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SERIES H: AUDIOVISUAL AND MULTIMEDIA SYSTEMS

**Analysis of class-based home network QoS
solutions**

ITU-T H-series Recommendations – Supplement 11



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Supplement 11 to ITU-T H-series Recommendations

Analysis of class-based home network QoS solutions

Summary

Supplement 11 to ITU-T H-series Recommendations provides the gap analysis of class-based home network QoS solutions. Specifically, five documents in relevant SDOs which contain provisions of home network QoS solutions are analysed. Some aspects of class-based QoS solutions such as the number of classes and practices of DiffServ code point (DSCP) are compared and summarized. In addition, this supplement identifies some issues that need to be considered in future Recommendations.

Source

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Keywords

Class-based QoS, DSCP, home network.

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Introduction

There are two types of QoS mechanisms, i.e., class-based and session-based QoS mechanisms, used in the home network. The class-based QoS mechanism has an advantage of simplicity; however, it does not guarantee the level of QoS unlike the session-based QoS scheme. In a typical class-based QoS mechanism, each IP packet is classified into a small number of classes which are typically 4-8, and its priority is identified by QoS marking using a certain value, e.g., DSCP. Each network device uses this marking information within the IP packet to find its relative priority and handles the packet according to the priority.

An important issue on the class-based scheme is that all devices including bridging and terminal devices need to comply with the single policy. Without having a well-coordinated single policy, the integrity of QoS will be lost. This means that such network is not different from the "best-effort network" because packets cannot be treated differently based on the priority.

This nature of class-based QoS mechanism raises a challenge for standardization. There are some documents which include the description of QoS marking, and consistency among these documents needs to be checked.

Furthermore, it may not be enough even if all the home network documents are completely consistent. The home network is typically connected to the access network through UNI that is defined by each telecom carrier. As mentioned in [ITU-T H.622], the home network has two roles: extension of access network and interconnection between home network devices. In [ITU-T H.622], the former case is called the primary domain, while the latter case is called the secondary domain. It is possible and likely that the both domains will overlap physically, particularly in case of the IP-based home network. This means that the traffic complying with the access network specification can compete for the network resources with the traffic complying with the different home network specification. Inconsistency between the home network and the access network specifications may undermine the transmission quality.

Supplement 11 to ITU-T H-series Recommendations

Analysis of class-based home network QoS solutions

1 Scope

This supplement provides the gap analysis of the class-based home network QoS solutions. The purpose of this supplement is to clarify the problems which will result in not having well-harmonized QoS solutions in the home network, but this supplement does not intend to provide any requirements for implementation or any preferred documents/solutions analysed in this supplement. In addition, this supplement focuses on the use of DSCP, particularly in association with applications.

The information indicated in this supplement may be useful for future work, including development of new Recommendations.

2 References

- [ITU-T G.1010] Recommendation ITU-T G.1010 (2001), *End-user multimedia QoS categories*.
- [ITU-T H.622] Recommendation ITU-T H.622 (2008), *A generic home network architecture with support for multimedia services*.
- [ITU-T Y.1221] Recommendation ITU-T Y.1221 (2002), *Traffic control and congestion control in IP-based networks*.
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- [IEEE 802.1D] IEEE 802.1D (2004), *IEEE Standard for Local and metropolitan area networks Media Access Control (MAC) Bridges*.
- [IEEE 802.11] IEEE 802.11 (2007), *IEEE Standard for information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications*.
- [DSL-F TR-098] DSL Forum TR-098 Amendment 2 (2008), *Internet Gateway Device Data Model for TR-069*.
- [DSL-F TR-101] DSL Forum TR-101 (2006), *Migration to Ethernet-Based DSL Aggregation*.
- [DSL-F TR-124] DSL Forum TR-124 (2006), *Functional Requirements for Broadband Residential Gateway Devices*.
- [DSL-F TR-133] DSL Forum TR-133 (2005), *DSLHome TR-064 Extensions for Service Differentiation*.
- [DLNA] IEC 62481-1 (2007), *Digital living network alliance (DLNA) home networked device interoperability guidelines – Part 1: Architecture and protocols*.
- [DVB-IP] ETSI TS 102 034 (2007), *Digital Video Broadcasting (DVB); Transport of MPEG-2 TS Based DVB Services over IP Based Networks*.
- [HGI] Home Gateway Initiative (2006), *Home Gateway Technical Requirements: Release 1.0*.
- [UPnP] UPnP QoS (2006), *UPnP QoS Architecture: 2*.

