INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

Y.2011
(10/2004)

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

Next Generation Networks – Frameworks and functional architecture models

General principles and general reference model for Next Generation Networks

ITU-T Recommendation Y.2011

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ITU-T Recommendation Y.2011

General principles and general reference model
for Next Generation Networks

Summary

This Recommendation specifies general principles and a general reference model for Next Generation Networks.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

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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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

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1 Scope

The seven layered Open Systems Interconnection Basic Reference Model (OSI BRM) as described in ITU-T Rec. X.200 [1] has long provided a basis for a model of communication, and the general principles still apply. However, the layering and protocol hierarchy defined in the OSI BRM cannot be directly applied in the Next Generation Network (NGN) environment and have to be interpreted in specific ways to accommodate the NGN environment.

This Recommendation describes general principles applicable to Next Generation Networks (NGNs) as well as a Basic Reference Model for NGNs, based on the generic foundations first laid down under the Global Information Infrastructure (GII) in ITU-T Recs Y.100 [2] and Y.110 [3], and basic communication architecture principles specified in ITU-T Rec. X.200 [1].

The general reference architecture model described in this Recommendation should enable the support of the overall NGN characteristics as given in ITU-T Rec. Y.2001 [4].

In particular, it is neutral with respect to specific protocols and/or technologies. It is more flexible than ITU-T Rec. X.200 [1] with respect to the positioning of functionality, and is not constrained to a specific hierarchical ordering of protocol layers.

2 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 X.200 (1994) | ISO/IEC 7498-1:1994, *Information technology – Open Systems Interconnection – Basic Reference Model: The basic model.*

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

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

[4]   ITU-T Recommendation Y.2001 (2004), *General overview of NGN.*

[5]   IETF RFC 791 (1981), *Internet Protocol – DARPA Internet Program – Protocol Specification.*

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

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

[8]   ITU-T Recommendation I.322 (1999), *Generic protocol reference model for telecommunication networks.*

[9]   ITU-T Recommendation G.993.1 (2004), *Very high speed digital subscriber line transceivers*.

[10]   ITU-T Recommendation G.807/Y.1302 (2001), *Requirements for automatic switched transport networks (ASTN)*.

[11]   ITU-T Recommendation G.8080/Y.1304 (2001), *Architecture for the automatically switched optical network (ASON), plus Amendment 1 (2003)*.

[12]   ITU-T Recommendation Y.1241 (2001), *Support of IP-based services using IP transfer capabilities*.

[13]   ITU-T Recommendation Y.1711 (2004), *Operation and maintenance mechanism for MPLS networks*.

[14]   IETF RFC 3471 (2003), *Generalized Multi-Protocol Label Switching (GMPLS) Signaling Functional Description*.

[15]   ITU-T Recommendation M.3010 (2000), *Principles for a telecommunications management network*.

[16]   ITU-T Recommendation M.3010 Amendment 1 (2003), *TMN conformance and TMN compliance*.

[17]   ITU-T Recommendation M.3400 (2000), *TMN management functions*.

[18]   ITU-T Recommendations M.3050.x series (2004), *Enhanced Telecom Operations Map (eTOM)*.

[19]   ITU-T Recommendation X.700 (1992), *Management framework for Open Systems Interconnection (OSI) for CCITT applications*.

[20]   ITU-T Recommendation X.701 (1997) | ISO/IEC 10040:1998, *Information technology – Open Systems Interconnection – Systems management overview*.

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

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

[23]   IETF RFC 2616 (1999), *Hypertext Transfer Protocol – HTTP/1.1*.

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

[25]   ITU-T Recommendation Y.1541 (2002), *Network performance objectives for IP-based services*.

[26]   IETF RFC 2205 (1997), *Resource ReSerVation Protocol (RSVP) – Version 1 Functional Specification*.

[27]   IETF RFC 2748 (2000), *The COPS (Common Open Policy Service) Protocol*.

[28]   IETF RFC 793 (1981), *Transmission Control Protocol – DARPA Internet Protocol – Protocol Specification*.

[29]   ITU-T Recommendation Y.1251 (2002), *General architectural model for interworking*.

3   Terms and Definitions

This Recommendation defines or uses the following terms:

3.1   application services: See ITU-T Rec. Y.110 [3].

3.2   baseware services: See ITU-T Rec. Y.110.

3.3   control plane: The set of functions that controls the operation of entities in the stratum or layer under consideration, plus the functions required to support this control (see 8.1.1 for some details).

3.4   data plane: The set of functions used to transfer data in the stratum or layer under consideration.

3.5   horizontal relationship: See ITU-T Rec. Y.110.

3.6   infrastructural services: See ITU-T Rec. Y.110.

3.7   management plane: The set of functions used to manage entities in the stratum or layer under consideration, plus the functions required to support this management (see 8.1.2 for some details).

3.8   middleware services: See ITU-T Rec. Y.110.

3.9   NGN service stratum: That part of the NGN which provides the user functions that transfer service-related data and the functions that control and manage service resources and network services to enable user services and applications (see also 7.1).

3.10   NGN transport stratum: That part of the NGN which provides the user functions that transfer data and the functions that control and manage transport resources to carry such data between terminating entities (see also 7.1).

3.11   player: See ITU-T Rec. Y.110.

3.12   role: See ITU-T Rec. Y.110.

3.13   user plane: A synonym for data plane.

3.14   vertical relationship: See ITU-T Rec. Y.110.

4   Abbreviations and Acronyms

This Recommendation uses the following abbreviations:

3GPP	3rd Generation Partnership Project
ADSL	Asymmetric Digital Subscriber Line
ASON	Automatic Switched Optical Network
ATM	Asynchronous Transfer Mode
BRM	Basic Reference Model
COPS	Common Open Policy Service
FCAPS	Fault, Configuration, Accounting, Performance and Security
FTTH	Fibre to the Home
GII	Global Information Infrastructure
GMPLS	Generalized Multi-Protocol Label Switching
HDTV	High Definition Television
HTTP	Hypertext Transfer Protocol
IETF	Internet Engineering Task Force
IP	Internet Protocol
IWF	Interworking Function
IWU	Interworking Unit

MFA	Management Functional Area
MPLS	Multiprotocol Label Switching
NAT	Network Address Translation
NGN	Next Generation Network
NGN BRM	Next Generation Network Basic Reference Model
NNI	Network to Network Interface
OSI	Open Systems Interconnection
OSI BRM	Open Systems Interconnection Basic Reference Model
PLMN	Public Land Mobile Network
POA	Point of Attachment
PSTN	Public Switched Telephone Network
QoS	Quality of Service
RSVP	Resource Reservation Protocol
SIP	Session Initiation Protocol
TCP	Transmission Control Protocol
TE	Terminal Equipment
TMN	Telecommunications Management Network
UMTS	Universal Mobile Telecommunications System
UNI	User to Network Interface
VDSL	Very high speed Digital Subscriber Line

5 Relationship to Global Information Infrastructure

The Global Information Infrastructure (GII) environment creates a more heterogeneous mix of technological and operational domains. Choices of core technologies can vary and a full set of services is being provided, by, say, a multi-service network. Consequently an end-to-end path may traverse many varied technologies encompassing a variety of protocol arrangements.

