TTC標準
Standard

JJ-300.00

Home-network Topology Identifying Protocol (HTIP)

Version 3.0

Established on May 25, 2017

THE TELECOMMUNICATION TECHNOLOGY COMMITTEE

Introduction

This document provides the TTC original Standards formulated and put into effect by the Technical Assembly. It contains unabbreviated version of ‘JJ-‘ Standards, which have not been defined as international standards.

In case of dispute, the original to be referred is the Japanese version of the text.

We trust that greater understanding of TTC Standards by a wider range of users will further contribute to the development of telecommunications.

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<Reference>

1. Overview

This document defines a home-network topology identifying protocol (HTIP) used to identify the topology of a home network. This HTIP only applies to the broadcast domain in the link layer. Manager, the software which identifies the home-network topology, can be located on any terminal in the home network. Each HTIP-IP Terminal which incorporates the controlled device functions defined by the UPnP Device Architecture ([1]) transmits device information to Manager. Each HTIP-NW equipment and HTIP-IP Terminal which incorporate the LLDP Agent functions (transmit-only mode) defined by IEEE 802.1AB ([7]) transmits both device information and link information (a MAC forwarding table) in the home network. Manager collects the device information and link information from HTIP-IP Terminals and HTIP-NW equipments in the home network and identifies the home network topology on the basis of the collected information.

Manager can also check the connectivity of the HTIP-IP Terminals and HTIP-NW equipments. This document only defines the protocol for the information transmission from the HTIP-IP Terminals and HTIP-NW equipments without describing details of Manager functionality.

2. Reason for Selecting UPnP Device Architecture ([1]) and IEEE 802.1AB ([7])

To facilitate implementation and reduce processing load, this HTIP uses the UPnP Device Architecture ([1]) and IEEE 802.1AB ([7]) for the transmission of device information from HTIP-IP Terminals and IEEE 802.1AB ([7]) for the transmission of device information and link information from HTIP-NW equipments. The UPnP Device Architecture ([1]) is selected because the architecture is already prevalent among the devices that are connected to home networks, provides functions to transmit device information, and allows addition of the device information to be transmitted.

On the other hand, such protocols as SNMP ([9]), LLDP ([7]), or LLDP-MIB ([7]) are generally used to collect device information and link information from NW equipments. However, the NW equipments intended for use with home networks often do not have the capability of L3 protocol stack. For the devices that do not support SNMP ([9]), this HTIP is designed to incorporate only LLDP ([7]) and implement the LLDP Agent in transmit-only mode, which uses only the L2 protocol stack. Processing load on NW equipments can be reduced because they need not constantly monitor the packets and frames to be received but perform one-way transmission of information in many cases.

The conventional usage of LLDP specifies a multicast address as a destination of LLDPDU frames. However, if NW equipment B that does not support LLDP ([7]) and SNMP ([9]) exists between Manager and NW equipment A that transmits LLDPDU frames, the Manager can neither receive LLDPDU frames from HTIP-NW equipment A nor even recognize the existence of HTIP-NW equipment A. Because LLDP ([7]) allows the change of destination MAC addresses, this HTIP configures LLDPDU frame destination MAC addresses as basically broadcast addresses. This design enables Manager to collect information from arbitrary HTIP-NW equipments and estimate the topology of a home network even if devices, which do not implement LLDP, are connected to the home network. LLDP ([7]) also allows addition of the information to be transmitted. LLDP ([7]) is selected because of these advantages.

3. Relation with International Standards

This HTIP was defined on the basis of such standards as UPnP Device Architecture ([1]) and IEEE 802.1AB ([7]).

4. Differences from Above International Standards

4.1 UPnP Device Architecture [1]

This HTIP defined new elements to be added in the device description document the L3 Agent uses for the transmission of device information. This HTIP also defined a description policy for the device information elements already defined in the device description document. The definition of new elements complies with the UPnP Device Architecture ([1]) and is not an extension of the specification. Likewise, the definition of the description policy for existing elements does not exceed the range of description content definition by the UPnP Device Architecture ([1]) but only puts limitations on the description content. Therefore, the definition of the description policy is not an extension of the specification.

4.2 IEEE 802.1AB [7]

This HTIP defined the TLVs for device information and link information in the vendor-specific extension fields (TLV Type = 127) defined by IEEE 802.1AB ([7]) (see Section 6.3). This HTIP also defined the destination MAC address for the LLDPDU frame containing these TLVs as "FF-FF-FF-FF-FF-FF" in case of the broadcast. This definition is not an extension of the specification because LLDPDU frame destination MAC addresses are optional.

5. Changes to International Standards

None

6. Industrial Property Right

None

7. Revision History

Version	Date	Description
1.0	August 30, 2010	Established
1.1	February 23, 2011	▸ "HTIP-IP Terminals" and "HTIP-NW equipments" have been newly defined. ▸ The description of a TLV for storing a MAC forwarding table has been modified. ▸ Figure 6-2 has been modified.
2.0	August 27, 2015	▸ Amended descriptions for L2Agent to be able to reside in HTIP IP Terminals ▸ Added a data format for MAC address to make it possible to use MAC address of non-Ethernet data link layer. ▸ Expanded the length of device category to 255 octets. ▸ Added XML tags described in DDD of UPnP and definitions of TLV included in LLDPU, in order for L2Agent and L3Agent to transmit information which is useful to identify the failure point in the system, such as indication of channel usage, radio signal strength, communication error rate, pairing status, and equipment status. ▸ Added a method to transmit Ethernet frames containing LLDPU using an encapsulation protocol over IP protocol to transmit LLDPU over non-Ethernet data link layer. ▸ Described that bridge forwarding between LoWPAN and non-LoWPAN is included in the category of link layer broadcast domain. ▸ Added TLV which indicates transmission interval of LLDPU by the L2Agent.

3.0	May 25, 2017	▶ Added the definition of the XML tag described in UPnP's DDD and the definition of TLV to be included in LLDPDU for useful information for identifying the cause of the failure. New definitions for L2 and L3 agent are as follows: response time, number of associated devices, number of active nodes, link quality, number of retransmissions, CPU usage rate, memory usage rate, HDD usage rate, and remaining battery level, ▶ Added the interface to configure the condition to notify the communication quality information from Manager to L2 and L3 Agent. ▶ Described that L2 Agent can send the device and link information by unicast.

8. Working Group Developing This Standard

Version 1.0: TTC Next-generation Home Network System Working Group

Version 1.1: TTC Next-generation Home Network System Working Group

Version 2.0: TTC Next-generation Home Network System Working Group

Version 3.0: TTC IoT Area Network Working Group

1. Introduction

1.1 Purpose of HTIP

The IP Terminals that can be connected in home networks are increasing lately. The transmission media to send IP packets to such IP Terminals are varied in type, including not only UTP cables but also power lines, telephone lines, coaxial cables, and wireless lines. There also are various types of intermediate connection devices (NW equipments) available for connecting the diverse transmission media and relaying IP packets.

In spite of these circumstances, many home network users only have little knowledge of networking. When a problem occurs in the service a user is using with an IP Terminal in a home network, the user usually begins inspection by checking connections at a lower layer, locate the problem, and find its cause. If the user has little knowledge of networking, the user often can hardly find even the connection path for the IP Terminal. Therefore, such users cannot locate the problem and recover from the problem.

The HTIP defined by this specification enables an arbitrary IP Terminal or NW equipment connected in a home network not only to identify the device information of other IP Terminals and NW equipments in the same home network but also to identify the overall topology of the home network. This specification also provides a mechanism to check the connectivity of the IP Terminals and NW equipments that have the HTIP installed. It is expected that the HTIP defined here will enable presentation of a home network topology diagram to home network users and the users will be able to locate problems in individual home networks with reference to the topology diagram and recover from the problems. It is also optionally possible to collect information useful for fault isolation.

1.2 Preconditions

This document defines only the interfaces between devices. Internal processes in each device must be designed by the person who implements each home network system. Values of elements (e.g., MAC address and data length in TLVs) must be described by binary notation unless otherwise instructed.

2. References

2.1 Standards

[1] ISO/IEC 29341-1: "Information technology - UPnP Device Architecture - Part 1: UPnP Device Architecture Version 1.0", Edition 1.0, December 2008.

[2] ISO/IEC 29341-2: "Information technology - UPnP Device Architecture - Part 2: Basic Device Control Protocol - Basic Device", Edition 1.0, December 2008.

[3] ITU-T Rec. "G.9971, Requirements of transport functions in IP home network", June 2010.

[4] TTC Next-generation Home Network Systems Working Groups: "JJ-300.01 (The List of Device Category)", Edition 2.0, August 27, 2015.

2.2 Other documents

[5] IEEE Computer Society: "802.1D, IEEE Standard for Local and metropolitan area networks, Media Access Control (MAC) Bridges", 2004.

[6] IEEE Computer Society: "802.3-2008, Part 3: Carrier sense multiple access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications", December 2008.

[7] IEEE Computer Society: "802.1AB-2009: Local and Metropolitan Area Networks - Station and Media Access Control Connectivity Discovery", September 2009.

[8] Internet Assigned Numbers Authority (IANA): "IANAifType-MIB DEFINITIONS", ver. 200905060000Z, May 2009.

[9] J. Case, et al.: RFC1157, "Simple Network Management Protocol", Internet Engineering Task Force (IETF), September 1990.

[10] J. Postel: RFC 792, "INTERNET CONTROL MESSAGE PROTOCOL", Internet Engineering Task Force (IETF), September 1981.

[11] UPnP Forum: "UPnP Device Management 1.0", July 2010.

[12] S. Hanks, T. Li, et al.: RFC 1701, “Generic Routing Encapsulation (GRE)”, Internet Engineering Task Force (IETF), October 1994.

[13] G. Montenegro, N. Kushalnagar, et al.: RFC 4944, “Transmission of IPv6 Packets over IEEE 802.15.4 Networks”, Internet Engineering Task Force (IETF), September 2007.

3. Terms and Acronyms

3.1 Terms

IP Terminal:

A hardware terminal that has an IP address and terminates IP packets.

HTIP-IP Terminal:

An IP Terminal in which L3 Agent or L2 Agent is installed. One or more L3 Agents or L2 Agents can reside on one HTIP-IP Terminal.

NW equipment:

A hardware device that has two or more ports and a function to transfer frames and packets received at one port to the other port by using a MAC forwarding table. Some types of NW equipment connect different transmission media to each other. NW equipments exclude the devices (e.g., repeater hubs) that do not use a MAC forwarding table even when they have a frame and packet transfer function.

HTIP-NW equipment:

An NW equipment in which L2 Agent is installed. Only one L2 Agent can reside on one HTIP-NW equipment. L3 Agent can also reside on an HTIP-NW equipment.

Agent:

A collective term for L3 Agent and L2 Agent

Manager:

A software program that collects device and link information from individual Agents and identifies the

topology of home network. Manager also checks its connectivity with individual Agents. Manager can operate on either an IP Terminal or an NW equipment.

L3 Agent:

A software program that resides on an HTIP-IP Terminal and transmits device information to Manager.

L2 Agent:

A software program that resides on an HTIP-NW equipment or HTIP-IP Terminal and transmits device and link information to Manager.

Access gateway:

A device that has a function to connect the networks with different IP subnets to each other and provides an interface between a home network and a WAN. An access gateway has the functions of both IP Terminal and NW equipment.

Port:

A hardware interface to input or output data from or to another IP Terminal or NW equipment

MAC address list:

A MAC address list retained by an NW equipment

3.2 Acronyms

AGW:	Access Gateway
DDD:	Device Description Document
DM:	Device Management protocol
GRE:	Genric Routing Encapsulation
HTIP:	Home-network Topology Identifying Protocol
ICMP:	Internet Control Message Protocol
IP:	Internet Protocol
LAN:	Local Area Network
LLDP:	Link Layer Discovery Protocol
LLDPDU:	LLDP Data Unit
LV:	Length, Value
L2:	Layer 2
L3:	Layer 3
MAC:	Media Access Control
MIB:	Management Information Base
OUI:	Organizationally Unique Identifier
RFC:	Request for Comments
TLV:	Type, Length, Value
TTL:	Time to Live
UDA:	UPnP Device Architecture
UTP:	Unshielded Twisted Pair
UPnP:	Universal Plug and Play
WAN:	Wide Area Network
LoWPAN:	Low power Wireless Personal Area Networks

4. Scope of HTIP

Figure 4 shows the home network as the applicable scope of this specification. This specification applies only to the link-layer broadcast domain enclosed by solid line in Figure 4. The scope of this specification excludes identification of the topology in the WAN and the topology under the IP Terminal. The HTIP defined by this specification does not relate to, for example, the topology of the display units connected to IP Terminals by analog cables and the topology under the routers (except for the AGW) connected to the home network.

No AGW or one AGW is installed in a LAN. One or more IP Terminals are connected to the LAN. No NW equipment or one or more NW equipments are connected to the LAN.

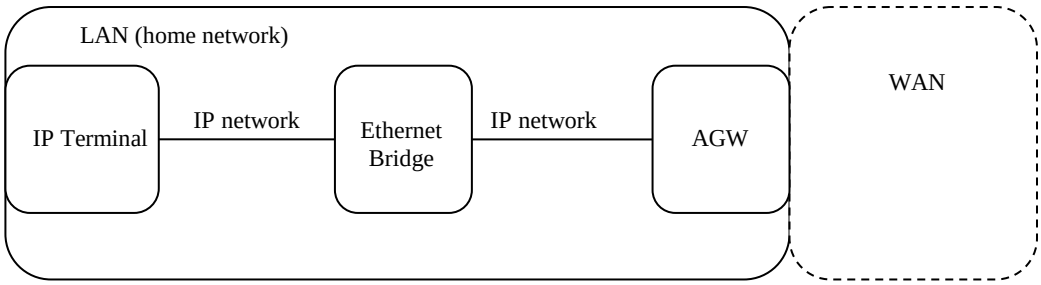

Figure 4 Scope of a home network to which HTIP is applied

5. Requirements

5.1 Definition of implementation levels

This section defines the classification of implementation levels: Required, recommended, and optional.

Required:

A required feature is a mandatory feature that must be implemented to ensure the compatibility of this specification when HTIP is implemented. The phrase "must be implemented" or "implementation required" refers to a required feature.

Recommended:

A recommended feature is a feature that is not always required to ensure the compatibility of this specification but should be implemented to enhance performance when HTIP is implemented. The phrase "should be implemented" or "implementation recommended" refers to a recommended feature.

Optional:

An optional feature is a feature that is not required to ensure the compatibility of this specification but may be implemented. The phrase "may be implemented" or "implementation optional" refers to an optional feature.

5.2 Required capabilities

To comply with the HTIP defined by this specification, one or more L3 Agents or L2 Agents that meet the capability requirements listed below must be installed in an IP Terminal. In addition, only one L2 Agent that meets the capability requirements listed below must be installed in an NW equipment. L3 Agent and L2 Agent must meet the capability requirements listed below. The capability requirements below comply with the terminal management interface requirements defined by ITU-T SG15 G.9971 ([3]).

i. L3 Agent must be able to acquire the IP and MAC addresses of the HTIP-IP Terminal where L3 Agent resides. L3 Agent must also be able to transmit the IP and MAC addresses to Manager in the manner described in Section 6.2. (Required feature corresponding to G.9971 ([3]) R11-C1 and R11-C2)

ii. L2 Agent must be able to acquire the MAC forwarding table retained by the HTIP-NW equipment where L2 Agent resides. L2 Agent must also be able to transmit the MAC forwarding table to Manager in the manner described in Section 6.3. (Required feature corresponding to G.9971 ([3]) R11-C3)

iii. L3 Agent must be able to transmit device information to Manager in the manner described in Section 6.2. (Required feature corresponding to G.9971 ([3]) R11-C4)

iv. L2 Agent must be able to transmit device information to Manager in the manner described in Section 6.3. (Required feature corresponding to G.9971 ([3]) R11-C5)

v. For the connectivity check between Manager and L3 Agent, L3 Agent should be able to respond to a request from Manager in the manner described in Section 7.1. (Recommended feature corresponding to G.9971 ([3]) R11-L2)

vi. For the connectivity check between Manager and L2 Agent, L2 Agent should be able to periodically transmit frames to Manager in the manner described in Section 7.2. (Recommended feature corresponding to G.9971 ([3]) R11-L2)

vii. L2 Agent must be able to acquire the MAC address of the HTIP-IP Terminal where L2 Agent resides. L2 Agent must also be able to transmit the MAC address to Manager in the manner described in Section 6.3. (Required feature)

viii. When L2 Agent transmits an LLDPDU encapsulated in an IP packet in the manner described in Section 6.3, L2 Agent must be able to acquire the IP address of the HTIP-NW equipment or HTIP-IP Terminal where L2 Agent resides. (Required feature when this applies)

6. Collection of Information To Identify Home Network Topology

This chapter describes the sequence of operations of L3 Agent and L2 Agent on HTIP. Figure 6-1 shows the information that is transmitted to identify the topology of a home network. Manager receives device information from L3Agent and device and link information from L2 Agent, respectively (link information is received only when L2 Agent resides on the HTIP-NW equipment). Note, however, that Manager shall be able to receive device information and/or link information from a specific Agent without using the communication defined in this chapter if Manager and the specific Agent reside on the same HTIP-IP Terminal or HTIP-NW equipment.

Manager analyzes the information collected from all Agents in the home network, and then identifies the topology of the home network. The home network topology diagram created by this operation enables the connectivity check on an HTIP-IP Terminal and the HTIP-NW equipments existing on the connection path between the HTIP-IP Terminals. The home network topology diagram also enables the user to locate problems when an IP service is disabled on an HTIP-IP Terminal. The method of connectivity check between Manager and Agent is described in Chapter 7.

