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

Next Generation Networks – Frameworks and functional architecture models

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Framework to support signalling for IPv6-based NGN

Recommendation ITU-T Y.2054

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Recommendation ITU-T Y.2054

Framework to support signalling for IPv6-based NGN

Summary

Recommendation ITU-T Y.2054 specifies the features of signalling using Internet Protocol version 6 (IPv6), requirements, and interworking scenarios to support signalling in IPv6-based next generation network (NGN) environments.

Source

Recommendation ITU-T Y.2054 was approved on 29 February 2008 by ITU-T Study Group 13 (2005-2008) under Recommendation ITU-T A.8 procedure.

Keywords

IPv6, NGN, QoS, signalling.

FOREWORD

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Framework to support signalling for IPv6-based NGN

1 Scope

This Recommendation specifies the requirements and guidelines for supporting the existing signalling protocols and signalling for supporting several functions required in Internet Protocol version 6 (IPv6)-based next generation networks (NGN) using the IPv6 features.

This Recommendation covers the following:

- Features of signalling using IPv6
- Requirements of signalling for transport/service control and interworking
- Functional architecture for signalling in IPv6-based NGN
- Signalling interworking scenarios between IPv6-based NGN and other networks

The implementation methods for the delivery of signalling messages in IPv6 are not covered by this Recommendation.

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

[ITU-T Y.2051] Recommendation ITU-T Y.2051 (2008), *General overview of IPv6-based NGN*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 IPv6-based NGN [ITU-T Y.2051]: 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.

3.1.2 service continuity [b-ITU-T Q.1706]: The ability for a moving object to maintain ongoing service over including current states, such as user's network environment and session for a service.

3.1.3 signalling [b-ITU-T I.112]: The exchange of information specifically concerned with the establishment and control of connections, and with management, in a telecommunication network.

3.1.4 signalling interworking [b-ITU-T Q.300]: Signalling interworking is the controlled transfer of signalling information across the interface between signalling systems where the significance of the transferred information is identical or where the significance is translated in a defined manner.

3.1.5 user [b-ITU-T M.60]: A person or a machine delegated by a customer to use the services and/or facilities of a telecommunications network.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 flow: This refers to a sequence of packets sent from a particular source to a particular destination where common routing is applied. When using IPv6, a flow is identified by IPv6 3-tuple including source/destination IP addresses and flow label.

3.2.2 flow label: The 20-bit field in the IPv6 header is used by a source to label the packets of a flow. This label identifies IPv6 packets with the same origin and destination. The identified packets can be treated equally in the network.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations:

ANI	Application-Network Interface
CN	Correspondent Node
CoA	Care-of-Address
CR-LDP	Constraint-based Routed Label Distribution Protocol
DHCPv6	Dynamic Host Configuration Protocol for IPv6
DiffServ	Differentiated Services
FEC	Forwarding Equivalent Class
GMPLS	Generalized MultiProtocol Label Switching
HA	Home Agent
ICMP	Internet Control Message Protocol
IP	Internet Protocol
IPv4	Internet Protocol version 4
IPv6	Internet Protocol version 6
IMS	IP Multimedia Subsystem
IntServ	Integrated Services
ISDN	Integrated Services Digital Network
LDP	Label Distribution Protocol
LSP	Label Switched Path
MN	Mobile Node
MPLS	MultiProtocol Label Switching
NACF	Network Attachment Control Function
NGN	Next Generation Network
NNI	Network-Network Interface
PSTN	Public Switched Telephone Network
QoS	Quality of Service
RACF	Resource and Admission Control Function

RSVP	Resource Reservation Protocol
RSVP-TE	Resource Reservation Protocol-Traffic Engineering
SIP	Session Initiation Protocol
SLA	Service Level Agreement
UNI	User-Network-Interface
VoIP	Voice over IP
VPN	Virtual Private Network

5 Conventions

This Recommendation basically assumes that IPv6-based NGN uses both existing signalling protocols and newly developed signalling for supporting NGN functions. Thus, this Recommendation presents guidelines on how to support the existing signalling protocols and signalling for supporting several functions required in NGN using the IPv6 features.

6 Features of signalling using IPv6

6.1 Features of the existing signalling protocols

There are several existing signalling protocols in Internet Protocol version 4 (IPv4) networks, providing some form of control delivery mechanism with or without quality of service (QoS) support. Like Internet control message protocol (ICMP), such kind of signalling protocol is for information notification only. Similar to resource reservation protocol (RSVP), however, some signalling may transfer QoS-related information that can be used by a node to determine the control of resource of the node.

