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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 IPv6-based NGN

Recommendation ITU-T Y.2051

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Recommendation ITU-T Y.2051

General overview of IPv6-based NGN

Summary

Recommendation ITU-T Y.2051 identifies a next generation network (NGN) which mainly operates with Internet Protocol version 6 (IPv6) features. This Recommendation provides the general requirements of IPv6-based NGN and its overall architecture.

Source

Recommendation ITU-T Y.2051 was approved on 29 February 2008 by ITU-T Study Group 13 (2005-2008) under Recommendation ITU-T A.8 procedure.

Keywords

IPv6, NGN.

FOREWORD

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Introduction

Internet Protocol version 6 (IPv6) is emerging to form the basis of the next generation networks (NGNs). It is expected that IPv6-based networks will replace IPv4-based networks in order to overcome the ultimate limitations of Internet Protocol version 4 (IPv4). That is, NGNs will gradually migrate to IPv6-based NGNs.

The NGN is a packet-based network to provide telecommunication services with the help of underlying transport-related technologies and various access technologies. IPv6 is a well-defined transport protocol to support the NGN transport functions. It provides considerable flexibility to NGN. These flexibilities are beneficial for improving network provisioning and operations, as well as the services to be offered to the NGN providers and users.

Recommendation ITU-T Y.2051

General overview of IPv6-based NGN

1 Scope

This Recommendation defines an IPv6-based NGN to support IPv6 addressing, signalling, multi-homing, and migration. Additionally, it identifies the overall architecture and general requirements for IPv6-based NGN. The scope of this Recommendation covers:

- classification of IP-based networks
- definition of IPv6-based NGN
- functional architecture for IPv6-based NGN
- general requirements for IPv6-based NGN

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.

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

[ITU-T Y.2011] Recommendation ITU-T Y.2011 (2004*), General principles and general reference model for Next Generation Networks.*

[ITU-T Y.2012] Recommendation ITU-T Y.2012 (2006), *Functional requirements and architecture of the NGN release 1*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following term defined elsewhere:

3.1.1 next generation network [ITU-T Y.2001]: A packet-based network able to provide telecommunication services and 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 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 IPv6-based NGN: This refers to NGN that supports addressing, routing protocols, and services associated with IPv6. An IPv6-based NGN shall recognize and process the IPv6 headers and options, operating over various underlying transport technologies in the transport stratum.

3.2.2 IPv6-based functions and FEs: These are NGN functions and FEs which recognize and process the IPv6 protocol with its headers and options. They have their own specific roles including IPv6.

3.2.3 IPv6-enabled functions and FEs: These are NGN functions and FEs which recognize the IPv6 protocol with its headers and options. They have their own specific roles in NGN except IPv6.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AH	Authentication Header
ESP	Encapsulating Security Payload
FE(s)	Functional Entity(-ies)
ICMPv6	Internet Control Message Protocol for the Internet Protocol Version 6
IP	Internet Protocol
IPsec	Internet Protocol Security
IPv4	Internet Protocol Version 4
IPv6	Internet Protocol Version 6
NAC	Network Attachment Control
NAPT	Network Address and Port Translation
NGN	Next Generation Network
QoS	Quality of Service
RA	Router Advertisement
RAC	Resource and Admission Control
RSVP	Resource ReserVation Protocol
SIP	Session Initiation Protocol

5 Conventions

None.

6 Overview of IP-based networks

6.1 Classification of IP-based networks

IP-based networks are classified into IPv4 and IPv6 according to the IP protocol types used. Their behaviours differ according to the features of each protocol version. This criterion to classify IP-based networks is also applied to differentiate instantiations of NGN, since NGN is based mainly on transport technologies employing IP.