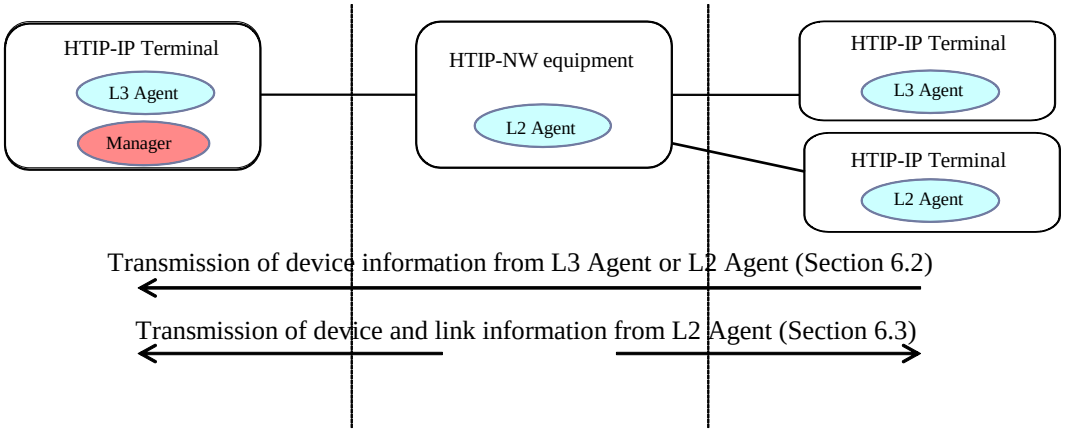

Figure 6-1 Information that is transmitted to identify the home network topology

6.1 Device information and link information

Device information is managed by each Agent. The device information consists of at least four items of data, (a) to (d), listed below.

(a) Device category

(b) Manufacturer code

(c) Model name

(d) Model number

Device category (a) indicates the type of the device (Agent), for example, television or DVD recorder. Manufacturer code (b) indicates the company that manufactured the device (Agent). A company ID (OUI code[1]) registered with the IEEE is used as the manufacturer code. Model name (c) indicates the brand or series name given by the manufacturer to the device (Agent). Model number (d) indicates the model number given by the manufacturer to the device (Agent). The maximum length of the value of one device category (a) is 255 octets. The length of the value of manufacturer code (b) is fixed to 6 octets. The maximum length of the values of model name (c) and model number (d) is 31 octets.

The device information managed by the Agent of the HTIP-IP Terminal may include channel usage information (e), radio signal strength information (f), communication error rate information (g), and status information (h) of the communication interface that the HTIP-IP Terminal uses for communication, all of which are useful information for fault isolation in a home network. Also, the LLDPDU transmission interval (i) can be included.

Futhermore, response time (j), number of associated devices (k), number of active nodes (l), link quality (m), number of retransmissions (n), CPU usage rate (o), memory usage rate (p), HDD usage rate (q), remaining battery level (r) can be also included.

The device information managed by the Agent of the HTIP-NW equipment may include status information (h), which is useful information for fault isolation in a home network. Also, the LLDPDU transmission interval (i) can be included.

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1 See "IEEE OUI and Company_id Assignments" in the IEEE website at http://standards.ieee.org/regauth/oui/.

The link information is retained by the NW equipment, and the required information is the same as that in the MAC forwarding table. The MAC forwarding table contains the information on pairs of a port of the NW equipment and the MAC address of the IP Terminal or another NW equipment connected to the port. The NW equipment receives packets transmitted from the IP Terminal or frames transmitted from the HTIP-NW equipment, and then stores, in the MAC forwarding table, the source MAC address in the L2 header in these packets and frames. The MAC forwarding table of an NW equipment shall exclude the NW equipment's own MAC address.

The link information managed by the Agent of the HTIP-NW equipment may include pairing information, channel usage information, radio signal strength information, and communication error rate information, all of which are useful information for fault isolation in a home network.

6.2 Transmission of device information from L3 Agent using UPnP controlled device functions ([1])

On HTIP, L3 Agent in a home network transmits device information by using UPnP controlled device functions ([1]) to Manager residing on a device in the home network. The UPnP controlled device functions defined by UDA ([1]) must be implemented on L3 Agent.

L3 Agent transmits device information to Manager by using the Basic Device Information part for the root device in the DDD. This specification stipulates that only one DDD should be provided per L3 Agent. For the detailed method and timing of device information collection from L3 Agent by Manager, see Chapter 2, "Description", of UDA ([1]). When IPv6 is used, see Annex of UDA ([1]) for the detailed method and timing. This specification defines some new elements to be added in the Basic Device Information part in the DDD described in UDA ([1]) and a policy for describing values in existing elements to transmit device information to Manager. For the device information that can be contained in each field, see Table 6-1. When the L3 Agent on an HTIP-IP Terminal transmits the device information of the HTIP-IP Terminal to Manager, the MAC and IP addresses of the HTIP-IP Terminal are set in the L2 and IP headers of the packet. Therefore, the MAC and IP addresses of the HTIP-IP Terminal can be transmitted to Manager (Item i of Section 5.2).

Regarding the device category (a), The List of Device Category ([4]) must be referenced, and only the value of the category of the relevant device must be described in the <htip:X_DeviceCategory> element[2]. Multiple categories can be listed in the element. When describing multiple values of categories, the values must be separated by a comma (,). Linear white space (LWS) must not be inserted before and after each comma. The following characters can be used for describing the device category:

[a-zA-Z0-9] | [-'()+./:=?;!*#@$_%]

Regarding the manufacturer code (b), only the relevant company ID registered with the IEEE must be described in the <htip:X_ManufacturerOUI> element[2]. If the manufacturer of the installed device has not obtained a registered company ID, no value may be described in the <htip:X_ManufacturerOUI> element. The <htip:X_ManufacturerOUI> element must always be prepared even without a value described, and the manufacturer name must be described in the <manufacturer> element. Neither <htip:X_DeviceCategory> nor <htip:X_ManufacturerOUI> element is allowed to appear multiple times in the same DDD. The following characters can be used for describing the manufacturer code (b):

[a-fA-F0-9]

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2 The namespace for the element shall be http://www.ttc.or.jp/Home-network WG/JJ-300.00.

Regarding the model name (c), only a model name must be described in the <modelName> element. If the HTIP-IP Terminal does not have any name corresponding to the model name (c), no value may be described in the <modelName> element. However, the <modelName> element must always be prepared even without a value described because the <modelName> element is defined as a required feature by UDA ([1]).

Regarding the model number (d), only a model number must be described in the <modelNumber> element. The following characters can be used for describing the model name (c) and model number (d):

#x20 | [a-zA-Z0-9] | [-'()+,./:=?;!*#@$_%]

Regarding the channel usage information (e), a string representing an integer value (0 to 100) must be described in the <htip:X_ChannelStatus> element[2]. The smaller the value is, the less frequently the channel is used. A value equal to or larger than 75 indicates that it is undesirable to use the channel for communication. The channel usage information (e) is unique to each communication interface. Therefore, when the HTIP-IP Terminal has multiple communication interfaces, UPnP communication is established for each communication interface by using the IP address of that communication interface and the channel usage information (e) of the communication interface is transmitted through the communication interface. The following characters can be used for describing the channel usage information (e). (Optional feature)

[0-9]

Regarding the Received Signal Strength Indicator (f), a string representing an integer value (0 to 100) must be described in the <htip:X_Rssi> element[2]. A larger value indicates greater radio signal strength. A value equal to or smaller than 25 indicates that the radio signal strength is not suitable for communication. The radio signal strength information (f) is unique to each communication interface. Therefore, when the HTIP-IP Terminal has multiple communication interfaces, UPnP communication is established for each communication interface by using the IP address of that communication interface and the radio signal strength information (f) of the communication interface is transmitted through the communication. The following characters can be used for describing the radio signal strength information (f). (Optional feature)

[0-9]

Regarding the communication error rate information (g), a string representing an integer value (0 to 100) must be described in the <htip:X_ErrorRate> element[2]. A larger value indicates more errors. A value equal to or larger than 75 indicates that the communication error rate is not suitable for communication. The communication error rate information (g) is unique to each communication interface. Therefore, when the HTIP-IP Terminal has multiple communication interfaces, UPnP communication is established for each communication interface by using the IP address of that communication interface and the communication error rate information (g) is transmitted through the communication. The following characters can be used for describing the communication error rate information (g). (Optional feature)

[0-9]

Regarding the status information (h), a string representing an integer value (0 to 255) must be described in the <htip:X_Status> element[2]. 0 indicates that there is no error, and a value other than 0 indicates that there is one or more errors. The values other than 0 are unique to each device and can be interpreted by acquiring the necessary information

from the device vendor. A white space can be put after the integer value, and a desired alphanumeric text string can be put after the white space. The status information (h) is unique to each device. Therefore, when the HTIP-IP Terminal has multiple communication interfaces, UPnP communication is established for each communication interface by using the IP address of that communication interface and the same status information (h) is transmitted through the communication. The following characters can be used for describing the status information (h). (Optional feature)

[0-9 a-zA-Z.,!?/*+-]

Regarding the response time (j), a string representing an integer value (0 or more) must be described in the <htip:X_RT> element[2]. The value indicates millisecond. The response time (j) is unique to each device. Therefore, when the HTIP-IP Terminal has multiple communication interfaces, UPnP communication is established for each communication interface by using the IP address of that communication interface and that communication interface's response time (j) is transmitted through the communication. The following characters can be used for describing the response time (j). (Optional feature)

[0-9]

Regarding the number of associated devices (k), a string representing an integer value (0 or more) must be described in the <htip:X_NumAss> element[2]. The value indicates number of associated devices. Because the number of associated devices (k) is unique to each NW equipment, HTIP-NW equipment transmits. The following characters can be used for describing the number of associated devices (k). (Optional feature)

[0-9]

Regarding the number of active nodes (l), a string representing an integer value (0 or more) must be described in the <htip:X_NumAct> element[2]. The value indicates number of devices that communicated within a certain time. Because the number of active nodes (l) is unique to each NW equipment, HTIP-NW equipment transmits. The following characters can be used for describing the number of active nodes (l). (Optional feature)

[0-9]

Regarding the link quality (m), a string representing an integer value (0 to 100) must be described in the <htip:X_LQ> element[2]. The larger value, indicates that the quality is better. A value less than or equal to 25 indicates that the link quality is not suitable for communication. The link quality (m) is unique to each communication interface. Therefore, when the HTIP-IP Terminal has multiple communication interfaces, UPnP communication is established for each communication interface by using the IP address of that communication interface and that communication interface's link quality (m) is transmitted through the communication. The following characters can be used for describing the link quality (m). (Optional feature)

[0-9]

Regarding the number of retransmissions (n), a string representing an integer value (0 or more) must be described in the <htip:X_RetC> element[2]. The value indicates the number of retransmissions. In the case of the HTIP-IP Terminal, the number of retransmissions (n) is unique to each communication interface. Therefore, when the HTIP-IP Terminal has multiple communication interfaces, UPnP communication is established for each communication interface by using the IP address of that communication interface and that communication interface's number of retransmissions (n) is transmitted through the communication. In the case of the HTIP-NW equipment, the number of retransmissions (n) is

unique to each communication partner. Therefore, The MAC address of the communication partner is stored in the attribute value "partner" in the <htip: X_RetC> tag, and the number of retransmissions (n) for each communication partner is transmitted by the HTIP-NW equipment. The following characters can be used for describing the number of retransmissions (n). (Optional feature)

[0-9]

When describing the MAC address of the communication partner, each octet of the MAC address is made a character string expressed in 2 digits hexadecimal (00 to FF). The following characters can be used for describing MAC address. (Optional feature)

[0-9 A-F]

Regarding the CPU usage rate (o), a string representing an integer value (0 to 100) must be described in the <htip:X_CPU> element[2]. The larger value, higher the CPU usage rate, indicating poor performance. A value of 75 or more indicates that performance is not suitable for operation. The CPU usage rate (o) is unique to each device. Therefore, when the HTIP-IP Terminal has multiple communication interfaces, UPnP communication is established for each communication interface by using the IP address of that communication interface and the same CPU usage rate (o) is transmitted through the communication. The following characters can be used for describing the CPU usage rate (o). (Optional feature)

[0-9]

Regarding the memory usage rate (p), a string representing an integer value (0 to 100) must be described in the <htip:X_MEM> element[2]. The larger value, higher the memory usage rate, indicating poor performance. A value of 75 or more indicates that performance is not suitable for operation. The memory usage rate (p) is unique to each device. Therefore, when the HTIP-IP Terminal has multiple communication interfaces, UPnP communication is established for each communication interface by using the IP address of that communication interface and the same memory usage rate (p) is transmitted through the communication. The following characters can be used for describing the memory usage rate (p). (Optional feature)

[0-9]

Regarding the HDD usage rate (q), a string representing an integer value (0 to 100) must be described in the <htip:X_HDD> element[2]. The larger value, higher the HDD usage rate, indicating poor performance. A value of 75 or more indicates that performance is not suitable for operation. The HDD usage rate (q) is unique to each device. Therefore, when the HTIP-IP Terminal has multiple communication interfaces, UPnP communication is established for each communication interface by using the IP address of that communication interface and the same HDD usage rate (q) is transmitted through the communication. The following characters can be used for describing the HDD usage rate (q). (Optional feature)

[0-9]

Regarding the remaining battery level (r), a string representing an integer value (0 to 100) must be described in the <htip:X_Power> element[2]. The larger value, indicating more the remaining battery power. A value less than or equal to 25 indicates that the battery level is low. The remaining battery level (r) is unique to each device. Therefore, when the HTIP-IP Terminal has multiple communication interfaces, UPnP communication is established for each communication interface by using the IP address of that communication interface and the same remaining battery level

(r) is transmitted through the communication. The following characters can be used for describing the remaining battery level (r). (Optional feature)

[0-9]

This document only specify the methods of describing values of the <htip:X_DeviceCategory>, <htip:X_ManufacturerOUI>, <modelName>, <modelNumber>, <htip:X_ChannelStatus>, <htip:X_Rssi>, <htip:X_ErrorRate>, <htip:X_Status>, <htip:X_RT>, <htip:X_NumAss>, <htip:X_NumAct>, <htip:X_LQ>, <htip:X_RetC>, <htip:X_CPU>, <htip:X_MEM>, <htip:X_HDD>, and <htip:X_Power> elements without specifying descriptions of other elements. The following shows an example of the DDD for an HTIP-compliant L3 Agent. The placeholders described in this example in italics include those described in UDA ([1]).

<friendlyName>*short user-friendly title*</friendlyName>
<manufacturer>*manufacturer name*</manufacturer>
<manufacturerURL>*URL to manufacturer site*</manufacturerURL>
<modelDescription>*long user-friendly title*</modelDescription>
<modelName>model name (c)</modelName>
<modelNumber>model number (d)</modelNumber>
<modelURL>*URL to model site*</modelURL>
<serialNumber> *manufacturer's serial number* </serialNumber>
<UDN>*uuid:UUID*</UDN>
<UPC>*Universal Product Code*</UPC>
<htip:X_DeviceCategory xmlns:htip="http://www.ttc.or.jp/Home-network WG/JJ-300.00">device category information (a)</htip:X_DeviceCategory>
<htip:X_ManufacturerOUI xmlns:htip="http://www.ttc.or.jp/Home-network WG/JJ-300.00">manufacturer code (b)</htip:X_ManufacturerOUI>
<htip:X_ChannelStatus xmlns:htip="http://www.ttc.or.jp/Home-network WG/JJ-300.00">channel usage information (e)</htip:X_ChannelStatus>
<htip:X_Rssi xmlns:htip="http://www.ttc.or.jp/Home-network WG/JJ-300.00">radio signal strength information (f)</htip:X_Rssi>
<htip:X_ErrorRate xmlns:htip="http://www.ttc.or.jp/Home-network WG/JJ-300.00">communication error rate information (g)</htip:X_ErrorRate>
<htip:X_Status xmlns:htip="http://www.ttc.or.jp/Home-network WG/JJ-300.00">status information (h)</htip:X_Status>
<htip:X_RT xmlns:htip="http://www.ttc.or.jp/Home-network WG/JJ-300.00">response time (j)</htip:X_RT>
<htip:X_NumAss xmlns:htip="http://www.ttc.or.jp/Home-network WG/JJ-300.00">number of associated devices (k)</htip:X_NumAss>
<htip:X_NumAct xmlns:htip="http://www.ttc.or.jp/Home-network WG/JJ-300.00">number of active nodes (l)</htip:X_NumAct>
<htip:X_LQ xmlns:htip="http://www.ttc.or.jp/Home-network WG/JJ-300.00">link quality (m)</htip:X_LQ>
<htip:X_RetC xmlns:htip="http://www.ttc.or.jp/Home-network WG/JJ-300.00" partner="MAC address of

the communication partner”>number of retransmissions (n)</htip:X_RetC>

<htip:X_CPU xmlns:htip=“http://www.ttc.or.jp/Home-network WG/JJ-300.00”>CPU usage rate (o)</htip:X_CPU>

<htip:X_MEM xmlns:htip=“http://www.ttc.or.jp/Home-network WG/JJ-300.00”>memory usage rate (p)</htip:X_MEM>

<htip:X_HDD xmlns:htip=“http://www.ttc.or.jp/Home-network WG/JJ-300.00”>HDD usage rate (q)</htip:X_HDD>

<htip:X_Power xmlns:htip=“http://www.ttc.or.jp/Home-network WG/JJ-300.00”>remaining battery level (r)</htip:X_Power>