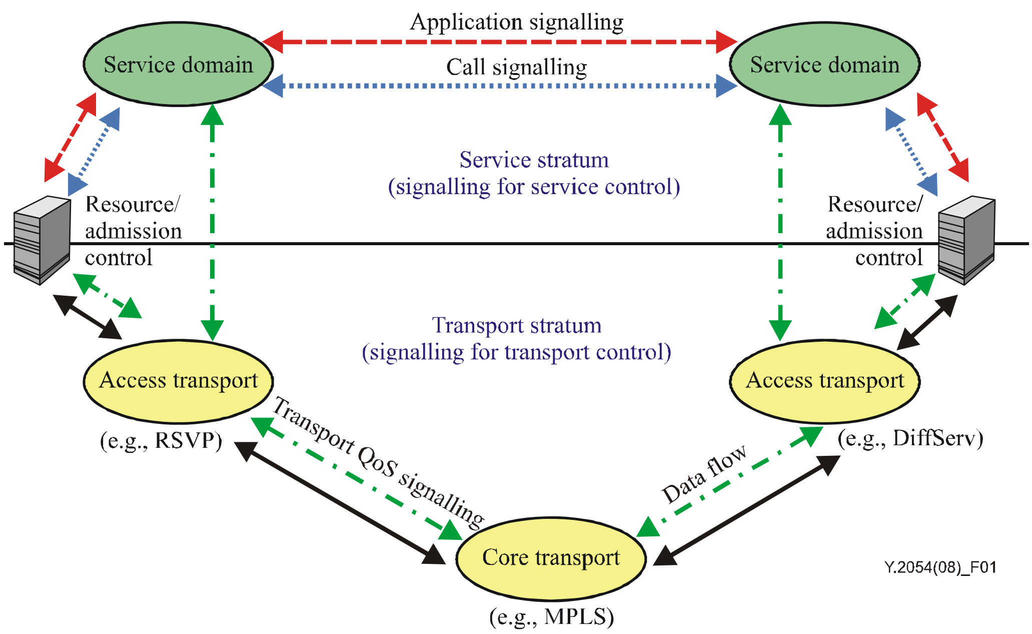

Figure 1 – Classification of existing signalling

In analysing the features of existing signalling mechanisms, the signalling protocols of the transport stratum and service stratum can be considered. As shown in Figure 1, the transport stratum consists of access and core domains; transport QoS signalling is used to perform bandwidth reservation, admission control, and QoS mapping. In the service stratum, call signalling for call set-up/release and application signalling to support various services are supported. The following are the features of the existing signalling protocols:

- *Signalling for the transport stratum*:
  - RSVP-TE (including RSVP-TE extension for GMPLS)

    Resource reservation protocol-traffic engineering (RSVP-TE) [b-IETF RFC 3209] based on RSVP [b-IETF RFC 2205] is used for the integrated services (IntServ) model. Both RSVP and RSVP-TE are implemented at the Internet protocol (IP) layer. RSVP is defined to support QoS in IP networks with fine granularity, although this leads to scalability problems. RSVP-TE has some additional concepts such as label distribution, aggregated flow, and explicit route.
  - CR-LDP (including CR-LDP extension for GMPLS)

    Constraint-based routed label distribution protocol (CR-LDP) [b-IETF RFC 3472] from label distribution protocol (LDP) is used for almost the same purpose as RSVP-TE. CR-LDP contains extensions to enable LDP to extend its capabilities, e.g., set up paths based on explicit route constraints, QoS constraints, and other constraints.
- *Signalling for the service stratum*:
  - SIP and H.323

    Session initiation protocol (SIP) and H.323 play a key role in call control for session-based services in NGN. In particular, SIP is an application-layer control protocol for creating, modifying, and terminating sessions with one or more participants.
  - H.248

    H.248 is the media gateway control protocol for use in distributed switching environments. Use of this protocol enables controlling media gateways to set up media (e.g., voice traffic) paths through the distributed network.

6.2 IPv6 features to support signalling

A large percentage of users in NGN will use IPv6 addresses due to the lack of IPv4 addresses, etc. Emphasis is placed on these applications to use the QoS mechanism supported by the IPv6 protocol. Therefore, signalling using IPv6 for NGN is required; existing signalling protocols are concerned only with the delivery of signalling messages over IPv4 networks.

From the signalling viewpoint, the IPv6 protocol has the following features related to QoS and other capabilities:

- *Flow label*

  Flow label enables classification of packets belonging to a specific flow and flow-specific treatment. The key advantage of flow label is that transit routers need not open the inner packet to identify the flow; thus aiding in the identification of the flow when using encryption and other scenarios.
- *Traffic class*

  The traffic class field may be used to set specific precedence or differentiated service code point values.
- *Extension headers*

  The extension header can ensure both flexibility and efficiency in the creation of the IPv6 datagram. All fields required only for special purposes, e.g., QoS support, are put into extension headers and placed in the packet, when necessary. In particular, signalling in IPv6 can use the extension header of IPv6. A signalling packet specifies the route through the routing header; the data packet is simply switched according to flow labels in each router on the path specified using the signalling packet.

To control the service stratum and transport stratum, signalling used in IPv6-based NGN can use the above-mentioned IPv6 features as shown in Figure 2.