This Recommendation builds upon the GII environment described in ITU-T Rec. Y.100 [2], the GII Overview, and, in particular, the concept of "federation of networks" of diverse technologies with diverse services and (end-)user applications.

This Recommendation also adopts the principles specified in ITU-T Rec. Y.110 [3], the GII Principles and Framework Architecture, in respect of the "Enterprise Model", the distinction between "roles" and "players", and the separation between various "infrastructural roles".

An NGN is regarded as the realization of the GII, or at least some component thereof, and this Recommendation develops the architectural model to reflect such realizations.

6 Relationship to ITU-T Rec. X.200 – OSI Basic Reference Model

The OSI Basic Reference Model (OSI BRM) [1] specifies a model for specific 7-layer architecture. Whilst the stated scope of OSI BRM could be construed to be totally generic for all open systems standards development, in practice the OSI BRM has become synonymous with the rigidity associated with the seven layers defined therein, specific characteristics of each layer so defined, and the specific OSI layer protocols that were developed to match these characteristics.

However, the "concepts of a layered architecture" described in clause 5/X.200 [1] apply to all layered architectures. Clause 5/X.200 provides all the necessary definitions, characteristics and properties required to describe any kind of layered structure, not just the specific OSI structure.

The primary difficulties arise when the number and specific characteristics of the 7 layers of the OSI BRM are considered. As far as NGN systems (non-OSI systems) are concerned, all or some of the following situations may be encountered:

•   the number of layers may not equal seven;

•   the functions of individual layers may not correspond to those of the OSI BRM;

•   certain prescribed or proscribed conditions/definitions of the OSI BRM may not be applicable;

•   the protocols involved may not be OSI protocols;[1]

•   the compliance requirements of the OSI BRM may not be applicable.

This is not to say that the functionality resembling that described in the OSI BRM is not present in most systems, but rather that the functionality may be distributed quite differently, say across a fewer or greater number of layers, or just simply differently distributed, and not layered in the same rigid hierarchical fashion as that specified in the OSI BRM.

NGN architectures require a greater amount of flexibility than was envisaged when ITU-T Rec. X.200 was developed. Annex A identifies some areas of ITU-T Rec. X.200 which are either too restrictive and/or insufficient to accommodate recent, emerging or expected future technology. Additionally, a detailed list of items retained from ITU-T Rec. X.200 since applicable to NGN is given in Annex B. A list of items not retained (not applicable to NGN) from ITU-T Rec. X.200 is also given in Annex B.

7   Basic functionality divisions in NGN

The separation of services from transport, allowing them to be offered separately and to evolve independently, is the key cornerstone of NGN characteristics (see ITU-T Rec. Y.2001 [4]).

A second cornerstone are the relationships of the NGN to the principles of ITU-T Recs G.805 [6], G.809 [7] and Y.110 [3].

7.1   Separation between services and transport

The separation is represented by two distinct blocks or strata of functionality. The transport functions reside in the **transport stratum** and the service functions related to applications reside in the **service stratum**.

The horizontal relationship [3] aspects are shown in Figure 1 and the vertical relationship [3] aspects of this decoupling are shown in Figure 2. There are several points of note to be made.

Firstly, there is a set of **transport functions** that are solely concerned with conveyance of digital information, of any kind, between any two geographically separate points. A complex set of layer networks may be involved in the transport stratum, constituting layers 1 through 3 of the OSI 7-layer Basic Reference Model. The transport functions provide connectivity.

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[1]   One notable example being the Internet Protocol [5].

In particular, the transport stratum facilitates:

• user-to-user connectivity;

• user-to-services platform connectivity;

• services platform-to-services platform connectivity.

In general, any and all types of network technologies may be deployed in the transport stratum, including connection-oriented circuit-switched (CO-CS), connection-oriented packet-switched (CO-PS) and connectionless packet-switched (CLPS) layer technologies according to ITU-T Recs G.805 [6] and G.809 [7]. For NGN it is considered that IP (Internet Protocol) [5] may be the preferred protocol used to provide NGN services as well as supporting legacy services.

The services platforms provide the user services, such as a telephone service, a Web service, etc. The service stratum may involve a complex set of geographically distributed services platforms, or in the simple case just the service functions in two end-user sites.

Secondly, there is a set of **application functions** related to the service to be invoked. In this stratum services may be, e.g., voice services (including telephone service), data services (including but not limited to Web-based services), or video services (including but not limited to movies and TV programmes), or some combination thereof (e.g., multimedia services such as video telephony and gaming). Since there are many other service classification schemes (e.g., real-time/non-real-time services and unicast/multicast/broadcast services), Figure 1 provides an example list of services that are expected to be operated over next generation networks.
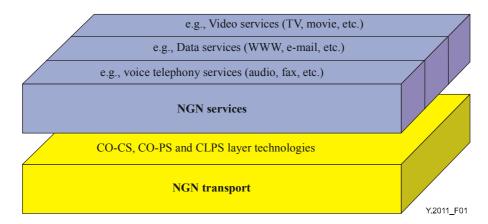

Figure 1/Y.2011 – Separation of services from transport in NGN

Each stratum comprises one or more layers, where each layer is conceptually composed of a **data (or user) plane**, a **control plane**, and a **management plane**.[2]

In general, each stratum will have its own set of roles, players and administrative domains (see ITU-T Rec. Y.110 [3]). The roles involved in service(s) provision are independent from those involved in transport connectivity provision. Each stratum needs to be treated separately from a

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[2] In this Recommendation, the terms "data plane"/"user plane", "control plane", and "management plane" are used in a general architectural and logical sense. Each stratum is considered to contain functions to transfer data, functions to control the operation of entities involved in transferring such data, and functions to manage entities within the stratum. It should be noted that there is a multiplicity of definitions of these terms already in use in ITU-T Recs (e.g., I.322 [8], G.993.1 [9], G.807/Y.1302 [10], G.8080/Y.1304 ([11]), Y.1241 [12], Y.1711 [13], etc.). However, these are mainly technology specific and therefore not entirely appropriate at this level of abstraction. They should be considered in the context of the relevant technology when progressing the Functional Requirements and Architecture of the NGN.

technical point of view. This is achieved by mandatory decoupling of the user (or data) planes of the two strata.