<iconList>

<icon>

<mimetype>*image/format*</mimetype>

<width>*horizontal pixels*</width>

<height>*vertical pixels*</height>

<depth>*color depth*</depth>

<url>*URL to icon*</url>

</icon>

XML to declare other icons, if any, go here

</iconList>

Table 6-1 Correspondence of device information and elements in the DDD

Element to contain device information	Device information	Maximum length of string containable in element (octets)	Frequency of transmission	Direction of transmission
htip:X_DeviceCategory	(a) Device category	255	Periodic (LLDPDU transmission interval)	L3 Agent -> Manager
htip:X_ManufacturerOUI	(b) Manufacturer code	6	Periodic (LLDPDU transmission interval)	L3 Agent -> Manager
modelName	(c) Model name	31	Periodic (LLDPDU transmission interval)	L3 Agent -> Manager
modelNumber	(d) Model number	31	Periodic (LLDPDU transmission interval)	L3 Agent -> Manager
htip:X_ChannelStatus	(e) Channel usage information	3	Periodic (LLDPDU transmission interval)	L3 Agent -> Manager
htip:X_Rssi	(f) Radio signal strength information	3	Periodic (LLDPDU transmission interval)	L3 Agent -> Manager
htip:X_ErrorRate	(g) Communication error rate information	3	Periodic (LLDPDU transmission interval)	L3 Agent -> Manager
htip:X_Status	(h) Status information	64	Periodic (LLDPDU transmission interval)	L3 Agent -> Manager
htip:X_RT	(i) Response time	6	Periodic (LLDPDU transmission interval)	L3 Agent -> Manager
htip:X_NumAss	(j) Number of associated devices	3	Periodic (LLDPDU transmission interval)	L3 Agent -> Manager
htip:X_NumAct	(k) Number of active nodes	3	Periodic (LLDPDU transmission interval)	L3 Agent -> Manager
htip:X_LQ	(l) Link quality	3	Periodic (LLDPDU transmission interval)	L3 Agent -> Manager
htip:X_RetC	(m) Number of retransmissions	3	Periodic (LLDPDU transmission interval)	L3 Agent -> Manager
htip:X_CPU	(n) CPU usage rate	3	Periodic (LLDPDU transmission interval)	L3 Agent -> Manager

htip:X_MEM	(o) Memory usage rate	3	Periodic (LLDPDU transmission interval)	L3 Agent -> Manager
htip:X_HDD	(p) HDD usage rate	3	Periodic (LLDPDU transmission interval)	L3 Agent -> Manager
htip:X_Power	(q) Remaining battery level	3	Periodic (LLDPDU transmission interval)	L3 Agent -> Manager
htip:X_ComInterval	(r) Sampling interval time and transmission interval time for communication quality information	64	non-periodic (only at the time of setting)	Manager -> L3 Agent (Setting) L3 Agent -> Manager (Reply)
htip:X_SysInterval	(s) Sampling interval time and transmission interval time for device quality information	64	non-periodic (only at the time of setting)	Manager -> L3 Agent (Setting) L3 Agent -> Manager (Reply)

Table 6-1 lists the items of device information, the elements to contain the information, and the maximum lengths of the strings that can be contained in individual elements. The UPnP DM protocol ([11]) should be implemented on L3 Agent to enable L3 Agent to also transmit various items of information other than the device information, which are shown in Table 6-1, to Manager.

If L3 Agent is developed as plug-in software, the device in which to install the plug-in L3 Agent might not be known beforehand when the plug-in L3 Agent is developed. In such cases, a functionality that is closest to that of the plug-in software shall be selected from The List of Device Category ([4]) and described as the device category (a). In addition, the manufacturer code of the software manufacturer shall be described as the manufacture code (b), and the model name and model number of the plug-in software shall be described as the model name (c) and model number (d), respectively.

UDA ([1]) is a document that defines the basic functions of UPnP. Therefore, implementing UPnP Basic, UPnP IGD, UPnP DM, and DLNA devices in compliant with UDA ([1]) is equivalent to implementing the UPnP controlled device functions defined by UDA ([1]). If a UPnP controlled device has already been implemented on an IP Terminal, the device information of the IP Terminal shall be described in the Basic Device Information part in the existing DDD according to the policy described above. If no UPnP device has been implemented on an IP Terminal, a UPnP Basic device ([2]) can be implemented on the IP Terminal effectively to reduce the load of HTIP implementation. This is because the UPnP Basic device, unlike a normal UPnP device, eliminates the need to define control, eventing, and presentation functions.

6.2.1 Transmission of setting information using UPnP controlled device functions ([1])

Manager can transmits setting information by using UPnP controlled device functions ([1]) to L3 Agent on a device

connected toa home network. When Manager uses UPnP controlled device function ([1]), the UPnP controlled device functions defined by UDA ([1]) shall be implemented on Manager. The use of the UPnP controlled device functions [1] is the same as described in 6.2

The L3 Agent that receives the setting information responds with the updated result after reflecting the setting information. Therefore, the UPnP controlled device functions defined by UDA ([1]) shall be implemented on the L3 Agent.

Regarding the sampling interval and transmission interval as communication quality information (s), a character string and a string representing an integer value (0 or more) must be described in the <htip:X_ComInterval> element[2]. The communication quality information includes the channel usage information (e), the Received Signal Strength Indicator (f), the communication error rate information (g), the response time (j), the number of associated devices (k), the number of active nodes (l), the link quality (m), and the number of retransmissions (n).

When the Manager sets the sampling interval to measure the communication quality information, one space character is placed after the character string "Smpl", an integer value representing the sampling interval (milliseconds) after the space character. When setting the transmission interval for the L3 Agent sending the communication quality information to the Manager, one space character is placed after the character string "Send", an integer value representing the transmission interval (milliseconds) after the space character. To set both the sampling interval and the transmission interval, put a single ", (comma)" character between the above two kinds of character strings. Furthermore, put one character ", (comma)" after the above character string and put "000" indicating setting information transmission after one character ", (comma)".

When the L3 Agent responds to the setting of the sampling interval for the communication quality information, one space character is placed after the character string "Smpl", an integer value representing the sampling interval after updating (milliseconds) after the space character. When responding to the setting of the transmission interval for the communication quality information, one space character is placed after the character string "Send", an integer value representing the transmission interval after updating (milliseconds) after the space character. To respond to the setting of the sampling interval and the transmission interval, put a single ", (comma)" character between the above two kinds of character strings. Furthermore, put one character ", (comma)" after the above character string and put an integer value indicating the update result after one character ", (comma)". "000" indicates that no update error exists, and values other than "000" indicate that an error exists. The meaning of values other than "000" is device specific and should be interpreted by obtaining information from equipment vendors. For example, "100" means "no interval changing function", "200" means "setting instruction value is out of the corresponding range", "201" means "sampling interval value is out of the corresponding range", "202" means "transmission interval value is out of the corresponding range", "203" means "out of the corresponding range for both sampling interval value and transmission interval value", "210" means “can not set the sampling interval and transmission interval to different values", "220" means “Transmission interval is longer than sampling interval, buffer shortage", etc. If the setting information can not be reflected, the L3 Agent responds with the latest setting information to the Manager. The following characters can be used for describing the Sampling interval and transmission interval of communication quality information (s). (Optional feature)

[0-9 delmnpS,]

Regarding the sampling interval and transmission interval of device quality information (t), a character string and a string representing an integer value (0 or more) shall be described in the <htip:X_SysInterval> element[2]. The device

quality information includes the status information (h), the CPU usage rate (o), the memory usage rate (p), the HDD usage rate (q), and the remaining battery level (r).

When the Manager sets the sampling interval to measure the device quality information, one space character is placed after the character string "Smpl", an integer value representing the sampling interval (milliseconds) after the space character. When setting the transmission interval for the L3 Agent sending the device quality information to the Manager, one space character is placed after the character string "Send", an integer value representing the transmission interval (milliseconds) after the space character. To set both of the sampling interval and the transmission interval, put a single ", (comma)" character between the above two kinds of character strings. Furthermore, put one character ", (comma)" after the above character string and put "000" indicating setting information transmission after one character "(comma)".

When the L3 Agent responds to the setting of the sampling interval of the device quality information, one space character is placed after the character string "Smpl", an integer value representing the sampling interval after updating (milliseconds) after the space character. When responding to the setting of the transmission interval of the device quality information, one space character is placed after the character string "Send", an integer value representing the transmission interval after updating (milliseconds) after the space character. To respond to the setting of the sampling interval and the transmission interval, put a single ", (comma)" character between the above two kinds of character strings. Furthermore, put one character ", (comma)" after the above character string and put an integer value indicating the update result after one character ", (comma)". "000" indicates that no update error exists, and values other than "000" indicate that an error exists. The meaning of values other than "000" is device specific and can be interpreted by obtaining information from equipment vendors. For example, "100" means "no interval changing function", "200" means "setting instruction value is out of the corresponding range", "201" means "sampling interval value is out of the corresponding range", "202" means "transmission interval value is out of the corresponding range", "203" means "out of the corresponding range for both sampling interval value and transmission interval value", "210" means “can not set the sampling interval and transmission interval to different values", " 220 " means “Transmission interval is longer than sampling interval, buffer shortage", etc. Even when the setting information can not be reflected, the L3 Agent responds with the latest setting information to the Manager. The following characters can be used for describing the Sampling interval and transmission interval of device quality information (t). (Optional feature)

[0-9 delmnpS,]

The following shows an example of the DDD for an HTIP-compliant Manager and L3 Agent. The placeholders described in this example in italics include those described in UDA ([1]).

<friendlyName>*short user-friendly title*</friendlyName>
<manufacturer>*manufacturer name*</manufacturer>
<manufacturerURL>*URL to manufacturer site*</manufacturerURL>
<modelDescription>*long user-friendly title*</modelDescription>
<modelName>model name (c)</modelName>
<modelNumber>model number (d)</modelNumber>
<modelURL>*URL to model site*</modelURL>
<serialNumber> *manufacturer's serial number* </serialNumber>
<UDN>*uuid:UUID*</UDN>
<UPC>*Universal Product Code*</UPC>

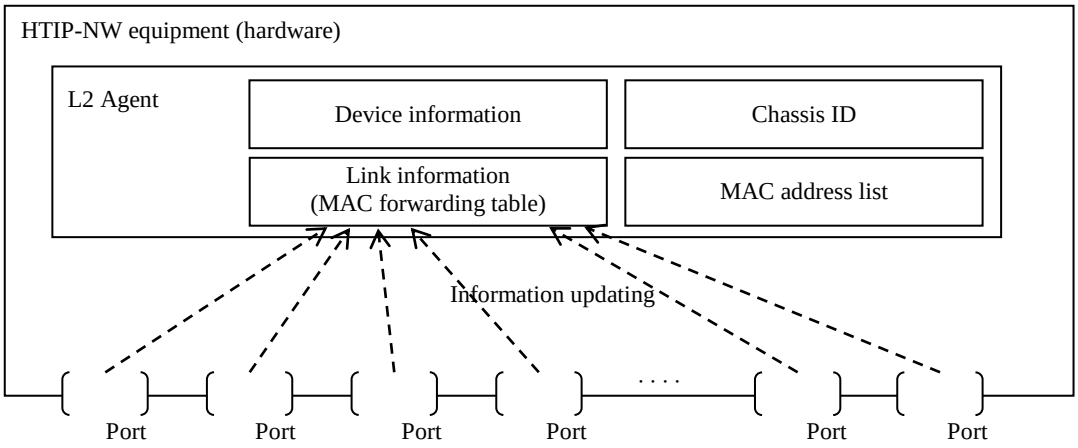
<htip:X_ComInterval xmlns:htip="http://www.ttc.or.jp/Home-network WG/JJ-300.00">sampling interval and transmission interval of communication quality information (s)</htip:X_ComInterval>
<htip:X_SysInterval xmlns:htip="http://www.ttc.or.jp/Home-network WG/JJ-300.00">sampling interval and transmission interval of device quality information (t)</htip:X_SysInterval>
<iconList>
<icon>
<mimetype>*image/format*</mimetype>
<width>*horizontal pixels*</width>
<height>*vertical pixels*</height>
<depth>*color depth*</depth>
<url>*URL to icon*</url>
</icon>
XML to declare other icons, if any, go here
</iconList>

6.3 Transmission of device and link information from L2 Agent

L2 Agent must transmit device and link information to Manager by using LLDP ([7]). There is also another possible method to use LLDP ([7]) only for transmission of the address of an HTIP-NW equipment or HTIP-IP Terminal on which L2 Agent resides and use SNMP ([9]) for transmission of device and link information. The possible method might be defined in the next or later version of HTIP. This version of HTIP uses only LLDP ([7]) to transmit device and link information.

Figure 6-2 shows a topology of an HTIP-NW equipment and a L2 Agent. Basically, The L2 Agent transmits device or link information etc. from all ports of the HTIP-NW equipment via LLDP Agents (in transmit-only mode) defined by IEEE 802.1AB ([7]).

(a) Flow of information when the MAC forwarding table information is updated



(b) Flow of information when LLDPDU frames are transmitted

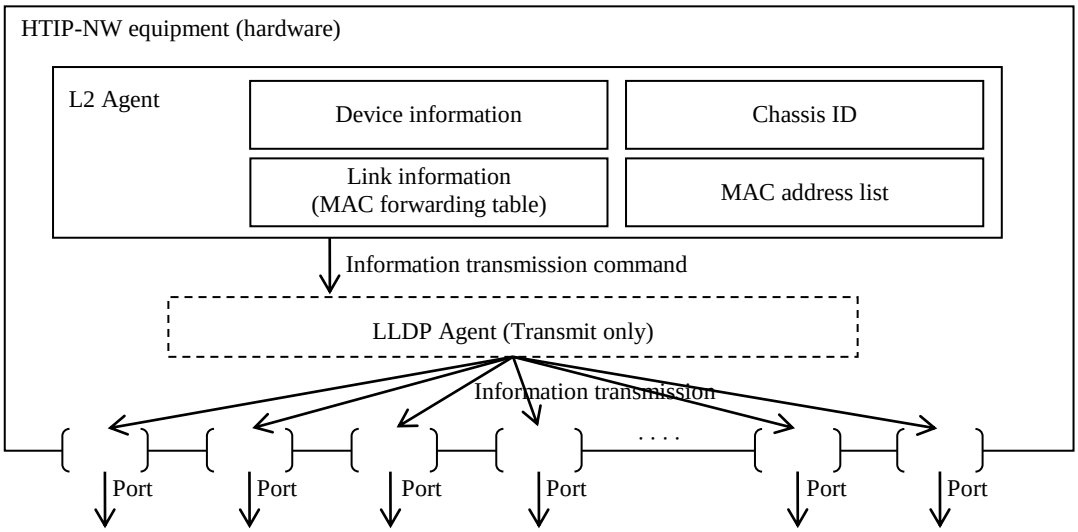


Figure 6-2 Architecture of HTIP-NW equipment and L2 Agent

More than one LLDP Agent can be installed in an HTIP-NW equipment. However, one LLDP Agent shall manage one MAC address. One LLDP Agent may be installed separately for each port on an HTIP-NW equipment, or only one LLDP Agent may be installed for all ports as shown in Figure 6-2. The number of LLDP Agents on an HTIP-NW

equipment shall be determined depending on the implementation condition.

The L2 Agent on an HTIP-NW equipment retains at least such management objects as the chassis ID that can identify the HTIP-NW equipment, link information, a list of the HTIP-NW equipment's own MAC addresses (hereinafter called the "MAC address list"), and device information. IEEE 802.1AB ([7]) also defines various other management objects (LLDP MIB ([7])). However, whether to incorporate the management objects defined by IEEE 802.1AB ([7]) shall be determined depending on the implementation condition because whether they can be incorporated also depends on the device performance. The L2 Agent transmits management objects to individual LLDP Agents. Then, the LLDP Agents store the management objects in LLDPDU frames and transmits them from ports the LLDP Agents manage. This enables the L2 Agent to transmit the management objects from all ports of the HTIP-NW equipment.

(a) Flow of information when LLDPDU frames are transmitted

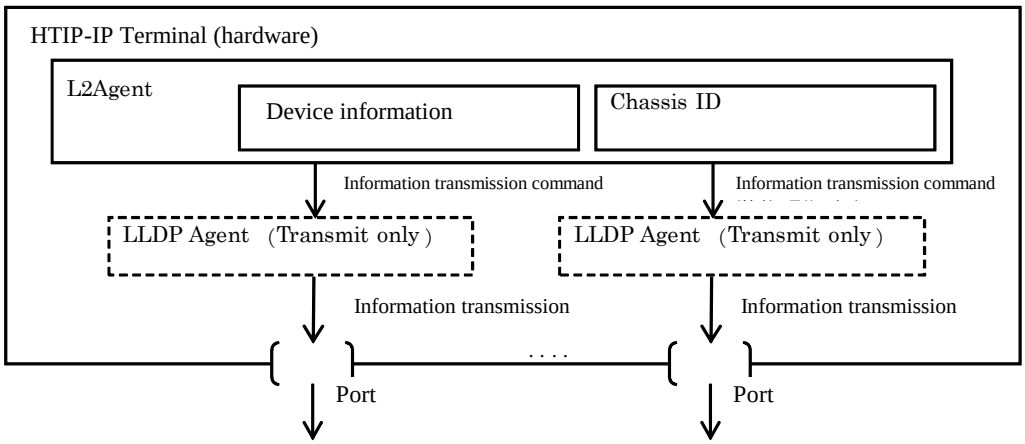


Figure 6-3 Architecture of HTIP-IP Terminal and L2 Agent

Figure 6-3 shows the architecture of HTIP-IP Terminal and L2 Agent. The L2 Agent transmits the device information and other information from all the ports of the HTIP-IP Terminal via the LLDP Agent (transmit only mode) defined by IEEE 802.1AB [7]. More than one LLDP Agent can be installed in the HTIP-IP Terminal. Note that each LLDP Agent shall manage a single MAC address. The HTIP-IP Terminal may have an LLDP Agent for each of its ports, as shown in Figure 6-3, or a single LLDP Agent for all its ports. The number of LLDP Agents in the HTIP-IP Terminal shall be determined depending on the implementation condition.

