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Access networks – In premises networks

Requirements of transport functions in IP home networks

Recommendation ITU-T G.9971

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Recommendation ITU-T G.9971

Requirements of transport functions in IP home networks

Summary

Recommendation ITU-T G.9971 specifies the functional requirements of transport functions in an IP home network associated with the wired access network based on the generic architecture described by Recommendation ITU-T G.9970: "Generic home network transport architecture". This Recommendation first clarifies the position of the home network in end-to-end transport networks as well as the home network functional architecture, and then provides the functional requirements for the transport capabilities of some key components in the home network, such as the access gateway (AGW), IP terminal, etc. Moreover, it mentions some other functional requirements, such as QoS control, management and security so that the operators can reliably provide their services all the way to the IP terminal.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T G.9971	2010-07-29	15

Keywords

Access gateway, control, Ethernet, home network, IP, management, NT, ONT, ONU, security.

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Requirements of transport functions in IP home networks

1 Scope

This Recommendation specifies the functional requirements of transport functions in an IP home network associated with the wireline access network based on the generic architecture described by [ITU-T G.9970]: "Generic home network transport architecture". As popularity of broadband services such as FTTH, VDSL and DOCSIS 3.0 increases, this Recommendation covers the cases of home networks connecting to wireline access networks such as these. Services on this home network are triple play services, such as voice, video and data transfer services. However, incorporation of fixed mobile convergence (FMC) using in-home base station is for further study. Once a home network is connected to an access network, mechanisms need to exist that allow the network operator to manage fault, performance, transfer capability, addressing and security for the home network. In many cases, these will be the same as those used to manage the access network. Note that although the NT/ONT, which terminates an access network, is also studied in this Recommendation from the view point of the home network management, it is out of scope that devices are directly connected to NT/ONT without an AGW. Moreover, the scope only includes the case where Ethernet MAC service (which may be over a variety of physical layers) is provided at the WAN side of NT/ONT.

While [ITU-T G.9960], [ITU-T G.9961] and [ITU-T G.9972] specify the physical layer, such as transceiver, and the mapping between the physical layer and Layer 2 protocols, this Recommendation studies the subject of IP and Ethernet bridging technologies, which does not overlap with the scope of these Recommendations.

This Recommendation first clarifies the position of the home network in end-to-end transport networks as well as the home network functional architecture, and then provides the functional requirements for the transport capabilities of some key components in the home network, such as the access gateway (AGW), IP terminal, etc. Moreover, it mentions some other functional requirements, such as QoS control, management and security so that the operators can reliably provide their services all the way to the IP terminal.

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 G.9960] Recommendation ITU-T G.9960 (2009), *Unified high-speed wire-line based home networking transceivers – Foundation*.

[ITU-T G.9961] Recommendation ITU-T G.9961 (2010), *Data link layer (DLL) for unified high-speed wire-line based home networking transceivers*.

[ITU-T G.9970] Recommendation ITU-T G.9970 (2009), *Generic home network transport architecture*.

[ITU-T G.9972] Recommendation ITU-T G.9972 (2010), *Coexistence mechanism for wireline home networking transceivers*.

[ITU-T H.622] Recommendation ITU-T H.622 (2008), *A generic home network architecture with support for multimedia services*.

[ITU-T I.371] Recommendation ITU-T I.371 (2004), *Traffic control and congestion control in B-ISDN*.

[ITU-T Y.1541] Recommendation ITU-T Y.1541 (2006), *Network performance objectives for IP-based services*.

[ITU-T Y.1563] Recommendation ITU-T Y.1563 (2009), *Ethernet frame transfer and availability performance*.

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

[BBF TR-069] Broadband Forum TR-069 (2007), *CPE WAN Management Protocol v1.1, including its Amendment 2*.

[MEF 10.2] Technical Specification MEF 10.2 (2009), *Ethernet Service Attributes Phase 2.0*.

3 Definitions

This Recommendation defines the following terms:

3.1 access gateway (AGW): The AGW associates the access network with the IP home network and handles IP-related protocol packets for these networks. The AGW provides IP and/or Ethernet services to the home network side. Its definition in this Recommendation is equal to the Internet gateway device (IGD)/residential gateway (RG) in the Broadband Forum or the home gateway in the HGI. Note that it is different from the terminologies used in [b-ITU-T Y.2091]: its "access gateway" means edge router, while its "residential gateway" means terminal adaptor.

3.2 network termination/optical network termination (NT/ONT): The NT/ONT terminates the optical access network and then generally provides the Layer 2 services to the home network side.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AGW Access Gateway

FMC Fixed Mobile Convergence

FTTH Fibre to The Home

ICMP Internet Control Message Protocol

IP Internet Protocol

IPCP Internet Protocol Control Protocol

IPV6CP IPv6 Control Protocol

LA Local Agent

LLDP Link Layer Discovery Protocol

LM Local Manager

L2F Layer 2 Forwarding

L3F Layer 3 Forwarding

L1T Layer 1 Termination

L2T	Layer 2 Termination
L2TP	Layer 2 Tunneling Protocol
L3T	Layer 3 Termination
MAC	Media Access Control
NAPT	Network Address and Port Translation
NAT	Network Address Translation
NAT-PT	NAT-Protocol Translation
NGN	Next Generation Networks
NSP	Network Service Provider
NT	Network Termination
ONT	Optical Network Termination
PD	Prefix Delegation
PPP	Point-to-Point Protocol
QoS	Quality of Service
RA	Remote Agent
RM	Remote Manager
RMS	Remote Management Server
RSVP	Resource Reservation Protocol
SIP	Session Initiation Protocol
SLAAC	StateLess Address AutoConfiguration

5 Conventions

local area network (LAN): It represents the home network side of AGW.

wide area network (WAN): It represents the access network side of AGW.

6 Position of home network in end-to-end networks

This clause describes a managed home network within the context of end-to-end transport networks as shown in Figure 6-1. The end-to-end network consists of the home network, the AGW, access networks, the core network and some application servers.

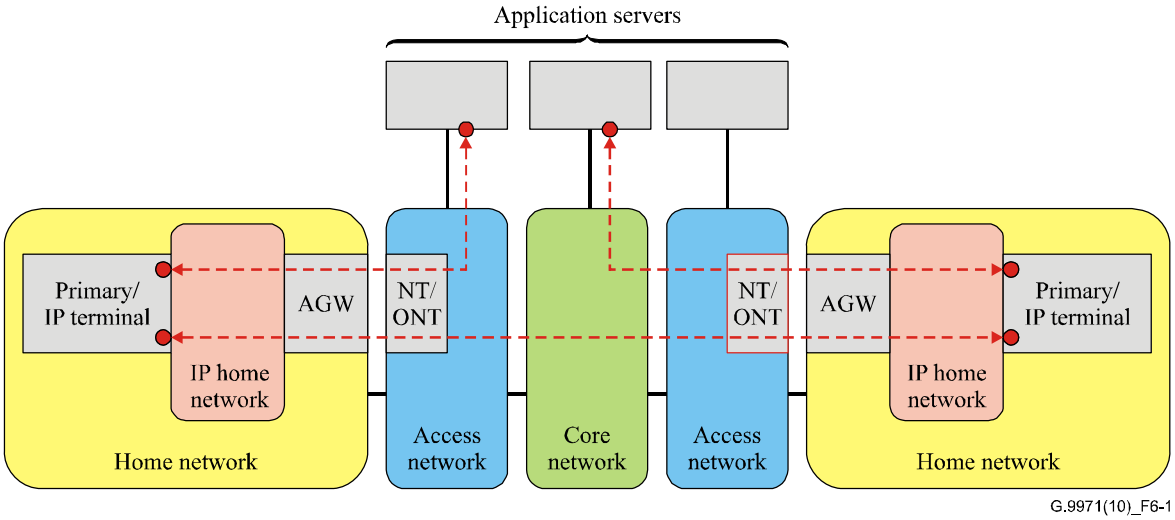

Figure 6-1 – Home network to be managed in end-to-end networks

The primary terminal is the end-point where the service from the NSP is terminated, according to [ITU-T H.622]. That is, the end-to-end services are provided between two primary terminals or between each application server and each primary terminal. The AGW connects the IP home network with the access network, which is terminated by NT/ONT. Moreover, the primary terminal defined in the application layer normally attaches to the IP home network, in which case the primary terminal is called IP terminal in transport layer, according to [ITU-T G.9970]. Therefore, the IP terminal, the IP home network, the AGW, the access networks including NT/ONT, the core network and their relevant control networks could be managed by the NSPs. In order to achieve this, this Recommendation specifies the functions needed in each device within the IP home network, such as the IP terminal, the Ethernet bridge, the AGW as well as NT/ONT. The requirements in this Recommendation are more detailed than [ITU-T G.9970]. Note that the case is out of scope where the IP terminal is directly connected to NT/ONT without AGW. Moreover, only the case where Ethernet MAC is used at the WAN side of NT/ONT is included in this Recommendation.

7 Typical IP home network configurations

This clause describes configurations of the IP home network to be studied in this Recommendation. Figure 7-1 shows two kinds of IP home network configuration. Configuration 1 shows that one Ethernet bridge either aggregates the traffic from multiple IP terminals to the AGW or bridges the traffic between two IP terminals. Note that multiple Ethernet bridges can be put in cascade between the IP terminal and the AGW. On the other hand, configuration 2 shows that each IP terminal is directly connected to the AGW. Although this figure shows the separate type AGW, this Recommendation also studies the aggregate type AGW that combines NT/ONT.

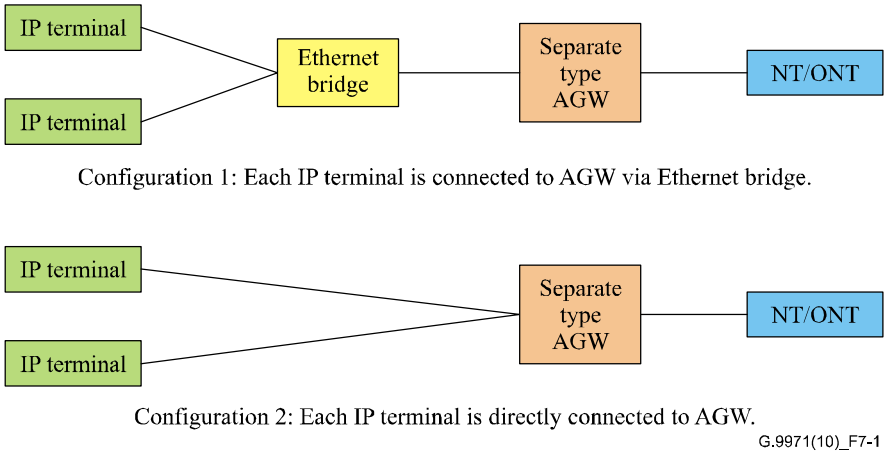

Figure 7-1 – Typical IP home network configurations

8 IP home network functional architecture

Key devices can be defined by using the following functional components:

– Layer 1 termination (L1T): Termination functions of physical layer, such as Ethernet PHY.