Taking consideration of this, IP-based networks relevant to NGN should be classified according to the following:

- IPv6-based NGN: This is a NGN which supports addressing, routing, protocols and services associated with IPv6.
- IPv4-based NGN: This is a NGN which supports addressing, routing protocol and services associated with IPv4.
- IPv6-based non-NGN: This is an IPv6-based packet network which does not comply with NGN.
- IPv4-based non-NGN: This is an IPv4-based packet network which does not comply with NGN.

Figure 1 shows the various IP-based networks from a NGN point of view.

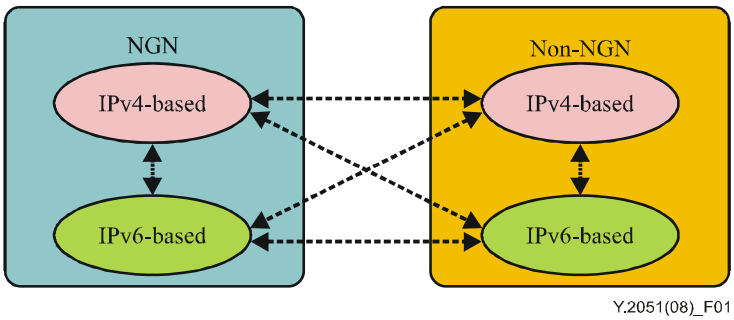

Figure 1 – Classification of IP-based networks

6.2 Key features of IPv6-based networks compared with IPv4-based

Clarifying the differences between IPv4 and IPv6 is very useful for identifying the operations of IPv4 and IPv6, which influence network design and service operations.

Key features of IPv4 and IPv6 are summarized in Table 1.

Table 1 – Key features of IPv4 and IPv6

		IPv4	IPv6
Packet Format	Size of IPv6 header	Variable size	Constant size
	Optional headers	Optional headers	Extension headers and options
Addressing	Addressing spaces	Lack of address spaces	Large address spaces
	End-to-end communications	No	Yes
	Types of addresses	Unicast, multicast and broadcast	Unicast, multicast and anycast
	Scopes of addresses	Local and global	Link-local, local and global
	Address configuration to an interface	A address	Multiple addresses
	Address allocation to an equipment	Multiple interface/addresses	Multiple interfaces/addresses
	Address Autoconfiguration	Using private addresses	Using public addresses

Table 1 – Key features of IPv4 and IPv6

		IPv4	IPv6
	Hierarchical addressing	–	Yes
	Address Renumbering	–	Yes
QoS	Management of service conflicts	Type of Service field	Traffic class field
	Identification of traffic flows	None	Flow label field
	Recognition of control/expedite data	None	Hop-by-Hop extension header
Security	AH header	Optional	Mandated
	ESP header	Optional	Mandated
Mobility	Detection of new networks	–	RA messages
	Generation of new addresses	–	Autoconfiguration
	Mobility headers	–	Mandated
	Option header: Destination option, routing, etc.	Optional	Mandated

There are key features of IPv6 which may significantly impact NGN in various ways, such as addressing schemes, QoS, security and mobility.

- *Simplified packet format*

  IPv6 headers are simplified from IPv4 headers. Some IPv4 header fields have been dropped or made optional to limit their bandwidth cost. They also have a constant size to reduce the common processing cost of packet handling.

- *Expanded addressing scheme*

  IPv6 addressing schemes have a large addressing space due to an increased size of the IP address fields to support more levels of addressing hierarchy, a much greater number of addressable nodes and interfaces, and a simpler autoconfiguration of addresses. The scalability of multicast routing is improved by adding a "scope" field to multicast addresses. In addition, a new type of address called an "anycast address" is defined and is used to send a packet to any of a group of nodes.

- *QoS*

  A flow label and traffic class fields in IPv6 header are added to enable the labeling of packets belonging to particular traffic "flows" for which the sender requests special handling, such as non-default quality of service or "real-time" service. In addition, IPv6 hop-by-hop header with router-alert option will indicate the contents of IPv6 packets to support the selective processing of the intermediate nodes.