Based on the above discussions and considering the key cornerstone of NGN which is separation of services and transport, the following concepts are defined:

NGN service stratum: That part of the NGN which provides the user functions that transfer service-related data and the functions that control and manage service resources and network services to enable user services and applications. User services may be implemented by a recursion of multiple service layers within the service stratum. The NGN service stratum is concerned with the application and its services to be operated between peer entities. For example, services may be related to voice, data or video applications, arranged separately or in some combination in the case of multimedia applications. From an architectural perspective, each layer in the service stratum is considered to have its own user, control and management planes (but see notes below).

NGN transport stratum: That part of the NGN which provides the user functions that transfer data and the functions that control and manage transport resources to carry such data between terminating entities. The data so carried may itself be user, control and/or management information. Dynamic or static associations may be established to control and/or manage the information transfer between such entities. An NGN transport stratum is implemented by a recursion of multiple layer networks as described in ITU-T Recs G.805 [6] and G.809 [7]. From an architectural perspective, each layer in the transport stratum is considered to have its own user, control and management planes (but see notes below).

NOTE 1 – The data (or user), control and management planes always exist in a logical sense for every layer.

NOTE 2 – However, in practice, a control or management plane may be null for a particular layer.

NOTE 3 – In NGNs employing unified control plane technology according to ITU-T Rec. G.807/Y.1302 [10], such as ASON ([11]) and GMPLS [14], equivalent control plane functions at multiple layers can be instantiated in a single protocol.

NOTE 4 – In NGNs employing unified management plane technology according to ITU-T Rec. M.3010 ([15], [16]) equivalent management plane functions at multiple layers can be instantiated in a single protocol (within and across NGN strata).

For both the NGN service stratum and the NGN transport stratum, the general architectural concepts of data (or user) plane, control plane and management plane can be logically identified. This is shown in Figure 2.
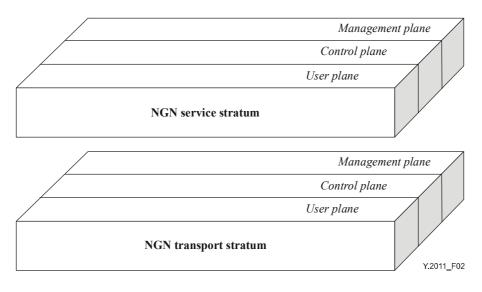

Figure 2/Y.2011 – NGN Basic Reference Model (NGN BRM)

It is also shown in the figure that in addition to the user planes of the service and transport being decoupled, the control and management planes of the two strata are separated as well.

In the context of NGN management and NGN control, it is important to consider and define:

a) **NGN management plane** as the union of service stratum management plane and transport stratum management plane;

b) **NGN control plane** as the union of service stratum control plane and transport stratum control plane.

Since a union of sets allows for overlap, the definitions cover the possibility of common management and/or control functions.

It is important to note that the concept of NGN planes does not imply any vertical integration of planes but still requires the definition of reference points between planes of different strata. The concept is introduced to ease the transition from the functional view to the implementation view of the NGN architecture by introducing a management view and a control view of the NGN. Considerations of the implementation, management and control views of the NGN are outside the scope of this Recommendation but could be the subject of a separate Recommendation if necessary.

7.2 Relationships between NGN basic reference model and ITU-T Recs G.805, G.809 and Y.110

The functional architecture principles of ITU-T Recs G.805 [6] and G.809 [7] will apply to the vertical relationships between layer networks within an NGN. Some aspects are detailed in clause 9 below. Note that the applicability of ITU-T Recs G.805 [6] and G.809 [7] to the NGN service stratum is for further study.

The principles of ITU-T Rec. Y.110 [3] on roles, players and organizations in the Enterprise Model, on services and applications in the Structural Model, on functions and interfaces in the Functional Model, and on components in the Implementational Model will apply. Some aspects are detailed in clause 8.

8 General functional model

ITU-T Rec. Y.110 [3] formalizes a structural model where services and service components are described separately. It provides:

• An enterprise model which identifies players and roles, i.e., business activities within value chains, such as structural roles and infrastructural roles. This is outside the scope of this Recommendation but could be the subject of a separate Recommendation if necessary.

• An implementation model which is more concerned in the way functions are distributed and implemented in equipment. It also identifies the protocols which are passing across interfaces between equipment. This can be seen as a physical realization of an NGN in our context. This aspect is described in this clause in a general high-level form.

As in GII, the NGN should also separate the analysis of services and functions.

ITU-T Rec. Y.110 can be used as a guideline for de-composition into Infrastructural services, Application services, Middleware services and Baseware services.

ITU-T Recs G.805 [6], G.809 [7], G.807/Y.1302 [10], M.3010 ([15], [16]), M.3400 [17], M.3050.x [18], X.700 [19] and X.701 [20] have already been issued on the functional aspects of the (transport) network operation. NGN study should consider them and the relationships between functions, services and resources should be identified for the two NGN strata.

The services and functions are related to each other, since functions are used to build services. Moreover, there are some similarities between the sub-types of the services and functions. However, there is not a one-to-one relationship between functions and services, and this is another

reason why they should be kept separate. The same function (e.g., user authentication) can be used for the delivery of two different services.

Figures 7-2/Y.110 and 8-3/Y.110 [3] show various functions relative to:

• infrastructural services and application services;

• middleware services;

• baseware services including telecommunication services;

• resources (such as processing and storage service components).

It is convenient to assemble these functions into two distinct groups, or planes, one comprising all control functions and another comprising all management functions. The grouping of functions of the same type (i.e., control or management) allows the functional inter-relationships within a given group to be defined as well as the information flows between functions in the given group. Additionally Figure 8-3/Y.110 shows functions for the transfer of information between distant locations which are detailed in 8.5/Y.110. In the case of ITU-T Rec. Y.110 [3] the functions illustrated in Figures 7-2/Y.110 and 8-3/Y.110 can be broadly categorized and generalized, as shown in Figure 3 below, to form a general functional model.