– Layer 2 termination (L2T): Termination functions of Ethernet port, such as MAC address assignment.

– Layer 2 forwarding (L2F): Ethernet bridging functions using MAC forwarding table as well as L2 QoS processing, such as L2/L2 QoS mapping, which will be discussed in clause 10. Note that L2F of Ethernet bridge also contains L2/L2 mapping function between Ethernet and wireless within LAN, for example.

– Layer 3 termination (L3T): Termination functions of IP port, such as IP address assignment.

– Layer 3 forwarding (L3F): IP routing functions using IP routing table as well as L3 QoS processing, such as L3/L3 and L3/L2 QoS mappings, which will be discussed in clause 10.

By using these functional components, IP terminal can be composed of L1T, L2F, L2T, L3F and L3T, as shown in Figure 8-1 (A). On the other hand, Ethernet bridge and NT/ONT can be composed of L1T and L2F, as shown in Figure 8-1 (B).

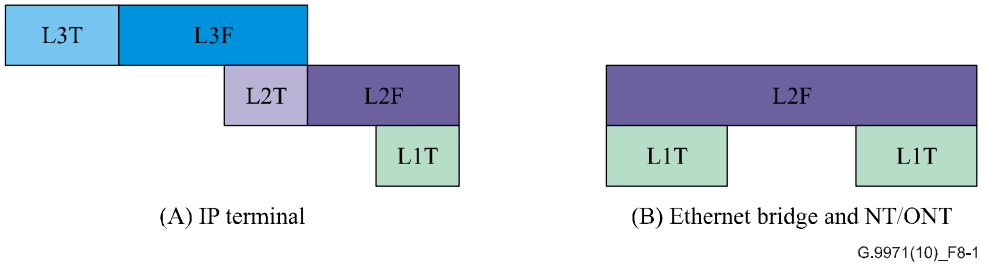

Figure 8-1 – Functional components of IP terminal, Ethernet bridge and NT/ONT

It is complicated to show transport layer functions of AGW in one figure, because there are various kinds of AGW. As shown in Figure 8-2, there are three fundamental types of separate type AGW, which does not combine NT/ONT.

a) NAT/NAPT type: Source or destination IP address of an IP packet is changed after being forwarded in AGW in accordance with NAT/NAPT. Note that a MAC address in Layer 2 is terminated in each port.

b) IP router type: An IP packet is just forwarded in AGW without changing its source and destination IP addresses. Note that a MAC address in Layer 2 is terminated in each port.

c) Ethernet bridge type: An Ethernet packet is just forwarded in AGW without changing its source and destination MAC addresses.

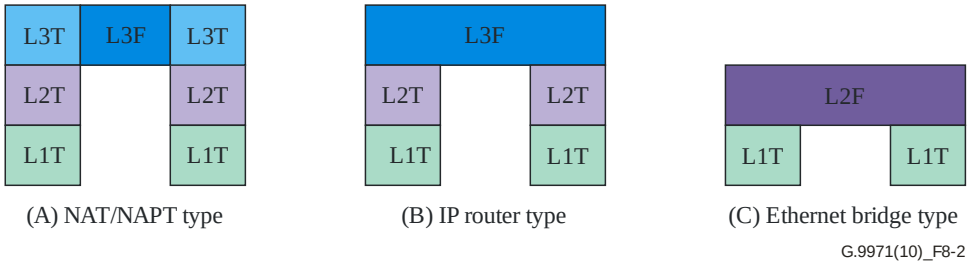

Figure 8-2 – Functional components of separate type AGW

On the other hand, Figure 8-3 shows three types of aggregate type AGW combining NT/ONT. Each type in Figure 8-3 corresponds to that in Figure 8-2. For example, Figure 8-3 (B) shows that an IP packet received at the WAN-side of NT/ONT is forwarded in Layer 2 and then is forwarded in Layer 3 to the LAN-side of AGW. Moreover, Figure 8-3 (C), Ethernet bridge type AGW combined with NT/ONT, shows that IP packets directly flow from WAN to LAN or from LAN to WAN. Although this case is only similar to the NT/ONT case without the AGW, some security function is required for Figure 8-3 (C) case in the AGW.

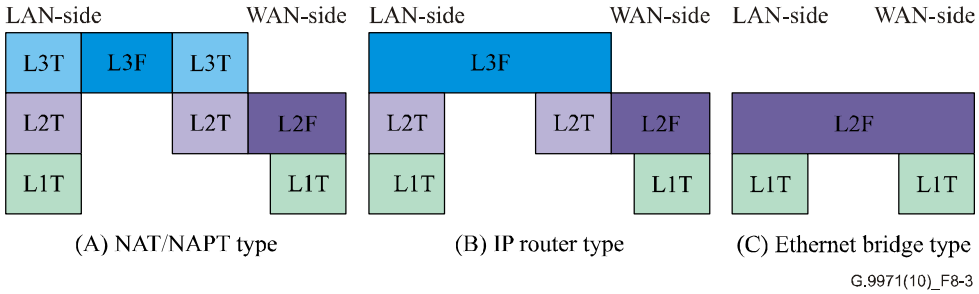

Figure 8-3 – Functional components of aggregate type AGW

In contrast to the above WAN-side features of AGW, three types of LAN-side physical ports can be identified for AGW, as shown in Figure 8-4. Although Figure 8-4 depicts the configuration of LAN-side ports for NAT/NAPT separate type AGW, it is also applied to its corresponding aggregate type AGW as well as IP router separate/aggregate type AGWs. In each type, an IP packet from each LAN-side port can be forwarded to the WAN-side port in Layer 3. However, the following distinctions can be found in each type. Note that each type takes as an example that AGW has three LAN-side physical ports.

(X) Hub type: As LAN-side ports are physically connected with each other, an Ethernet packet from each LAN-side port is broadcast to all the LAN-side ports.

(Y) Bridge type: As LAN-side ports are connected with each other through Layer 2 forwarding (L2F), an Ethernet packet from each LAN-side port is transported to the target LAN-side port based on its MAC forwarding table.

(Z) Multiple segments type: As LAN-side ports are connected with each other through Layer 3 forwarding (L3F), an IP packet from each LAN-side port is routed to the target LAN-side port based on its IP routing table.

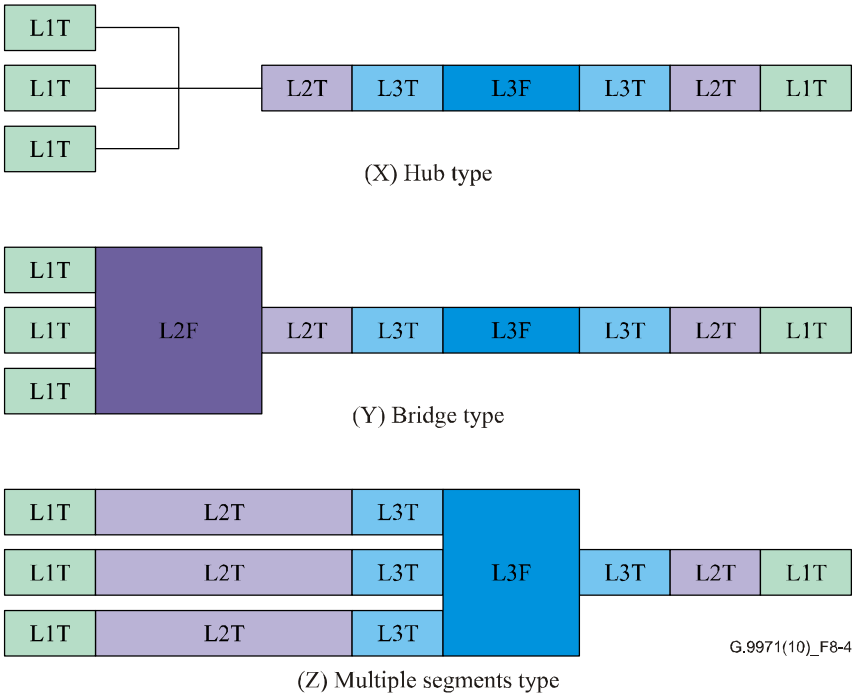

Figure 8-4 – LAN side physical ports of NAT/NAPT separate type AGW

In order to help understanding, Figure 8-5 shows three key devices, such as IP terminal, Ethernet bridge and NAT/NAPT aggregate type AGW with bridge type LAN ports as well as their relationship with IP home network and Ethernet home network.

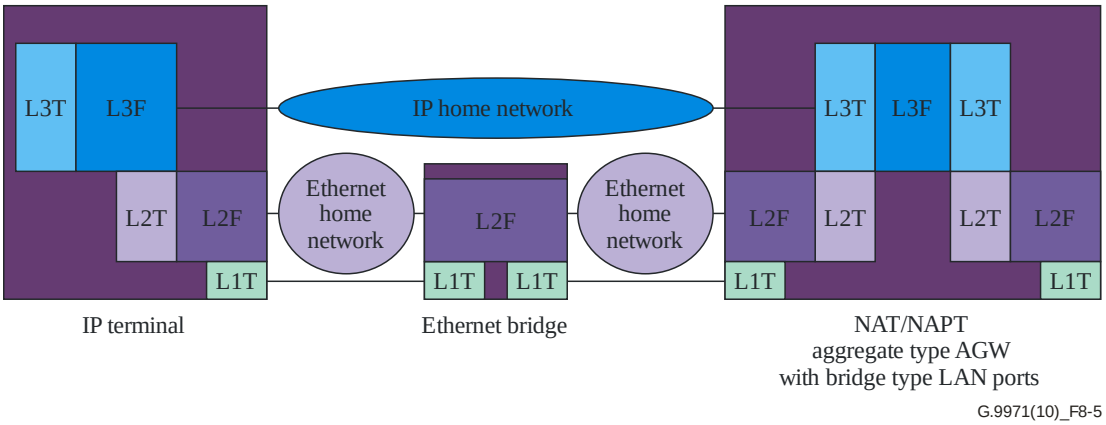

Figure 8-5 – An example of home network functional architecture

To summarize, the following transport layer functional requirements can be identified for the IP home network key devices, such as IP terminal, Ethernet bridge, AGW and NT/ONT.