The L2 Agent in the HTIP-IP Terminal shall retain at least a chassis ID that can identify the HTIP-IP Terminal and the device information as management objects. IEEE 802.1AB [7] defines various management objects (LLDP MIB [7]). Whether to incorporate the management objects defined by IEEE 802.1AB [7] shall be determined depending on the implementation condition because whether they can be incorporated depends on the terminal performance. The L2 Agent transmits to each LLDP Agent the management object information that may include information unique to each communication interface (port). Each LLDP Agent stores those management objects in LLDPDU frames and transmits them from the port that LLDP Agent manages. In the case of port-specific information, the LLDP Agent selects and transmits the information related to only the corresponding port. It shall be made possible for Manager to identify the port corresponding to the LLDPDU by the HTIP-IP Terminal including the Port ID TLV of the LLDP in the LLDPDU to indicate the transmission port. This enables the L2 Agent to transmit the management object information from all the ports of the HTIP-IP Terminal.

After L2 Agent has started, each LLDP Agent must transmit an LLDPDU frame when the timer count reaches 0

periodically or when a change is observed in the management objects each LLDP Agent retains. The interval of LLDPDU transmission shall be determined depending on the implementation condition. For the detailed timing and method of transmission, see IEEE 802.1AB ([7]). (In IEEE 802.1AB ([7]), a transmission interval of 30 seconds is recommended.) The transmission interval can be transmitted using the LLDPDU TLV.

Figure 6-4 shows the structure of the LLDPDU frame that is transmitted from L2 Agent. The fields from "Destination MAC Address" to "LLDP Ethertype" make up the Ethernet header. Basically, L2 Agent sets the destination MAC address in the Ethernet header to "FF-FF-FF-FF-FF-FF", which is the broadcast address defined by IEEE 802.3 ([6]) as shown in Table 6-2. With reference to IEEE 802.1D ([5]), the NW equipment that receives the LLDPDU frame shall perform an action in accordance with the address group (shown in Table 6-2 in this specification) that includes the destination MAC address of the received LLDPDU frame. The source MAC address in the Ethernet header is the MAC address of the relevant port.

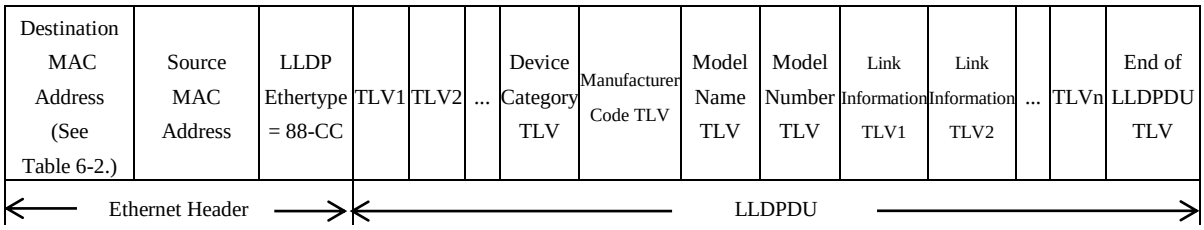


Figure 6-4 LLDPDU frame structure

Table 6-2 Destination MAC address

Name	Value
Group Address: Broadcast address	FF-FF-FF-FF-FF-FF

When HTIP is used in the data link layer that cannot directly transmit an Ethernet frame including the LLDPDU (e.g., 802.15.4), the Ethernet frame may be transferred using an encapsulation protocol over the IP on the assumption that the device in which the L2 Agent resides is capable of IP communication. When an encapsulation protocol is used, it is required to support GRE [12] as an encapsulation protocol and any other encapsulation protocol may also be used.

When GRE is used as an encapsulation protocol, Checksum, Routing, Key, Sequence Number, and Strict Source Route in the GRE header shall not be used, Recursion Control, Flags, and Version Number shall all be set to 0, and Protocol Type shall be set to 0x6558 (Transparent Ethernet Bridging). The destination IP address of the GRE packet shall be the broadcast IP address (255.255.255.255 or subnet broadcast address) for IPv4 or the multicast address for all nodes on the local link (ff02::1) for IPv6. The TTL in the IP header shall be set to 1 so that the packet is not transferred beyond the link layer broadcast domain. The source IP address of the GRE packet shall be the IP address of the communication interface via which the encapsulated packet is transmitted. As for those LLDP frames to be encapsulated, the destination MAC address shall be as defined in Table 6-2 and the source MAC address shall be 02:00:00:00:00:00 (locally assigned MAC address). Manager shall identify the transmission source device of the encapsulated LLDP frame based on the Chassis ID TLV contained in the LLDPDU and the transmission port based on the Port ID TLV.

Several examples are given below to explain how GRE packets are processed. What is referred to as an intermediate device below is a device capable of transferring IP packets via a bridge (including transfer between a data link layer using LoWPAN [13] and a non-LoWPAN data link layer) to enable an application in the home network to accomplish IP communication.

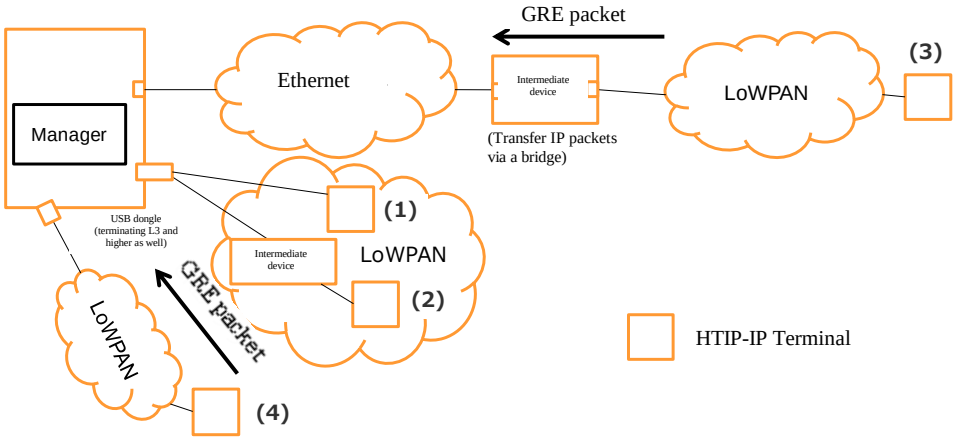


Figure 6-5 Network topology assumed for examples of GRE packet processing

(1) Case in which the device that has the Manager installed directly accommodates the non-Ethernet data link layer and is connected to the HTIP-IP Terminal via a single hop

The device that has the Manager installed receives the GRE packet, retrieves LLDP frames from the GRE packet, and processes them.

(2) Case in which the device that has the Manager installed directly accommodates the non-Ethernet data link layer and is connected to the HTIP-IP Terminal via two hops

The device that has the Manager installed receives the GRE packet transferred via a bridge, retrieves LLDP frames from the GRE packet, and processes them.

When the L2 Agent is installed in the intermediate device, the intermediate device also receives the GRE packet, retrieves LLDP frames from the GRE packet and processes them. The information acquired by the intermediate device is transmitted to the Manager using extension link information.

(3) Case in which the device that has the Manager installed is connected to the HTIP-IP Terminal via two hops through an intermediate device that bridges the Ethernet and non-Ethernet data link layers

The device that has the Manager installed receives the GRE packet transferred via a bridge, retrieves LLDP frames from the GRE packet, and processes them.

When the L2 Agent is installed in the intermediate device, the intermediate device also receives the GRE packet, retrieves LLDP frames from the GRE packet and processes them. The information acquired by the intermediate device is transmitted to the Manager using extension link information.

(4) Case in which the device that has the Manager installed is connected to the non-Ethernet data link layer via a USB dongle that terminates not only the non-Ethernet data link layer but also an upper layer protocol (e.g., ECHONET Lite) and is connected to the HTIP-IP Terminal via a single hop

The USB dongle that terminates not only the non-Ethernet data link layer but also an upper layer protocol receives the GRE packet, retrieves LLDP frames from the GRE packet, and processes them. The LLDP frame information is transmitted via the interface for HTIP information transmission to the device that has the Manager installed.

L2 Agent uses the vendor-specific extension fields (TLV Type = 127) defined by IEEE 802.1AB ([7]) as shown in Figure 6-6 to transmit device and link information as TLVs. These TLVs contain the TTC OUI code "E0-27-1A" and the information defined by TTC. The length of strings in a TLV must be represented in units of octet. For details of the notation method, see IEEE 802.1AB ([7]).

The LLDPDU must store the TLVs that are defined as required TLVs by IEEE 802.1AB ([7]). See Section 6.3.1 for

how to use the required TLVs (TLV Type = 0 to 3) and optional TLVs. In addition, each single LLDPDU that is transmitted from the LLDP Agent on the HTIP-NW equipment must always include the TLVs containing the device category (a), manufacturer code (b), model name (c), model number (d), and device ID defined in Section 6.3.2 as well as the TLV to store the link information defined in Section 6.3.3. Each single LLDPDU transmitted from the LLDP Agent on the HTIP-IP Terminal must always include the TLVs containing the device category (a), manufacturer code (b), model name (c), model number (d), and device ID defined in Section 6.3.2. Table 6-3 lists the values of the TTC Subtype shown in Figure 6-6. When the TTC Subtype is "1", the TLV indicates device information. When the TTC Subtype is "2", the TLV indicates link information.

If an LLDPDU frame contains too many TLVs and its length exceeds 1,500 bytes, L2 Agent must control the number of TLVs to reduce the LLDPDU frame length to 1,500 bytes or less, without transmitting the frame in segments. How to select the TLVs to be removed from the LLDPDU frame longer than 1,500 bytes shall be determined depending on the implementing condition.

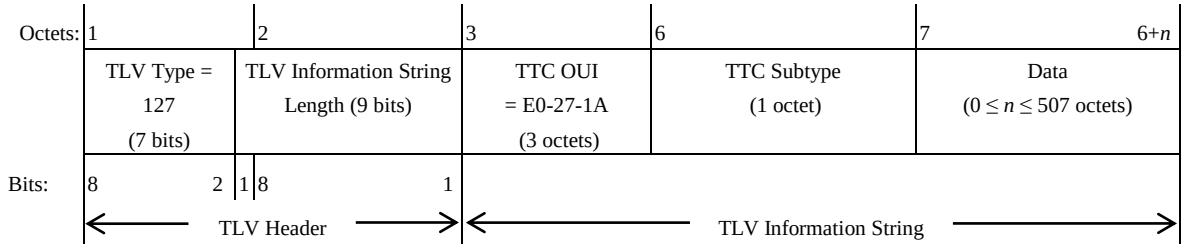


Figure 6-6 Usage of vendor-specific extension fields

Table 6-3 Correspondence of TTC Subtype values and the information to be stored

TTC Subtype	Data	Required, recommended, or optional	Reference section
1	Device information	Required	Section 6.3.2
2	Link information	Required for the HTIP-NW equipment; not required for the HTIP-IP Terminal	Section 6.3.3
3	MAC address list	Optional	Section 6.3.4
4	Extension link information	Optional for the HTIP-NW equipment; not required for the HTIP-IP Terminal	Section 6.3.5
5	Extension MAC address list	Optional for the HTIP-NW equipment; not required for the HTIP-IP Terminal	Section 6.3.6
6	Setting information	Optional	Section 6.3.7
0 or 7-255	Reserved		

As an optional implementation, the L2 Agent can also transmit by unicast, device information, link information, etc.

In that case, the L2 Agent sets the destination MAC address of the Ethernet header as shown in Table 6-4.

Table 6-4 Destination MAC address

Name	Value
Individual address	destination MAC address

In the case of using the destination MAC address in Table 6-4, When GRE is used as an encapsulation protocol, the destination IP address of the GRE packet shall be the specific IP address of the destination as both IPv4 and IPv6. As for those LLDP frame to be encapsulated, the destination MAC address shall be as defined in Table 6-4 and the destination MAC address.

6.3.1 Description format of required and optional TLVs defined by IEEE 802.1AB ([7])

LLDPDU must always include the four TLVs (TLV Type = 0 to 3) that are defined as required TLVs by IEEE 802.1AB ([7]). Although the TLV whose TLV Type is "4" is not defined as required by IEEE 802.1AB ([7]), the TLV should be implemented as described below.

- TLV of TLV Type = 0 (End Of LLDPDU TLV [7])

  As defined by IEEE 802.1AB, the TLV whose TLV Type is "0" must contain zeroes in the 2-octet field. For details, see IEEE 802.1AB ([7]).

- TLV of TLV Type = 1 (Chassis ID TLV [7])

  The TLV whose TLV Type is "1" must contain the ID to identify an HTIP-NW equipment in the home network. This specification stipulates that one MAC address (Chassis ID Subtype = 4) of ports of the HTIP-NW equipment must be set as the ID of the HTIP-NW equipment in the TLV of TLV Type = 1 defined by IEEE 802.1AB ([7]). When the HTIP-NW equipment or HTIP-IP Terminal has multiple LLDP Agents and multiple MAC addresses, a representative MAC address must be selected and stored in the TLV. IEEE 802.1AB ([7]) stipulates that the TLV whose TLV Type is "1" is required and LLDPDU frame can contain only one TLV whose TLV Type is "1". Therefore, this TLV (TLV Type = 1) cannot be used to transmit any other information than the ID identifying the HTIP-NW equipment or HTIP-IP Terminal. This TLV contains the same value for all LLDPDUs transmitted from individual LLDP Agents belonging to an HTIP-NW equipment or HTIP-IP Terminal. Even when ports of the HTIP-NW equipment or HTIP-IP Terminal are interchanged, the chassis ID must not be changed.

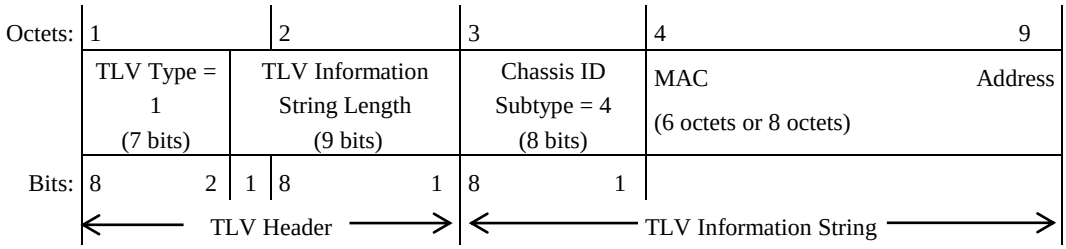


Figure 6-7 TLV that contains the ID (MAC address)

The above description is intended for a data link layer that uses the MAC addresses defined by IEEE Std 802 (MAC48, EUI48, EUI64). When the L2 Agent handles any other data link layer, a locally assigned value must be used as the chassis ID (Chassis ID Subtype = 7). Since a locally assigned value is defined as an alphanumeric string by IEEE 802.1AB [7], a string that represents each octet of the representative

MAC address as a two-digit hexadecimal number (00 to FF) must be used as the chassis ID. This TLV value must be the same for all LLDPDUs that are transmitted from each LLDP Agent that belongs to the HTIP-NW equipment or HTIP-IP Terminal. Even if the ports of the HTIP-NW equipment or HTIP-IP Terminal are changed, the chassis ID must not be changed.

- TLV of TLV Type = 2 (Port ID TLV [7])

  The TLV whose TLV Type is "2" must contain the ID to identify a port (or an interface or an HTIP-NW equipment), but its value shall be determined depending on the mounting condition. For details, see IEEE 802.1AB ([7]). Because the value of this TLV is prepared for each LLDP Agent, the value may possibly be varied by LLDPDU transmitted from each LLDP Agent.

- TLV of TLV Type = 3 (Time To Live TLV [7])

  The TLV whose TLV Type is "3" must contain a TTL value, but the value shall be determined depending on the mounting condition. For details, see IEEE 802.1AB ([7]). Because the value of this TLV is prepared for each LLDP Agent, the value may possibly be varied by LLDPDU transmitted from each LLDP Agent.

- TLV of TLV Type = 4 (Port Description TLV [7])

  The TLV whose TLV Type is "4" must contain the interface information of the port LLDP Agent manages. The description format of this TLV shall be determined depending on the implementation condition, but the communication standard information of the port LLDP Agent manages should be described in this TLV. Examples of the information include "HD-PLC" or "HomePlug" for power line communication and "802.11 b/g/n" for wireless communication. The interface standard name corresponding to the port must be described in the data part of this TLV by using the string format shown in Table A. If the port complies with multiple interface standards, multiple strings indicating the names of the standards must be described in the data part of this TLV. Because the value of this TLV is prepared for each LLDP Agent, the value may possibly be varied by LLDPDU transmitted from each LLDP Agent. The ASCII character set must be used for describing the value of this TLV. The following characters can be used:

  #x20 | [a-zA-Z0-9] | [-'()+,./:=?;!*#@$_%]

6.3.2 Device information transmission using LLDP

Figure 6-8 shows the TLV format to store device information. IDs are assigned to individual items of device information, and the data corresponding to each ID is stored by using a TLV format. Table 6-5 lists device information IDs and the corresponding items of device information to be stored.