3 Definitions

This supplement uses the following term defined elsewhere:

3.1 home network [ITU-T H.622]: Home network is the collection of elements that process, manage, transport, and store information, thus enabling the connection and integration of multiple computing, control, monitoring, communication, and entertainment devices in the home.

4 Abbreviations and acronyms

This supplement uses the following abbreviations and acronyms:

ATM	Asynchronous Transfer Mode
BE	Best Effort
DLNA	Digital Living Network Alliance
DSCP	DiffServ Code Point
HGI	Home Gateway Initiative
HPNA	Home Phoneline Networking Alliance
HTTP	HyperText Transfer Protocol
IP	Internet Protocol
PLC	Power Line Communication
QoS	Quality of Service
SDO	Standards Development Organization
TIN	Traffic Importance Number
VAS	Value Added Service
VLAN	Virtual Local Area Network
WMM	Wi-Fi Multimedia

5 Framework for home network QoS

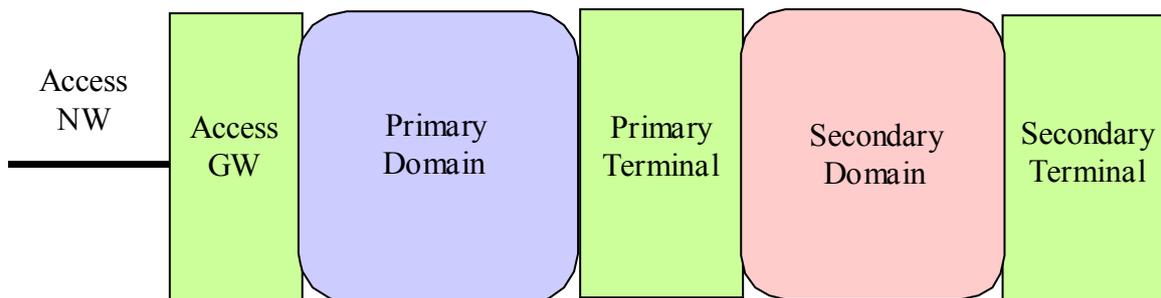


Figure 5-1 – Application model of home network defined in [ITU-T H.622]

As defined in [ITU-T H.622], it is recognized that the home network has two distinctive roles: connecting terminal devices to the access network and connecting terminal devices for communications within the home. The two different cases are referred to as primary and secondary domains, respectively. The primary domain is a collection of home network elements functioning as

an extension of the access network and thus connecting the primary terminal, which terminates multimedia services offered by the network and service provider. In the same way, the secondary domain is a collection of home network elements connecting primary and/or secondary terminals for communications within the home.

Figure 5-2 illustrates the framework for harmonization of class-based QoS solutions that need to be studied in this context.