R8-1: IP terminal requires transport layer 1, 2 and 3 functions, as shown in Figure 8-1 (A).

R8-2: Ethernet bridge and NT/ONT requires transport layer 1 and 2 functions, as shown in Figure 8-1 (B).

R8-3: Separate type AGW, which is one of the three types shown in Figure 8-2, requires corresponding transport layer functions.

R8-4: Aggregate type AGW, which is one of the three types shown in Figure 8-3, requires corresponding transport layer functions.

R8-5: Separate/aggregate type AGWs may have LAN-side transport layer functions shown in Figure 8-4.

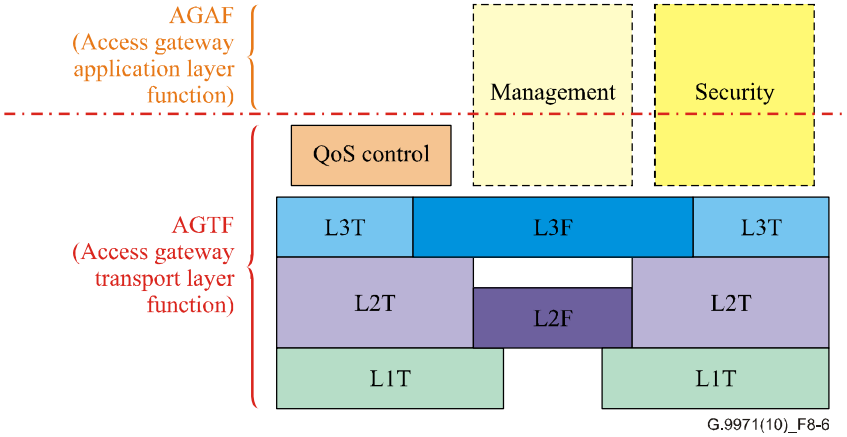

Figure 8-6 – Functional architecture of separate type AGW

In addition to the transport layer 1, 2 and 3 functions described above, some associated functions, such as QoS control, management and security, are also needed. This is illustrated in Figure 8-6, which shows separate type AGW as an example. Note that as this Recommendation focuses on transport layer 2 and 3, its scope of QoS control functions is only on layer 2 and 3. Moreover, although management and security functions are related to transport layer 1, 2 and 3 as well as the functions above layer 4, this Recommendation handles only layer 2 and 3 aspects for them. Accordingly, the following requirement can be identified.

R8-6: Layer 2 and 3 of each device associated with the IP home network, such as IP terminal, Ethernet bridge, AGW and NT/ONT, require QoS control, management and security when needed. Figure 8-6 illustrates this for separate type AGW as an example.

Before discussing these three issues, it is better to clarify IP network configuration in access and home network. Clause 9 describes IP configuration and its assignment in the IP home network, considering possible services. Based on it, clause 10 discusses QoS control for each key device, such as IP terminal, Ethernet bridge, AGW and NT/ONT. In the same manner, clause 11 discusses the remote and local management, while clause 12 discusses the security aspect.

9 IP network configuration and IP address assignment

This clause describes IP network configuration as well as how to assign IP addresses for each IP network configuration. IP network configuration in the IP home network can be categorized based on how IP connection is established in the access network and the home network by the end user or NSP. Note that this clause describes only IP address assignment that is necessary for transporting IP packets, which is described in clause 8. Some other IP addresses necessary for loopback or management purposes will be described in clause 11.

According to its overview described in clause 8.3 of [ITU-T G.9970], the following three fundamental cases can be identified.

(A) Native IPv4/IPv6 connection to AGW (see Figure 9-1): The upper figure shows that a native IPv4 address is assigned at the WAN-side port of the AGW by using NSP's DHCPv4, while local IPv4 addresses are assigned at AGW's LAN-side port and at the IP terminal by using end-user's DHCPv4. The lower figure shows that NSP's DHCPv6-PD (prefix delegation) provides IPv6 prefix for the home network, while IPv6 addresses are assigned at the IP terminal by using the end-user's DHCPv6 or SLAAC (stateless address

autoconfiguration) based on the provided IPv6 prefix. NAT/NAPT type AGW is used for the former, while IP Router type AGW is used for the latter.

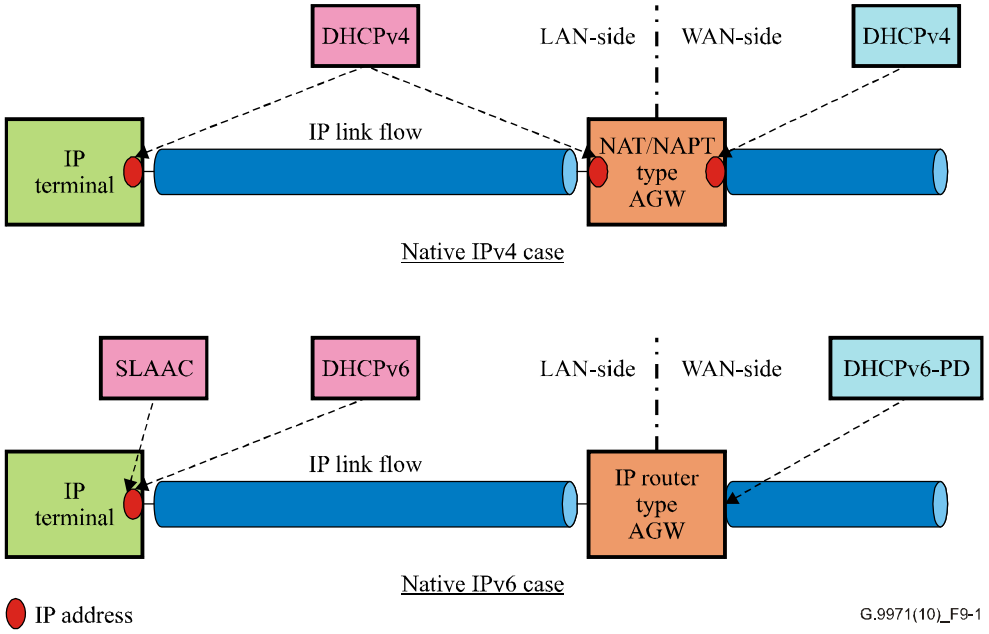

Figure 9-1 – Native IPv4/IPv6 connection to AGW

(B) Either IPv4 over PPP or IPv6 over PPP connection to AGW (see Figure 9-2): The upper figure shows that an IPv4 address for IPv4 over a PPP connection is assigned at the WAN-side port of the AGW by using NSP's IPCP, while local IPv4 addresses are assigned at the AGW's LAN-side port and at the IP terminal by using the end-user's DHCPv4, the same as the above (A). The lower figure shows that unnumbered IPv6 over a PPP connection is established at the WAN-side port of the AGW by using NSP's IPv6CP. Moreover, NSP's DHCPv6-PD provides IPv6 prefix for the home network, while IPv6 addresses are assigned at the IP terminal by using the end-user's DHCPv6 or SLAAC based on the provided IPv6 prefix. As in case (A), NAT/NAPT type AGW is used for the former, while IP router type AGW is used for the latter.

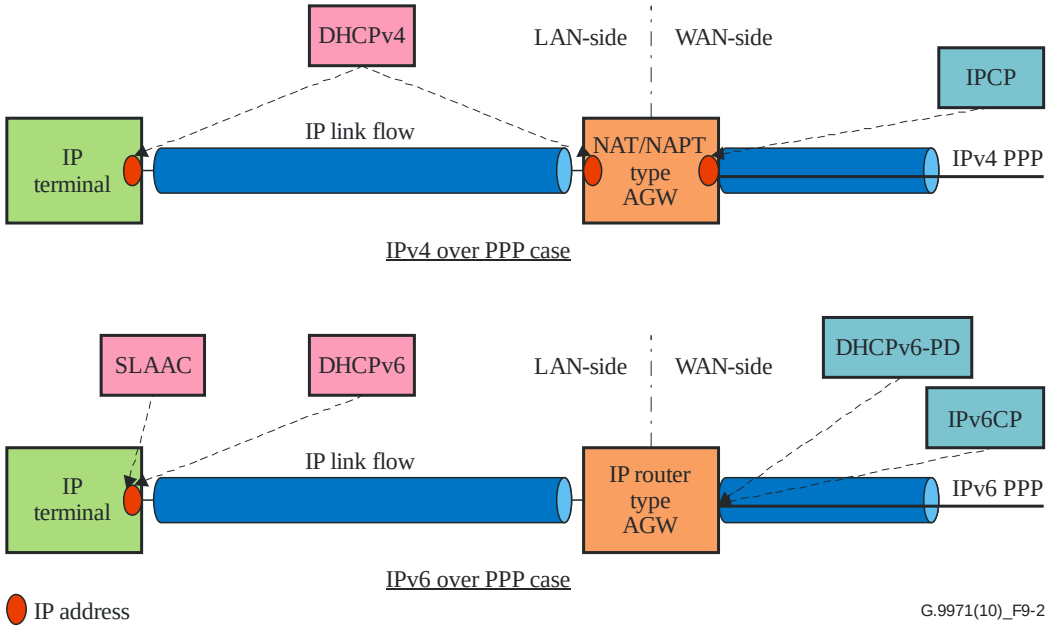

Figure 9-2 – Either IPv4 over PPP or IPv6 over PPP connection to AGW

(C) Either IPv4 over PPP or IPv6 over PPP connection to IP terminal (see Figure 9-3): The upper figure shows that an IPv4 address for IPv4 over a PPP connection is assigned at the IP terminal by using NSP's IPCP. In the same way, the lower figure shows that an IPv6 address for IPv6 over a PPP connection is assigned at the IP terminal by using NSP's IPv6CP to establish the PPP session and either SLAAC or DHCPv6 for the IPv6 address. Ethernet bridge type AGW is used for both cases.