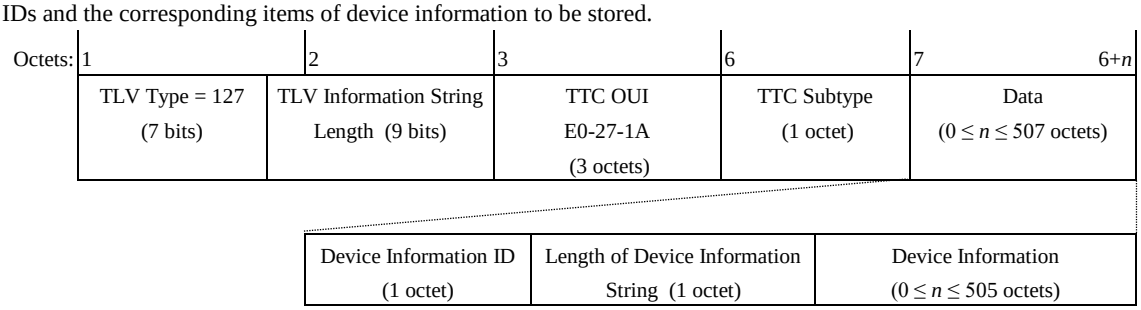


Figure 6-8 Device information TLV using device information ID

Table 6-5 Correspondence of device information IDs and the device information to be stored

Device information ID	Device information	Required, recommended, or optional
1	Device category	Required
2	Manufacturer code	Recommended
3	Model name	Recommended
4	Model number	Required
20	Channel usage information	Optional
21	Radio signal strength information	Optional
22	Communication error rate information	Optional
23	Response time	Optional
24	Number of associated devices	Optional
25	Number of active nodes	Optional
26	Link quality	Optional
27	Number of retransmissions	Optional
50	Status information	Optional
51	CPU usage rate	Optional
52	Memory usage rate	Optional
53	HDD usage rate	Optional
54	Remaining battery level	Optional
80	LLDPDU transmission interval	Optional
255	Vendor-specific extension field	
0, 5-19, 28-49, 55-79, or 81-254	Reserved	

The following defines the formats of TLVs and value descriptions for the device information listed in Table 6-5:

- TLV for the device category (a) of HTIP-NW equipment or HTIP-IP Terminal

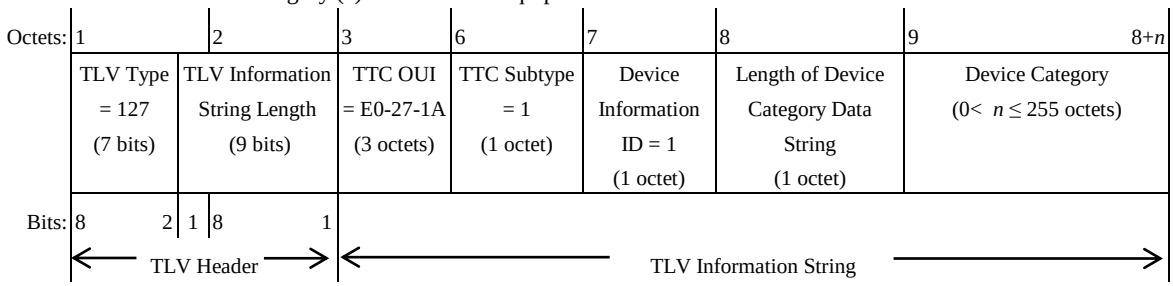


Figure 6-9 TLV to store the device category (a)

Regarding the device category (a), The List of Device Category ([4]) must be referenced, and only the value of the category of the relevant device must be described in the same manner as described in Section 6.2. When describing multiple values of categories, the values must be separated by a comma (,). LWS must not be inserted before and after each comma. The ASCII character set must be used for describing the device category. The following characters can be used:

[a-zA-Z0-9] | [-'()+./:=?;!*#@$_%]

- TLV for the manufacturer code (b) of HTIP-NW equipment or HTIP-IP Terminal

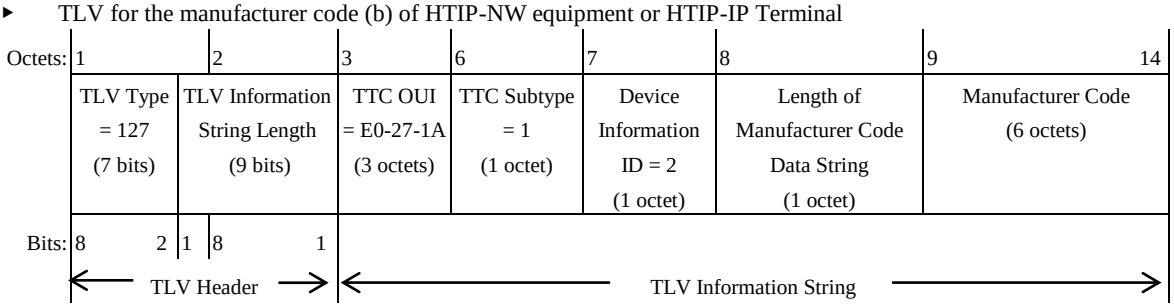


Figure 6-10 TLV to store the manufacturer code (b)

Regarding the manufacturer code (b), only the relevant company ID registered with the IEEE must be described in the same manner as described in Section 6.2. If the manufacturer of the installed device has not obtained a registered manufacturer code, the TLV (TLV Type = 127) for the manufacturer code shall not be stored in the LLDPDU frame or, even when the TLV (TLV Type = 127) for the manufacturer code is stored in the LLDPDU frame, the data part to contain the manufacturer code shall be set to null (by setting the data length in the 8th octet to "0"). The ASCII character set must be used for describing the manufacturer code (b). The following characters can be used:

[a-fA-F0-9]

- TLV for the model name (c) (series or brand name) of HTIP-NW equipment or HTIP-IP Terminal

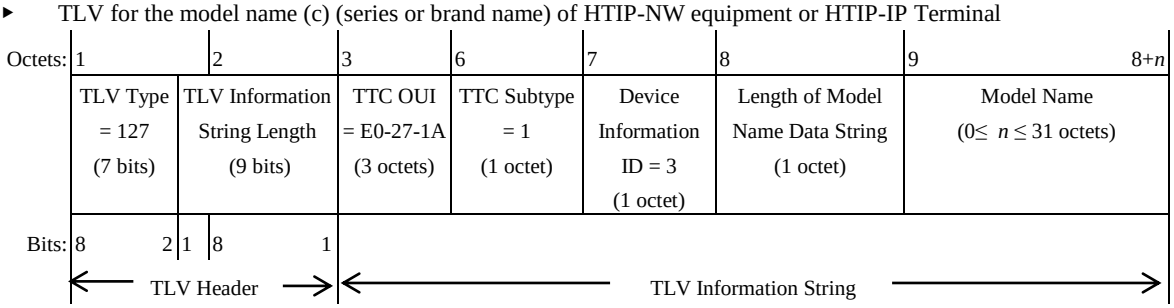


Figure 6-11 TLV to store the model name (c)

Regarding the model name (c), only the model name must be described in the same manner as described in Section 6.2. If the HTIP-NW equipment does not have any name corresponding to the model name, the TLV (TLV Type = 127) for model name shall not be stored in the LLDPDU frame or, even when the TLV (TLV Type = 127) for model name is stored in the LLDPDU frame, the data part to contain the model name shall be set to null (by setting the data length in the 8th octet to "0").

- TLV for the model number (d) of HTIP-NW equipment or HTIP-IP Terminal

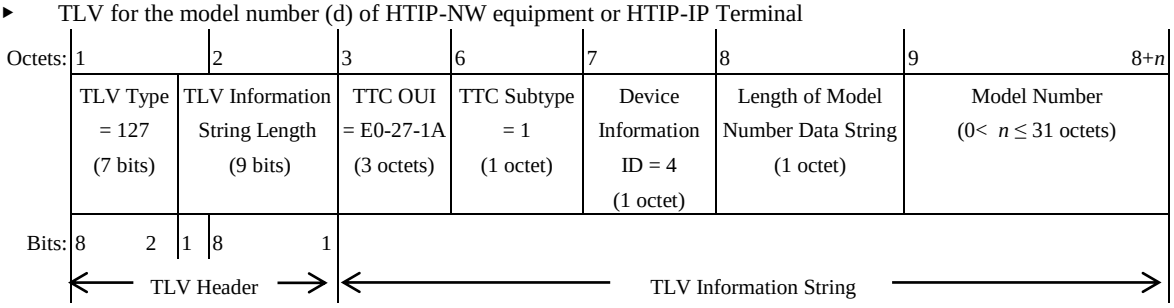


Figure 6-12 TLV to store the model number (d)

Regarding the model number (d), only the model number must be described in the same manner as described in Section 6.2. The ASCII character set must be used for describing the model name (c) and model number (d). The following characters can be used:

[a-z-Z0-9] | [-'()+,./:=?;!*#@$_%]

- TLV for the channel usage information (e) of HTIP-IP Terminal

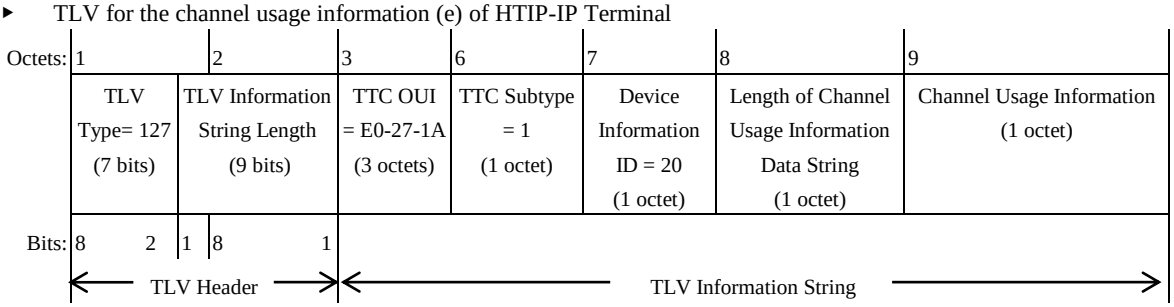


Figure 6-13 TLV to store the channel usage information (e)

Regarding the channel usage information (e), binary data of one octet representing an unsigned integer value (0 to 100) must be set. The smaller the value is, the less frequently the channel is used. A value equal to or larger than 75 indicates that it is undesirable to use the channel for communication. (Optional feature)

- TLV for the radio signal strength information (f) of HTIP-IP Terminal

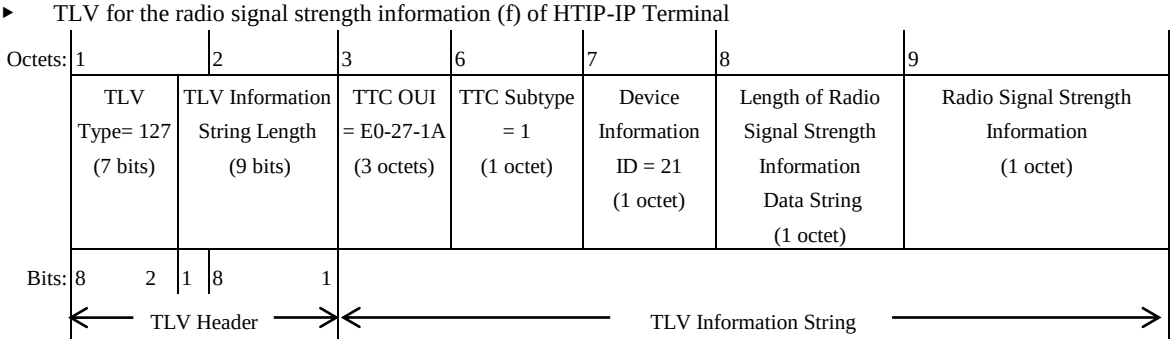


Figure 6-14 TLV to store the radio signal strength information (f)

Regarding the radio signal strength information (f), binary data of one octet representing an unsigned integer value (0 to 100) must be set. A larger value indicates greater radio signal strength. A value equal to or smaller than 25 indicates that the radio signal strength is not suitable for communication. (Optional feature)

- TLV for the communication error rate information (g) of HTIP-IP Terminal

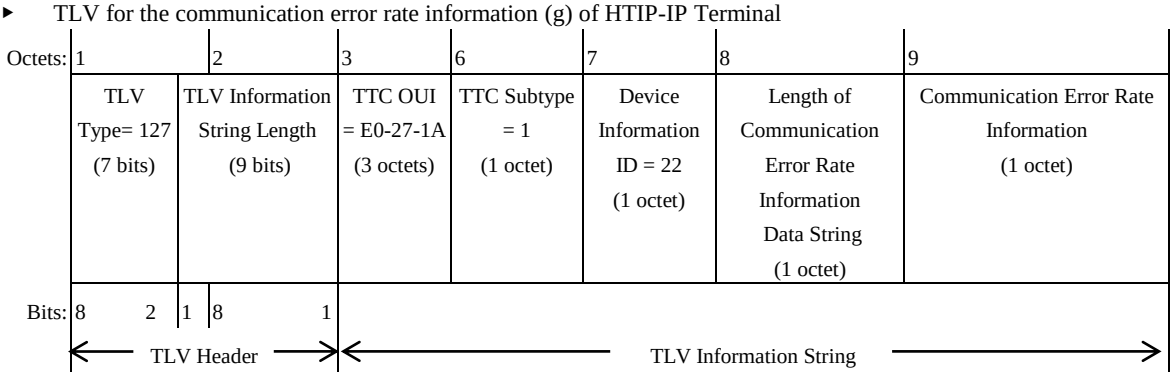


Figure 6-15 TLV to store the communication error rate information (g)

Regarding the communication error rate information (g), binary data of one octet representing an unsigned integer value (0 to 100) must be set. A larger value indicates more errors. A value equal to or larger than 75 indicates that the communication error rate is not suitable for communication. (Optional feature)

- TLV for the status information (h) of HTIP-IP Terminal and HTIP-NW equipment

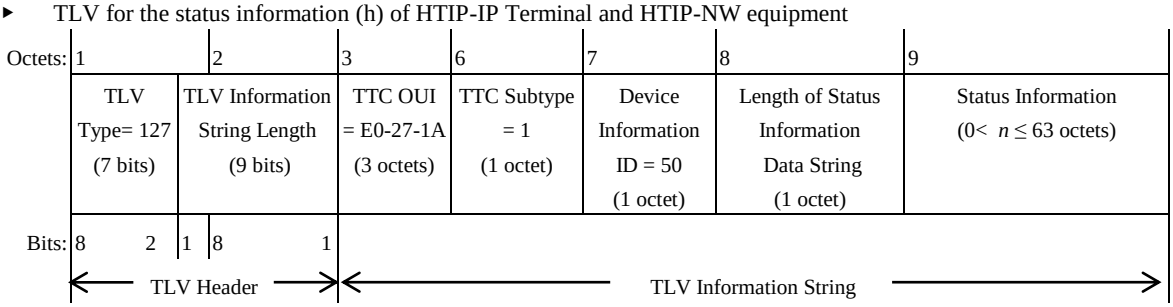


Figure 6-16 TLV to store the status information (h)

When the status information (h) is used, binary data of one octet representing an unsigned integer value (0 to 255) must always be set. 0 indicates that there is no error, and a value other than 0 indicates that there is one or more errors. The values other than 0 are unique to each device and can be interpreted by acquiring the necessary information from the device vendor. A desired alphanumeric text string can be put after the unsigned integer value. When the length of the status information data string is greater than 1, the applicable string is the second and subsequent octets of the status information data. The following characters can be used for describing a desired alphanumeric text string. (Optional feature)

[0-9 a-zA-Z.,!? /*+-]

- TLV for the LLDPDU transmission interval (i) of HTIP-IP Terminal and HTIP-NW equipment

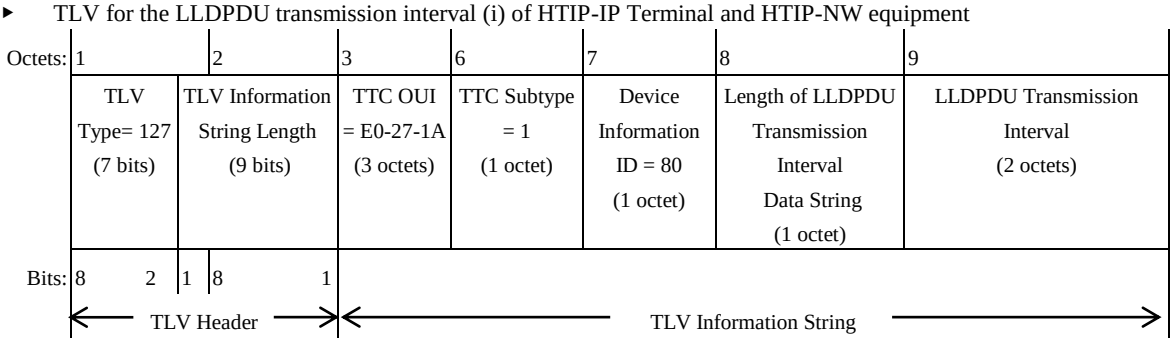


Figure 6-17 TLV to store the LLDPDU transmission interval (i)

When the LLDPDU transmission interval (i) is used, binary data of two octets representing an unsigned integer value (1 to 65535) that shows the transmission interval in seconds must be set. (Optional feature)

- TLV for the response time (j) of HTIP-NW equipment and HTIP-IP Terminal

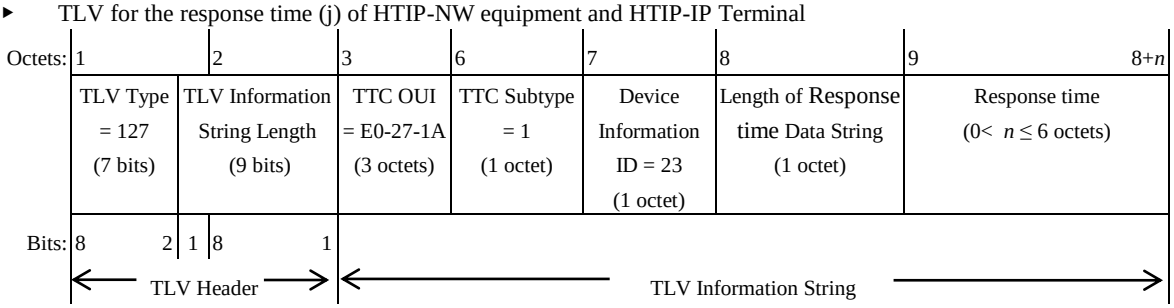


Figure 6-18 TLV to store the response time (j)