Figure 3 shows, in the third dimension, relationships between service resources and NGN service stratum functions and between transport resources and NGN transport stratum functions. Note that the figure also shows separated control and management planes according to Figure 2 but does not show the possibility of common management or control functions for service and transport strata.
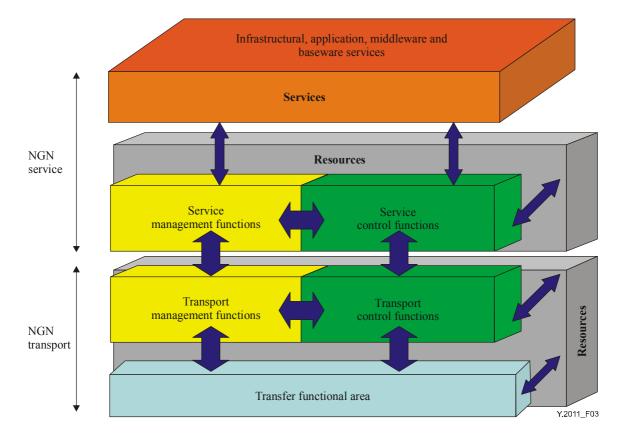

Figure 3/Y.2011 – General functional model

Resources provide physical and non-physical (i.e., logical) components (e.g., transmission links, processing and storage, etc.) which are used to provide services and networks. As in GII, resources should be dealt with separate from the functions and the services.

Resources may include transport resources that are identified for instance for inventory management (e.g., switches, routers, transmission links, etc.), and processing and storage resources like processing platforms, on which services and applications can run (services platforms), or databases for application content storage.

8.1 Functions

This subclause focuses on the functions. At the functional level, emphasis should naturally be given to the separation of a number of concerns.

The Management functions shown in Figure 3 interact with the resources, and management functions are used to build services. This approach is in line with the scope of TMN management context (see ITU-T Recs M.3010 where TMN management services are defined by the descriptions of roles, related resources and TMN functions (see ITU-T Recs M.3400 and M.3050.0).

The same considerations apply to the Control functions and the Transfer functions with regard to interactions to the services and the resources.

8.1.1 Control functions

The support of multimedia services and other types of services while enabling generalized mobility requires very well designed control functions since services depend on careful network resource allocations through control (or management) functions. The complete study of service invocation by an end-user is a key aspect when designing NGN architectures. It seems relevant for the NGN functional architecture study to focus on what is often labelled the "invocation" process, i.e., processes belonging to what is traditionally called the "Control".

The Control functions involved in the "invocation" process can be classified in two general sets, the functions related to the control of services (e.g., functions such as User Authentication, User Identification, Service Admission Control, Application Server functions) and functions related to the control of transport network(s) (e.g., functions such as Network Admission Control, Network Resource/Policy Control, Dynamic Connectivity Provision).

8.1.2 Management functions

It needs to be kept in mind that other customer operations processes are very much correlated to the "invocation" process by interacting with the network, either prior to a service invocation or following a service invocation. Those processes belong to what is usually called the "Management".

Management plane requirements should consider the management processes and functions as described in ITU-T Recs M.3050.x series. TMN management functions are also specified in ITU-T Rec. M.3400 and are classified according to the Management Functional Areas (MFAs) or FCAPS Management categories, as given in ITU-T Recs M.3010, X.700 and X.701, namely:

• Fault Management;
• Configuration Management;
• Accounting Management;
• Performance Management;
• Security Management.

ITU-T Rec. M.3050.0 should also be consulted for background information on ITU-T's Management Service/Function approach.

While the management of the transport plane is well understood, the management of the service plane is for further study. It is expected, however, that the management of the two NGN strata will be similar regarding the behaviour of managed objects (e.g., configuration of service resources vs configuration of transport resources). The status of managed objects (i.e., their attributes and

notifications) will certainly be different (e.g., a list of NGN service objects vs a list of NGN transport connectivity objects in support of NGN services).

8.1.3   Transfer functions

The transfer functions should be kept separate from the corresponding control and management functions. ITU-T Recs G.805 and G.809 describe the network as a transport network for the information transfer capability. These Recommendations therefore are concerned with the definition of functions related to the transfer of user information as well as to the transfer of network information (such as management or control information).

These Recommendations provide for generic transport network functions such as adaptation functions and trail termination functions.

8.2   Resources

It is also useful to represent the resources of the overall NGN model as being separate from the functions and the services. The resources contain physical and non-physical (i.e., logical) components used to construct networks, connectivities and services.

Without resources it would not be possible to build up networks nor to set up connectivities nor to provide services.

ITU-T Rec. Y.110 describes the concept of resources of the GII, bringing together network resources, processing and storage resources, and middleware resources in order to offer services to the users (see Figures 7-3/Y.110 and 7-4/Y.110).

9   Multi-layer aspects

The flexible and heterogeneous nature of the NGN architecture requires coordination among strata, among OSI layers, among G.805/G.809 layers, among core and access components, among service networks, etc. The degree of switching performed at each layer may vary. The OSI-based layer 1 and layer 2 technologies offer the possibility of migrating packet switching functionality to the nodes located at the network borders (i.e., edge devices).

The relationships and interactions between various layers and associated components require sustainable coordination. If layers operate independently, conflicts and inefficiencies will occur. In extreme cases, race and deadlock conditions can result.

In cooperating layered networks, there are two controlling entities: one is for controlling the higher layer network, and the other is for controlling the lower layer network. The ordering of networks within this hierarchy refers to the service requester/provider relationship between the networks: the higher layer network requests services from the lower layer network. There is information exchange between these two entities in order to interact the two networks. Information exchanged may include resource and topology information.

The distinction between the two layers is shown in Figure 4. In this figure it can be seen that hops between nodes in the higher (client) layer network may span multiple hops within the lower (server) layer network. Interacting between the two networks at the borders (edges) allows resource and topology information to be exchanged and used for coordinating activities.
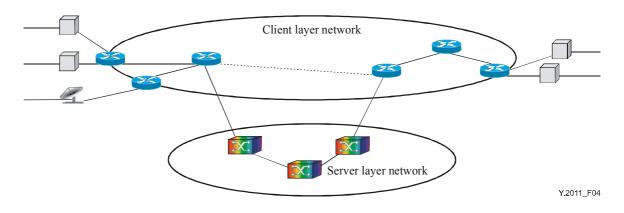
Figure 4/Y.2011 – Illustration of cooperation between layered networks

A prime example of layering of networks is the demarcation between (the user planes of) a service and transport network as described in previous clauses in this Recommendation. However, as described, the layering of networks may also involve recursive layering. This recursion may result in an instance of the same protocol being used in both the client layer network and the server layer network. Further, a single network may itself be comprised of multiple network layers – this is called a multi-layer network.

ITU-T Recs G.805 and G.809 contain a well-defined set of layering concepts where a layer provides a service to another layer (referred to as server and client in this clause), and explain the recursive use of the link connection and trail concepts which represent an aspect of inter-layer interaction, especially the hierarchical structure of data transfer in transport networks.