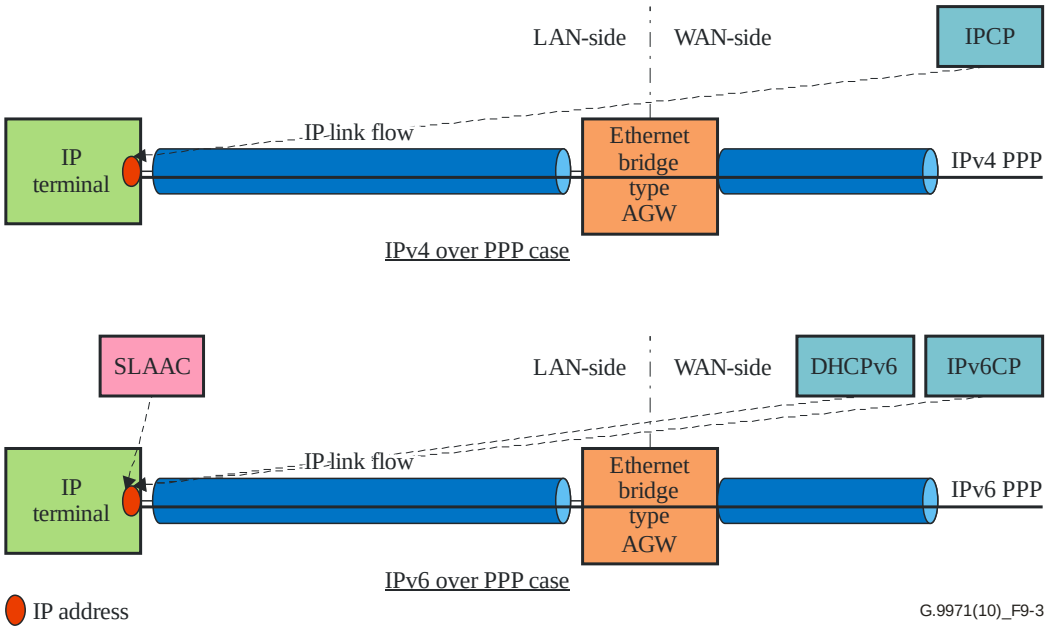

Figure 9-3 – Either IPv4 over PPP or IPv6 over PPP connection to IP terminal

Moreover, there are some other types of IP network configuration, which can be derived from the fundamental three cases described above. The first case is IPv6 over IPv4 where IPv6 terminal wants to communicate with WAN-side IPv6 servers through IPv4 WAN. Figure 9-4 shows this in more detail where an IPv4 address of IPv4 over PPP is assigned at the WAN-side port of the AGW first, and then the NSP's DHCPv6-PD over L2TP over this IPv4 provides IPv6 prefix for the home network, while IPv6 addresses are assigned at the IP terminal by using the end-user's DHCPv6 or SLAAC based on the provided IPv6 prefix. IPv6 IP terminal can communicate with IPv6 servers in WAN by using IPv6 over IPv4 L2TP. The second case is IPv6/v4 NAT-PT (protocol translation) where the IPv4 terminal wants to communicate with IPv6 application servers in WAN. Figure 9-5 shows this in more detail where an IPv4 address of IPv4 over PPP is assigned at the WAN-side port of the AGW by using the NSP's IPCP, while local IPv4 addresses are assigned at the AGW's LAN-side port and at the IP terminal by using the end-user's DHCPv4. Moreover, as an IPv6 address over L2TP over IPv4 is assigned at the WAN-side port of the AGW, IPv4 IP terminal can communicate with IPv6 application servers in WAN by using this IPv6 over L2TP over IPv4. IP router type AGW is used for Figure 9-4, while NAT/NAPT type AGW is used for Figure 9-5.

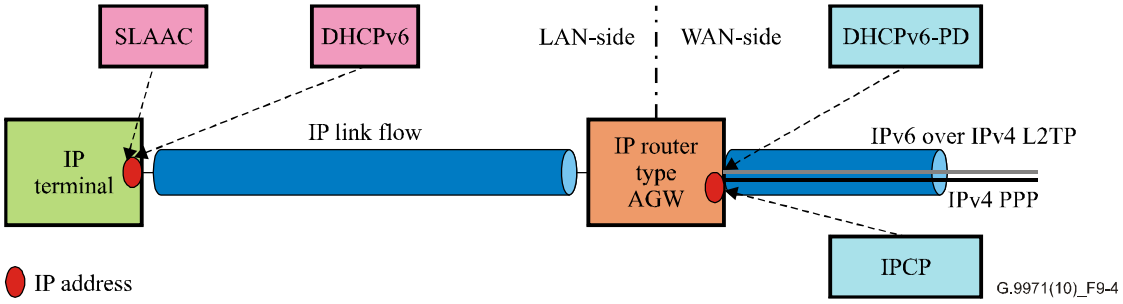

Figure 9-4 – IPv6 over L2TP over IPv4 to AGW with IPv6 to IP terminal

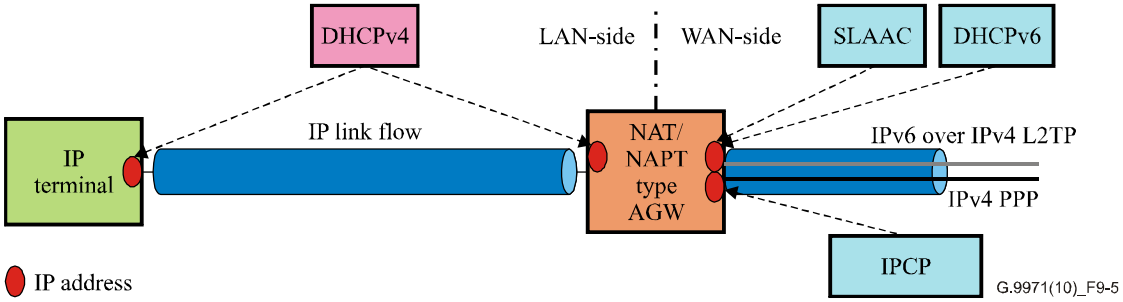

Figure 9-5 – IPv6 over L2TP over IPv4 to AGW with IPv4 to IP terminal

10 QoS control

This clause describes the architecture for QoS control in the IP home network, and then lists the functional requirements for the AGW as well as other devices. QoS control can be discussed not only for the IP and Ethernet layers but also for other layer 2 protocols, e.g., IEEE 802.11, and lower layer protocols. Therefore, QoS mapping should be specified between each two layers. However, as the scope of this Recommendation is IP and Ethernet layers, it only discusses the QoS mapping between these two layers as shown in Figure 10-1. QoS mappings other than this should refer to other standard documents, such as DLNA, UPnP and [ITU-T G.9960]. For example, mapping between IP and Ethernet is applied to the interface between L3F and L2T within the IP terminal, and to the interface between L3T and L2T within the AGW in Figure 8-5.

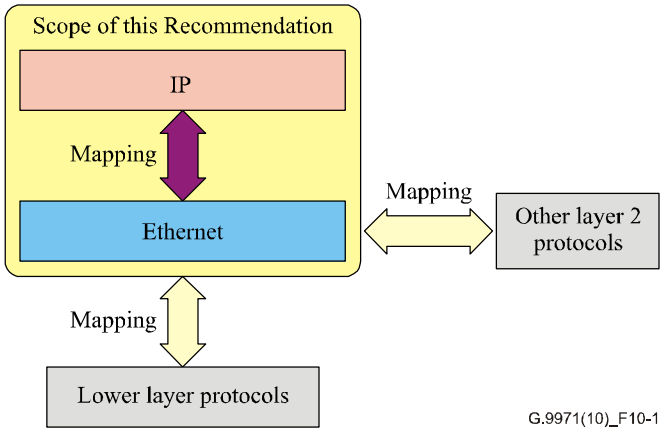

Figure 10-1 – Scope of QoS control

10.1 Two kinds of QoS guaranteed services

There are two kinds of QoS guaranteed services: one is that the QoS is guaranteed in the end-to-end along the communication path between users or between a user and an application server in the WAN, the other is that the QoS is guaranteed by hop-by-hop in the network. The former, the end-to-end QoS guaranteed service, is realized by standardized parameterized QoS control protocols, such as SIP and RSVP for IP, as well as admission control. The parameterized QoS control protocols guaranteed end-to-end QoS after the communication path is admitted by admission control. Note that end-to-end QoS is guaranteed irrespective of network types, network configurations and the implementation of each network element. On the other hand, the latter, the hop-by-hop QoS guaranteed service, is realized by standardized prioritized QoS control protocols, such as Diffserv for IP and VLAN service for Ethernet. Note that as the prioritized QoS control protocols guaranteed only hop-by-hop QoS in the network, QoS cannot be guaranteed in the end-to-end of the network.

10.2 Three device types for QoS control

QoS control is performed in the Ethernet bridge, NT/ONT and IP terminal as well as in various kinds of AGW in the home network. These devices are grouped into three categories based on QoS control types in each layer, as shown in Figure 10-2.

a) Layer 3 QoS control device: Only IP packet QoS control is performed at L3F. Examples of this type are the following separate type AGWs: (A) NAT/NAPT type and (B) IP router type in Figure 8-2 as well as (X) Hub type and (Z) Multiple segments type in Figure 8-4.

b) Layer 2 and 3 QoS control device: Both Ethernet and IP QoS control is performed at L2F and L3F, respectively. Examples of this type are (A) IP terminal in Figure 8-1 as well as (Y) bridge type of separate type AGW in Figure 8-4. In addition to these, this type of device also includes all the aggregate type AGWs that correspond to separate type AGWs described in the above Layer 3 QoS control device.

c) Layer 2 QoS control device: Only Ethernet QoS control is performed at L2F. Examples of this type are (B) Ethernet bridge or NT/ONT in Figure 8-1. In addition to these, this type of device also includes (C) Ethernet bridge type of separate type AGW in Figure 8-2 as well as the aggregate type AGW corresponding to this separate type AGW.

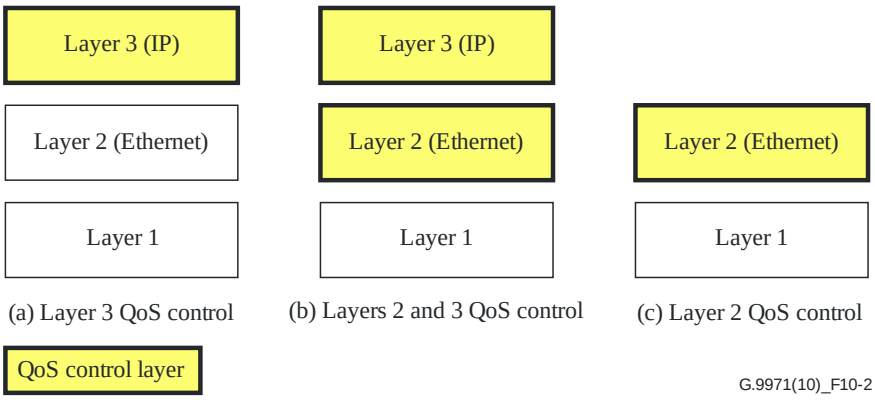

Figure 10-2 – Three device types for QoS control

10.3 Home network QoS control for each QoS service

There are three methods to perform QoS control in the home network depending on the QoS services provided by WAN and the QoS control supported by LAN. These are shown in Figure 10-3.