When the response time (j) is used, binary data of 1 octet or more representing an unsigned integer value (0 or more) that shows the response time in millisecond must be set. (Optional feature)

- TLV for the number of associated devices (k) of HTIP-NW equipment

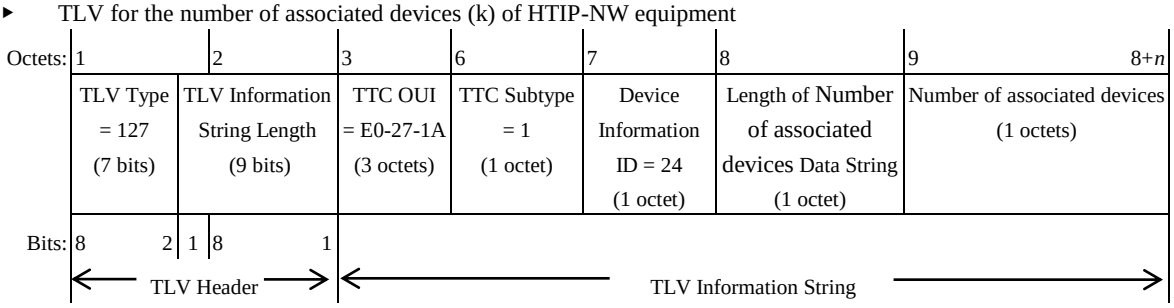


Figure 6-19 TLV to store the number of associated devices (k)

When the number of associated devices (k) is used, binary data of 1 octet representing an unsigned integer value (0 or more) that shows the number of associated devices must be set. (Optional feature)

- TLV for the number of active nodes (l) of HTIP-NW equipment

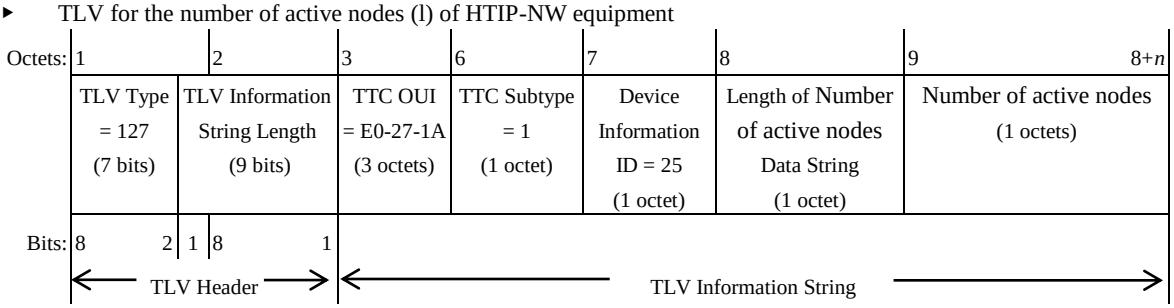


Figure 6-20 TLV to store the number of active nodes (l)

When the number of active nodes (l) is used, binary data of 1 octet representing an unsigned integer value (0 or more) that shows the number of devices communicated within a specific time must be set. (Optional feature)

- TLV for the link quality (m) of HTIP-NW equipment and HTIP-IP Terminal

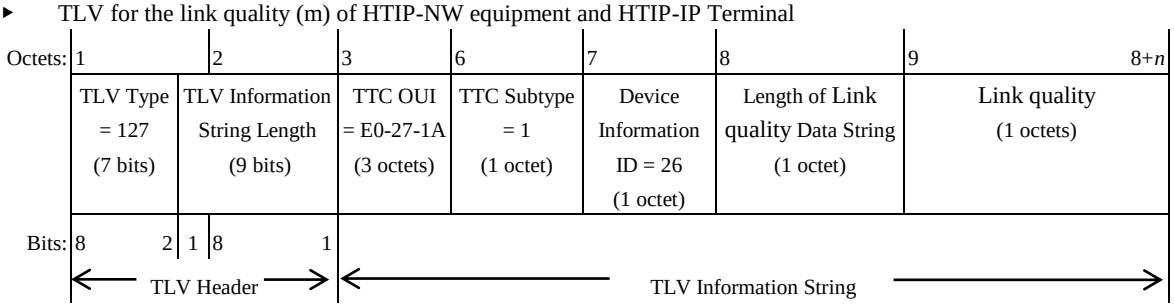


Figure 6-21 TLV to store the link quality (m)

When the link quality (m) is used, binary data of 1 octet representing an unsigned integer value (0 to 100) that shows the link quality must be set. The larger value, indicates that the quality is good. A value less than or equal to 25 indicates that the link quality is not suitable for communication. (Optional feature)

- TLV for the number of retransmissions (n) of HTIP-NW equipment and HTIP-IP Terminal

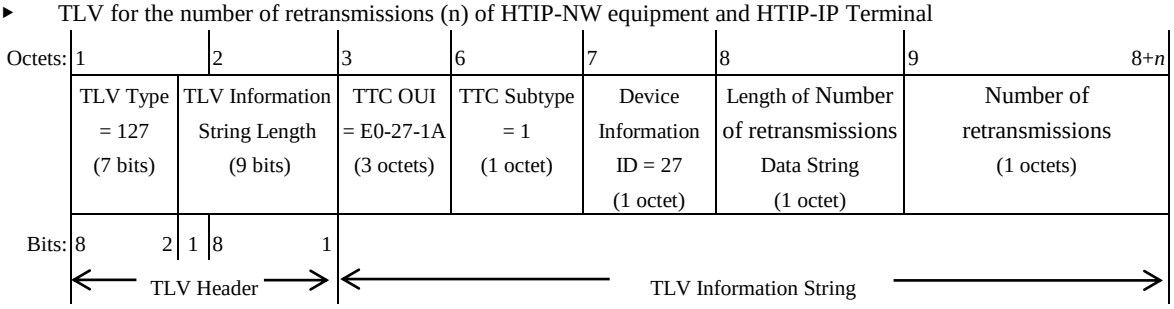


Figure 6-22 TLV to store the number of retransmissions (n)

When the number of retransmissions (n) is used, binary data of 1 octet representing an unsigned integer value (0 or more) that shows the number of retransmissions must be set. (Optional feature)

- TLV for the CPU usage rate (o) of HTIP-NW equipment and HTIP-IP Terminal

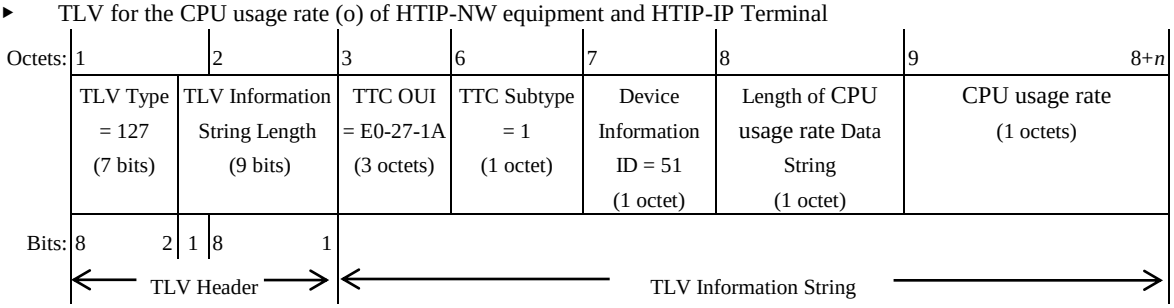


Figure 6-23 TLV to store the CPU usage rate (o)

When the CPU usage rate (o) is used, binary data of 1 octet representing an unsigned integer value (0 to 100) that shows the CPU usage rate must be set. The larger value, higher the CPU usage rate, indicating poor performance. A value of 75 or more indicates that performance is not suitable for operation. (Optional feature)

- TLV for the memory usage rate (p) of HTIP-NW equipment and HTIP-IP Terminal

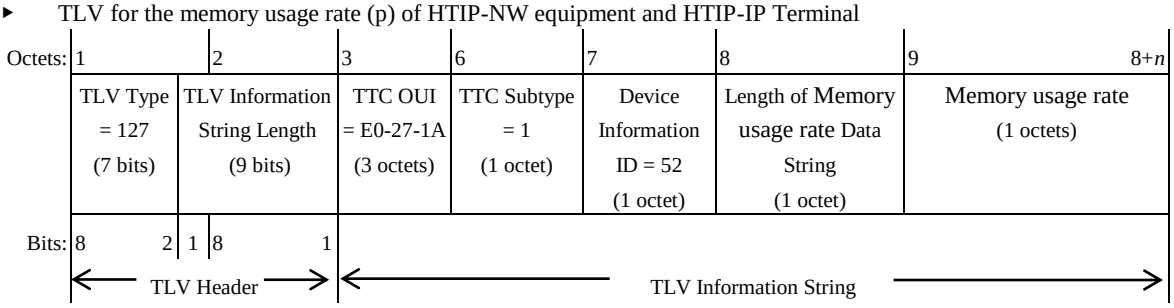


Figure 6-24 TLV to store the memory usage rate (p)

When the memory usage rate (p) is used, binary data of 1 octet representing an unsigned integer value (0 to 100) that shows the memory usage rate must be set. The larger value, higher the memory usage rate, indicating poor performance. A value of 75 or more indicates that performance is not suitable for operation. (Optional feature)

- TLV for the HDD usage rate (q) of HTIP-NW equipment and HTIP-IP Terminal

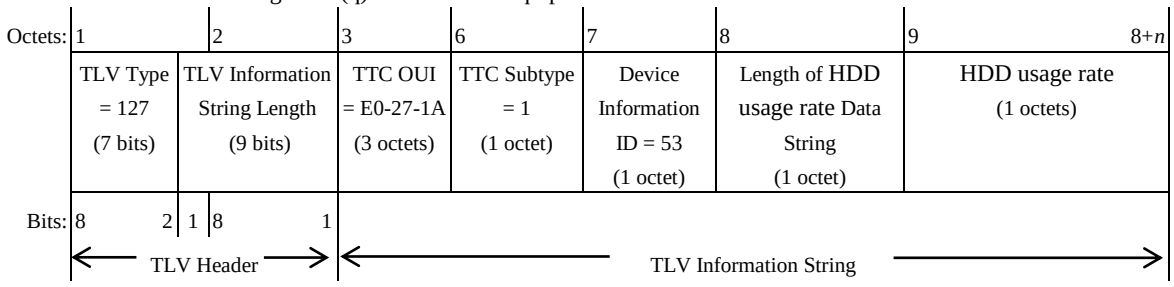


Figure 6-25 TLV to store the HDD usage rate (q)

When the HDD usage rate (q) is used, binary data of 1 octet representing an unsigned integer value (0 to 100) that shows the HDD usage rate must be set. The larger value, higher the HDD usage rate, indicating

poor performance. A value of 75 or more indicates that performance is not suitable for operation. (Optional feature)

- TLV for the remaining battery level (r) of HTIP-NW equipment and HTIP-IP Terminal

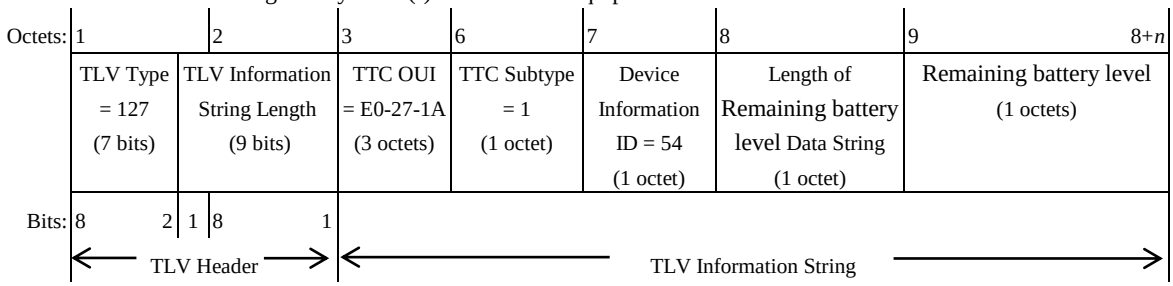


Figure 6-26 TLV to store the remaining battery level (r)

When the remaining battery level (r) is used, binary data of 1 octet representing an unsigned integer value (0 to 100) that shows the remaining battery level must be set. The larger value, indicating more the remaining battery power. A value less than or equal to 25 indicates that the battery level is low. (Optional feature)

- Method of uniquely defining the device information other than device information (a) to (r)

Figure 6-27 shows the data structure of the TLV that must be created when transmitting device information other than the device information (a) to (r) to Manager. "255" must be stored as the device information ID in the 7th octet. The IEEE OUI code indicating the name of the company or organization that uniquely defined the device information must be described by using 6 octets of ASCII characters. Then, the device information type specified by the company or organization that uniquely defined the device information, the length of data part, and the data must be stored.

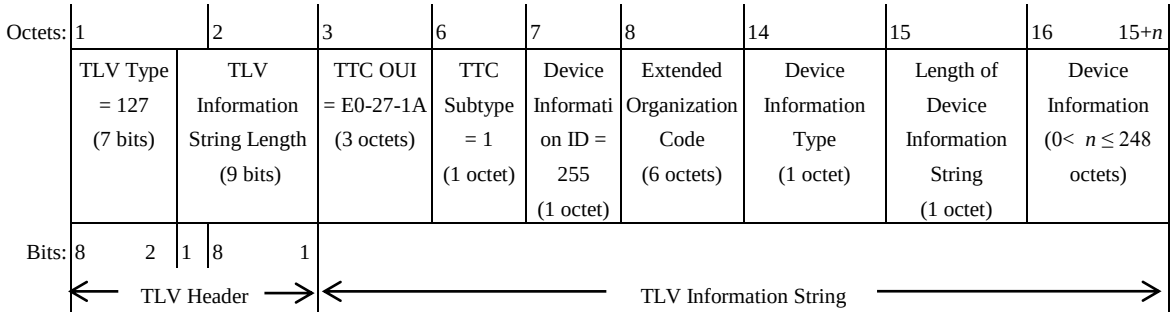


Figure 6-27 TLV for the uniquely defined device information to be transmitted

6.3.3 Link information transmission using LLDP

As with the device information, the L2 Agent on the HTIP-NW equipment must transmit to Manager, the IP Terminal connected to each port of the HTIP-NW equipment or the information of the MAC forwarding table in which the MAC address information of the HTIP-NW equipment is collected. For each port of the HTIP-NW equipment, the TLV shown below must be stored in the LLDPDU frame. Assume, for example, that the HTIP-NW equipment has multiple ports connecting UTP cables (hereinafter called "UTP ports") and a wireless port. When two IP Terminals are connected to UTP port 1, one IP Terminal is connected to UTP port 2, and two IP Terminals are connected to the wireless port, only a total of three MAC forwarding table TLVs shown below may be stored in the LLDPDU port. L2

Agent must store the three MAC forwarding table TLVs together with device information in the LLDPDU frame. For the port that connects nothing, the MAC forwarding table TLV need not be stored or, even when stored, "0" may be set in the "9+m+n"th octet (indicating the number of MAC addresses) of the TLV. By obtaining the link information, Manager can create a home network topology diagram.

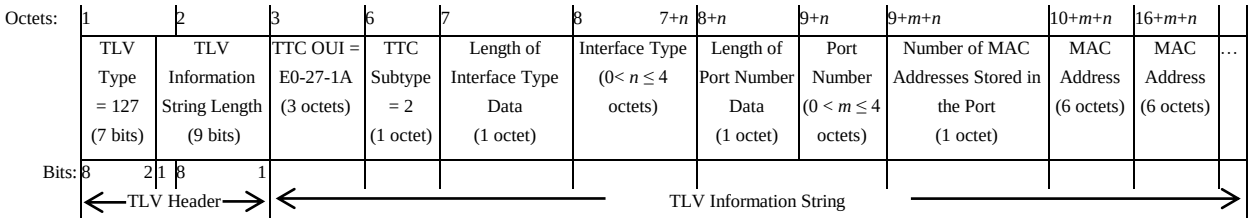


Figure 6-28 MAC forwarding table TLV

- Length of interface type data (1 octet)

  Specify the length of the interface type data string.

- Interface type (up to 4 octets)

  Specify the interface type of the port. Refer to IANAifType ([8]) for interface types, and describe the number corresponding to the interface type by binary notation.

  IANAifType ([8]) defines interface types for wired line (UTP cable), wireless line, power line, and coaxial cable as described below. To specify the interface type of the port, use the number (shown below) that corresponds to the interface type of the port. In the following description, parenthesized explanations are excerpts from IANAifType ([8]).

  Wired line: 6 (*ethernetCsmacd, -- for all ethernet-like interfaces, -- regardless of speed, as per RFC3635*)

  Wireless line: 71 (*ieee80211, -- radio spread spectrum*)

  PLC: 174 (*plc, -- Power Line Communications*)

  Coaxial cable: 236 (*mocaVersion1, --MultiMedia over Coax Alliance (MoCA) Interface, -- as documented in information provided privately to IANA*)

- Length of port number data (1 octet)

  Specify the length of the port number data string.