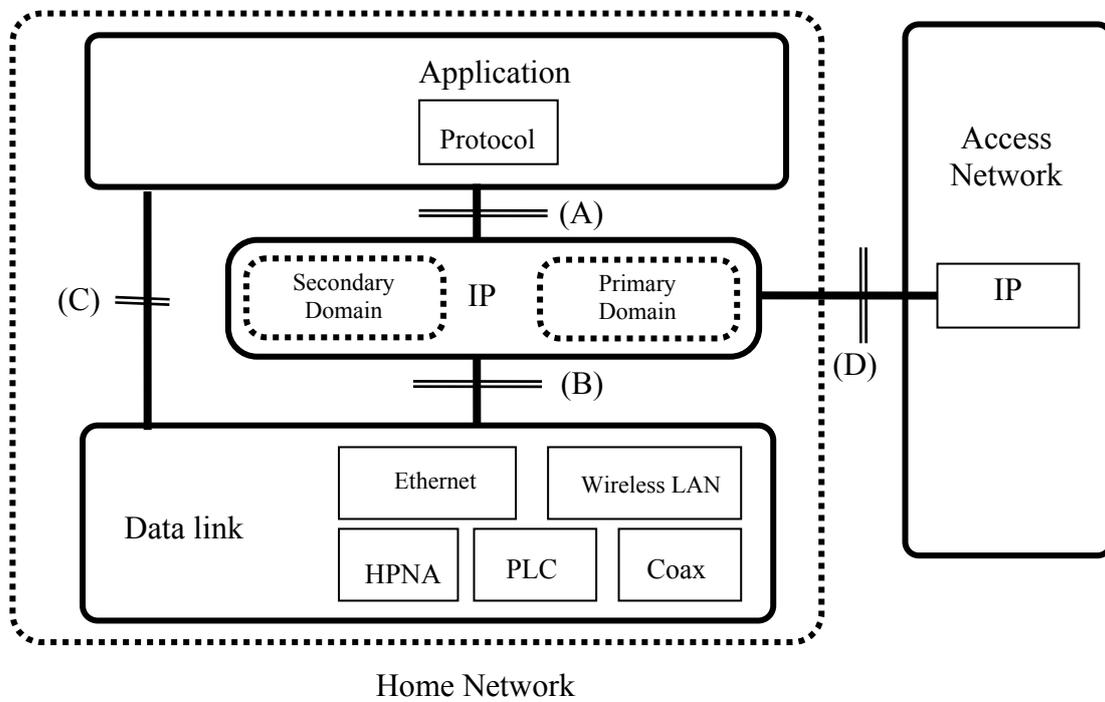


Figure 5-2 – Framework for harmonization of home network QoS solutions

The four interfaces on which harmonization should be established are defined in Figure 5-2.

Interface (A)

Interface (A) provides the association between an IP-level priority and an application (or a protocol used in the application). It is important to assign a protocol to a certain level of priority. Each application is not aware of what types of data link technology are used in the home network. Also, the data link technology used between bridging devices, not directly connected to the end device, is hardly visible to the end device and the application residing in the end device. A typical use of this interface is to give a higher priority for audio and video stream than other types of data traffic such as HTTP for web services.

Interface (B)

Interface (B) provides the association between an IP-level priority and a data-link level priority. This interface is important because it is not likely that all the bridging devices in the home network are able to read the IP-level priority, DSCP value. Instead of reading DSCP value, these devices typically read a lower layer marking value such as Ethernet priority. Without having any consistent policy of this interface, desirable QoS in the home network is not expected.

Interface (C)

Interface (C) provides the association between an application and a data-link level priority. Unlike interfaces (A) and (B), the direct use of this interface is a minor case. However, some data link

specifications, for example, [IEEE 802.1D], contain the indication of a certain priority associated with an application. It may be useful to make consistency at this interface to realize a solid and well-harmonized QoS scheme.

Interface (D)

Interface (D) provides the association of an IP-level priority between the access and the home network. If the policy, e.g., a choice of DSCP value, of the network provider is different from that of the home network, remarking of packets needs to take place at the device around UNI. Currently, a few documents address this interface. However, it is essential for end-to-end QoS, and therefore further study is needed.

6 Comparison and issues

6.1 Comparison of existing practices

There are documents published by various SDOs defining priority levels and the use of marking. Analysis of these documents gives a good guidance on how to harmonize home network QoS solutions. Table 6-1 lists the documents indicating the use of traffic priority levels in the home network.

Table 6-1 – List of analysed documents

Document	Note
[DSL-F TR-133]	This document provides the priority linkage between DSCP and data link technologies such as ATM, VLAN, and 802.11e in its Appendix B. The service associated with each level of priority is not clear. 21 values of DSCP appear in the table of L2/3 QoS mapping.
[DLNA]	DLNA sets four levels of QoS priority called DLNAQOS_3/2/1/0. Each DLNAQOS is associated with a DSCP value. Also, it provides the linkage between these QoS levels and priority levels specific to data link technologies such as IEEE 802.1Q and WMM.
[DVB-IP]	This document provides priority of traffic in its clause 7.4 that is applicable in the home network.
[HGI]	This document has tables defining priority at the egress port of the home gateway, end device, and infrastructure device. Linkage to PLC is mentioned, but it does not specify the PLC technologies.
[UPnP]	UPnP QoS provides the linkage between DSCP values and priorities specific to some data link technologies in its Appendix A, while it mostly adopts the session-based scheme, called parameterized QoS scheme. Relative priority of traffic is set by the traffic importance number (TIN) and linked to other priority-based marking such as DSCP and VLAN priority.

Table 6-2 is a summary of these documents and compares some key aspects of home network QoS: the number of classes, the use of DSCP, data link technologies identified, and interface information as shown in Figure 5-2.

The number of classes varies from 4 ([DLNA] and end device of [HGI]) to 8 ([DSL-F TR-133], infrastructure device of [HGI] and [UPnP]).