1) QoS service type 1: Best-effort services are provided by WAN, while LAN supports non-QoS control. In such a case, there is no way to provide for QoS guaranteed services between two IP terminals.

2) QoS service type 2: Multiple QoS guaranteed services are provided by the WAN. LAN also supports QoS control, but WAN cannot control it. It is noted that managed best-effort services (i.e., Class 5 specified in [ITU-T Y.1541]) are also one of the classes in the QoS guaranteed services in the WAN. Although QoS control is terminated at the AGW, QoS guaranteed services can be provided between two IP terminals if using QoS mapping at each AGW. Note that QoS mapping is for L2/L2 or L3/L3; it does not map across layers. This type of service corresponds to "NGN Release 1 model", which is specified by [ITU-T Y.2001].

3) QoS service type 3: QoS guaranteed services are provided by WAN. Moreover, LAN supports QoS control, which WAN can also control. Accordingly, QoS guaranteed services can be terminated at the IP terminal. AGW, IP terminal and other devices in the home network will cooperatively perform QoS guaranteed control for the LAN-WAN traffic to use QoS guaranteed services in WAN, taking into account the traffic within the LAN. This type corresponds to "NGN Release 2 model" providing end-to-end NGN services, which is also specified by [ITU-T Y.2001].

Note that QoS guaranteed services mean either end-to-end QoS guaranteed service realized by parameterized QoS or hop-by-hop QoS guaranteed service realized by prioritized QoS.

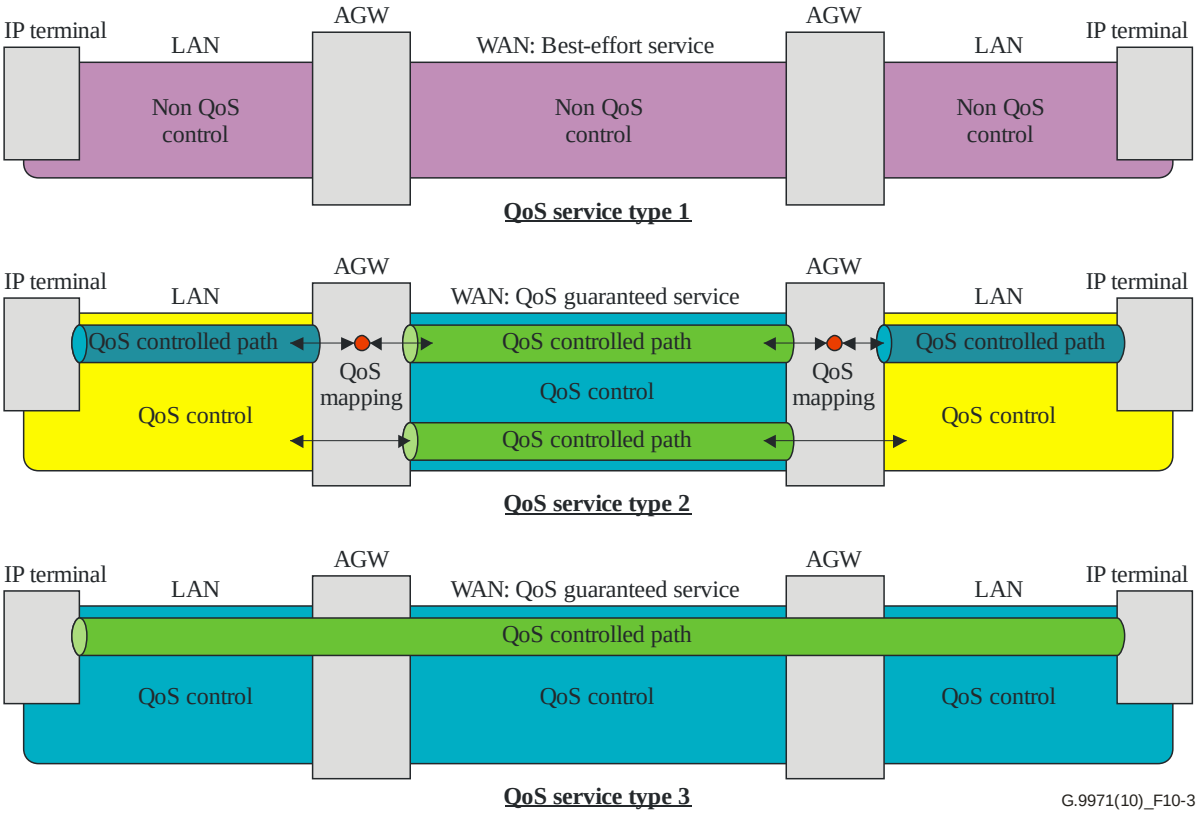

Figure 10-3 – Relationship between QoS service types and QoS control

10.4 Parameters for QoS control

This clause describes two kinds of parameters used for QoS control: one is traffic descriptors characterizing user traffic flows; the other is QoS parameters representing quality objectives for the end-to-end QoS guaranteed services based on SLA.

Recommended traffic descriptors are listed as follows. Although these parameters have been specified for [MEF 10.2], these can be also applied to IP.

– CIR: Committed information rate

– CBS: Committed burst size

– EIR: Excess information rate

– EBS: Excess burst size

Recommended QoS parameters can be identified in some ITU-T Recommendations. [ITU-T Y.1541] specifies QoS parameters for IP as follows:

– IPTD: IP packet transfer delay

– IPDV: IP packet delay variation

– IPLR: IP packet loss ratio

– IPER: IP packet error ratio

On the other hand, [ITU-T Y.1563] specifies QoS parameters for Ethernet as follows:

– FTD: Frame transfer delay

– FDV: Frame delay variation

– FLR: Frame loss ratio

– FER: Frame error ratio

10.5 Functional components for QoS control

Based on [ITU-T I.371], this clause describes functional components for QoS control as follows. Figure 10-4 shows a functional architecture for QoS control, where the queuing block contains the functional components, such as 4), 5) and 6) below. Note that it is symmetric from LAN to WAN and from WAN to LAN in general. Traffic descriptors in clause 10.4 are used in 1), 5), 6) and 7) below, while QoS parameters are used in 7) below. Both traffic descriptors and QoS parameters from the control and/or management planes are first received by equipment manager, which then transfers them to admission control as well as sets them onto policing, bandwidth control and traffic shaping for the end-to-end QoS guaranteed services. Moreover, as a special case, the equipment manager also sets traffic descriptors onto bandwidth control and traffic shaping for the hop-by-hop QoS guaranteed services.

1) Policing: Policing function detects traffic according to certain rules and applies rules to these traffic flows that may cause packets to be dropped, marked, or receive other treatment. Some traffic descriptors for Ethernet and/or IP are provisioned for detecting such traffic flows before user communication is initiated. This function can be located at the ingress of AGW LAN/WAN sides for example.

2) Classification: Classification function recognizes the type of each traffic flow and assigns "priority" to each. This recognition is performed according to values of specific fields in the Ethernet frame or IP packet or both of them. This function can be located at the ingress of AGW LAN/WAN sides for example.

3) Marking: Marking function writes "priority" in each Ethernet frame or IP packet according to the result of "classification". Otherwise, a specific "priority" value is provisioned. This function can be located at the ingress of AGW LAN/WAN sides for example.

4) Priority control: Priority control function controls input of traffic flows to queues according to the priority level either assigned by "Classification" or written by "Marking". Strict priority (SP) is a typical mechanism for this function.

5) Bandwidth control: Bandwidth control function controls output of traffic flows from stored queues in order to guarantee a minimum bandwidth based on CIR and CBS of traffic descriptors. Bandwidth control function assigns bandwidth for traffic flows by using scheduling mechanisms, such as weighted fair queuing (WFQ), weighted round robin (WRR), deficit round robin (DRR), etc.

6) Traffic shaping: Traffic shaping function also controls output of traffic flows from stored queues, similar to bandwidth control. However, the purposes of this traffic shaping function are the restriction of traffic flows below the maximum transfer rate as well as the reduction of delay variation in every traffic flow.

7) Admission control: Admission control function manages and judges whether to accept or reject each managed traffic flow for the end-to-end QoS guaranteed services based on the traffic descriptors and QoS parameters before user communication is initiated. One example is the SIP case. The management plane provisions QoS parameters onto the admission control via equipment manager. After admission control receives the traffic descriptors from the control plane via the equipment manager, it judges to accept the traffic flow by comparing the received traffic descriptors with the already-provisioned QoS parameters as well as analysing whether or not the network resources can be used via another control plane. In case of acceptance, the admission control sends its acceptance message to the policing and queuing. Another example is RSVP case. After admission control receives the traffic descriptors and QoS parameters from the control plane via the equipment manager, it judges to accept the traffic flow by analysing whether or not the network resources can be used by using another control plane. In case of acceptance, the admission control sends its acceptance message to the policing and queuing. Judgement algorithms in admission control are out of scope in this Recommendation.

8) Traffic measurement: Based on [ITU-T Y.1540], traffic measurement function counts incoming and outgoing traffic to evaluate offered traffic load. Several counting units can be specified, such as the number of bytes, the number of Ethernet frames or IP packets. Examples of counting mechanisms are jumping window and sliding window as described in [ITU-T I.371].