- *Security support*

  IPv6 supports built-in IPsec services such as authentication, data integrity and data confidentiality using authentication header (AH) and encapsulating security payload (ESP) extension headers. These enable end-to-end security services via global IP addresses even though intermediate nodes do not understand the IPsec headers.

- *Mobility support*

  IPv6 capabilities such as neighbour discovery, address resolution and reachability detection support the mobility services using destination option, routing and mobility extension headers.

7 Overview of IPv6-based NGN

7.1 Definition of IPv6-based NGN

IPv6-based NGN is defined as a NGN which supports addressing, routing, protocols and services associated with IPv6. This applies not only to transport aspects in access and core networks but also includes other functions such as end user, transport control and application/service support functions in [ITU-T Y.2011] and [ITU-T Y.2012].

Taking into consideration these definitions and features, IPv6-based NGN could be identified as illustrated in Figure 2.

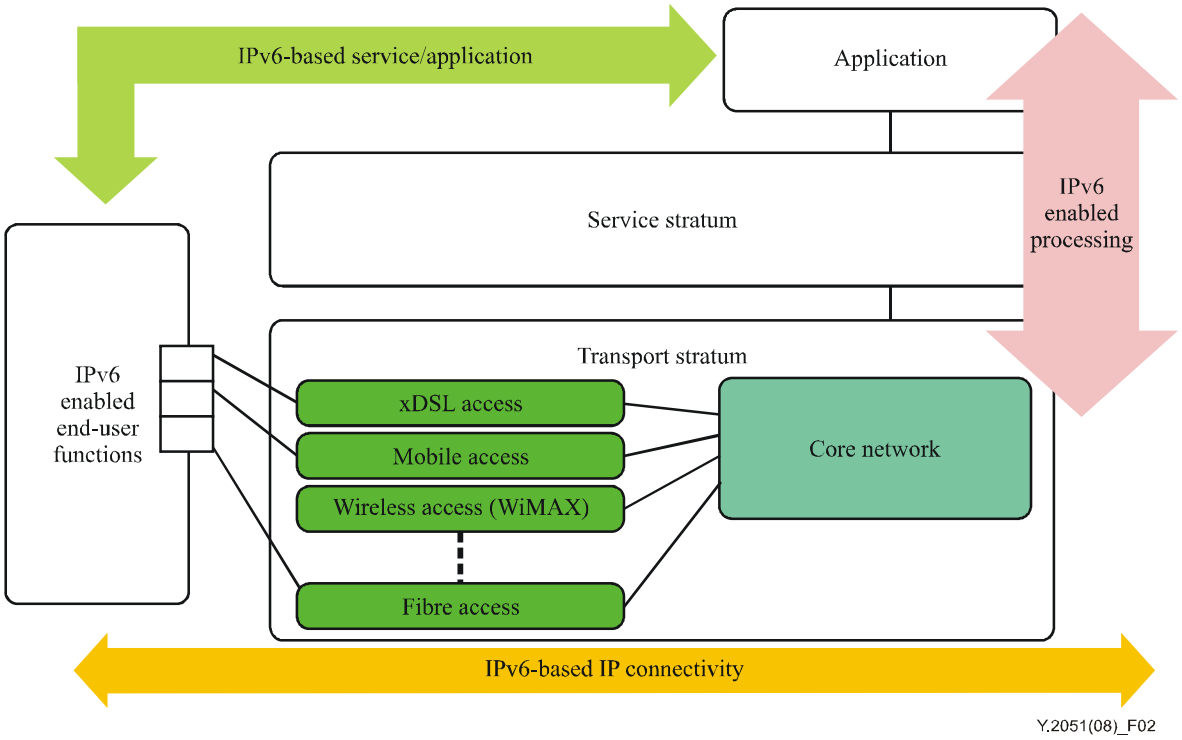

Figure 2 – Overview of IPv6-based NGN

As shown in Figure 2, there are three relationships among the NGN functions and FEs in order to describe the IPv6-based NGN.