ITU-T Recs G.807/Y.1302 and G.8080/Y.1304 include requirements, architecture and mechanisms for the control of such a hierarchical transport network, and inter-layer interaction in this clause intends control information exchange between hierarchically different layers' control entities beyond ITU-T Rec. G.8080/Y.1304.
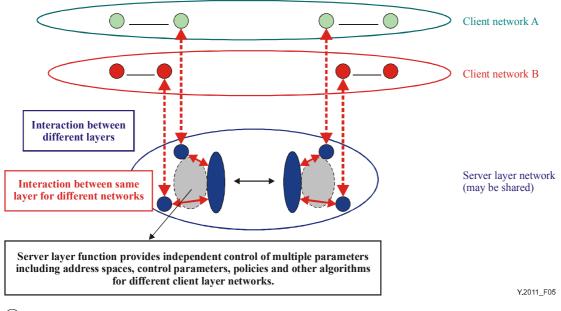
9.1 Inter-layer and intra-layer interaction

Inter-layer interaction can occur between two distinct client/server layers. Depending on the realization of the inter-layer interaction, internal and external interfaces have to be defined to exchange such control information. This may require extensions to existing protocols.

The exchanged information may include details of the capabilities, topology, and resource information provided by the server layer network to the client layer network.

Intra-layer interaction can occur between functional entities within the same layer to support the existence of multiple networks at another layer.

Examples of such interaction may include address mapping functions when independent address spaces are used for different (layer) networks.

Figure 5/Y.2011 – Inter/intra-layer interaction

9.2 Coordination activities

Coordination among appropriate functional entities in the client layer networks and server layer network is required to enable:

- seamless and economical support of multiple client layer networks by a single server layer network;
- ability of negotiation and dynamic resource (re-)allocation in the server layer network according to the client layer network requirements;
- simultaneous and efficient handling of multiple layers' resources;
- failure detection and coordination of different layers' recovery mechanisms;
- virtual separation of the control entities as well as policy and management functions for the different client/server layer networks, including independent address spaces for different (layer) networks.

9.3 Multi-layer network scenario in NGN

Figure 6 shows a typical multi-layer network scenario that may be present in an NGN. The inter/intra-layer functional interactions, as described in 9.1, are demonstrated by means of distributed control plane entities.

Further, by separating the address spaces of the client layer network and the server layer network, multiple distinct client layer networks can be easily accommodated.

Inter-layer interaction occurs between the functional entities in the control planes of different layers. Intra-layer interaction occurs between the functional entities within the control plane entities in the server layer in order to support the client-layer control planes. The control plane entities in a client layer interact across the server layer as though they were adjacent (dashed arrows).
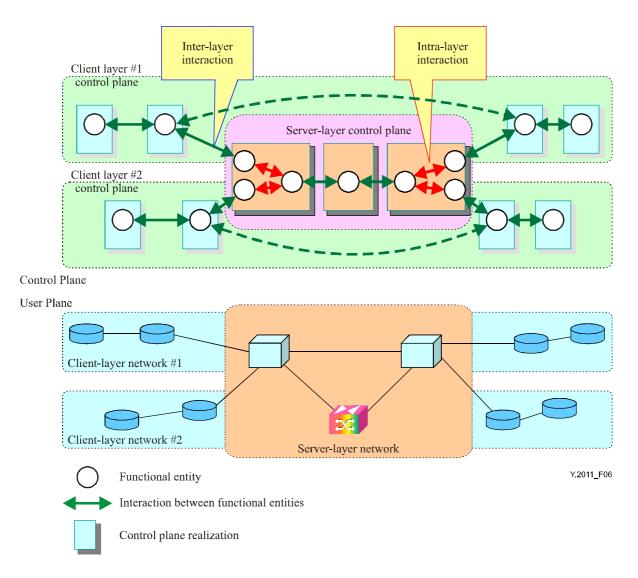
Figure 6/Y.2011 – Multi-layer network scenario

Functional entity

Interaction between functional entities

Control plane realization

10   Service convergence by NGN

A fundamental characteristic of NGN is the ability to deliver a wide variety of services including voice, video, audio and visual data, via session and interactive based services in unicast, multicast and broadcast[3] modes.

Based on the separation of services and transport in NGN, the focus is on transmission techniques and network functions rather than content definition.

Furthermore, wireline and wireless technologies can be used interchangeably for delivery of services.

The NGN can be used in a consistent manner anytime and anywhere across various environments using converged terminal equipment (i.e., those terminals capable of accepting all services) in a digital environment.

The concurrent delivery of all content types will allow their simultaneous presentation on single terminal equipment (TE) or on separate devices as required. An example is shown in Appendix I.

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[3]   In the context of this Recommendation, the term broadcast (with small "b") is used only in relation to the transmission technique, and having no relation to the service being offered.

11 Multimedia services

Support for a wide range of services, in particular multimedia services, is one of the fundamental characteristics of NGN (see ITU-T Rec. Y.2001 [4]). Therefore the functional architecture of the NGN should include multiple methods for service access and request of resource support.

11.1 The support of multimedia services

One of the key characteristics of the NGN should be the ability to support multimedia services (e.g., conversational services, videoconferencing, streaming, etc.). There should be no restriction on how users access these services or on types of protocols that may be used to invoke them. In addition, there should be no restriction on the way that resources are requested to support multimedia services. Generally speaking, several families of services will exist, such as conversational services and data services, and specific techniques are needed for each purpose.

11.2 The access to the services and the support (of the services) requests

In the PSTN, the end-users invoke their desired service (i.e., establishing a call) by sending a signal to the network. Upon receiving this signal, the network acts on two things, first to establish the call and second to provide the necessary resources required by this call.

Present conversational services for telecom carriers are mostly designed based on "call control" or "session control" principles using call servers, service session control servers, or similar entities. Voice over IP techniques rely on protocols such as H.323 [21] or SIP [22] and carrier applications include entities such as Gatekeepers [21] and SIP proxies [22].

By contrast data services are most often reached through a communication session established between terminals and services platforms. This session can be established through various means such as the IP address [5] of the target services platform (e.g., initial provision of the IP address in PC software) or after an access session through a Web portal over different protocols such as HTTP [23]. Consequently, it is the services platforms that request the required resources.

Generally, while conversational services are supported by resources set-up through signalling processes initially emitted by end-user terminals, data services are supported by resources set-up upon services platforms request. Both cases are illustrated below.

Consequently, NGN network architectures should accommodate both ways. In particular, both ways of requesting resources, through a session control entity or through a services platform, should be permitted by an NGN network.