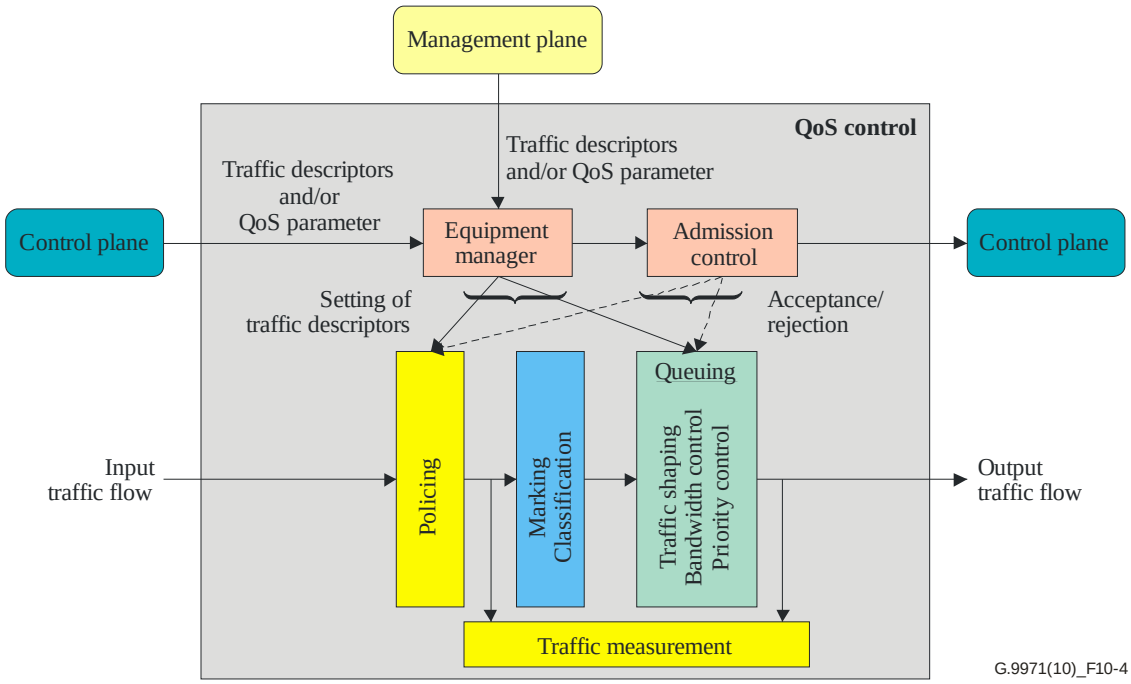

Figure 10-4 – Functional architecture for QoS control

All of these functional components are not always required for each device. Clause 10.6 describes the functional components necessary for each QoS service type in clause 10.3. Note that as QoS service type 1 "Best-effort service" requires only traffic measurement functions, it is not worthwhile studying it. Therefore, clause 10.6 focuses on QoS service type 2 and 3.

10.6 Typical QoS control functional components of each device for QoS service type 2 and 3

This clause identifies QoS control functional components necessary for each device, which is categorized as device type (a), (b) and (c) in clause 10.2. Required functional components depend on QoS service type 2 and 3, as described in clause 10.3. Each QoS service type 2 and 3 is divided into two. One is end-to-end QoS guaranteed service, which is realized by using parameterized QoS control protocol. The other is hop-by-hop QoS guaranteed service, which is realized by using prioritized QoS control protocol.

Table 10-1 shows control functional components for QoS service type 2 in case of (A) end-to-end QoS guaranteed service as well as in case of (B) hop-by-hop QoS guaranteed service. Moreover, Table 10-2 shows control functional components for QoS service type 3 in case of (A) end-to-end QoS guaranteed service as well as in case of (B) hop-by-hop QoS guaranteed service. Note that Tables 10-1 and 10-2 show only separate type AGWs. However, QoS control functional components necessary for aggregate type AGWs can be easily derived from these tables. For example, both aggregate type AGW (A) and (B) in Figure 8-3 correspond to separate type AGW (A) and (B) in Figure 8-2, while aggregate type AGW (C) in Figure 8-3 corresponds to separate type AGW (C) in Figure 8-2.

Table 10-1 – Control functional components for QoS service type 2

(A) In case of end-to-end QoS guaranteed service

Device	Separate type AGW			NT/ONT
Device type (see clause 10.2)	(a)	(b)	(c)	(c)
Policing	R	R for L3; O for L2	R	R
Classification	R	R for L3; O for L2	R	R
Marking	O[a)]	O[a)]	O[a)]	O[a)]
Priority control	R	R for L3; O for L2	R	R
Bandwidth control	R	R for L3; O for L2	R	R
Traffic shaping	R	R for L3; O for L2	R	R
Admission control	R	R for L3; O for L2	R	R
Traffic measurement	O[c)]	O[c)]	O[c)]	O[c)]

(B) In case of hop-by-hop QoS guaranteed service

Device	Separate type AGW			NT/ONT
Device type (see clause 10.2)	(a)	(b)	(c)	(c)
Policing	O	O	O	O
Classification	R	R for L3; O for L2	R	R
Marking	O[a)]	O[a)]	O[a)]	O[a)]
Priority control	R	R for L3; O for L2	R	R
Bandwidth control	O[b)]	O[b)]	O[b)]	O[b)]
Traffic shaping	O[b)]	O[b)]	O[b)]	O[b)]
Admission control	N/A	N/A	N/A	N/A
Traffic measurement	O[c)]	O[c)]	O[c)]	O[c)]

R Recommended

O Optional

N/A Not Applicable

a) If specific value in Ethernet MAC and/or IP header has to be overwritten, the support of this functional component is recommended.

b) If transfer bandwidth has to be limited and/or surplus bandwidth has to be shared with already provisioned traffic flows, the support of these functional components is recommended.

c) If traffic flows have to be measured for traffic management, the support of this functional component is recommended. This function should not affect user traffic flows.

Table 10-2 – Control functional components for QoS service type 3

(A) In case of end-to-end QoS guaranteed service

Device	IP terminal	Ethernet bridge	Separate type AGW			NT/ONT
Device type (see clause 10.2)	(b)	(c)	(a)	(b)	(c)	(c)
Policing	N/A	R	R	R for L3; O for L2	R	R
Classification	R for L3; O for L2	R	R	R for L3; O for L2	R	R
Marking	O[a)]	O[a)]	O[a)]	O[a)]	O[a)]	O[a)]
Priority control	R for L3; O for L2	R	R	R for L3; O for L2	R	R
Bandwidth control	R for L3; O[b)] for L2	R	R	R for L3; O[b)] for L2	R	R
Traffic shaping	R for L3; O[b)] for L2	R	R	R for L3; O[b)] for L2	R	R
Admission control	R for L3; O for L2	R	R	R for L3; O for L2	R	R
Traffic measurement	O[c)]	O[c)]	O[c)]	O[c)]	O[c)]	O[c)]

(B) In case of hop-by-hop QoS guaranteed service

Device	IP Terminal	Ethernet bridge	Separate type AGW			NT/ONT
Device type (see clause 10.2)	(b)	(c)	(a)	(b)	(c)	(c)
Policing	N/A	O	O	O	O	O
Classification	R for L3; O for L2	R	R	R for L3; O for L2	R	R
Marking	O[a)]	O[a)]	O[a)]	O[a)]	O[a)]	O[a)]
Priority control	R for L3; O for L2	R	R	R for L3; O for L2	R	R
Bandwidth control	O[b)]	O[b)]	O[b)]	O[b)]	O[b)]	O[b)]
Traffic shaping	O[b)]	O[b)]	O[b)]	O[b)]	O[b)]	O[b)]
Admission control	N/A	N/A	N/A	N/A	N/A	N/A
Traffic measurement	O[c)]	O[c)]	O[c)]	O[c)]	O[c)]	O[c)]

R Recommended
O Optional
N/A Not Applicable

a) If specific value in Ethernet MAC and/or IP header has to be overwritten, the support of this functional component is recommended.

b) If transfer bandwidth has to be limited and/or surplus bandwidth has to be shared with already provisioned traffic flows, the support of these functional components is recommended.

c) If traffic flows have to be measured for traffic management, the support of this functional component is recommended. This function should not affect user traffic flows.

10.7 QoS control requirements for QoS service type 2

As a first step, this Recommendation discusses QoS control requirements focusing on QoS service type 2 (NGN release 1), as outlined in the previous clauses. The following requirement can be identified first.

R10-1 AGW and NT/ONT should support L2 QoS control and/or L3 QoS control for NGN Release 1 services. Table 10-1 can be referred to for the required QoS control functional components for each device.

At least L3 QoS control is required for offering L3 services. However, L3/L2 QoS mapping should be performed in L3F, in the case where L2 QoS control is provided. Therefore, the following requirements can be identified.

R10-2: AGW should support L3 QoS control in the case where the network provides only L3 QoS control for NGN Release 1 services.

R10-3: In the case where the network provides both L3 and L2 QoS control for NGN Release 1 services, AGW should support L3 and L2 QoS control including L3/L2 QoS mapping, while NT/ONT should support L2 QoS control.

L2/L2 and/or L3/L3 QoS mapping should be performed in AGW when providing QoS guaranteed services to the IP terminal in NGN Release 1. As QoS guaranteed services are divided into end-to-end QoS guaranteed and hop-by-hop services, they are discussed separately as follows.

Figure 10-5 shows an example for realizing hop-by-hop QoS guaranteed services. Note that WAN and LAN management planes may correspond to remote manager and local manager, respectively, which will be described in clause 11. Note that QoS mapping, such as mapping between LAN/WAN markings, is required in QoS control functional components other than admission control. The following scenario can be found:

– LAN management plane sets proprietary LAN marking specifications onto AGW.
– After retrieving LAN marking specifications, WAN management plane sets the mapping between proprietary LAN and standardized WAN markings onto QoS control of AGW.
– QoS control components of IP terminal sends control messages containing proprietary marking #l.
– QoS control components of AGW maps the received marking #l to the corresponding standardized marking #w in WAN and then sends control messages containing marking #w to WAN.

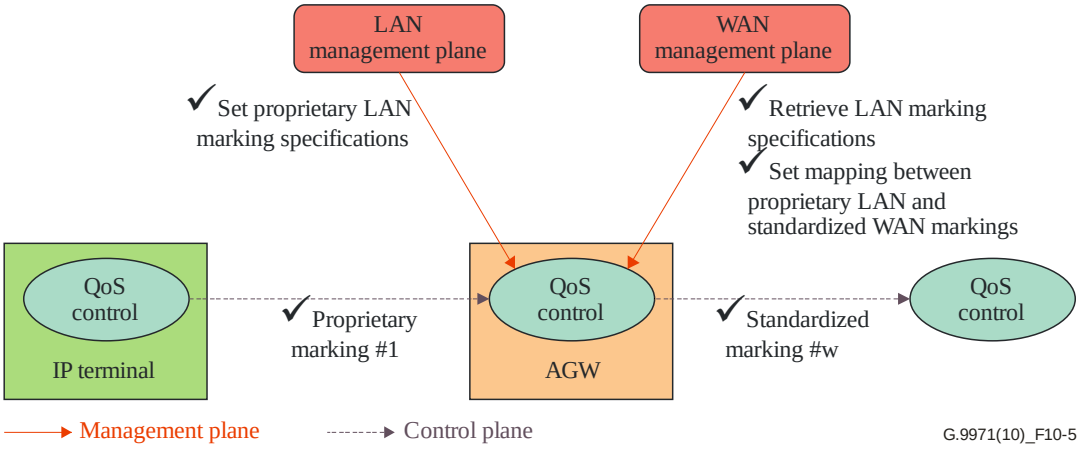

Figure 10-5 – A realization of hop-by-hop QoS guaranteed services in QoS service type 2

Figure 10-6 shows an example for realizing end-to-end QoS guaranteed services. Similar to hop-by-hop QoS service scenario, the mapping between proprietary LAN and standardized WAN markings is needed. Moreover, QoS mapping, such as mapping of LAN/WAN traffic descriptors and mapping of LAN/WAN markings, as well as QoS parameters are required in QoS control functional components, such as admission control, policing, bandwidth control and traffic shaping. The following scenario can be found. Note that the following scenario only describes the one other than marking mapping.

