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SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS

Next Generation Networks – Frameworks and functional architecture models

General overview of NGN

ITU-T Recommendation Y.2001

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General overview of NGN

Summary

Considering new market realities characterized by factors such as: open competition among operators due to deregulation of markets, explosion of digital traffic, e.g., due to the increasing use of "the Internet", increasing demand for new multimedia services, increasing demand for a general mobility, convergence of networks and services, etc., the NGN (Next Generation Network) is conceived as a concrete implementation of the GII (Global Information Infrastructure). Recommendations in the Y series provide the foundation of the Next Generation Networks (NGN). However, implementation issues were not adequately addressed in GII. As a consequence, the NGN should be understood as the further step in the realization of GII concept.

The target of NGN is to ensure that all elements required for interoperability and network capabilities support applications globally across the NGN while maintaining the concept of separation between transport, services and applications.

This Recommendation is intended to be used as background information to assist the development of Recommendations, standards and of implementation guidelines for the realization of Next Generation Networks.

Source

ITU-T Recommendation Y.2001 was approved on 17 December 2004 by ITU-T Study Group 13 (2005-2008) under the ITU-T Recommendation A.8 procedure.

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Decoupling between transport and service, generalized mobility, GII, NGN, overview.

FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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Introduction

The concept of an NGN (Next Generation Network) has been introduced to take into consideration the new realities in the telecommunications industry, characterized by factors such as: competition among operators due to ongoing deregulation of markets, explosion of digital traffic, e.g., increasing use of "the Internet", increasing demand for new multimedia services, increasing demand for a general mobility, convergence of networks and services, etc.

ITU-T has already initiated standardization of the new generation of networks with the Global Information Infrastructure (GII) Project which produced a number of GII Recommendations in the Y series. However, implementation issues were not in the scope of the GII. As a result, GII Recommendations have to be complemented by additional specifications and implementation guidelines for concrete realizations.

A major goal of the NGN is to facilitate convergence of networks and convergence of services. The common understanding is that the NGN has to be seen as the concrete realization of concepts defined for the GII.

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General overview of NGN

1 Scope and purpose

A number of ITU-T standardization activities are related to the establishment of implementation guidelines, standards and Recommendations for the realization of a Next Generation Network. The major task of the NGN activities is to ensure that all elements required for interoperability and network capabilities to support applications globally across the NGN are addressed by ITU-T standardization activities.

This Recommendation is intended to help and to be used as background information to assist the development of Recommendations, Standards and of implementation guidelines for the realization of the Next Generation Networks. This is to ensure that all elements required for interoperability and network capabilities to support applications globally across NGN are adequately addressed by ITU-T standardization activities. The use of this Recommendation is not restricted solely to the ITU Members.

The scope of this Recommendation is to give a general overview of what constitutes and defines a Next Generation Network (NGN). More specifically, this Recommendation identifies the fundamental characteristics and capabilities that an NGN should be able to support.

2 References

2.1 ITU-T references

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[1] ITU-T Recommendation Y.100 (1998), *General overview of the Global Information Infrastructure standards development.*

[2] ITU-T Recommendation Y.110 (1998), *Global Information Infrastructure principles and framework architecture.*

[3] ITU-T Recommendation Y.130 (2000), *Information communication architecture.*

[4] ITU-T Recommendation Y.140 (2000), *Global Information Infrastructure (GII) – Reference points for interconnection framework.*

[5] ITU-T Recommendation Y.140.1 (2004), *Guideline for attributes and requirements for interconnection between public telecommunication network operators and service providers involved in provision of telecommunication services.*

[6] ITU-T Recommendation X.200 (1994), *Information technology – Open Systems Interconnection – Basic Reference Model: The basic model.*

[7] ITU-T Recommendation G.805 (2000), *Generic functional architecture of transport networks.*

[8] ITU-T Recommendation G.809 (2003), *Functional architecture of connectionless layer networks.*

[9] ITU-T Recommendation M.3030 (2002), *Telecommunications Markup Language (tML) framework.*

