vertically, the NGN is separated into two areas: the service stratum and the transport stratum.

The service stratum can be further separated into services/control functions and application functions.

The transport stratum is divided both horizontally and vertically. As the transport stratum is completely separated from the service stratum, it requires its own transport control plane to control bearer functions, such as the required QoS mechanism for a given session, and implement policy and admission. The transport network can also be divided into access and core.

The linkage between the two strata is provided by the resource and admission control functions (RACF) for bearers, and by the network access and attachment functions in association with the user profile.

The service types and related capability sets of Release 1 defined by Working Group 1 are shown in Table 1.

Several NGN related studies had already expressed an interest in reusing the 3GPP IM, and the ITU-T FGNGN adopted the results from these groups and reused the 3GPP IMS as the basis for call/session control of real-time conversational communications in NGN.

Standards meetings are never as smooth as the outputs would sometimes suggest, and during the FGNGN meetings there were many debates about the appropriateness of the IMS, especially from an architectural viewpoint. To satisfy all the participants, the fifth FGNGN meeting decided to take two different approaches to architectural modeling. One approach defines a general architecture model, while the other provides a specific case-oriented architec-

[1] Stage 1 is an overall service description from the user's standpoint. Stage 2 is an overall description of the organization of the network functions to map service requirements into network capabilities. Stage 3 is the definition of switching and signaling capabilities needed to support services defined in stage 1. Each stage consists of several steps.