First, there is a relationship between end-user functions and transport stratum. IPv6-based NGN allows flexible use of various access infrastructures to maximize the benefits of using IPv6. One such example is the use of multi-homing and mobility features, that is, IPv6-based NGN user terminal or equipment has a capability to handle multiple heterogeneous access interfaces and/or multiple IPv6 addresses through single or multiple access interfaces during the mobility between one network and the other.

Second, there is a relationship between end-user functions and applications. IPv6-enabled end-user functions may acquire the information through application in order to support a secure and robust IPv6 transport. One such example is key management for IP security.

Finally, there is a relationship between the application and transport stratum. The application stratum could request the transport stratum to keep the high quality services. One such example is resource reservation.

7.2 Functional architecture of IPv6-based NGN

An IPv6-based NGN shall conform to NGN principles, so the general architecture shall be based on the NGN architecture identified in [ITU-T Y.2012]. IPv6-based NGN also comprises the transport stratum and the service stratum as shown in Figure 3.

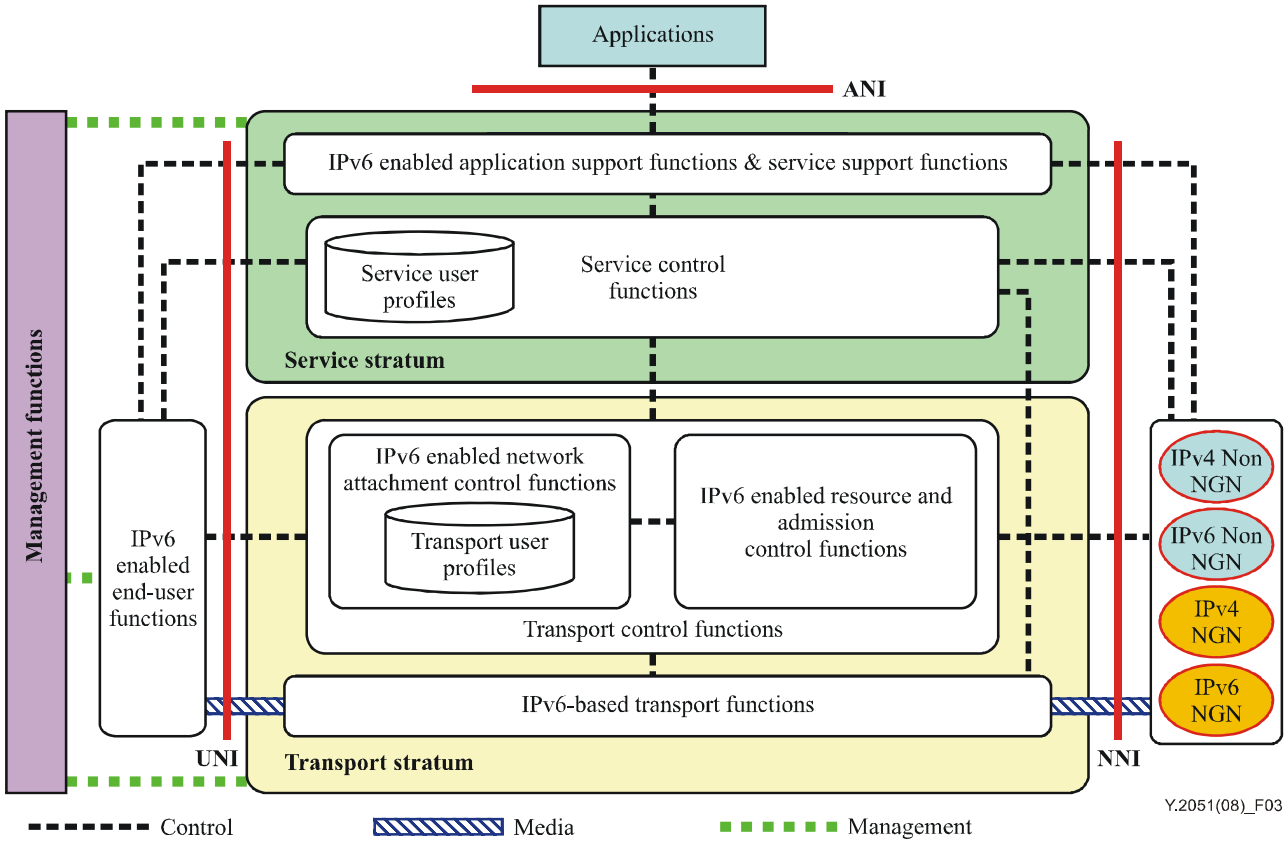

Figure 3 – Functional architecture of IPv6-based NGN

Several functions in this architecture model are affected by the features of IPv6 protocol: transport functions, end-user functions, network attachment control (NAC) functions, resource and admission control (RAC) functions and application and service support functions.

IPv6-based transport functions should be used to interconnect a variety of access networks and to transport the IPv6 services over the core transport network using the IPv6 multi-homing and hierarchical addressing features. These access networks might be homogeneous or heterogeneous. If they are heterogeneous, IPv6-based transport function shall support multi-homing capability to provide multiple network connections to the users over a variety of heterogeneous access networks. Therefore, all transport functions and functional entities (FEs) should fully support all of the IPv6 features.

IPv6-enabled end-user functions should support IPv6 features to provide multiple network connections to the end-user.

IPv6-enabled NAC functions should support IPv6 features such as autoconfiguration, multi-homing and detecting network attachment. The NAC functions are responsible for dynamic configuration of IPv6 addresses and other configuration parameters associated with user equipment. Therefore,