[10] ITU-T Recommendation H.248.1 (05/2002), *Gateway control protocol: Version 2.*

[11] ITU-T Recommendation E.164 (1997), *The international public telecommunication numbering plan.*

[12] ITU-T Recommendation H.323 (2003), *Packet-based multimedia communications systems.*

2.2 IETF references

[13] IETF RFC 3261 (2002), *SIP: Session Initiation Protocol.*

3 Definitions

This Recommendation defines the following terms:

3.1 Next Generation Network (NGN): 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.

3.2 generalized mobility: The ability for the user or other mobile entities to communicate and access services irrespective of changes of the location or technical environment. The degree of service availability may depend on several factors including the Access Network capabilities, service level agreements between the user's home network and the visited network (if applicable), etc. Mobility includes the ability of telecommunication with or without service continuity.

4 Abbreviations

This Recommendation uses the following abbreviations.

3G	Third Generation Wireless Systems
API	Application Programming Interface
DNS	Domain Name System
GII	Global Information Infrastructure
GPRS	General Packet Radio Service
GSM	Global System for Mobile communications
ISDN	Integrated Services Digital Network
NAPT	Network Address Port Translation
NGN	Next Generation Network
OSA	Open Service Access
PC	Personal Computer
PSTN	Public Switched Telephone Network
QoS	Quality of Service
SDO	Standards Development Organization
SIP	Session Initiation Protocol
tML	telecommunications Markup Language
UMTS	Universal Mobile Telecommunications System

UPT Universal Personal Telecommunication

URI Unified Resource Identifier

URL Unified Resource Locator

VHE Virtual Home Environment

WLAN Wireless Local Area Network

5 Objectives of the NGN

NGN should fulfil the requirement of the environment described in ITU-T Recs Y.100 [1], Y.110 [2], Y.130 [3] and Y.140 [4] or Y.140.1 [5], for example to:

- promote fair competition;
- encourage private investment;
- define a framework for architecture and capabilities to be able to meet various regulatory requirements;
- provide open access to networks;

while:

- ensuring universal provision of and access to services;
- promoting equality of opportunity to the citizen;
- promoting diversity of content, including cultural and linguistic diversity;
- recognizing the necessity of worldwide cooperation with particular attention to less developed countries.

6 Fundamental characteristics of NGN

The term NGN as defined in clause 3 is commonly used to give a name to the changes to the service provision infrastructures that have already started in the telecommunication industry.

The NGN can be further defined by the following fundamental characteristics:

- packet-based transfer;
- separation of control functions among bearer capabilities, call/session, and application/ service;
- decoupling of service provision from transport, and provision of open interfaces;
- support for a wide range of services, applications and mechanisms based on service building blocks (including real time/ streaming/ non-real time and multimedia services);
- broadband capabilities with end-to-end QoS (Quality of Service);
- interworking with legacy networks via open interfaces;
- generalized mobility (see 3.2 and 8.7);
- 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;
- compliant with all regulatory requirements, for example concerning emergency communications, security, privacy, lawful interception, etc.

7 NGN capabilities

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. Within the NGN there is an increased emphasis on service customization by the Service Providers whereby some of them will offer their customers the possibility to customize their own services. NGN should be comprised of service related APIs (Application Programming Interfaces) in order to support the creation, provisioning and management of services.

One of the main characteristics of NGN is the **decoupling of services and transport**, allowing them to be offered separately and to evolve independently. Therefore in the NGN architectures, there shall be a clear separation between the functions for the services and the functions for the transport. NGN allows the provisioning of both existing and new services independently of the network and the access type used.

In NGN the **functional entities** controlling policy, sessions, media, resources, service delivery, security, etc., may be distributed over the infrastructure, including both existing and new networks. When they are physically distributed, they communicate over open interfaces. Consequently, the identification of reference points is an important aspect of NGN. Protocols need to be standardized to provide the communication between communicating functional entities. **Interworking** between NGNs of different operators and between NGN and existing networks such as PSTN (Public Switched Telephone Network), ISDN (Integrated Services Digital Network) and GSM (Global System for Mobile communications) is provided by means of gateways.