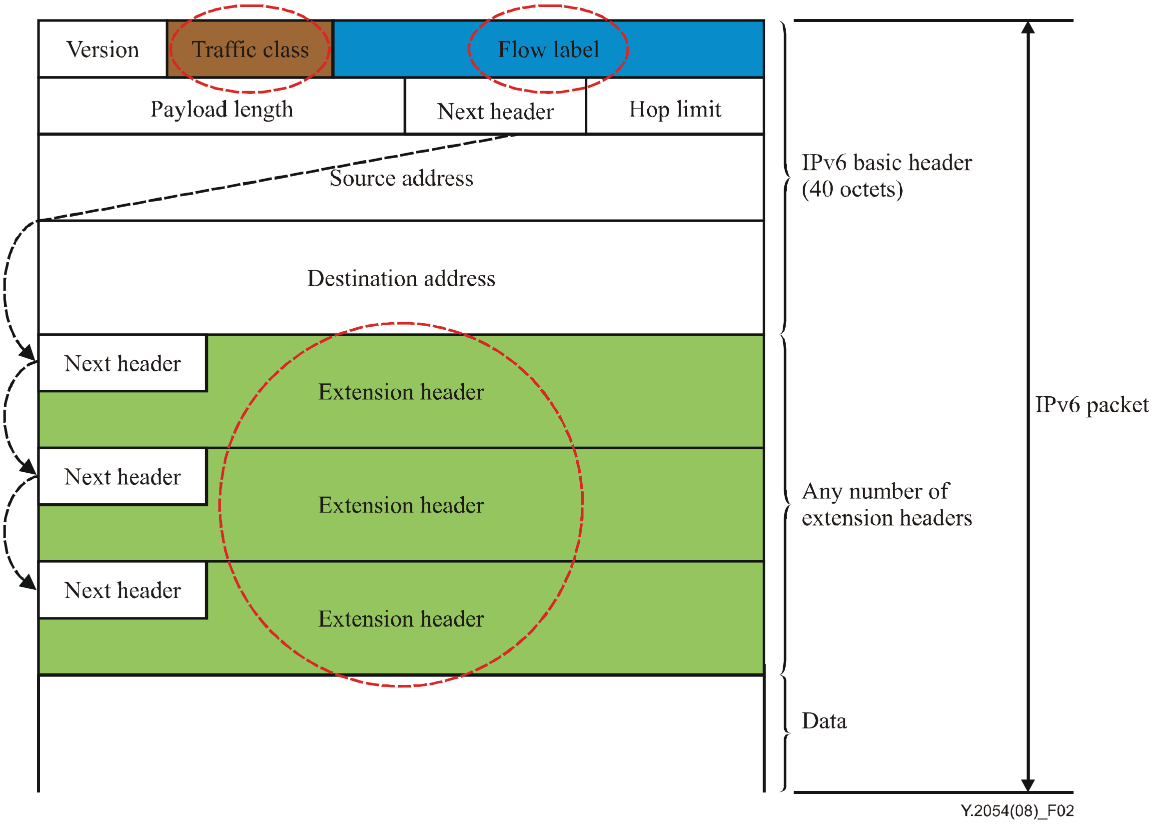

Figure 2 – Header of the IPv6 packet

7 Requirements for signalling in IPv6-based NGN

For signalling, IPv6-based NGN shall use the IPv6 features and support signalling without modifying the existing signalling protocols. To use the flow label and traffic class of IPv6, label-binding information for flow state and priority information should be specified as an important context for signalling packets. In particular, for emergency services [b-ITU-T E.106], [b-ITU-T Y.1271], the priority flow control function shall be applied to provide premium access to network resources.

IPv6-based NGN shall be able to support the QoS negotiation procedure and deal with resource allocation requests including traffic parameters according to the service level agreement (SLA) with users. For the negotiation with users, the means for the authentication and authorization of signalling requests shall be provided. Likewise, for protection/restoration to prevent signalling loss due to failure, etc., signalling resiliency shall be supported.

Signalling in IPv6-based NGN shall support address auto-configuration as well as various kinds of wired/wireless interfaces with unicast and multicast/anycast addresses. Providing QoS in mobile environments requires signalling to support the mobility of nodes and dynamic behaviours of related flows and allow the efficient re-establishment after the handover [b-IETF RFC 3726].

7.1 Requirements of signalling for transport and service control

IPv6-based NGN can use several kinds of signalling for control in the transport stratum and service stratum. The following requirements of signalling from the viewpoint of transport and service control are presented in detail:

- Signalling for transport control is used to provide the QoS-enabled route via network nodes. IPv6-based NGN shall support the following requirements for switching and forwarding control using signalling:
  - Support for the admission control function through interaction with the resource reservation function.
  - QoS-enabled route establishment and release.
  - Priority control using the IPv6 traffic class field to provide differentiated services (DiffServ).
  - Support for the protection function to cope with failure, etc.
  - Support for binding update and router advertisement function for mobile IPv6.
  - Support for network configuration and tunneling for the virtual private network (VPN) service environment.
  - Support for signalling for control transport elements including connectivity check, fault detection, loopback and alarm indication, etc., at the physical layer and link layer.
- Signalling for service control is used to provide services using various applications. IPv6-based NGN shall support the following requirements to control service using signalling:
  - Flow classification/aggregation and mapping according to the IPv6 flow label, traffic class, and application types.
  - Support for call/session establishment and release using SIP protocol, etc.
  - Support for the signalling gateway function for media conversion, payload processing of voice over IP (VoIP), and multimedia applications (e.g., H.248).
  - Support for the service platform environment for emerging NGN services.

7.2 Requirements of signalling for interworking

IPv6-based NGN will emerge gradually from the access network with the new IPv6 application of NGN terminals. Accordingly, signalling used in the current network shall be operated in IPv6-based NGN environments without causing the deterioration of functions and QoS performance. Therefore, signalling for interworking plays very important roles in the transition from IPv4 to IPv6. IPv6-based NGN shall consider the existing circuit-based network as well as the IPv4 network. The following requirements of signalling for IPv6-based NGN in terms of interworking with other networks and protocol translation are presented in detail:

- IPv6-based NGN shall support the following requirements for signalling using IPv6 in terms of interworking with other networks:
  - Support for interworking with the IPv6 network or IPv4 network.
  - Support for interworking with the existing public switched telephone network (PSTN)/integrated services digital network (ISDN).
  - Support for interworking with mobile/wireless networks.
  - Support for interworking with broadcasting networks.
- IPv6-based NGN shall support the following requirements for signalling using IPv6 from the viewpoint of protocol translation:
  - Support for network address translation between IPv4/IPv6 protocols.