All the documents contain information on the linkage between the DSCP value and the data link level priority. But heterogeneous coverage of data link technologies can be found among these documents. Most of documents select two or three data link technologies, and Ethernet-based technologies such as [IEEE 802.1D] are the most widely referred ones. In addition, WiFi-based technologies such as WMM/802.11e tend to be considered.

Some documents contain the indication of a certain priority associated with a specific application. Also, like DLNA and UPnP, some documents have their own set of parameters or definition of class that is linked to individual priority scheme like DSCP and VLAN priority. This kind of information is also mentioned in the table.

Table 6-2 – Summary of QoS priority defined in each document

Reference	No. of Class	DSCP	Data link	IF (Figure 5-2) (A/B/C/D)	Note
[DSL-F TR-133]	8	X	ATM VLAN 802.11	B/C	
[DLNA]	4	X	802.1Q/VLAN 802.11	A/B	Each priority is linked to DLANQOS_x (x=0-3).
[DVB-IP]	5	X	802.1p	A/B	Traffic type includes voice bearer, two types of video bearer, video signalling and best-effort data.
[HGI]	HG Egress	X	802.11 PLC	A/B/C	Services are categorized as voice, video, VAS (value added service) and BE. Each type of service is categorized into downstream, upstream and transit by the direction of traffic.
	Infrastructure device	X	802.1D 802.11 PLC	B	
	End Device	X	802.11 PLC	A/B/C	
[UPnP]	8	X	802.1D/VLAN Home Plug HPNA	B/C	Each priority is linked through TIN (traffic importance number).

6.1.1 Interface (A)

Although all the documents rely on DSCP for its QoS scheme, inconsistencies are observed in the choice of DSCP values and priority values associated with these values. This issue is summarized in Table 6-3 where the DSCP values are given considering the priority associated with each value.

Table 6-3 – DSCP used in the home network related documents

		Broadband forum	DLNA	DVB-IP	HGI	UPnP	
DSCP	Lower than BE		0x08		0x08	0x08	
					0x10	0x10	
	BE	0x00	0x00	0x00	0x00	0x00	
	Higher than BE	0x08, 0x0A, 0x0C, 0x0E					
		0x10, 0x12, 0x14, 0x16					
		0x18, 0x1A, 0x1C, 0x1E			0x1A	0x18	0x18
		0x20, 0x22, 0x24, 0x26			0x24	0x20	0x20
					0x22		
		0x28, 0x2E	0x28	0x2E	0x28	0x28	
		0x38, 0x30				0x30	0x30
	0x38			0x38	0x38		

The priority can be categorized into three types of priority; "lower than best effort", "best effort" and "higher than best effort". In the ideal situation, the priority associated with each DSCP value needs to be identical. In the table, the DSCP values which are supposed to have the same priority are placed on the same line.

6.1.2 Interface (B)

Some documents contain provisions or information on how DSCP can be mapped to the data link layer QoS marking. Tables 6-4 and 6-5 show the comparison of this kind of mapping among documents.

[IEEE 802.11] has four classes of priority scheme, in which AC_VO, AC_VI, AC_BE and AC_BK are used for indicating priority levels. Broadband Forum, DLNA, and HGI provide mapping between DSCP and associated priority for [IEEE 802.11] as shown in Table 6-4.

Ethernet is a typical home network transmission medium. Prioritization of packets is provided as a part of Ethernet standard such as [IEEE 802.1Q], 802.1p, and [IEEE 802.1D]. All the schemes analysed in this supplement provide mapping with DSCP as shown in Table 6-5.

Table 6-4 – DSCP and 802.11 priority

		Broadband forum		DLNA		HGI		
		DSCP	802.11	DSCP	802.11	DSCP	802.11	
Priority	Lower than BE			0x08	AC_BK	0x08	AC_BK	
				0x10	AC_BK	0x10	AC_BK	
	BE	0x00	AC_BE AC_BK	0x00	AC_BE	0x00	AC_BE	
	Higher than BE	0x0E/0x0C/ 0x0A/0x08	AC_BE					
		0x16/0x14/ 0x12/0x10	AC_VI					
		0x1E/0x1C/ 0x1A/0x18	AC_VI	0x18	AC_BE	0x18	AC_BE	
		0x26/0x24/ 0x22/0x20	AC_VO	0x20	AC_VI	0x20	AC_VI	
		0x2E/0x28	AC_VO	0x28	AC_VI	0x28	AC_VI	
		0x30	AC_VO	0x30	AC_VO	0x30	AC_VO	
		0x38	AC_VO	0x38	AC_VO	0x38	AC_VO	