NGN will support both existing and "NGN aware" **end terminal devices**. Hence terminals connected to NGN will include analogue telephone sets, fax machines, ISDN sets, cellular mobile phones, GPRS (General Packet Radio Service) terminal devices, SIP [13] (Session Initiation Protocol) terminals, Ethernet phones through PCs (Personal Computers), digital set top boxes, cable modems, etc.

Specific **issues** include the migration of voice services to the NGN infrastructure, Quality of Service related to real-time voice services (with guaranteed bandwidth, guaranteed delay, guaranteed packet loss, etc.) as well as Security. NGN should provide the security mechanisms to protect the exchange of sensitive information over its infrastructure, to protect against the fraudulent use of the services provided by the Service Providers and to protect its own infrastructure from outside attacks.

At present, similar services are offered to users both on so-called fixed accesses and on mobile networks. However, these services are still considered, up to now, as different customers, with different service configurations and no bridging possible between the different services. A major feature of NGN will be **generalized mobility**, which will allow a consistent provision of services to a user, i.e., the user will be regarded as a unique entity when utilizing different access technologies, regardless of their types.

8 Areas of key importance

This clause provides a summary of the areas of key importance in the provision of Next Generation Networks and is not necessarily exhaustive.

8.1 General framework and architectural principles

A functional methodology and general model would enable an NGN to be described in terms of control, management and transfer functions that can be abstracted and represented separately from the major areas to be addressed in NGN (such as resources, services and transport).

The applicability of ITU-T Recs such as Y.110 [2], X.200 [6], G.805 [7] and G.809 [8] will be taken into account.

8.2 Architecture models for the NGN

The functional architecture would decompose NGN into sets of entities each providing a unique function. Relationships and connection between functions would be identified in terms of reference points. Useful groupings of functions would be described to represent certain practical physical realizations. Consideration will be given to reference points which may be candidates, at which interfaces could be defined.

NGN functional architectures should take into account the following aspects:

- Consideration of the use of generic reference modelling techniques, to help identify additional standards needed to support NGN compliant communications services either within an operator domain or in between operator domains.
- Definition of interworking functions to support legacy (non-NGN aware) terminals.
- Determination of how end-to-end services, call control and user mobility can be supported across heterogeneous networks.
- Functionality definition of NGN-aware terminals in terms of software upgrade mechanisms, redundancy and evolution of less expensive terminals, version negotiation and management.

8.3 End-to-end Quality of Service

The ways in which different end systems can reach agreement on the end-to-end QoS for a call and how the parameter sets of the upper layer protocol can be used to control the lower layer, transport and access level QoS mechanisms need to be defined.

QoS mechanisms are best divided into two topics: a "vertical" mechanism linking the upper and lower layer QoS mechanisms (e.g., diffserv, etc.) and a lower layer "horizontal" mechanism which should link the lower layer QoS control between different domains and networks.

With regard to end-to-end QoS in NGN, the following aspects need to be considered:

- end-to-end QoS class definition for telephony over packet networks;
- end-to-end multimedia QoS class definition framework and a method of identifying QoS classes of individual media components;
- specification of how to use lower layer QoS mechanism to achieve upper layer QoS within the network;
- inter-domain lower layer QoS control;
- end user perception of QoS.

8.4 Service platforms

Two of the important key aspects of NGN are the separation of service control and provision from the underlying network, and the extension of service control for telephony and multimedia.

The required service platforms should offer open interfaces, using APIs (e.g., such as those of the Parlay Group) and/or proxy servers, for third-party service providers use. The resulting services will need to be accessible to end users as they roam between networks and, naturally, end-to-end services should be available between users connected to different networks using different service providers.

From a service platform point of view, NGN should take into account the following aspects:

- definition of service control architectures covering both OSA (Open Service Access) APIs and proxy aspects;
- enhancement of mechanisms to support provision of services across multiple networks covering both service roaming and interconnectivity of services;
- development of mechanisms to support user presence and user control of service customization and profiles;
- impact of user mobility on service platforms.