– Support for gateway functions for interworking with application signalling, e.g., SIP.

– Support for signalling mapping for end-to-end QoS guarantee.

8 Functional architecture to support signalling in IPv6-based NGN

IPv6-based NGN shall conform to the NGN principles. Thus, the general architecture shall be based on the NGN architecture prescribed in [ITU-T Y.2012]. IPv6-based NGN also consists of the transport stratum and service stratum as described in [ITU-T Y.2051].

Figure 3 shows the overall architecture for signalling in IPv6-based NGN. Several functions in this architecture model affect the features of the IPv6 protocol, transport functions, end-user functions, network attachment control functions (NACF), resource and admission control functions (RACF), application, and service support functions. Each signalling supports several functions for IPv6-based NGN.

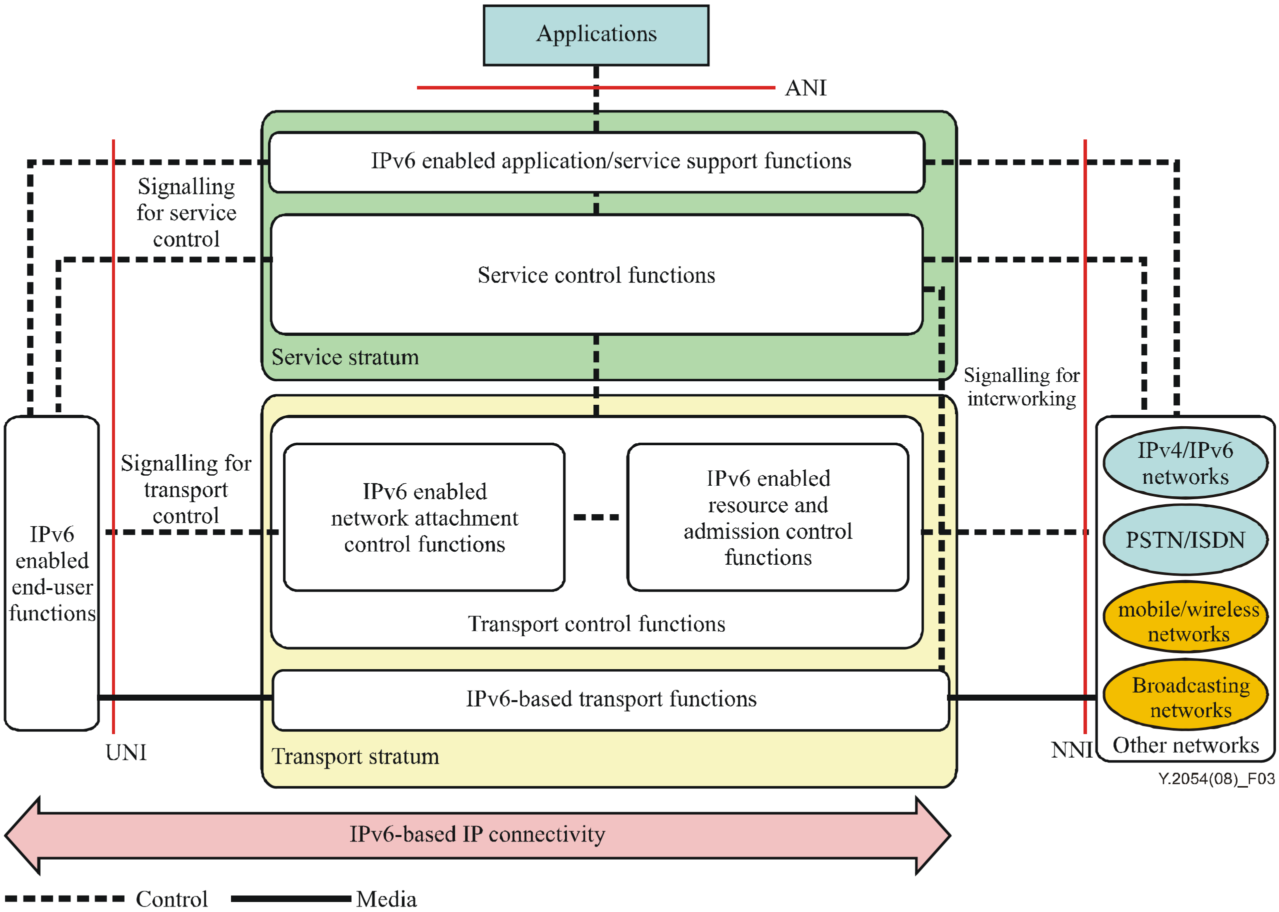

Figure 3 – Overall architecture for signalling in IPv6-based NGN

There are three kinds of signalling flow in IPv6-based NGN:

- Signalling for service control supports the functional entities related to the IPv6-based transport functions and transport control functions including IPv6-enabled NACF and RACF.
- Signalling for transport control supports the functional entities related to service control functions and IPv6-enabled application/service support functions.
- Signalling for interworking interacts with signalling for other networks at the point of network-network interface (NNI).

Some signalling messages communicate with the service stratum and transport stratum through internal interfaces. The IPv6 protocol can be used to deliver these signalling messages in the network to use several features of IPv6.