Table 6-5 – DSCP and Ethernet priority

		Broadband forum		DLNA		DVB-IP		HGI		UPnP		
		DSCP	802.1Q	DSCP	802.1D	DSCP	802.1p	DSCP	802.1D	DSCP	802.1Q	
Priority	Lower than BE	0x00	1	0x08	1			0x08	1	0x08	1	
				0x10	2			0x10	2	0x10	2	
	BE	0x00	0	0x00	0	0x00	0	0x00	0	0x00	0	
	Higher than BE	0x0E/0x0C/ 0x0A/0x08	3									
		0x16/0x14/ 0x12/0x10	4									
		0x1E/0x1C/ 0x1A/0x18	5	0x18	3	0x1A	3	0x18	3	0x18	3	
		0x26/0x24/ 0x22/0x20	6	0x20	4	0x22/ 0x24	4	0x20	4	0x20	4	
		0x2E/0x28	6	0x28	5	0x2E	5	0x28	5	0x28	5	
		0x30	7	0x30	6			0x30	6	0x30	6	
		0x38	7	0x38	7			0x38	7	0x38	7	

6.2 Observations and issues for future study

6.2.1 Issue (1) – Number of classes

It may not be necessary to have the same number of classes in every document. The important thing is to make harmonization among documents. Problems may happen if home network technologies with different policy are combined together. As shown in Table 6-3, [DSL-F TR-133] has seven classes, of which six are higher than BE and one is the same as BE. [HGI] has eight classes, of which two are lower than BE, five are higher than BE, and one is the same as BE. By simply combining these classes together, the combination of [DSL-F TR-133] and [HGI] has nine classes,

of which two are lower than BE, six are higher than BE, and one is the same as BE. Considering the number of classes (typically eight) supported by the data link technologies, the increased number of classes may not be handled sufficiently.

It might be possible to decrease the number of classes by combining some of the classes into one or a few number of classes. In this case, however, the number of priority levels for differentiation among services is decreased.

6.2.2 Issue (2) – Position of best effort

[DSL-F TR-133] and [DVB-IP] place BE at the lowest priority. In addition, some documents define a priority class such as "Background" below BE. Such class can be assigned to the traffic which will not have any impact on the quality of experience. This may increase the performance of certain services such as the conventional Internet services by providing better transmission performance than "Background". If these two different policies in [DSL-F TR-133] and [DVB-IP] are used together, this effect may not be realized or undermined.

6.2.3 Issue (3) – Identifying DSCP values

There are inconsistencies on the choice of DSCP values among documents.

Except for 0x00 used for BE, 0x38 and 0x28 are commonly used, excluding [DVB-IP]. For the classes lower than BE, 0x08 is relatively used, but this value is also assigned for a class higher than BE in [DSL-F TR-133] (also see issue (4)).

The inconsistent use of DSCP value causes problems in several ways. Firstly, this increases the number of classes which the bridging devices need to support. Secondly, the increased number of DSCP values may cause additional load for the bridging devices. Furthermore, in the well-harmonized home network, it is not necessary to use the number of DSCP values more than the number of service classes.

6.2.4 Issue (4) – DSCP value and corresponding priority

In Table 6-3, some DSCP values, for example 0x08 which is assigned for classes lower than BE in [DLNA], [HGI] and [UPnP], and also assigned for classes higher than BE in [DSL-F TR-133], are assigned for different priorities. This is a problem which happens if different technologies are combined together. It is desirable that every DSCP value is used to have a unique priority.

6.2.5 Issue (5) – Assignment of a priority class to a service or services

The current home network documents contain the assignment of a priority class to a service or services. In this assignment, the service like audio and video tends to be given a higher priority. In addition, there are some documents in which the highest priority is given to the signaling traffic. DLNA, which assigns DLNAQOS_3 to RTCP traffic, is one of the examples.

6.2.6 Issue (6) – Complete coverage of data link technologies

It is difficult to predict what kind of devices, and consequently data link technologies, will be installed in the home network. It is likely that the end users bring any technologies into their home. This means that the home network standard needs to cover data link technologies currently available as much as possible.

Covering all the data link technologies may not be enough, because it is likely that the new technology will be invented in the future. Requirements for such technologies will be beneficial in the development of new data link technologies.