Figure 7 shows how access to the services and the required supports are provided.
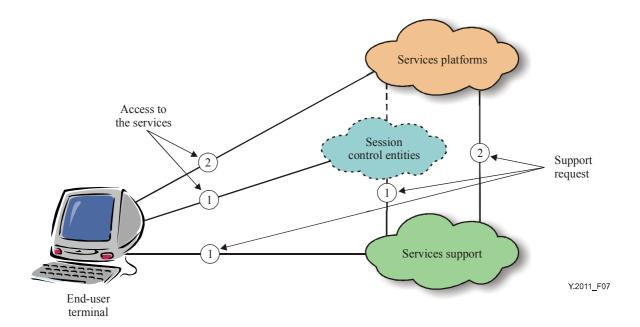
Figure 7/Y.2011 – Access to the services and the support request

NOTE 1 – Lines labelled 1 show services access and support request over signalling procedures emitted by end-user terminals, plus support request by session control entities.

NOTE 2 – Lines labelled 2 show services access and support request by services platforms.

The support of multimedia services is a key domain of study for the functional architecture of NGN. Very often, a strict association exists between the service considered and the way this service is accessed but also on how resources are requested to support the invoked service. Presently, most network architectures are still dedicated either to voice or data services. NGN architectures should permit the resources to be requested either in a "conversational" or in a "data-like" manner.

12   Identification and location

The advent of mobility services, different technologies and their interworking has increased the complexity for treatment of naming, numbering and addressing issues.

In the context of mobility services, number portability, etc., it can be seen that there is not necessarily any permanent relationship between the identity of an object (e.g., user or device) to be involved in a telecommunication activity and its location (i.e., the place in which it can be found). In all cases, a transient relationship is established between the telecommunication object and a location. Even in the fixed access cases, the user and/or the device may move from time to time, either retaining the same name or number or being allocated a new one. In the latter case, the previous name or number may be subsequently reassigned to a different user or device.

Thus, in general terms, the location of a given telecommunications object can be represented by the physical point of attachment (POA), at which the said object may be reached or found. This is shown below in Figure 8.
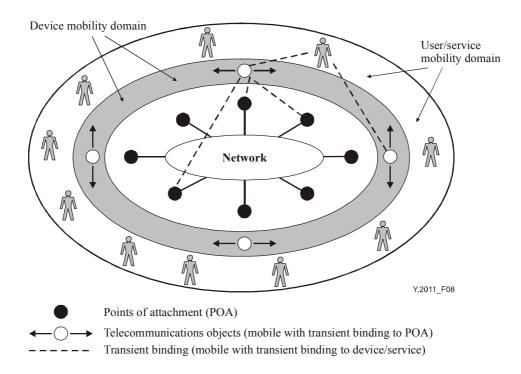
Figure 8/Y.2011 – Relationship of users, devices and locations

In turn, there may be no fixed relationship between a device or location and a given user. Thus, again transient relationships are formed to temporarily associate users and devices as well as users and locations.

Sophisticated directory and/or customized agent-based services allow various identification schemes to be used by both calling and called parties. These schemes, in general, have no fixed relationship to particular physical locations.

In general, three different and logically separate concepts need to be recognized:

a) users;

b) devices;

c) addressable locations at which users and/or devices are (or might be) reachable.

A more detailed discussion using "agent-based" solutions can be found in ITU-T Rec. Y.130 [24] where agents are introduced to perform tasks such as identification on behalf of communication parties rather than have the parties themselves perform the tasks.

13 Emergency communications

Highly reliable emergency communications are required by public safety and disaster relief agencies to perform recovery operations associated with disasters or serious events. Future advanced network development and evolution should take into consideration the requirements for public safety and disaster relief communications including:

• identification of suitable technologies (i.e., narrow-band and broadband aspects);

• interoperability and interworking between emergency communications capabilities and public networks;

• preferential access to communications resources capabilities, applications and facilities;

• preferential use of remaining operational resources.

14 Interactions between NGNs and non-NGN environments

Unlike an NGN, many existing networks and their services are vertically integrated, i.e., do not have a clear separation between services and packet transport.

It is clear that many services have to be operated across a hybrid combination of NGN and non-NGN technologies. In such cases interworking arrangements will be necessary. Interworking is a complex subject, involving arrangements between one or more layers of both the NGN and non-NGN architectures. This topic needs to be considered on a case by case basis.

Appendix II contains some preliminary information on some interworking aspects.

15 Security

NGN study needs to consider security of both transport networks and provided services. Detailed investigation of all security aspects is for further study.

16 Quality of Service (QoS)

The NGN should be able to support a wide range of QoS enabled services.

To offer these QoS services, it is necessary to define, at least:

1) Bearer service QoS classes;

2) QoS control mechanisms;

3) QoS control functional architecture;

4) QoS control/signalling.

16.1 QoS classes

The current standards distinguish teleservices, which are operated across terminals and networks (e.g., mouth-ear for voice) and bearer services that exclude terminals (from UNI to UNI). In an opened and deregulated market, it is not always possible to control the user's domestic installation. In an NGN environment, the network performance at the bearer service level should be taken into account.

The bearer service level is the level addressed by ITU-T Rec. Y.1541 [25]. But in an NGN environment, the mobile network should be taken into account. The UMTS QoS classes are defined in the 3GPP Technical Specification 23.107 (see Bibliography). Since NGN has to support different types of access networks, the harmonization of these specifications is needed to be able to manage end-to-end QoS in a non-homogeneous network.

16.2 QoS control mechanisms

In NGN, different QoS control mechanisms could be used, corresponding to different technologies and possibly different business models. Those QoS support mechanisms have a strong influence on the architecture that may be needed to provide them. As a matter of fact, there exists several different alternatives, depending for instance on user terminal capabilities or on service needs.

Three main scenarios can be identified:

1) **Service requested QoS**: The user terminal or the home gateway does not itself support native QoS signalling mechanisms. It requests a specific service to the Service controller, which determines the QoS needs for this service.

2) **User requested QoS with prior authorization**: The user terminal or the home gateway is able to send explicit QoS requests for its own QoS needs, but before doing this, prior authorization from the Service controller is required.

3)   **User requested QoS without prior authorization**: The user terminal or the home gateway is able to send explicit QoS requests for its own QoS needs, and does not require prior authorization from the Service controller.

Irrespective of the mechanism used to request QoS from the terminal, there exist several mechanisms to propagate QoS requests in a network and across networks.

16.2.1   Scenario 1: Service requested QoS

In the "Service requested QoS" scenario, the user terminal or home gateway does not itself support native QoS signalling mechanisms. It requests an application-specific service by sending a "Service Request" to a service controller. It is then the service controller's responsibility to determine the QoS needs of the requested service, to request network authorization from the network resource controller which then requests resource reservation to network.

This scenario has the advantage of not requiring any resource reservation signalling capabilities on the user terminal and can work with any protocol for the service session requests. The drawback of this proposal is the necessity to always go through a service controller for any service request, including bandwidth reservation changes during a session.