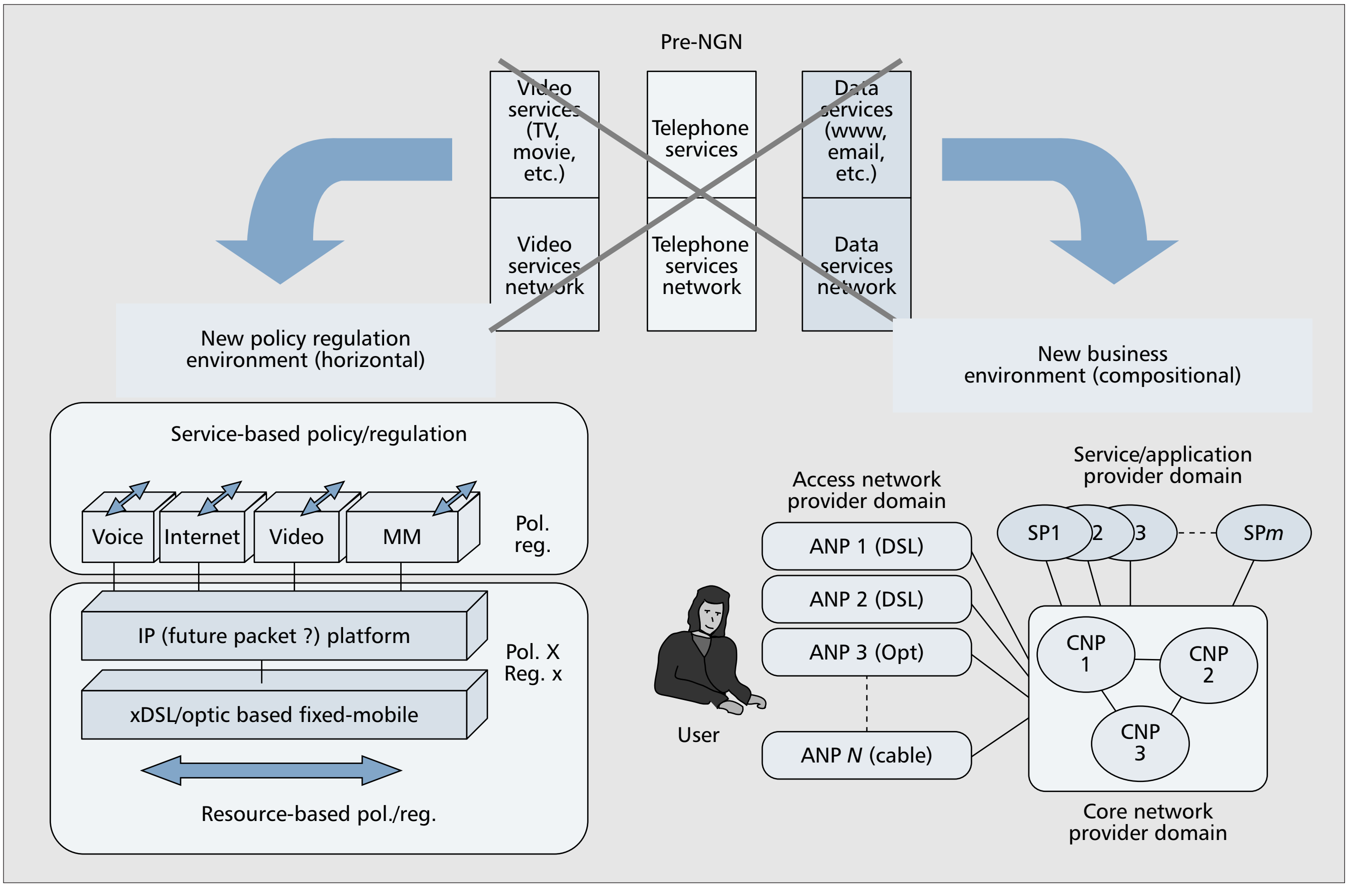

Figure 2. *Impacts of NGN [5].*

ture using the IMS. Detailed explanations of the two models are described in other companion articles.

FGNGN Release 1 Deliverables

Release 1 requirements were defined not only in the service and architectural aspects, but also for various capabilities such as QoS, mobility, security, control, and migration. The FGNGN Release 1 plan has identified all these aspects through activities in its various Working Groups and deliverables. The ITU-T also recognized that some important longer-term studies never managed to receive sufficient priority to be properly defined. The FGNGN therefore had within its ToR to investigate the requirements for future packet-based networks.

By May 2005 the FGNGN had completed three of the 26 planned deliverables. All deliverables have been assigned specific releases, and following the decision of SG 13, the FGNGN will try to complete at least the Release 1 deliverables. Table 2 show the FGNGN deliverables, categorized by release.

The Leading Role of SG 13 for Coordination in ITU-T

As part of the ToR of the FGNGN for filling the gaps between ITU-T study periods, the group was required to cover most of the key fundamental technical areas of NGN. Other important key areas remaining outside the ToR of FGNGN were management aspects (dealt with by ITU-T SG4); naming, numbering, addressing, and routing (NNAR, dealt with by ITU-T SG2); charging and billing (dealt with by ITU-T SG3); transmission aspects (dealt with by ITU-T SG15); signaling protocols (dealt with by ITU-T SG11); and QoS for network performance (dealt with by ITU-T SG12).

ITU-T SG13 is the lead group for NGN study in ITU-T, and its NGN work program, derived on behalf of all study groups in ITU-T, will lead the development of the ITU-T Release plan covering all these aspects in collaboration with other study groups.

The Impact of NGN

One of the important key features of the NGN is the separation between different functionalities that have an impact on the business models as well as regulatory implications.

The separation between the service and transport strata will have many impacts from various points of view, but the largest impact is likely to be a change in regulatory direction. Today, most services are tightly coupled with a specific transport network and signaling protocol, so regulation has been applied mainly in a vertical direction (e.g., regulation for service always also applies to the transport network). This will change with NGN to the horizontal direction, so there will be different regulations between services and transport networks. One example of this is that service could be regulated to encourage competition through flexible development, and transport networks could be derived from building infrastructure and resources. This is shown in the left side of Fig. 2.

The second important impact of NGN is the separation of access capabilities with core transport capabilities, as shown on the right of Fig. 2. This feature may influence changing business environments. The business of an access network provider domain will be dynamically expanded according to the various access technologies, and users may have much more freedom to choose access capabilities based on their specific requirements. Furthermore, another important aspect will be to stimulate convergence between fixed and mobile communications. Thus, users will choose some fixed and some mobile access capabilities, and combine either, or both, with core transport capabilities, using a single (or at least minimum) user subscription identification.

In the future NGN is likely to include telebroadcasting, which will provide convergence between telecommunications and broadcasting.

CONCLUSION

During the ITU-T FGNGN activities, a common question has been "What is the difference between an NGN and the Internet?" The question arises since both use IP as one important protocol. One clear difference of the NGN is that it does not restrict service delivery to best effort. The NGN will support various contractual services to meet users' dynamic requirements. The NGN will be a secure, trustworthy managed network. The NGN will provide an opportunity, not only to service providers building business based on specific capabilities, but also to industries developing systems. In addition to this, the NGN covers more than data communications, providing the migration and integration of traditional telephone networks. The evolution of current networks into NGN is an important aspect.

The future direction of NGN is undoubtedly the convergence of fixed and mobile networks and customer equipment. Currently, NGN standards groups are becoming tightly coupled with mobile groups (FGNGN and SG13 with SG19 in ITU-T; ETSI TISPAN with 3GPP, etc.). As fixed-mobile convergence develops, the distinction between fixed and mobile may disappear entirely, even in the last mile technologies. The other major trend for the future is likely to be telebroadcasting convergence.

The NGN is no longer a next generation objective, but is becoming a present generation reality.

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BIOGRAPHIES

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