autoconfiguration and multi-homing features should be provided by NAC functions to support the IPv6 mobility services.

IPv6-enabled RAC functions should support IPv6 features from the viewpoint of QoS and IPv4/IPv6 migration. RAC functions should be able to process the IPv6 extension headers and options to support the high quality services. They also extend the network address translation function to support IPv4/IPv6 migration.

IPv6-enabled application should support IPv6 features because IPv6 addresses should be included in application data. To deal with IPv6 nested application data, application layer gateway functions are required.

7.3 Impact of using IPv6 to NGN

IPv6 is a well-defined transport protocol to support the NGN transport functions. This clause mainly identifies the impact of using IPv6 to an NGN from various viewpoints.

- *Enhanced service capabilities*

  IPv6 enables congestion/flow control using additional QoS information such as flow label, etc. The flow label field of IPv6 header enables IPv6 flow identification independently of transport layer protocols. This means that new enhanced service capabilities can be introduced more easily in NGN.

  IPv6 supports better mobility by removing triangle routing problem.

  IPv6 supports secure networking using embedded IPv6 security solution such as ESP and AH.

- *Any-to-any IP connectivity*

  IP connectivity will be one of the vital features in order to cope with the increasing number of end users/devices. Using globally routable IPv4 addresses to network millions of devices, such as sensors, is not feasible. On the other hand, IPv6 offers the advantages of localizing traffic with unique local addresses, while making some devices globally reachable by assigning addresses which are scoped globally. Therefore, the greatest potential of IPv6 will be realized in the objects-to-objects communications. IPv6 can satisfy this end-to-end principle of the Internet.

- *Self-organization and service discovery using autoconfiguration*

  IPv6 can provide autoconfiguration capability using neighbour discovery protocol, etc. Through linking together the IP layer and lower layers, autoconfiguration enables with ease self-organization and service discovery of network management and reduces management requirements. In addition, address autoconfiguration of IPv6 protocol will facilitate NGNs to support dynamic address assignments and multiple user/network identities. That is, NGN end-users will be able to have multiple public and private identities by using the expanded addressing schemes of IPv6.