8.5 Network management

With regard to network management, the following aspects need to be considered:

- enhancement of the overall "core" network management architecture and definition of basic network management services and interfaces to suit NGN requirements (fault, configuration, accounting/charging, performance, security, customer administration, traffic and routing management);
- inclusion and application of new architectural concepts and new technologies such as tML [9] (telecommunications Markup Language).

8.6 Security

The fact that NGN security is crucial and involves many areas and SDOs (Standards Development Organizations), just underlines the strategic importance of this subject.

Within NGN, security issues interrelate with architecture, QoS, network management, mobility, billing and payment.

One of the most significant challenges facing the design of NGN security standards is the fact that the networks are no longer conceived as monolithic systems with well-known interfaces. Much of the standardization work in NGN security has to be based on guides and principles along with APIs so that a secure network can be built from a given selection of specific NGN components.

Security architecture is required to address in the context of NGN security challenges of network and service providers, enterprises, and consumers. The security architecture addresses security concerns for the management, control, and use of network infrastructure, services and applications. The security architecture in NGN shall provide a comprehensive, top-down, end-to-end perspective of network security and can be applied to network elements, services, and applications in order to detect, predict, and correct security vulnerabilities.

Security needs in NGN should evolve to:

- a comprehensive security architecture for NGNs;
- preparation of NGN operational security guidelines;
- NGN operational security policy;
- adequate NGN security protocols and APIs.

8.7 Generalized mobility

Generalized mobility (see also clause 3) means providing the ability of using different access technologies, at different locations while the user and/or the terminal equipment itself may be in movement allowing users to use and manage consistently their applications/customer services across existing network boundaries.

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.) and service discontinuity to some wired line accessed networks with strong limitations (such as UPT). In the future, mobility will be offered in a broader sense where users may have the ability to use more access technologies, allowing movement between public wired access points and public wireless access points of various technologies. This means that this movement will not necessarily force an interruption of an application in use or a customer service.

The general user requirements for mobility should include:

- ability to change access point and/or terminal;
- ability to get access from any network access point, including all access technologies identified above;
- ability to get services in a consistent manner, subject to the constraints experienced in their current situations;
- user availability and reachability should be known to network functions, and possibly to services and applications, including those provided by a third party.

Several capabilities should be considered for mobility:

- support of personal mobility;
- support of terminal mobility;
- support of both personal and terminal mobility.

Generalized mobility requires significant evolutions of current network architectures. Enabling more transparent fixed-wireless broadband communications and mobility across various access technologies appears as a major issue.

The following requirements for the NGN systems can be derived from the above objectives, in a mobility management perspective:

- consistent approach from initial third generation mobile systems (3G systems) and fixed systems;
- cost reduction (network deployment and operation);
- increased spectrum efficiency;
- mobility among different access systems.

In order to support generalized mobility, further work is needed to develop network functions at the control layer:

- identification and authentication mechanisms;
- access control and authorization function;
- location management;
- terminal and/or session address allocation and management;
- support of user environment management (e.g., VHE (Virtual Home Environment));
- user profile management;
- access to user data.

8.8 Network control architecture(s) and protocols

Considering the increasingly distributed nature of the control functions in NGN architectures, there is a need to study network control reference models encompassing:

- resource and QoS at the access to the network and in the core network;
- media processing, transcoding and information transfer;
- call/session control;
- service control.

The network control architecture model shall take into account the various control related functional requirements and will define typical functional groupings which interact through reference points.

Examples of functional groupings may include:

- media access gateway (at the network edge), with e.g., firewall, NAPT (Network Address Port Translation), transfer policy enforcement functions;
- resource control, including e.g., admission control, access request handling;
- access session control, including e.g., address allocation, user location, user access profile management;
- service control, including e.g., user registration, user service profile management, service requests handling, service interaction management.