Scenario 1 supports single-phase resource reservation or two-phase resource reservation, as follows:

•   In the first case, the network enables immediate activation and usage of network resources by the end-user;

•   In the second case, the service controller first asks for network QoS resources to be authorized and reserved. Once these resources have been reserved, the service controller continues its dialogue with the user concerning the service. This two-phase reserve/commit model guarantees that Access Network resources are available before offering service to the user.

16.2.2   Scenario 2: User requested QoS with prior authorization

In the "User requested QoS with prior authorization" scenario, the user terminal or home gateway is capable of signalling and managing its own QoS resources but requires prior authorization of these requests via the service controller. It requests an application-specific service by sending a "Service Request" to the service controller. The service controller is in charge of determining the QoS needs of the requested service and of requesting the network authorization from the network resource controller. Then, the terminal uses a specific signalling to request resource reservation (and commitment). This request could be managed in the access network with authorization of a network resource controller or directly by the network resource controller.

16.2.3   Scenario 3: User requested QoS without prior authorization

In the "User requested QoS without prior authorization" scenario, the user terminal or home gateway is capable of signalling and managing its own QoS resources. The terminal sends specific signalling to request resource reservation (and commitment) to the network resource controller.

16.3   QoS control functional architecture

The NGN QoS control functional architecture should be able to support the three scenarios for QoS control mechanisms as described in 16.2.

16.4   QoS control/signalling

The NGN QoS control/signalling should make use of protocols which have been or are already being defined (e.g., RSVP [26], COPS [27], etc.), in order to fulfil the requirements of the NGN QoS control functional architecture in specific physical implementation scenarios.

Annex A

Relationship of NGN to OSI BRM

This annex provides an overview of relationship between OSI basic reference model (OSI BRM) as specified in [1] and NGN.

A.1 Distribution of layer functionality

For each of the seven layers, the OSI BRM [1] defines very specific functions and service features. In an NGN, the services and functions may be distributed quite differently.

A.2 Ordering of protocol layers

The ordering of protocol layers is hierarchical in nature, and only a single ordering is described.

OSI layers 1-6 are considered to provide "step-by-step enhancement", in which functionality is accumulated as the layers increase. For example, if the Network Layer is the layer under consideration, it is assumed that the underlying layer contains a Data Link Layer protocol, and the overlying layer will contain the Transport Layer protocol. No allowance is made for the "recursive" layering which may be expected in an NGN environment, where say a Data Link Layer service (and protocol) is being offered over a Network Layer service (and protocol). In an NGN there may be no "natural" order to certain instances of protocol layering, which can arbitrarily result from differences in core technologies and services offered.

A.3 Peer semantics of layers

In the context of OSI, layer 4 has particular significance. An OSI End System is defined in 6.5.1.1 of the OSI BRM [1] as "the ultimate source or destination of data".

Additionally, in 7.4.2.3 of the OSI BRM [1] it is stated that "the transport layer is OSI end open system oriented and transport protocols operate only between OSI end open systems".

In today's environment there are many cases where the transport protocol, e.g., TCP (Transmission Control Protocol) [28], does not operate between the ultimate source and destination of data. This will occur in the case where firewalls are being used, or in the case where network-based devices offer simulated services.

In general, no absolute assumptions can be made about the nature or location of the end-points at which particular protocols are generated or terminated. Thus, the end-to-end rules of ITU-T Rec. X.200 may not apply in many cases.

A.4 Mode of transmission

The OSI BRM [1] places severe compliance restrictions on the modes of transmission that can be used in the network and transport layers. Clause 6.4.2 of OSI BRM [1] states:

"a)   A real open system as defined in 4.1.2 (of [1]) shall support a given mode of transport service over a network service of the same mode (utilizing conversion within the Network Layer if necessary); such a system may, in addition, provide conversion in the Transport Layer.

b)   A real system which only supports a given mode of transport service by providing conversion in the Transport Layer from a network service of the other mode is not fully open as defined in 4.1.2 (of [1]), since such a system would be incapable of communicating with a system which only supports the given mode of transport service over a network service of the same mode."

In other words, if there is a connection-oriented transport service there must be a connection-oriented network service. This rule is clearly violated in many NGN environments where there is a connection-mode transport service operating over a connectionless-mode network service. TCP [28] over IP [5] is one notable example of this.

Annex B

Principles retained/not retained from X.200 for NGN

This annex identifies parts of ITU-T Rec. X.200 for NGN which are applicable to NGN (see B.1), and parts of ITU-T Rec. X.200 for NGN which are not applicable to NGN (see B.2).

B.1   X.200 parts applicable to NGN

This clause identifies the clauses of ITU-T Rec. X.200 that are retained, and are applicable to NGNs. Explanatory notes are provided where appropriate. The numbers and titles of clauses are those of ITU-T Rec. X.200.

X.200/Clause 1 Scope

Most of this clause remains applicable, with following caveats:

The term "NGN" should be substituted for "OSI".

Clauses 1.10-1.14 should be ignored as they are specific to OSI layers only.

Clause 1.15 should be ignored.

X.200/Clause 2 Definitions

All the definitions remain applicable except those containing the term "OSI" which should be replaced by the term "NGN".

X.200/Clause 3 Notation

This clause is applicable with the exception of 3.2 which should be ignored (since it relates to specific OSI layering).

X.200/Clause 4 Introduction to Open Systems Interconnection (OSI)

This clause is applicable to NGN, by replacing the term "OSI" by "NGN".

X.200/Clause 5 Concepts of a layered architecture

This clause is applicable to NGN, by replacing the term "OSI" by "NGN", with the following exceptions:

Clause 5.3.3.3.5 is not applicable.

X.200/Annex B Alphabetical index to definitions

The list of terms in this annex is applicable to NGN, with the following exceptions:

open system interconnection environment (OSIE)

OSI end system

OSI-(N)-relay system

OSI resources

B.2 X.200 parts not applicable to NGN

This clause identifies the clauses of ITU-T Rec. X.200 that are not applicable to NGNs, and so are not retained. Explanatory notes are provided where appropriate. The numbers and titles of clauses are those of ITU-T Rec. X.200.

X.200/Clause 6 Introduction to the specific OSI layers

This clause is not applicable to NGN, although some of the embedded principles may be.

X.200/Clause 7 Detailed description of the resulting OSI architecture

This clause is not applicable to NGN, although some of the embedded principles may be.

X.200/Clause 8 Management aspects of OSI

This clause is not applicable to NGN systems.

X.200/Clause 9 Compliance and Consistency with this reference model

This clause is not applicable to NGN systems.

X.200/Annex A Brief explanation of how the layers were chosen

This annex is not applicable to NGN systems.

Appendix I

Example of convergence of services

This appendix provides as an example of convergence of services the coupling of distance learning with teleconferencing.