9 Scenarios for signalling interworking

9.1 Signalling interworking scenarios between IPv6 and IPv4

The current IP-based network will gradually transit from IPv4 to IPv6. Signalling interworking must be supported between the IPv6 network and the existing IPv4 network. The mapping of signalling in the IPv6 network together with signalling in the IPv4 network is required. There are three stages of evolution scenarios from the deployment viewpoint:

- First stage (stage 1): IPv4 ocean and IPv6 island.
- Second stage (stage 2): IPv6 ocean and IPv4 island.
- Third stage (stage 3): IPv6 ocean and IPv6 island.

For the first stage as shown in Figure 4, the IPv4-based, current core network (e.g., multiprotocol label switching (MPLS) network) and IPv6 access networks in the form of an island are deployed. In this environment, core signalling such as RSVP-TE and CR-LDP is used in an IPv4 ocean, and access signalling such as RSVP and RSVP-TE, in an IPv6 island. To support end-to-end QoS signalling, these protocols perform the mapping of IPv6 with IPv4. The flow label information of IPv6 headers should be translated into the forwarding equivalent class (FEC) [b-IETF RFC 3031] information of MPLS; hence the need for signalling interworking functions. Using such QoS signalling, flow information is transmitted in unchanged form from source to destination; the required resource is reserved, and the end-to-end path, established.

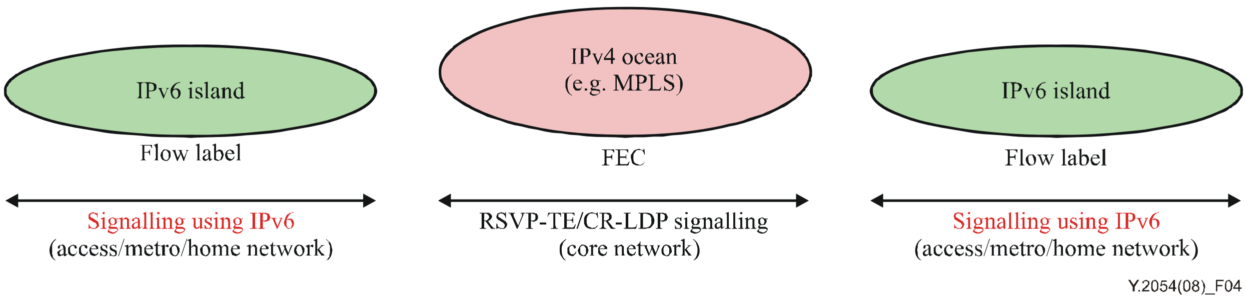

Figure 4 – Mapping of signalling between IPv6 and IPv4 (stage 1)

For the second stage as shown in Figure 5, the IPv6 network will form the backbone over an IPv4 network. This network consists of an IPv6-based core network in the form of an ocean and an IPv4-based access network in the form of an island. For example, if the existing IPv4 network is operated in MPLS, in this environment, core signalling such as RSVP-TE and CR-LDP is used in an IPv6 ocean; access signalling such as RSVP and RSVP-TE is used in an IPv4 island. The FEC information of IPv4 should be translated into the flow label information of IPv6.

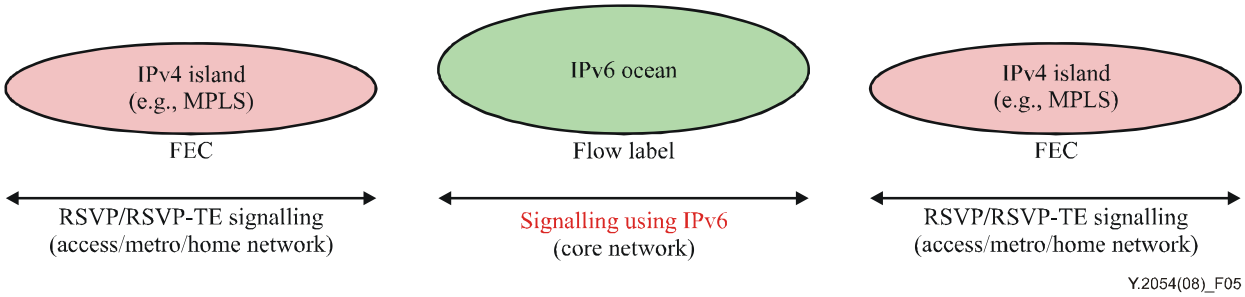

Figure 5 – Mapping of signalling between IPv6 and IPv4 (stage 2)

In the third stage as shown in Figure 6, the IPv6 protocol is implemented over both the core and access networks. In this environment, signalling protocols such as RSVP-TE may be used without signalling translation.

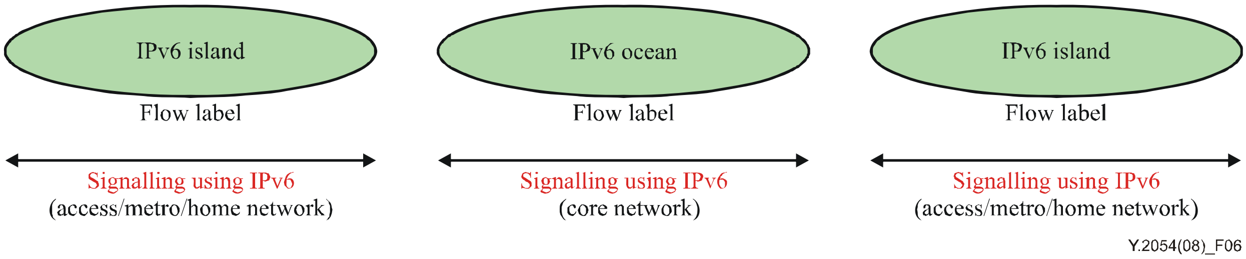

Figure 6 – Mapping of signalling between IPv6 and IPv4 (stage 3)

9.2 Signalling interworking scenarios between IPv6-based NGN and other networks

Signalling interworking between IPv6-based NGN and other networks is required. Other networks may consist of IP-based networks, PSTN/ISDN, mobile/wireless networks, broadcasting networks, etc.