6.2.7 Issue (7) – Coordination of priority between the access and home networks

It is generally believed that QoS should be supported on an end-to-end basis. This means that the home network QoS policy should be coordinated with that of the access network. Although the

current solutions identified in this supplement present QoS policy applicable to the home network, few documents address the coordination between the access and home network. A good home network QoS policy should support QoS not only within the home network but also with the access network. This supplement identifies interface (D) as defined in Figure 5-2 for this item.

This work will involve a similar analysis on the access network as shown in clause 6.1 and will be a difficult task for a single study group. Collaboration among study groups and SDOs should be promoted.

7 Approaches for future Recommendations

There are several approaches to increase the inconsistency among different standards for the home network QoS. This supplement identifies three approaches as mentioned below:

- Single policy
- Segmentation
- Dynamic configuration

The choice of these approaches depends on the technical development and efforts for harmonization among responsible standard bodies. This supplement does not define provisions for harmonization, but several alternatives are provided for further consideration for standardization. It should be noted that a level of collaboration has a great impact on the future strategy of this study. Efforts for future Recommendations are needed to collaborate and consider development in SDOs active in this area.

Also, it should be noted that the QoS and traffic class provisions for network defined in [ITU-T G.1010], [ITU-T Y.1221] and [ITU-T Y.1541] be considered in the future study in this area.

7.1 Single policy

As identified in the previous clauses, a problem that should be addressed is the inconsistency among different documents. Establishing a single policy is a straightforward solution for this problem.

In this approach, the work will result in some tables containing DSCP values, associated priority marking and relevant use of the marking. Such tables should exclude any ambiguity not to allow inconsistency caused by misinterpretation of the policy. Supplementary provisions may be useful to increase clarity.

The single policy which can be defined in the future should function on a variety of transmission technologies. The number of classes supported by the transmission technologies is diverse. For example, Ethernet supports eight classes, but some other transmission technologies only support four classes. This implies that the single policy should be sufficiently flexible to cover a variety of transmission technologies. Expansion and reduction of classes should be included as a part of the single policy.

Even after defining the single policy as a standard for the home network QoS, it is possible that some home network devices that are not compliant with the defined policy are still used in the home. To increase the manageability of the home network, technical solutions, for example, detection of non-compliant devices or services, may be useful.

7.2 Segmentation

Home network includes everything beyond the demarcation point with the access network. This means that the scope of the home network QoS is also broad. However, each document can be understood in the more specific context of home network or associated with a more likely use case, though such specific cases may not be clearly stated or mentioned in the document.

In [ITU-T H.622], the concept of primary and secondary home network elements is introduced. This concept recognizes the different aspects of the home network: connecting a terminal device to

the access network and connection between terminals for communication within the home. The physical configuration of home network is also affected by such different roles of home network.

If a certain type of home network technology is used in the specific part of home network rather than the home network in general, such home network technology no longer needs to be harmonized with other home network technologies. In this case, the future home network standard only needs to mention the risks of mixing home network technologies with different usages or defined provisions to avoid any unnecessary mixing. This work would identify the relevant use of each home network technology rather than technical harmonization among them.

This approach requires deeper analysis of the use case for each home network technology and physical configuration of home network, e.g., wiring. The expertise of transmission aspects of home network is expected. Also, it should be noted that this work carefully avoids introducing unnecessary complexity to the home network. It is likely that introducing the internal structure may also introduce the new definition of elements, network domains and constraints for home network. Considering the nature of home network, responsibility of an end-user rather than of the network provider, too many technical elements easily increase an operational burden for home networks.

7.3 Dynamic configuration

Contrary to the two approaches mentioned above, this approach is more technology oriented. To introduce a single policy into home network devices, this approach utilizes the downloading mechanism or configuration by the responsible entity. In this approach, home network devices need not comply with the globally defined single policy or have restrictions imposed on their usage. This is a flexible approach in which different policies can be introduced depending on the network environment.

There are many types of devices in the home network. Some kinds of devices, such as Ethernet switches, have an insufficient capability to handle the currently available remote configuration protocols. Existence of such devices should be considered. Also, the development of simpler mechanisms will help to increase dynamic configuration usage.

It is also important to examine the capability of the access gateway and its interfaces. Documents including [DSL-F TR-098], [DSL-F TR-101], [DSL-F TR-124], and [HGI] provide information on its technical characteristics.

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