- *Multi-homing using IPv6 addressing*

  IPv6 can handle multiple heterogeneous access interfaces and/or multiple IPv6 addresses through single or multiple access interfaces. Multi-homing can provide redundancy and fault tolerance.

7.4 Relationships with other IP-based networks

IPv6-based NGN will be deployed gradually while near-term NGNs will be realized based mainly on IPv4. This implies that a similar study of IPv6 related issues is also required for NGNs which transition from IPv4-based NGN to IPv6-based NGN, and for the inter-communication between them, etc. This study should be extended to cover other IP-based networks which belong to non-NGN domains.

Figure 4 explains the relationship of IPv6-based NGN with other IP-based networks. This figure identifies different communications relationship, taking into consideration the existence of other IP-based networks: intra-NGNs, inter-NGNs and interworking with non-NGNs.

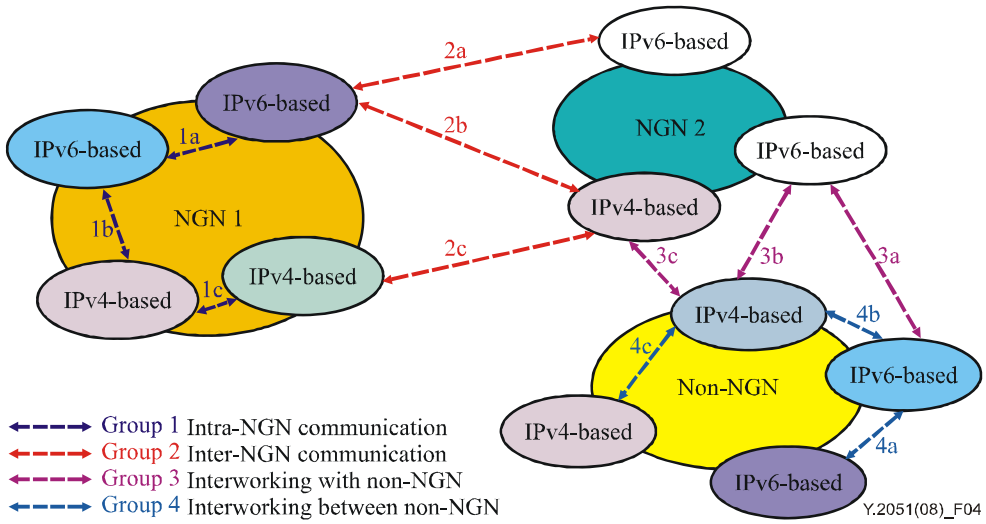

Figure 4 – Relationships of IPv6-based NGN with other IP-based networks

8 General requirements of IPv6-based NGN

IPv6 supports not only extensions of IP address space but also various advanced features which influence NGN functions and relevant functional entities. This clause identifies the general requirements of IPv6-based NGN which is influenced by IPv6 features. It is recognized that IPv6-based NGN shall satisfy NGN Release 1 requirements. Additional IPv6 features identified in this clause will be considered in the context of NGN Release 2 requirements from IPv6 point of view.

- IPv6-based NGN is required to support the IPv6 headers and their options.
  - It should recognize and process IPv6 headers and options.
- IPv6-based NGN is required to accommodate IPv6 addressing schemes.
  - It should support IPv6 address scoping.
  - It should support IPv6 autoconfiguration and neighbour discovery.
  - It should support multi-homing using IPv6 features.
- IPv6-enabled functions and FEs are required to support IPv6 headers and their options.
  - They should recognize IPv6 headers and options.
  - They should differentiate the QoS related control information from general IPv6 packet.
- IPv6-based NGN is required to support the migration and interworking without affecting the service provided to users.
  - It should support the interworking with IPv4-based NGN.
  - It should support the interworking with IPv4-based and/or IPv6-based non-NGN.

9 Security considerations

This Recommendation does not require any specific security considerations and aligns with the security requirements in [b-ITU-T Y.2701].

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