The network control functional models will be used as the basis to identify reference points for which there is a need for standardization. This should be based on ITU-T Rec. Y.140 [4]. Such reference points will be defined as standard interfaces where the control protocols will be defined and standardized on the basis of relevant protocol basis, e.g., by means of profiles for the reuse of already specified protocols, e.g., on the basis of H.248.1 [10] for media gateway control, or SIP [13] for call/session control.

The network control architecture models will take into account functional requirements at the network access (user-network interface), at the interfaces between networks (network-network interfaces) and at the interfaces between networks and service/application providers (e.g., network-providers interfaces).

8.9 Service capabilities and service architecture

Considering the present trends and future evolution of customer requirements for services involving real-time and non-real-time, wired and wireless, human-to-human, human-to-machine and machine-to-machine communications, it is required to:

- address the telecommunication service capabilities that the NGN should provide, considering separation between applications, services and networks;
- develop a suitable service architecture focused on the interfaces that are needed to support different business models and seamless communication in different environment.

The work should include the backward compatibility with and the evolution from the existing services and systems.

8.10 Interoperability of services and network in NGN

Considering that NGN will involve a large amount of protocols (including various profiles) at the services and network level, there is a need in the framework of NGN to ensure the interoperability among systems and networks.

This interoperability should include in particular:

- specifications of interoperable profiles for complex systems;

- specifications for compliance verification of standards;
- the development of the relevant procedures and documentation, including the development of tools.

8.11 Numbering, naming and addressing

Since the NGN consists of interconnected heterogeneous networks, using heterogeneous user access and heterogeneous user devices and that the NGN should provide a seamless capability, independent of access method and network, the NGN should address Numbering, Naming and Addressing.

Individual users may be identified by name/numbers using a name/number resolution system which will be able to translate a given name/number into a routable and valid address in order to establish a transfer (transport) facility (connection or flow).

Examples of such Naming/Numbering schemes may be:

- E.164 [11] numbering scheme;
- Unified Resource Locator (URL) scheme;
- unique name system (e.g., 1800Airways etc.);
- or other naming conventions such as H.323 [12], SIP [13], telephone and mail unified resource identifier (URIs (Unified Resource Identifier)). Use of international character set for URIs is for further study.

A user who requires access to another user may directly input one of the above-mentioned identifiers and then either the terminal or the network may translate the user input into an end-point address, either using a network internal database or a network external database (for example, accessed via a DNS (Domain Name System) translating mechanism).

NGN should be able to provide name and number portability.

8.11.1 Fundamental principles and requirements for name and/or numbering resolution

As a public operation network, the NGN shall meet the following requirements for the name resolution:

- Reliability: The name/number resolution system is directly related to the running of the NGN, so it should have carrier class reliability. It shall have two capabilities in the architecture. First, it should not be a single point of failure. Secondly, it should have excellent load balancing mechanisms. Good configuration and arrangement shall be conducted to meet the capacity requirements during the network planning.
- Integrity: While the name/number resolution system is directly related to the running of the public networks, it must be ensured that the name/number resolution systems will not conflict to each other and that the overall name/number translation databases will have only valid and reliable entries so that the whole system will not be affected in its integrity, especially when distributed systems are used.
- Security: The name/number resolution data are important network data that may directly impact the operation of the network, and they are also sensitive commercial data reflecting the structure and policy of the network operations. Accordingly, the name/number resolution system shall be a special system used only by this network, and certain security measures shall be in place. The security is mainly maintained by the means of user access authentication, data security, data privacy, network data synchronization and fault recovery.
- Sovereignty: While the network and the name/number resolution systems are designed to provide national and global services, it needs to be ensured that the sovereignty of an affected country to govern is not questioned.

8.12 Disaster and relief communications capabilities

Next Generation Networks need to be capable of providing disaster and relief communications capabilities, with a view to giving preferential access to representatives of appropriate organizations, and preferential treatment to emergency traffic.

Special measures may need to be taken, therefore, to ensure that disaster and relief requirements and capabilities are adequately accommodated in NGN.

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