For interworking with IP-based networks (case 1), signalling mapping between IPv6 and IPv4 is required as shown in Figure 7. In the case of interworking with non-IP networks (case 2), however, the mapping of flow label and physical/logical circuit or channel is required for end-to-end signalling as shown in Figure 8.

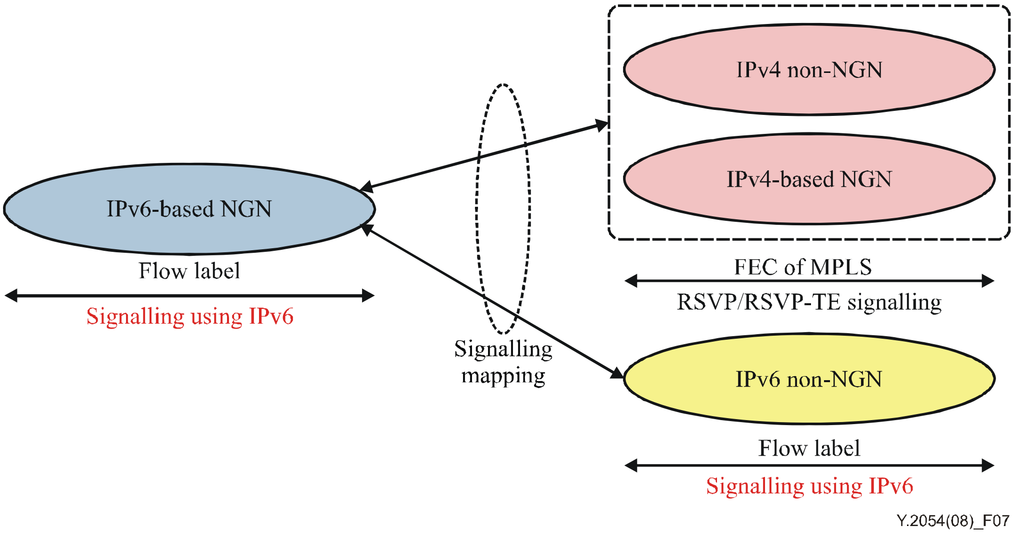

Figure 7 – Mapping of signalling for other networks (case 1)

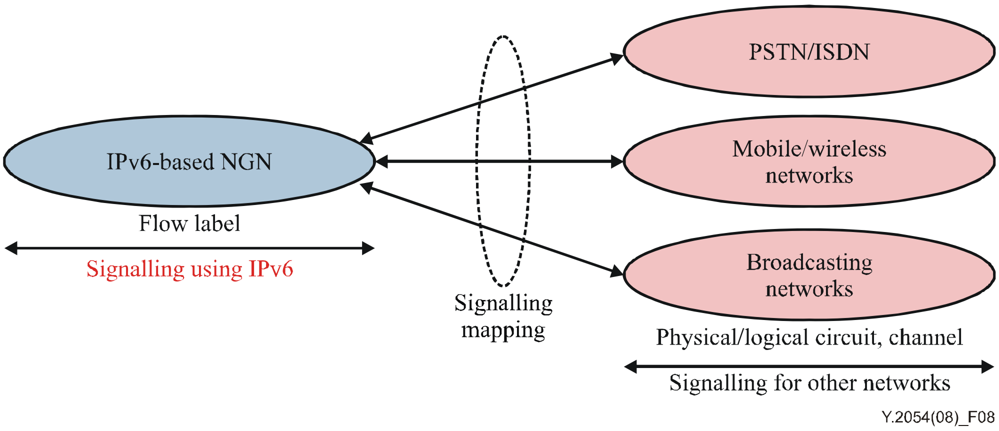

Figure 8 – Mapping of signalling for other networks (case 2)

10 Security considerations

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

Appendix I

Implementation concerns related to signalling in IPv6-based NGN

(This appendix does not form an integral part of this Recommendation)

For signalling in IPv6-based NGN, the delivery methods of the existing signalling protocols in networks using IPv6 extension headers should be considered. The use of such methods in the existing signalling protocols (e.g., RSVP-TE, CR-LDP, and SIP) is described in this appendix.

I.1 Router alert option within the hop-by-hop option header

The router alert option [b-IETF RFC 2711] within the IPv6 hop-by-hop option header has the semantics "routers should examine the datagram more closely." Using this option, IPv6 datagrams containing signalling messages are indicated, and action is taken.

For the value field in router alert option format, values are registered and maintained by the Internet Assigned Numbers Authority (IANA). The new value (= 3) for RSVP-TE messages can be used. Value 3 is subject to the approval of the Internet Engineering Task Force (IETF) and should be assigned by IANA. Other signalling messages may be added. In this case, the value for new signalling messages should be assigned by IANA. These works require collaboration with IETF.