– LAN management plane sets proprietary LAN traffic descriptor specifications onto AGW.

– After retrieving LAN traffic descriptor specifications, WAN management plane sets the mapping between proprietary LAN and standardized WAN traffic descriptors onto admission control of AGW. It also sets its QoS parameters.

– Admission control of the IP terminal sends control messages containing proprietary traffic descriptor #l.

– Admission control of AGW maps the received traffic descriptor #l to the corresponding standardized traffic descriptor #w in WAN and then sends control messages containing traffic descriptor #w to WAN.

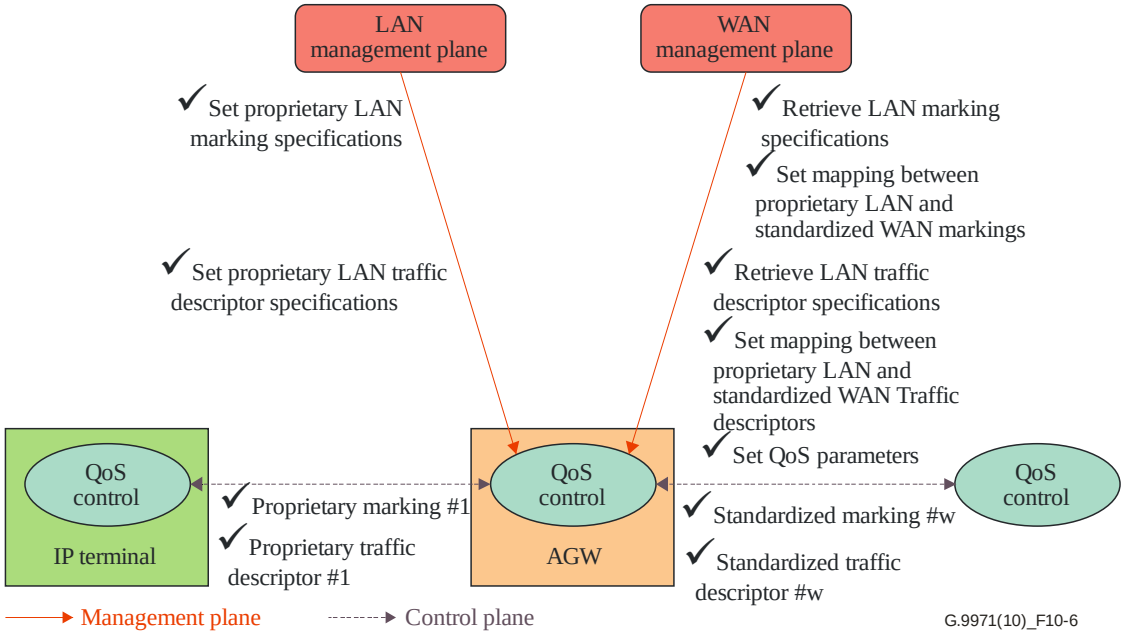

Figure 10-6 – A realization of end-to-end QoS guaranteed services in QoS service type 2

11 Home network management

11.1 Home network management architecture

Clause 8.2 of [ITU-T G.9970] shows two kinds of management schemes by the remote management server (RMS). Scheme A is when RMS directly manages the home network end devices, such as the IP terminal, the non-IP GW and the non-IP terminal. On the other hand, Scheme B is when the RMS manages such devices through the AGW. Scheme A will be used when the IP terminal is supplied by the NSP in the future, while Scheme B will be used when some management protocols for the home network, such as UPnP, are used by the end users. Therefore, this Recommendation describes the requirements for home network management architecture focusing on Scheme B. Although Scheme B addresses the situation where AGW manages various kinds of home network end devices, this Recommendation analyses management of the IP terminal as well as the devices composing the IP home network, such as Ethernet bridge. This is shown in Figure 11-1.

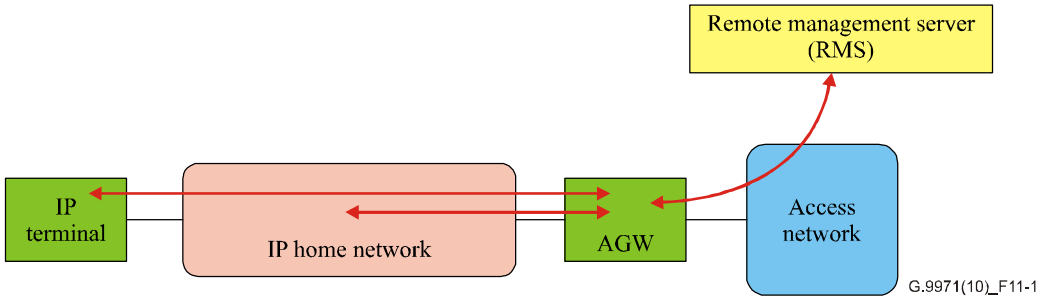

Figure 11-1 – Remote end device management configuration

Scheme B has two kinds of management interfaces: one is the management interface between RMS and AGW, the other is the one between AGW and each device in the IP home network. Figure 11-2 shows the functional management architecture for Scheme B. Note that this figure shows the case of the NAT/NAPT aggregate type AGW with the bridge type LAN ports. The definition of each functional component can be described below:

– Local agent (LA): According to the commands from the local manager, local L2 agent manages L2F of Ethernet bridge, while local L3 agent manages the IP terminal and the LAN-side parts of AGW.

– Local manager (LM): Management application functions for the IP home network, which interworks with the local agent.

– Remote agent (RA): According to the commands from the remote manager, it manages the WAN-side parts of the AGW. Moreover, it also interworks with the local manager in order to manage the IP home network.

– Remote manager (RM): Management application functions in the RMS, which interworks with the remote agent in the IP home network.

This Recommendation assumes the following management applications for the local manager:

1) Configuration management applications
   – To show L3 (IP) network topology in the IP home network.
   – To show L2 (Ethernet) network topology in the IP home network.
   – To set, get and show the management information of each device in the IP home network.
   – To upgrade the function of each device in the IP home network.
   – To get specific information of each device in the IP home network, such as URLs for logging data.
   – To reset or initialize each device in the IP home network.
2) Fault management applications
   – To check whether the management interface is set up properly or not.
   – To check whether each device in the IP home network is set up properly or not.
3) Performance management applications
   – To check the network performance of the IP home network.

Clause 11.2 describes the requirements for the RM-RA management interface, while clause 11.3 describes the requirements for the LM-LA management interface. Note that LM can reside in any device in the IP home network, although Figure 11-2 depicts the case where it resides in AGW. Moreover, there will be the case of only local M/A without remote M/A in order to manage the IP home network locally.

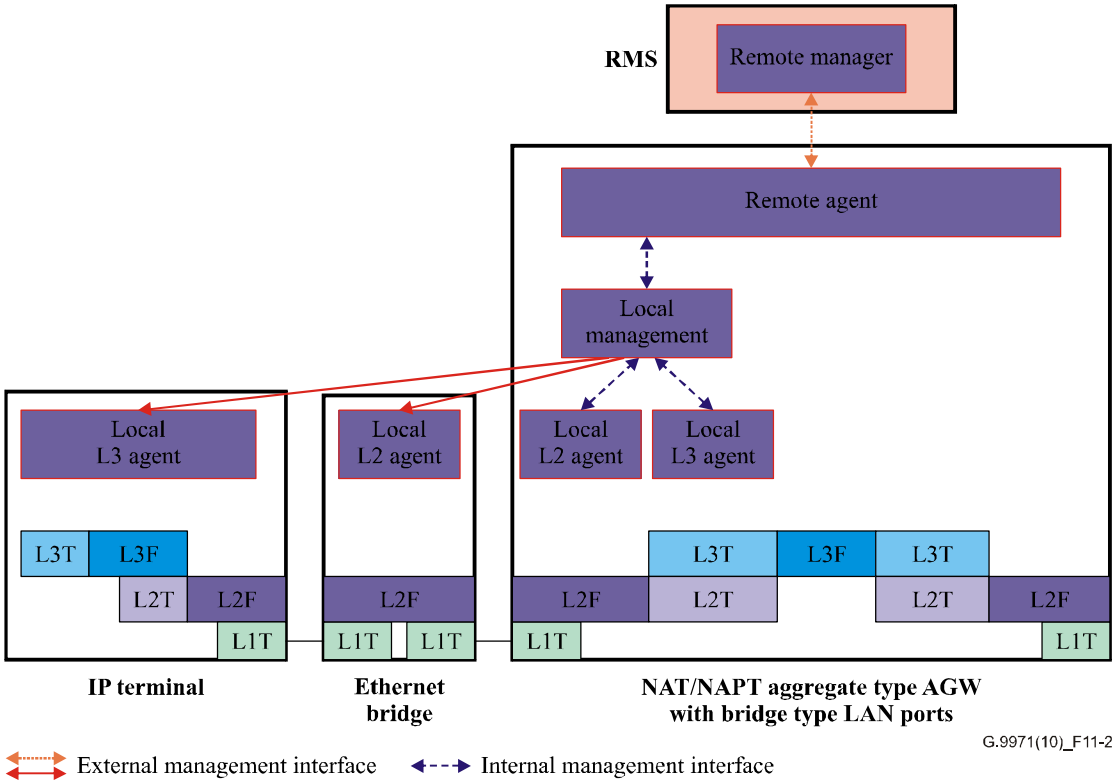

Figure 11-2 – An example of functional management architecture for Scheme B

11.2 Requirements for RM-RA management interface

Requirements for the management interface between RM and RA can be discussed from two aspects. One is the requirement for the management interface itself, while the other is the requirement for managing the WAN-side transport layer of the AGW. As this interface is already discussed in [BBF TR-069] and relevant documents, this Recommendation describes only the high-level requirements.