- Port number (up to 4 octets)

  Store the port number by binary notation. The port number is used to identify a port on an HTIP-NW equipment that has multiple ports of the same interface type (i.e., UTP ports) as in the case of a switch. The port number must be an integer value 0 or more and should be the same as the port number indicated on the HTIP-NW equipment cabinet.

  For an interface type that has only one port, "0" must be stored. When, for example, a switch has four UTP ports and one wireless port, port numbers must be assigned to the ports as shown in Table 6-6 below. Because there is only one wireless port, "0" must be assigned to that port.

Table 6-6 Example of port number assignment

Port Number	Interface Type (description in IANAifType ([8]))
1	6 (ethernetCsmacd)
2	6 (ethernetCsmacd)
3	6 (ehternetCsmacd)
4	6 (ethernetCsmacd)
0	71 (ieee80211)

- Number of MAC addresses stored in the port (1 octet)

  In the MAC forwarding table, specify the number of MAC addresses stored in the port.

- MAC address (6 octets)

  In the MAC forwarding table, specify the MAC addresses stored in the port.

6.3.4 MAC address list transmission from HTIP-NW equipment using LLDP

L2 Agent transmits the MAC address list of ports of an HTIP-NW equipment to enable Manager to identify the topology of a home network more accurately. The TLV is effective when the home network has an NW equipment that has a MAC copy function and the HTIP-NW equipment where the L2 Agent resides has two or more MAC addresses.

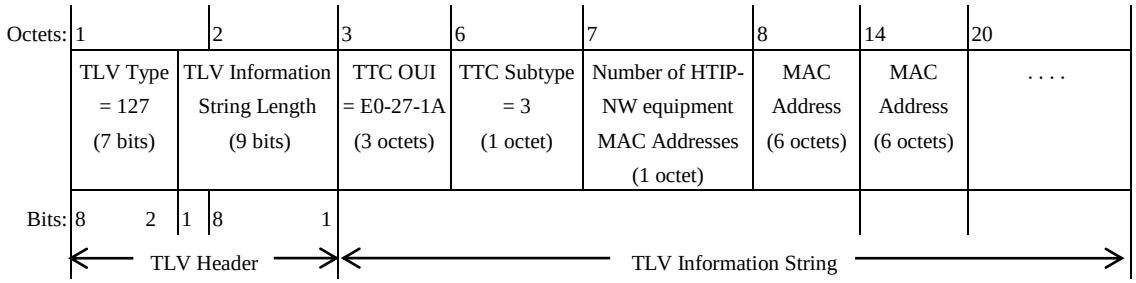


Figure 6-29 MAC address of NW equipment

6.3.5. Extension link information transmission using LLDP

The link information transmission defined in Section 6.3.3 is for the Ethernet data link layer. This section defines extension link information transmission for a non-Ethernet data link layer or for the purpose of transmitting pairing information and channel usage information (port-specific information), as well as radio signal strength information and communication error rate information (peer entity-specific information) etc, all of which are useful information for fault isolation in a home network, including those cases where the transmission is for the Ethernet data link layer.

To prevent an implementation compliant with an old standard from becoming completely unable to interpret the extension link information transmission compliant with a new standard as port-specific and peer entity-specific information that can be transmitted through the extension link information transmission is added as a result of a future revision of this standard, the following rules are set that must be observed when revising the extension link information transmission.

- None of the existing information must be deleted; new information must be added after the existing information.
- The format of added information must be: Length (1 octet) + data.

Fields are provided to indicate the number of information sets contained as port-specific information and the number

of information sets contained as peer entity-specific information. Therefore, as long as the revision rules above are observed, the implementation can handle the extension link information transmission compliant with a later version than that it complies with, by skipping uninterpretable information based on the length information, without generating an error, even if there are more information than the implementation can interpret when interpreting the extension link information transmission. When the implementation handles the extension link information transmission compliant with an older version than that it complies with, less information than the implementation can interpret may be contained. In this case, the implementation must also handle the contained information without generating an error.

The L2 Agent on the HTIP-NW equipment can transmit, to Manager, the information in the extension MAC forwarding table in which the MAC address information of the terminals or the HTIP-NW equipment connected to each port of the HTIP-NW equipment and information useful for fault isolation are stored. For each port, the TLV shown below must be stored in the LLDPDU frame. Assume, for example, that a certain HTIP-NW equipment has two wireless ports. When two terminals are connected to wireless port 1 and one terminal is connected to wireless port 2, it is sufficient to store a total of two extension MAC forwarding table TLVs shown below. The L2 Agent must store these two extension MAC forwarding table TLVs in the LLDPDU frame, together with device information. For a port for which pairing information exists but which is not connected to anything, it is sufficient to set "0" in the 10+m+nth octet (indicating the number of MAC addresses) of the extension MAC forwarding table shown in Figure 6-30. For a port for which pairing information does not exist and which is not connected to anything, the TLV does not need to be stored or, even when stored, it is sufficient to set "0" as both the number of MAC addresses stored in this port and the number of MAC addresses to be registered in pair with this port. By obtaining this extension link information, Manager can create a home network topology diagram and acquire information useful for fault isolation.

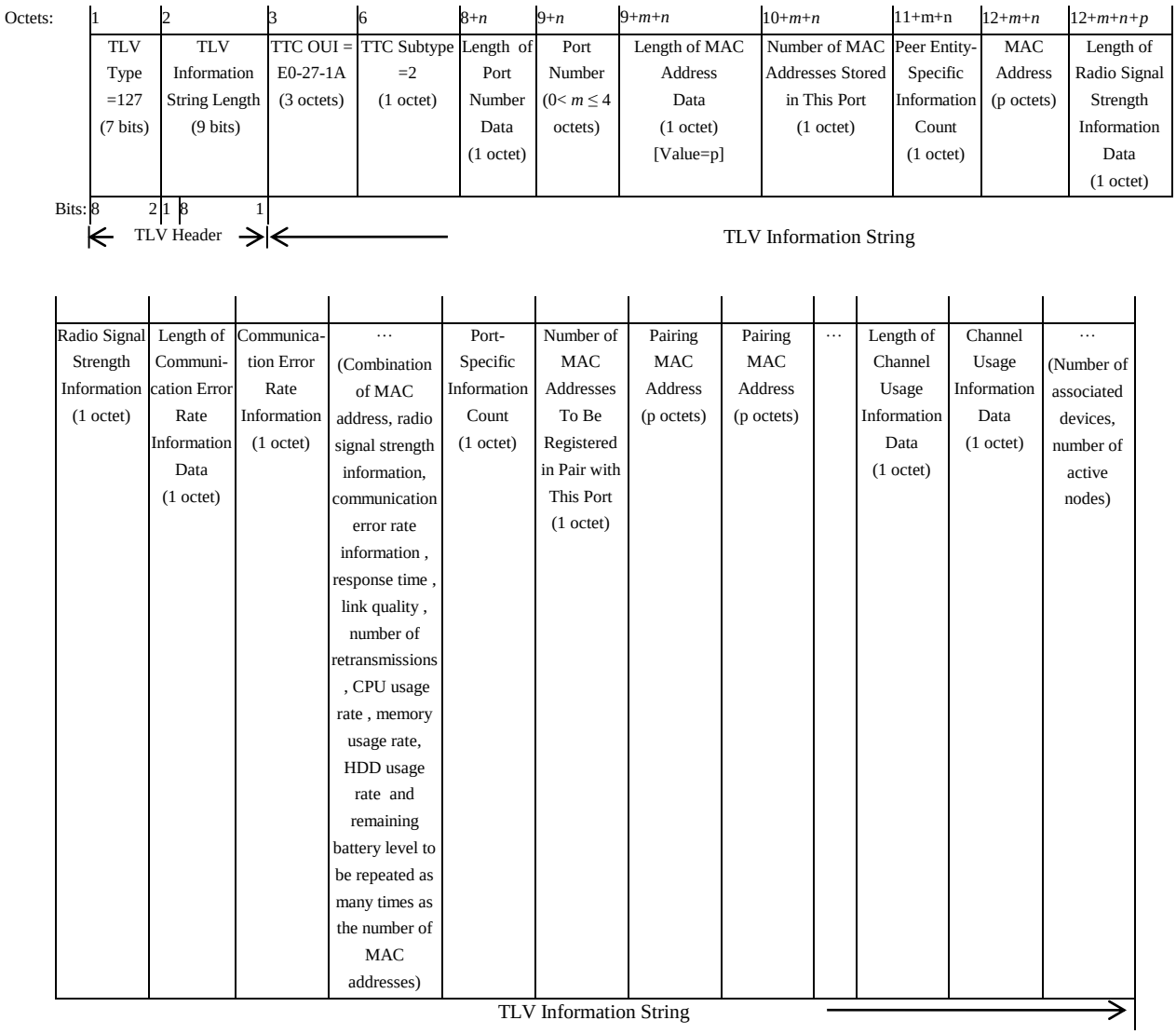


Figure 6-30 Extension MAC forwarding table TLV

- Length of the interface type data (1 octet)

  Specify the length of the interface type data string.

- Interface type (up to 4 octets)

  Store the interface type of the port. Refer to IANAifType [8] for interface types, and describe the number corresponding to the interface type in binary notation.

  IANAifType [8] defines interface types for wired line (UTP cable), wireless line, power line, and coaxial cable as described below. Use one of the numbers shown below that corresponds to the interface type of the port. In the following description, parenthesized explanations are excerpts from IANAifType [8].

  Wired line: 6 (*ethernetCsmacd, -- for all ethernet-like interfaces, -- regardless of speed, as per RFC3635*)

  Wireless line: 71 (*ieee80211, -- radio spread spectrum*)

  PLC: 174 (*plc, -- Power Line Communications*)

  Coaxial cable: 236 (*mocaVersion1, --MultiMedia over Coax Alliance (MoCA) Interface, -- as documented in information provided privately to IANA*)

- Length of the port number data (1 octet)

  Specify the length of the port number data string.

- Port number (up to 4 octets)

  Store the port number. Describe the number in binary notation. In the case of an HTIP-NW equipment that has multiple ports of the same interface type (UTP port), as in a switching hub, this number is used to identify each port. The port number must be an integer value equal to or larger than 0 and should be the same as the port number indicated on the HTIP-NW equipment chassis.

  For an interface type that has only one port, "0" must be stored. When, for example, a switching hub has four UTP ports and one wireless port, port numbers must be assigned to the ports as shown in Table 6-7 below. Because there is only one wireless port, "0" must be assigned to that port.

Table 6-7 Examples of port number assignment

Port Number	Interface Type (Description in IANAifType [8])
1	6 (ethernetCsmacd)
2	6 (ethernetCsmacd)
3	6 (ehternetCsmacd)
4	6 (ethernetCsmacd)
0	71 (ieee80211)

- Length of the MAC address data (1 octet)

  Show the length of the MAC address data of this port in the data link layer in octets.

- Number of MAC addresses stored in this port (1 octet)

  Number of MAC addresses stored in this port in the MAC forwarding table. The combination of the MAC address and peer entity-specific information count information (in the format of Length [1octet] + data) is repeated as many times as the number of MAC addresses. Specify 0 or a larger value.

- Peer entity-specific information count

  Number of information sets (in the format of Length [1octet] + data) contained for the peer entity indicated by the MAC address in the MAC forwarding table. In this version, this value must be set to "2". The implementation of this standard must handle an information count different from that defined for the version that it complies with, without generating an error.

- MAC address

  MAC address stored in this port in the MAC forwarding table. The data size of a single MAC address must be equal to the number of octets indicated by the length of the MAC address data.

- Length of the radio signal strength information data (1 octet)

  Show the length of the radio signal strength information data of the peer entity indicated by the MAC address in octets. If the radio signal strength information does not exist, specify "0".

- Radio signal strength information data

  Show the radio signal strength information data of the peer entity indicated by the MAC address. Binary data of one octet representing an unsigned integer value (0 to 100) must be set. A larger value indicates greater radio signal strength. A value equal to or smaller than 25 indicates that the radio signal strength is not suitable for communication.

- Length of the communication error rate information data (1 octet)

  Show the length of the communication error rate information data of the peer entity indicated by the MAC address in octets. If the communication error rate information does not exist, specify "0".

- Communication error rate information data

  Show the communication error rate information data of the peer entity indicated by the MAC address. Binary data of one octet representing an unsigned integer value (0 to 100) must be set. A larger value indicates more errors. A value equal to or larger than 75 indicates that the communication error rate is not suitable for communication.

- Length of the response time data (1 octet)

  Show the length of the response time data of the peer entity indicated by the MAC address in octets. If the response time does not exist, specify "0".

- Response time data

  Show the response time data of the peer entity indicated by the MAC address. Binary data of 1 to 6 octets representing an unsigned integer value (0 or more) indicating milliseconds must be set.

- Length of the link quality data (1 octet)

  Show the length of the link quality data of the peer entity indicated by the MAC address in octets. If the link quality does not exist, specify "0".

- Link quality data

  Show the link quality data of the peer entity indicated by the MAC address. Binary data of one octet representing an unsigned integer value (0 to 100) must be set. The larger value, indicates that the quality is good. A value less than or equal to 25 indicates that the link quality is not suitable for communication.

- Length of the number of retransmissions data (1 octet)

  Show the length of the number of retransmissions data of the peer entity indicated by the MAC address in octets. If the number of retransmissions does not exist, specify "0".

- Number of retransmissions data

  Show the number of retransmissions data of the peer entity indicated by the MAC address. Binary data of one octet representing an unsigned integer value (0 or more) indicating number of retransmissions must be set.

- Length of the CPU usage rate data (1 octet)

  Show the length of the CPU usage rate of the peer entity indicated by the MAC address in octets. If the CPU usage rate does not exist, specify "0".

- CPU usage rate data

  Show the CPU usage rate data of the peer entity indicated by the MAC address. Binary data of one octet representing an unsigned integer value (0 to 100) must be set. The larger value, higher the CPU usage rate, indicating poor performance. A value of 75 or more indicates that performance is not suitable for operation.

- Length of the memory usage rate data (1 octet)

  Show the length of the memory usage rate of the peer entity indicated by the MAC address in octets. If the memory usage rate does not exist, specify "0".

- Memory usage rate data

  Show the memory usage rate data of the peer entity indicated by the MAC address. Binary data of one octet representing an unsigned integer value (0 to 100) must be set. The larger value, higher the memory

usage rate, indicating poor performance. A value of 75 or more indicates that performance is not suitable for operation.

- Length of the HDD usage rate data (1 octet)

  Show the length of the HDD usage rate of the peer entity indicated by the MAC address in octets. If the HDD usage rate does not exist, specify "0".

- HDD usage rate data

  Show the HDD usage rate data of the peer entity indicated by the MAC address. Binary data of one octet representing an unsigned integer value (0 to 100) must be set. The larger value, higher the HDD usage rate, indicating poor performance. A value of 75 or more indicates that performance is not suitable for operation.

- Length of the remaining battery level data (1 octet)

  Show the length of the remaining battery level of the peer entity indicated by the MAC address in octets. If the remaining battery level does not exist, specify "0".

- Remaining battery level data

  Show the remaining battery level data of the peer entity indicated by the MAC address. Binary data of one octet representing an unsigned integer value (0 to 100) must be set. The larger value, indicating more the remaining battery power. A value less than or equal to 25 indicates that the battery level is low.

- Port-specific information count

  Number of port-related information sets contained (in the format of Length [1octet] + data, excluding the information of the MAC address to be registered in pair). In this version, this value must be set to "2". The implementation of this standard must handle an information count different from that defined for the version that it complies with, without generating an error.

- Number of MAC addresses to be registered in pair with this port (1 octet)

  Number of MAC addresses to be registered in pair with this port. The MAC address to be registered in pair is repeated as many times as the number of MAC addresses. Specify 0 or a larger value.

- Pairing MAC address

  MAC address to be registered in pair with this port. The data size of a single MAC address must be equal to the number of octets indicated by the length of the MAC address data.

- Length of the channel usage information data (1 octet)

  Show the length of the channel usage information data of this port in octets. If the channel usage information does not exist, specify "0".

- Channel usage information data

  Show the channel usage information data of this port. Binary data of one octet representing an unsigned integer value (0 to 100) must be set. The smaller the value is, the less frequently the channel is used. A value equal to or larger than 75 indicates that it is undesirable to use the channel for communication.

- Length of the number of associated devices data (1 octet)

  Show the length of the number of associated devices data of this port in octets. If the number of associated devices does not exist, specify "0".

- Number of associated devices data

  Show the number of associated devices data of this port. Binary data of one octet representing an unsigned integer value (0 or more) indicating the number of associated devices must be set.

- Length of the number of active nodes data (1 octet)

Show the length of the number of active nodes data of this port in octets. If the number of active nodes does not exist, specify "0".

- Number of active nodes data

  Show the number of active nodes data of this port. Binary data of one octet representing an unsigned integer value (0 or more) indicating the number of devices communicated within a specific time must be set.

Since the size of the Value field of the extension MAC forwarding table TLV is not more than 511 octets, all the information about a port may not be able to be stored in a single extension MAC forwarding table TLV, if many MAC addresses are to be registered for that port. In that case, multiple extension MAC forwarding table TLVs of the same port number may be contained in a single LLDPDU and the information of that port may be expressed as the union of information contained in multiple extension MAC forwarding table TLVs. Or, a MAC address for transmitting the information may be selected using an implementation-dependent method.

6.3.6. Transmission of the HTIP-NW equipment extension MAC address list using LLDP

The MAC address list transmission defined in Section 6.3.4 is for the Ethernet data link layer. This section defines the extension MAC address list transmission for a non-Ethernet data link layer.

Sending the MAC address list of ports of the HTIP-NW equipment to Manager enables the L2 Agent to identify the home network topology more accurately. This TLV is effective when the HTIP-NW equipment in which the L2 Agent resides has two or more MAC addresses.