The described method has some advantages and disadvantages. For one, the new protocol for signalling may not be implemented. The existing signalling message is also used without any change. Note, however, that all IPv6 datagrams containing a signalling message must include this option within their IPv6 hop-by-hop option headers. Thus, an additional option header is redundant.

The following are the details of the router alert option format for delivering signalling messages:

The router alert option has the following format:

000	00101	00000010	Value (2 octets)

Length (= 2)

The first three bits of the first byte are zero; value 5 in the remaining five bits denotes the hop-by-hop option type number. The IPv6 standard [b-IETF RFC 2205] specifies the meaning of the first three bits. By setting all three to zero, this specification requires nodes that do not recognize this option type to skip this option and continue processing the header. Moreover, the option must not change en route. There must be only one option of this type per hop-by-hop header regardless of the value.

Value: A 2-octet code in network byte order with the following:

Values	Description
0	Datagram contains a multicast listener discovery message [b-IETF RFC 2710].
1	Datagram contains an RSVP message.
2	Datagram contains an active networks message.
3-65535	Reserved to IANA for future use.

Values are registered and maintained by IANA.

Values can be extended for signalling messages (e.g., RSVP-TE) in the IPv6 network.

Appendix II

Examples of signalling using IPv6 features in IPv6-based NGN

(This appendix does not form an integral part of this Recommendation)

For various forms of control with signalling in IPv6-based NGN, mechanisms for control transport and service are supported. Resource reservation of the transport layer is traditionally considered to satisfy user QoS requirements, with signalling using IPv6 possessing good features to support QoS provision. Current applications use their own signalling; signalling using IPv6 helps the application ensure that users are satisfied with their QoS, which includes support for mobility and security, etc. Here, related examples of signalling using IPv6 features signalling are presented from the viewpoints of transport and service in IPv6-based NGN.

II.1 Examples of signalling using IPv6 features from the transport control viewpoint

For transport control, signalling using IPv6 can carry the QoS request information itself. For example, when a user requires QoS provision but has no other signalling method, the signalling message contains the user's QoS request information in the IPv6 header. A simple case involves the flow label of IPv6 indicating that the user requires a QoS class and the network mapping users' flow label together with its internal flow label that can satisfy the QoS class restrictions. Here, the examples of signalling using IPv6 features from the viewpoint of transport control are described in detail.

II.1.1 Traffic engineering using flow and priority information

Traffic engineering routes traffic flows across a network based on some parameters such as flow label or priority. As shown in Figure II.1, each node has several flows with varying priority of various data rates and QoS requirements. These flows are classified and scheduled based on the capability of making intelligent decisions on how resource allocation is controlled according to priority. Information with priority for QoS control is specified as an important context for signalling packets. For emergency services in particular, the priority flow control function can be applied to provide premium access to network resources.

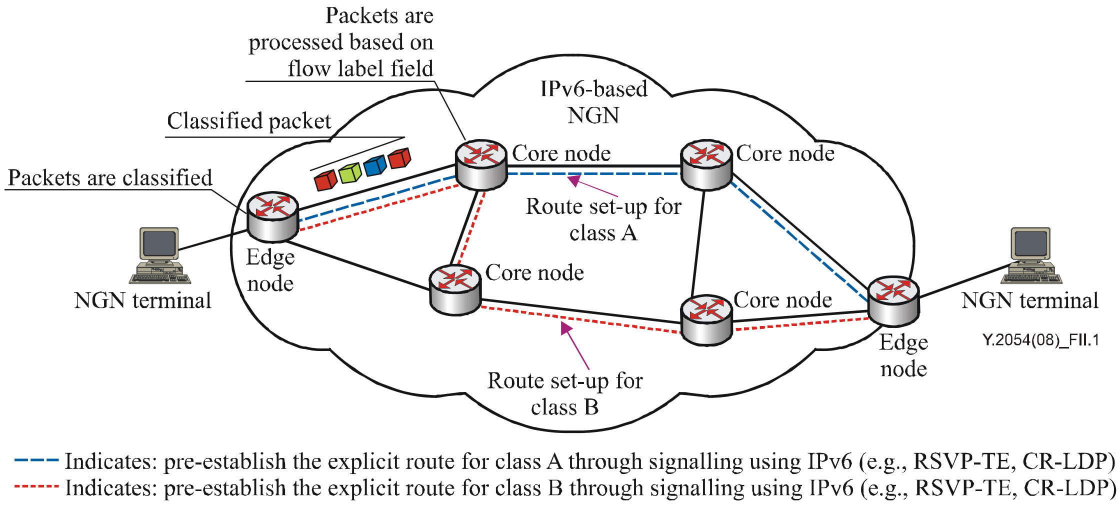

Figure II.1 – Example of traffic engineering using signalling in IPv6-based NGN

II.1.2 Mobility support

One of the key features in NGN is mobility support, which allows users to move around in the network. Without signalling support for mobility, a mobile node will not be able to continue its service while it is in motion. Moreover, handover is a key function for supporting mobility. After the handover, the full or partial re-establishment of states may be required due to route changes. Accordingly, signalling for IPv6 including the binding update function, etc., allows efficient re-establishment after the handover. Mobile IPv6 is used as an example of signalling using IPv6 in the mobile environment. Figure II.2 shows the example of signallling for mobility support in IPv6-based NGN.