The following requirements can be identified for the management interface:

R11-R1: The standardized protocols should be used for the RM-RA management interface. [BBF TR-069] is recommended.

R11-R2: IP address should be assigned to each RM and RA.

R11-R3: It should be checked whether the RM-RA management interface protocol is set up properly or not, when needed.

As shown in Figure 8-2, NAT/NAPT type AGW has L3T, while IP router type AGW does not have L3T. However, for the purpose of localizing the fault of the AGW WAN-side, IP address should be assigned to the WAN-side port of AGW. As described in clause 9, one has to keep in mind that there are several kinds of IP connection, such as native IPv4/v6, PPP, L2TP, etc. Therefore, the following requirements can be identified for managing transport layer of AGW.

R11-R4: RA should notify RM of its managing IP address of the AGW WAN-side. Note that the IP address should be assigned to each IPv4/v6, PPP, L2TP connection at the AGW WAN-side.

Moreover, as described at the end of clause 10, the following requirements can be identified for managing home network when providing NGN Release 1 services.

R11-R5: RA should notify RM of its managing LAN traffic descriptors specifications in case of providing QoS guaranteed services to the IP terminal in the end-to-end QoS guaranteed services of NGN Release 1.

R11-R6: RA should receive L2/L2 and/or L3/L3 QoS mapping, such as mapping between LAN/ WAN traffic descriptors, as well as QoS parameters in case of providing QoS guaranteed services to the IP terminal in the end-to-end QoS guaranteed services of NGN Release 1.

R11-R7: RA should notify RM of its managing marking specifications in case of providing QoS guaranteed services to the IP terminal in hop-by-hop QoS guaranteed services of NGN Release 1.

R11-R8: RA should receive L2/L2 and/or L3/L3 QoS mapping, such as mapping between LAN/WAN marking in case of providing QoS guaranteed services to the IP terminal in hop-by-hop QoS guaranteed services of NGN Release 1.

11.3 Requirements for LM-LA management interface

Requirements for the management interface between LM and LA can be discussed from two aspects. One is the requirement for management interface itself, while the other is the requirement for managing transport layer of the IP home network.

The following requirements can be identified for the former:

R11-L1: The standardized protocols should be used for the LM-LA management interface. The candidate protocols are ICMP, UPnP or LLDP.

R11-L2: It should be checked whether the data link layer (Ethernet) between LM and local L2 agent, as well as the network layer (IP) between LM and Local L3 agent, is set up properly or not, when needed.

As shown in Figure 8-2, NAT/NAPT type AGW has L3T, while IP router type AGW does not have L3T. However, for the purpose of localizing the fault of the AGW LAN-side, the IP address should be assigned to each LAN-side port of the AGW. Moreover, one must keep in mind that the IP address should be also assigned statically, although clause 9 is described in such a way that they are assigned automatically. Therefore, management requirements for the latter can be grouped into the following three categories.

1) Configuration management

   R11-C1: Local L3 agent can notify LM of its managing IP address.

   R11-C2: Local L3 agent can notify LM of its managing MAC address.

   R11-C3: Local L2 agent can notify LM of its managing MAC forwarding table.

   R11-C4: Local L3 agent can notify LM of the management information of its managing device, such as the product class, the manufacturer's name, the device model name and the device model number.

   R11-C5: Local L2 agent can notify LM of the management information of its managing device, such as the product class, the manufacturer's name, the device model name and the device model number.

   R11-C6: Local L3 agent can perform the setting of the management information of its managing device based on the commands from LM, for example, when static IP address setting is needed for its managing device.

   R11-C7: Local L3 agent can send back the management information of its managing device based on the command from the LM.

   R11-C8: Local L3 agent can send back the URLs to log its managing device, based on the command from the LM.

R11-C9: Local L3 agent can perform the reset or initialization of its managing device, based on the command from the LM.

2) Fault management

R11-F1: Local L3 agent can notify the LM of the status of its managing device, periodically or when the device is in an abnormal state.

R11-F2: Local L2 agent can notify the LM of the status of its managing device periodically or when the device is in an abnormal state.

3) Performance management

R11-P1: Local L3 agent can send back the number of packets per port or flow etc., based on the command from the LM.

12 Security management

Although security management is categorized into authentication/authorization, encryption and defence, this Recommendation discusses requirements for encryption and defence relevant to home network transport layer 2 and 3.

1) Encryption: The type of encryption and the key exchange protocol are relevant to this Recommendation.

2) Defence: Packet filtering methods to prevent suspicious traffic from/to the AGW are relevant to this Recommendation.

Appendix I

Relationship among home network standards

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

Figure I.1 shows which standardization bodies should be taken into account in order to study this Recommendation. As this Recommendation focuses on the architecture, QoS and management aspects of layer 2 and 3 in the home network, Broadband Forum, HGI, IEEE and UPnP are specifically the standardization bodies to coordinate with.

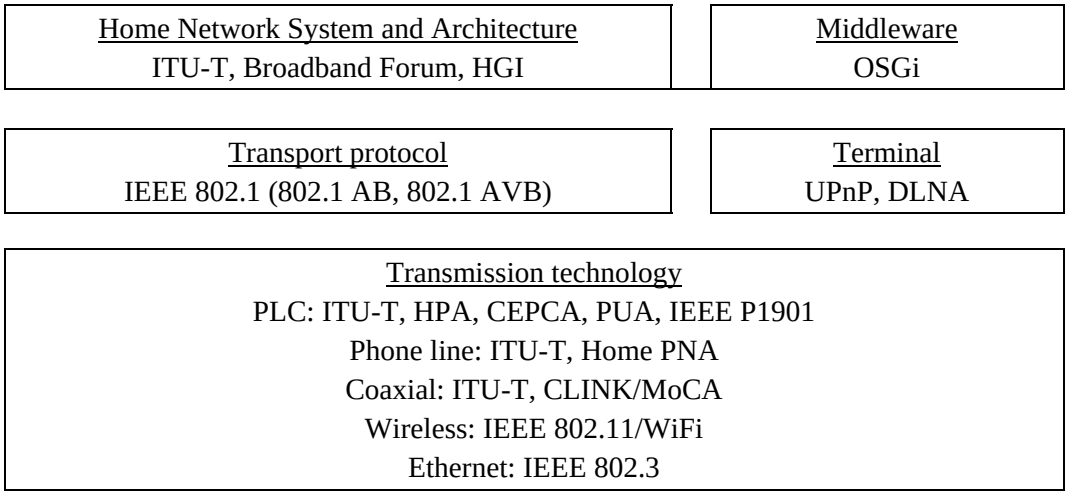

Figure I.1 – Major standardization bodies related to home network

Moreover, Figure I.2 shows the position of this Recommendation within ITU-T:

– Layer 1 and layer 2 specifications of the home network are being studied in Study Group (SG) 9 and SG 15, while this Recommendation discusses the architecture and high-level requirements of layer 2 and 3 of the home network on the basis of [ITU-T G.9970]. As the layer 2 of this Recommendation focuses only on MAC bridge including VLAN, there is no overlap with other Recommendations, although some cooperation may be needed.

– As this Recommendation assumes only Ethernet for the access network, the relevant access network Recommendations are ITU-T G.983.x-series, etc.

– As this Recommendation handles QoS in transport layer, NGN and QoS Recommendations in SG 13 and in SG 12, respectively, are referred to. On the other hand, SG 16 is studying home network architecture as well as QoS in application layer.

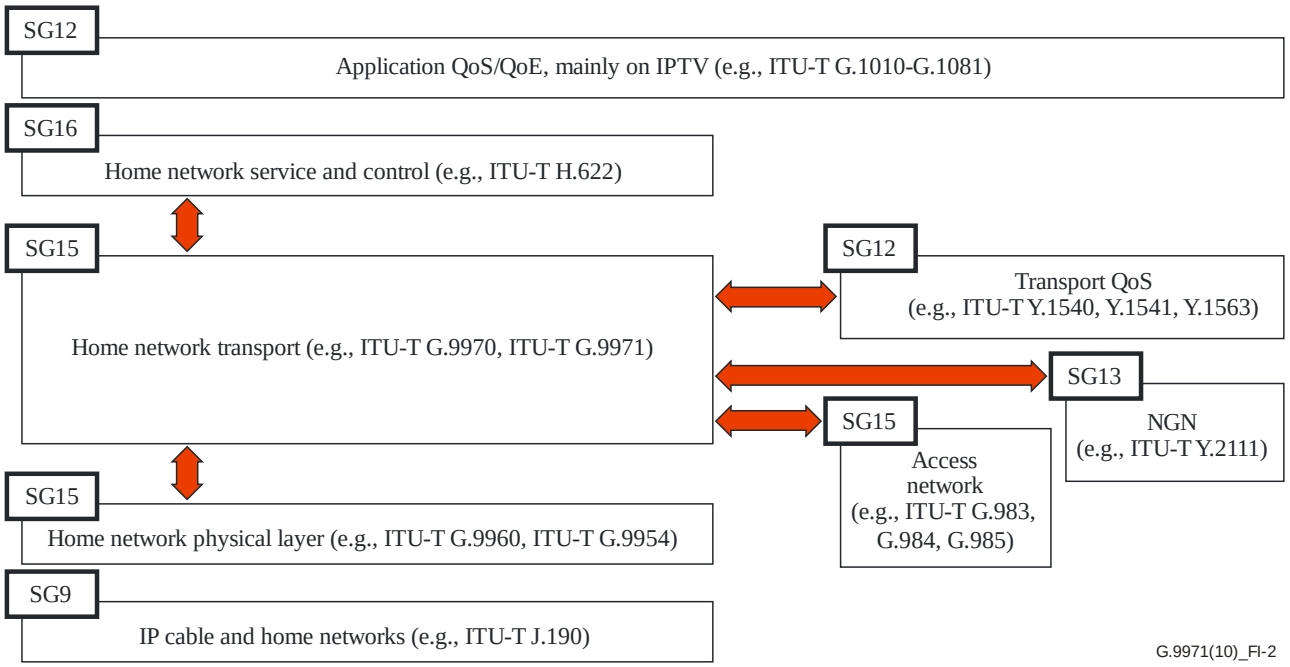

Figure I.2 – Relationship among ITU-T SGs for home network

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