I.1 Service scenario

The convergence offered by an NGN with broadband capabilities permits new service models. For example, it would be possible to broadcast to multiple participants, and use this together with interactive communications including wireless service for applications such as e-conferencing, e-commerce, e-education, e-medical, etc. As a typical example, coupling e-learning with a videoconference service could be achieved such that a chairman and participants could discuss a subject chapter during its broadcast. Subscriber, question and answer session would also be possible through the use of TV channels and videophone channels to a single terminal screen.

In Figure I.1 below, a lecture is being broadcast along with videophone sessions amongst various distant participants.

I.2 System configuration

The broadband convergence network comprises the transport network, Convergence-Home curb Network (C-HcN) as FTTH subscriber network, and application servers. The QoS is ensured through the use of MPLS (and cell based ATM). Subscriber access may be by wireless media, FTTH, ADSL, VDSL, or Cable Modem.
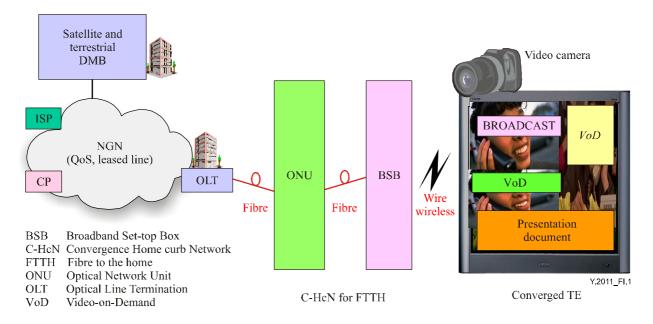
Figure I.1/Y.2011 – Illustrative example of convergence

Digital Multimedia Broadcast (DMB) is designed to provide television and radio programmes to mobile phone, notebook PC and other devices via satellite transmission and/or a terrestrial transmission system, where the user may pick up broadcast signals in moving vehicles.

Thus, a seamless service can be provided between fixed and mobile terminals.

A converged terminal for wireless and wireline operation is connected with CP (Content Provider) equipment and through a broadband backbone network for video contents delivery.

This model for convergence of services is a basis for a convergence framework that can be provided by NGN. In particular, further study is required to define the functions and their distribution across network elements and the interfaces between them.

The following items are of interest:

*   functions of ONU (Optical Network Unit) to connect from network side to curb of subscriber;
*   functions of BSB (Broadband Set-top Box) to connect from curb of subscriber to home network;
*   interfaces between ONU and BSB to transmission schemes;
*   service model for the delivery of converged services;
*   functions of the fixed and mobile TE;
*   the suitable stream transmission speed derivation in a wireline and a wireless section according to content requirements;
*   functions of video server, video editing and Web server.

Typical bandwidth requirements for support of each of the services proposed in Figure I.1 are:

*   HDTV: 20 Mbit/s × 3 channels, Videophone: 4 Mbit/s × 4 channels, Internet service: 20 Mbit/s, High Quality Voice Service: 2 Mbit/s;
*   Example total bandwidth: approximately 100 Mbit/s.

Appendix II

Interactions between NGNs and non-NGN environments

This appendix presents some preliminary information on interworking aspects of NGNs.

II.1 Introduction

An important aspect of providing seamless operation is the ability of interworking between NGNs, and between NGNs and other networks, such as PSTN.
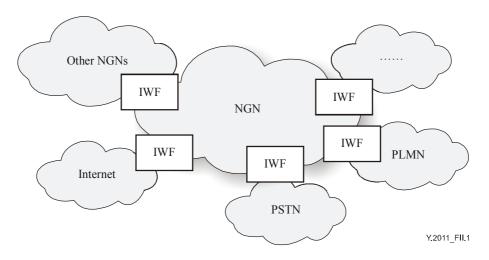

Figure II.1/Y.2011 – Interworking of NGN with other NGNs and legacy networks

It is envisaged that NGN will interwork with other networks to ensure:

• end-to-end communication capabilities for users of such networks as PSTN are preserved;

• content delivery capabilities for users of Internet, TV networks, etc.;

• step-by-step (transitional) deployment of NGN;

• inheritance of rich services from legacy networks.

II.2 Principle for IWF between NGNs

It has already been established in this Recommendation that the NGN is comprised of two strata namely, the NGN service stratum and the NGN transport stratum where each of these strata is comprised of user, control and management planes.

Interworking between NGNs or between an NGN and other networks can be either **service interworking** or **network interworking** as defined in ITU-T Rec. Y.1251 [29]. Figure II.2, which is based on Figure 4/Y.1251, shows interworking between two NGNs. The exact physical location of the interworking unit (IWU) containing the IWF (Interworking Function) is an implementation issue. IWFs are unique for each interworking case.
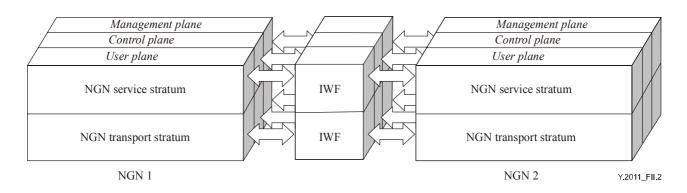
Figure II.2/Y.2011 – Interworking between the strata of two NGNs

To provide any instance of an IWF, the following may be considered:

a)   user plane's interworking may have responsibility for media flow processes, such as NAT, firewall operation, link mapping, QoS-relative processing, codec converting, etc.;

b)   control plane's interworking may have responsibility to exchange processing, such as connectivity control, service logical control, user policy negotiations, call signalling, addressing and routing, etc.;

c)   management plane's interworking may be used for such operations, when necessary, as settlement, bandwidth limitation policy, usage measurements, etc.;

d)   IWFs are unique and differ from each other when located in different layers.

II.3   Agent model for interworking

Notwithstanding the layer and plane architecture the IWF may be decomposed with agent-based architecture according to ITU-T Rec. Y.130 [24] as shown in Figure II.3.
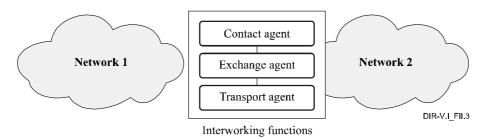

Figure II.3/Y.2011 – Agent-based architecture of IWF

•   the IWF in each layer can be composed of three logical agents;

•   in practice these agents can be combined, replicated, or divided into a number of further sub-entities, to achieve specific geographical distributions of network components that might be encountered in real-world cases;

•   networks interact with these agents according to the context defined by a connection/session instance established between communicating parties.

The agent-based model uses the following terms:

Contact Agent: see clause 8/Y.130.

Exchange Agent: see clause 9/Y.130.

Transport Agent: see clause 10/Y.130.

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