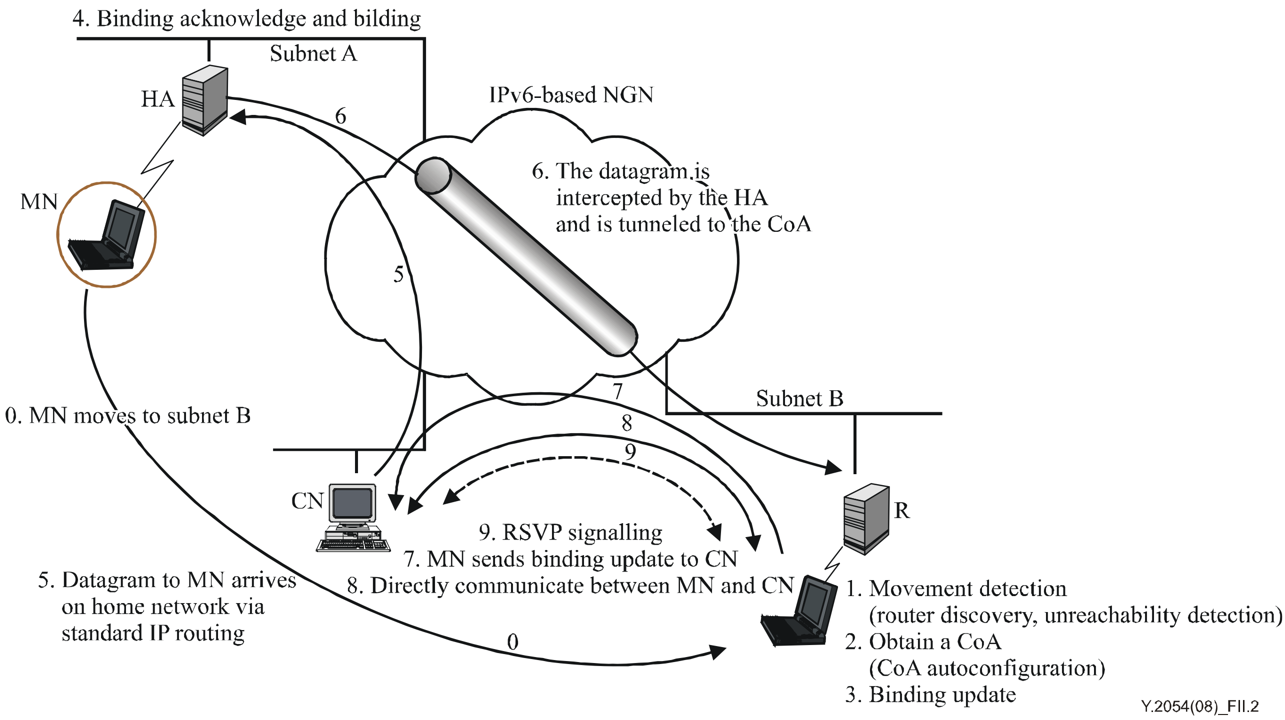

Figure II.2 – Example of signalling using IPv6 for mobility support

II.2 Examples of signalling using IPv6 features from the service control viewpoint

Applications use their own signalling to support services. IP phone applications generally use SIP signalling to establish and release sessions. Other multimedia applications can use H.248 signalling. This signalling protocol for specific applications is supported by the IPv6 protocol in IPv6-based NGN. In particular, signalling for NGN services in IPv6 should support various control functions in the service stratum of NGN.

II.2.1 QoS negotiation according to the SLA with users

In IPv6-based NGN, network providers can support multiple QoS provisions in networks. In this case, users can dynamically choose various QoS classes on a per need basis. First, a network needs to negotiate the QoS requirements with users to provide QoS. Users then send their traffic together with the flow label once the network agrees to provide the QoS requirements. The flow labels of users can be interpreted by networks.

The user can decide the flow label in the signalling message of IPv6 to get various QoS provisions. Upon receiving a signalling message, an access node can use the flow label of the user together with that of the network to provide differential or individual QoS in the transport network.

To support QoS negotiation among various terminal environments, IPv6 can provide control protocols such as ICMPv6, dynamic host configuration protocol for IPv6 (DHCPv6), etc. ICMPv6 is used for error reporting and control of IP transmission, and DHCPv6, for providing configuration information. These protocols have messages for extended functionality, e.g., user/terminal identification.

II.2.2 Call session control for interactive multimedia services

NGN services include the IP multimedia service, PSTN/ISDN emulation service, streaming service, etc. Among them, session-based services using service control functions in the service stratum are very important as emerging NGN services. In IPv6-based NGN, various applications using session can be supported using signalling.

For session control, signalling using IPv6 performs related functions such as registration, origination of sessions, and routing of session messages. To handle these functionalities, the flows of each application are classified into session-related and non-session-related flows. IPv6-based NGN supports IP multimedia subsystem (IMS)-based session control environments. Signalling using IPv6 supports related signalling protocol such as SIP and interacts with related functional entities in the service stratum. Signalling using IPv6 also follows the service configurations and procedures specified in the NGN functional architecture.

II.2.3 Service continuity

Basically, NGN should access networks regardless of whether wired/wireless interfaces are supported. Although users are assumed to move continuously, their connectivity should be maintained at any time. Thus, IPv6-based NGN should ensure service continuity for users in case of the transition between the wired and wireless environments. Location information and fast handover for the mobile user are also required. Efficient mobility management capabilities in IPv6-based NGN can be provided by signalling in combination with security features.

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