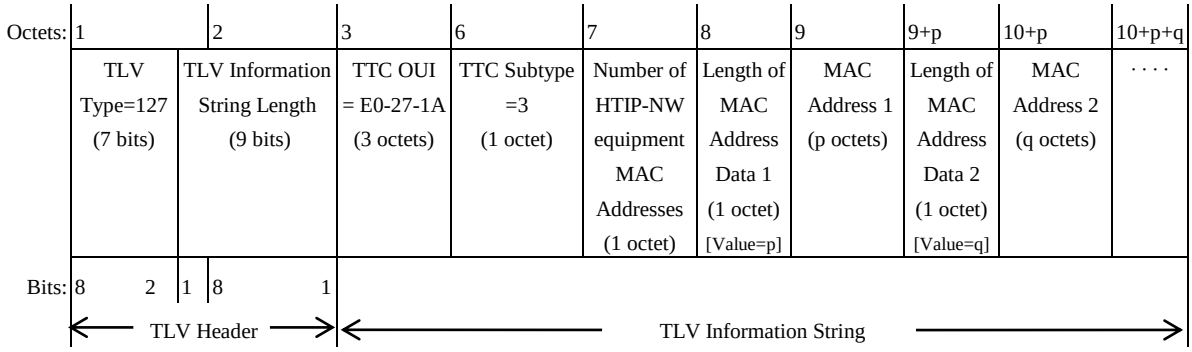


Figure 6-31 NW equipment extension MAC address

In the extension MAC address TLV shown in Figure 6-31, the combination of [Length of MAC address data n, MAC address n] is repeated as many times as the number of HTIP-NW equipment MAC addresses. The length of MAC address data n is the length of the MAC address data in the data link layer expressed in octets, and MAC address n expresses the MAC address with binary data representing the number of octets indicated by the length of MAC address data n. In order to handle the case where HTIP-NW equipment has multiple ports and the data link layer differs for each port (bridge transfer is performed between different data link layers through L2 address translation), the length of the MAC address data must be specified for each MAC address.

Since the size of the Value field of the extension MAC address list TLV is not more than 511 octets, all the information about an HTIP-NW equipment may not be able to be stored in a single extension MAC address list TLV, if that HTIP-NW equipment has many MAC addresses. In that case, multiple extension MAC address list TLVs may be contained in a single LLDPDU and the information of that HTIP-NW equipment may be expressed as the union of

information contained in multiple extension MAC address list TLVs. Or, a MAC address for transmitting the information may be selected using an implementation-dependent method.

6.3.7. Setting information transmission using LLDP

The Manager can transmit to L2 Agent of the setting information. When setting information is transmitted, the L2 Agent should transmit by unicast. The setting information includes the setting of the sampling interval or the transmission interval of the communication quality related information such as the channel use state information and the setting of the sampling interval or the transmission interval of the terminal quality related information such as the status information. By setting the sampling interval or transmission interval, it is possible to lower the network load and to grasp the device state more accurately.

Upon receiving the setting information, the L2 Agent reflects each sampling interval or transmission interval and then responds with the unicast of the update result.

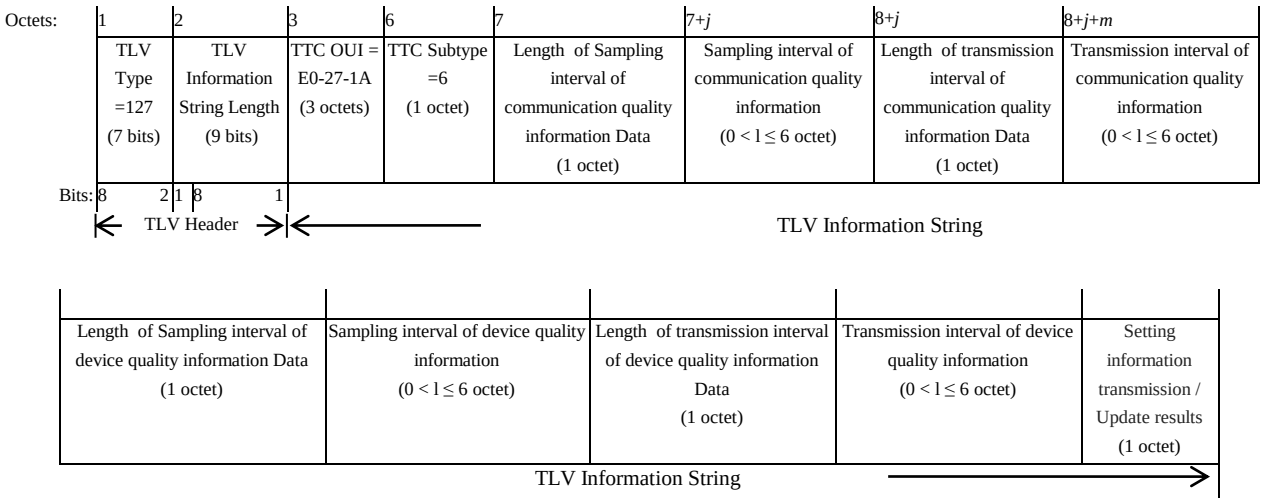


Figure 6-32 Setting infomation TLV

- Length of the Sampling interval of communication quality information data (1 octet)

  Describing the length of character string of sampling interval data of communication quality related information. The communication quality information refers to the channel usage information (e), the Received Signal Strength Indicator (f), the communication error rate information (g), the response time (j), the number of associated devices (k), the number of active nodes (l), the link quality (m), and the number of retransmissions (n).

  The sampling interval is an interval for measuring the above communication quality related information.

- Sampling interval of communication quality information data (MAX 6 octets)

  The sampling interval (milliseconds) of the communication quality related information is stored.

- Length of the Transmission interval of communication quality information data (1 octet)

  Describing the length of character string of transmission interval data of communication quality related information.

  The transmission interval is the interval at which the L2 Agent transmits the communication quality related information to the Manager.

- Transmission interval of communication quality information data (MAX 6 octets)

The transmission interval (milliseconds) of the communication quality related information is stored.

- Length of the Sampling interval of device quality information data (1 octet)

  Describing the length of character string of sampling interval data of device quality related information. The device quality information refers to the status information (h), the CPU usage rate (o), the memory usage rate (p), the HDD usage rate (q), and the remaining battery level (r).

  The sampling interval is an interval for measuring the above device quality related information.

- Sampling interval of device quality information data (MAX 6 octets)

  The sampling interval (milliseconds) of the device quality related information is stored.

- Length of the Transmission interval of device quality information data (1 octet)

  Describing the length of character string of transmission interval data of device quality related information.

  The transmission interval is the interval at which the L2 Agent transmits the device quality related information to the Manager.

- Transmission interval of device quality information data (MAX 6 octets)

  The transmission interval (milliseconds) of the device quality related information is stored.

- Setting information transmission / update result (1 octet)

  When the Manager transmits setting information to the L2 Agent, describe "000".

  When the L2 Agent responds to the Manager with the update result of the setting information, describe an integer value indicating the update result. "000" indicates that no update error exists, and values other than "000" indicate that an error exists. The meaning of values other than "000" is device specific and can be interpreted by obtaining information from equipment vendors.

  Example: "100" means "no interval changing function", "200" means "setting instruction value is out of the corresponding range", "201" means "sampling interval value is out of the corresponding range", "202" means "transmission interval out of the corresponding range", "203" means "out of the corresponding range for both sampling interval value and transmission interval value", "210" means “can not set the sampling interval and transmission interval to different values", "220" means “Transmission interval is longer than sampling interval, buffer shortage", etc.

7. Connectivity Test between Manager and Agent

If a problem occurs in an IP service used in a home network after Manager has identified the topology of the home network, the connectivity check by Manager for a specific L3 Agent or L2 Agent has a beneficial effect on locating the problem in the home network. The connectivity test checks whether frames and packets can be normally transferred in the data link and higher layers between two terminals.

7.1 Connectivity test for L3 Agent

Examples of connectivity test implementations include two methods. One is the connectivity test in which Manager retries to collect device information from L3 Agent. The other is the connectivity test in which Manager transmits an echo request message on ICMP ([10]) to L3 Agent and then receives an echo reply message on ICMP ([10]). The connectivity test through the collection of device information can be implemented with reference to Section 6.2.

The connectivity test using ICMP ([10]) enables a simple check on connectivity when Manager knows the IP address of the target IP Terminal. L3 Agent can transmit the IP address of the HTIP-IP Terminal, where the L3 Agent resides, to Manager by using the discovery function of UDA ([1]). This enables Manager to retain the tables of the IP

addresses and device information of the L3 Agents in the home network.

Using the device information table, Manager can specify the IP address of a target L3 Agent and transmit an ICMP echo request message to the IP address. Upon receiving the ICMP echo request message, the L3 Agent should return an ICMP echo reply message to Manager. Manager may determine that the connectivity with the L3 Agent is normal when Manager receives the ICMP echo reply message from the L3 Agent. Manager can determine that the connectivity is lost when Manager cannot receive the ICMP echo reply message from the L3 Agent within a specified time. The time to wait shall be specified depending on the implementation condition. For the connectivity test using ICMP ([10]), Manager should also consider the traffic of the home network adequately.

7.2 Connectivity test for L2 Agent

As described in Section 6.3.1, Manager can retain the ID (chassis ID stored in the TLV of TLV Type = 1) of the L2 Agent in the home network. Since an L2 Agent transmits LLDPDU to Manager at fixed intervals, Manager can determine that the connectivity with the target L2 Agent is normal when Manager receives an LLDPDU frame including the ID of the target L2 Agent. Manager can determine that the connectivity is lost when Manager cannot receive the LLDPDU frame including the ID of the target L2 Agent within the period of TTL included in the LLDPDU. Or, when the TLV of the LLDPDU transmission interval is included in the LLDPDU transmitted by the L2 Agent, connectivity may be considered to have been lost if an LLDPDU is not received for the duration equal to the time indicated by the TLV of the LLDPDU transmission interval multiplied by a constant (the value of the constant is to be determined depending on the implementation condition).

8. Implementation List

To comply with the HTIP defined by this specification, one or more L3 Agents or L2 Agents must be installed in an IP Terminal. In addition, only one L2 Agent must be installed in an NW equipment. Table 8 below summarizes the items of implementation that are required, recommended, or optional separately for L3 Agent or L2 Agent that must be installed in an IP Terminal and L2 Agent that must be installed in an NW equipment.

Table 8 Items of implementation for L3 Agent and L2 Agent

Terminal category	Item of implementation			Description	Required, recommended, or optional
L3 Agent	Implementation of UPnP Controlled Device ([1])			The required features defined in the UDA document ([1]) shall be treated as required items in this specification. Similarly, the recommended or optional features in the UDA document shall be treated as recommended or optional items, respectively, in this specification. This specification defines the basic functions of UPnP. Therefore, implementing UPnP Basic, UPnP IGD, UPnP DM, and DLNA devices is equivalent to implementing the UPnP controlled device functions.	Required
		Description in DDD	Device category description in <htip:X_DeviceCategory> element	Element namespace shall be http://www.ttc.or.jp/Home-network WG/JJ-300.00. For the manufacturer that does not have an OUI code, no value may be described in the <htip:X_ManufacturerOUI> element. However, the <htip:X_ManufacturerOUI> element must always be prepared, and the manufacturer's name must be described in the <manufacturer> element.	Required
			Manufacturer code description in <htip:X_ManufacturerOUI> element		
			Model name description in <modelName> element	For the terminal that does not have a model name, no value may be described in the <modelName> element. However, this element must always be prepared.	
			Model number description in <modelNumber> element		
			Channel usage information description in <htip:X_ChannelStatus> element	Can be used by a device that supports channel usage information transmission.	Optional
			Radio signal strength information description in <htip:X_Rssi> element	Can be used by a device that supports radio signal strength information transmission.	
			Communication error rate information description in <htip:X_ErrorRate> element	Can be used by a device that supports communication error rate information transmission.	
			Status information description in <htip:X_Status> element	Can be used by a device that supports status transmission.	
			Response time description in <htip:X_RT> element	Can be used by a device that supports response time transmission.	
			Number of associated devices description in <htip:X_NumAss> element	Can be used by a device that supports number of associated devices transmission.	
			Number of active nodes description in <htip:X_NumAct> element	Can be used by a device that supports number of active nodes transmission.	
			Link quality description in <htip:X_LQ> element	Can be used by a device that supports link quality transmission.	
			Number of retransmissions description in <htip:X_RetC> element	Can be used by a device that supports number of retransmissions transmission.	
			CPU usage rate description in <htip:X_CPU> element	Can be used by a device that supports CPU usage rate transmission.	

			Memory usage rate description in <htip:X_MEM> element		Can be used by a device that supports memory usage rate transmission.	
			HDD usage rate description in <htip:X_HDD> element		Can be used by a device that supports HDD usage rate transmission.	
			Remaining battery level description in <htip:X_Power> element		Can be used by a device that supports remaining battery level transmission.	
			Sampling interval of communication quality information description in <htip:X_ComSmpl> element		Can be used by a device that supporting change of sampling interval of communication quality information.	
			Transmission interval of communication quality information description in <htip:X_ComSend> element		Can be used by a device that supporting change of transmission interval of communication quality information.	
			Sampling interval of device quality information description in <htip:X_SysSmpl> element		Can be used by a device that supporting change of sampling interval of device quality information.	
			Transmission interval of device quality information description in <htip:X_SysSend> element		Can be used by a device that supporting change of transmission interval of device quality information.	
		Implementation of UPnP Device Management ([11])			Implementation shall follow the rules set by UPnP DM ([11]). The required features defined in the UPnP DM document ([11]) shall be treated as required items in this specification. Similarly, the recommended or optional features in the UPnP DM document shall be treated as recommended or optional items, respectively, in this specification.	Recommended
	Reply to ICMP [10] echo request					Recommended
L2 Agent	Implementation of LLDP Agent (Transmit only) ([7])				LLDP Agent must transmit MAC forwarding table and device information. LLDP Agent must also use "FF-FF-FF-FF-FF-FF" as the LLDPDU frame destination MAC address.	Required
		Storage of TLVs defined by 802.1AB ([7])	TLVs of TLV Type = 0 to 3		One of the MAC addresses of HTIP-NW equipment shall be selected as its chassis ID.	
			TLV of TLV Type = 4		The interface standard names applied to this port shall be described.	Recommended
		Storage of new TLVs	(a) Device category TLV			Required
			(b) Manufacturer code TLV		For the manufacturer that has not acquired a manufacturer code, this TLV shall not be stored in LLDPDU or the data part of this TLV shall be null.	Recommended
			(c) Model name TLV		For the HTIP-NW equipment that does not have a model name, this TLV shall not be stored in LLDPDU or the data part of this TLV shall be null.	
			(d) Model number TLV			Required
			(e) Channel usage information		Can be used by a device that supports channel usage information transmission.	Not required for HTIP-NW equipment; optional for HTIP-IP Terminal
			(f) Radio signal strength information		Can be used by a device that supports radio signal strength information transmission.	
			(g) Communication error rate information		Can be used by a device that supports communication error rate information transmission.	

			(h) Status information	Can be used by a device that supports status transmission.	Optional
			(i) LLDPDU transmission interval	Can be used by a device that supports LLDPDU transmission interval transmission.	Optional
			(j) Response time	Can be used by a device that supports response time transmission.	Optional
			(k) Number of associated devices	Can be used by a device that supports number of associated devices transmission.	Optional
			(l) Number of active nodes	Can be used by a device that supports number of active nodes transmission.	Optional
			(m) Link quality	Can be used by a device that supports link quality transmission.	Optional
			(n) Number of retransmissions	Can be used by a device that supports number of retransmissions transmission.	Optional
			(o) CPU usage rate	Can be used by a device that supports CPU usage rate transmission.	Optional
			(p) Memory usage rate	Can be used by a device that supports memory usage rate transmission.	Optional
			(q) HDD usage rate	Can be used by a device that supports HDD usage rate transmission.	Optional
			(r) Remaining battery level	Can be used by a device that supports remaining battery level transmission.	Optional
			Link information TLV		Required for HTIP-NW equipment; not required for HTIP-IP Terminal
			MAC address list TLV		
			Extension link information transmission TLV		Optional for HTIP-NW equipment; not required for HTIP-IP Terminal
			Extension MAC address list TLV		
			Setting information TLV		Optional

Appendix A List of Interface Standard Names

Table A lists the interface standard names that should be used for port description in the data part of the TLV (TLV Type = 4) in the LLDPDU frame to be transmitted by L2 Agent. When the strings of standard names shown in Table A are used for description of interface standard names in the TLV, the maximum throughput of communication line and the failures that might possibly occur can be assumed.

Table A Interface standard names

Communication line type	Value (standard name)	Remarks
Power line	HomePlug	
	HomePlug_AV	HomePlug AV
	HD-PLC	
	UPA	
	CEPCA	
	IEEE1901	IEEE P1901
	G.hn	
Telephone line	HomePNA	
	G.hn	
Coaxial cable	MoCA	
	c.Link	
	G.hn	
UTP cable or the like	IEEE802.3	
	IEEE802.4	
	IEEE802.5	
Special cable	IEEE1394	
	USB	
	HDMI	
Wireless line	IEEE802.11	
	IEEE802.11b	
	IEEE802.11g	
	IEEE802.11a	
	IEEE802.11n	
	IEEE802.15.1	
	IEEE802.15.3	
	IEEE802.15.3c	
	IEEE802.15.4	
	IEEE802.15.4a	
	IEEE802.15.4g	
	IEEE802.15.5	
	IEEE802.16e	
	WirelessHD	
	WHDI	
	Z-wave	
Optical wireless line	STD-T50	
	IEEE802.15.7	
	IrDA	