

International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.9973

(08/2017)

SERIES G: TRANSMISSION SYSTEMS AND MEDIA,
DIGITAL SYSTEMS AND NETWORKS

Access networks – In premises networks

Protocol for identifying home network topology

Recommendation ITU-T G.9973

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GENERAL CHARACTERISTICS COMMON TO ALL ANALOGUE CARRIER-TRANSMISSION SYSTEMS	G.200–G.299
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PACKET OVER TRANSPORT ASPECTS	G.8000–G.8999
ACCESS NETWORKS	G.9000–G.9999
Metallic access networks	G.9700–G.9799
Optical line systems for local and access networks	G.9800–G.9899
In premises networks	G.9900–G.9999

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Recommendation ITU-T G.9973

Protocol for identifying home network topology

Summary

Based on Recommendation ITU-T G.9971, Recommendation ITU-T G.9973 specifies the configuration management protocol. This protocol is used to manage devices in the Internet protocol (IP) home network for the purpose of showing users the layer 2 home network topology. Recommendation ITU-T G.9973 also enables fault management utilizing device information that the local agent (LA) of the device manages. They are described in TTC JJ-300.00.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T G.9973	2011-10-29	15	11.1002/1000/11405
2.0	ITU-T G.9973	2017-08-13	15	11.1002/1000/13340

Keywords

Access gateway, Ethernet, fault, home network, IP, LLDP, management, non-Ethernet data link, protocol, topology, UDA, UpnP.

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Table of Contents

	Page
1 Scope.....	1
2 References.....	1
3 Definitions	2
3.1 Terms defined elsewhere	2
3.2 Terms defined in this Recommendation.....	2
4 Abbreviations and acronyms	2
5 Conventions	3
6 The applied area of the protocol for identifying home network topology.....	3
7 Functional requirements of the protocol for identifying the home network topology	3
8 The protocol for identifying home network topology	4
8.1 Management information	5
8.2 Interaction between the local manager and the local L3 agent	5
8.3 Interaction between the local manager and the local L2 agent	6
9 Connectivity check between the local manager and the local agents	6
9.1 Connectivity check between the local manager and the local L3 agent.....	7
9.2 Connectivity check between the local manager and the local L2 agent.....	7
Annex A – Detailed fields and values of TLVs	8
Bibliography.....	9

Recommendation ITU-T G.9973

Protocol for identifying home network topology

1 Scope

Various kinds of Internet protocol (IP) terminal devices, such as personal computers (PCs), digital televisions (TVs), gaming devices, and portable music devices, have recently been, and continue to be, connected to the IP home network. Furthermore, their number is increasing. The kinds of transmission media (power line communication (PLC), wireless, unshielded twisted pair (UTP), etc.) used to connect each IP terminal are also becoming more varied. Under such circumstances, most users are unable to troubleshoot the IP home network by themselves, without the availability of appropriate network services. It is desired to introduce a simple and easy IP home network management that can localize the fault in each device and network and help recover from trouble.

[ITU-T G.9971] describes three kinds of management requirements for the IP home network: configuration management; fault management; and performance management. Based on [ITU-T G.9971], this Recommendation specifies the configuration management protocol that is described in [TTC JJ-300.00]. This protocol is used to manage devices in the IP home network for the purpose of showing the layer 2 (L2) home network topology to users within the home network only (behind the access gateway (AGW)). On the other hand, [b-BBF TR-069], covering the customer premises equipment (CPE) wide area network (WAN) management protocol, is the candidate for the remote home network management protocol from outside the AGW. Although it may be necessary in the future to study the interaction between this management protocol and the CPE WAN management protocol, it lies outside the scope of this Recommendation.

This Recommendation also enables fault management utilizing device information that the local agent (LA) of the device manages.

This Recommendation identifies devices on a single link as shown in Figure 8-1. Note that "a single link" means the one data link layer, which constitutes one IP domain between the AGW and the IP terminal. As the deployment of new link-layer technologies such as [b-IEEE 802.15.4] will enable and require the use of multiple links in the home network, this Recommendation covers multiple links composed of IP devices and may be extended to cover multiple links composed of IP and non-IP devices in the future.

Home network security is important. A device using this Recommendation to collect information about the home network will be required to take certain steps to ensure that the information is not accessible through the WAN interface of the AGW.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T G.9971] Recommendation ITU-T G.9971 (2010), *Requirements of transport functions in IP home networks*.

[IEEE 802.1AB] IEEE 802.1AB-2016, *IEEE standard for local and metropolitan area networks – Station and media access control connectivity discovery*.

- [IEEE 802.1D] IEEE 802.1D-2004, *IEEE Standard for local and metropolitan area networks: media access control (MAC) bridges*.
- [IETF RFC 1701] Internet Engineering Task Force Request For Comments 1701 (1994), *Generic routing encapsulation (GRE)*.
- [ISO/IEC 29341-1] ISO/IEC 29341-1:2011, *Information technology – UPnP Device Architecture – Part 1: UPnP Device Architecture Version 1.0*.
- [TTC JJ-300.00] TTC JJ-300.00 (2017), *Home-network topology identifying protocol (HTIP)*.

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AGW	Access Gateway
CPE	Customer Premises Equipment
DDD	Device Description Document
DVD	Digital Versatile Disk
GRE	Generic Routing Encapsulation
ICMP	Internet Control Message Protocol
ID	Identifier
IP	Internet Protocol
L2	Layer 2
L3	Layer 3
LA	Local Agent
LLDP	Link Layer Discovery Protocol
LLDPDU	LLDP Data Unit
LM	Local Manager
MAC	Media Access Control
OUI	Organizationally Unique Identifier
PC	Personal Computer
PLC	Power Line Communication
TLV	Type, Length, Value
TTL	Time To Live
TV	Television
UDA	UPnP Device Architecture

UTP	Unshielded Twisted Pair
UPnP	Universal Plug and Play
WAN	Wide Area Network

5 Conventions

In this Recommendation:

The keyword "**must**" implies that it is strictly required to claim conformance.

The keyword "**should**" implies that it is recommended for performance improvement, etc. although it is not absolutely required to claim conformance.

The keyword "**may**" implies that it is not required to claim conformance.

6 The applied area of the protocol for identifying home network topology

Figure 6-1 shows the home network area in which the protocol specified by this Recommendation is applied. Both the access network and the IP/non-IP home network behind the IP terminal lie outside the scope of this Recommendation. Moreover, the IP home network that is directly connected from the access network without the AGW also lies outside the scope.

The target home network is composed of the IP terminal, the network equipment and the AGW, where one or more IP terminals can be connected to the IP home network and zero or more pieces of network equipment can reside within the IP home network. The network equipment is a hardware device that has two or more ports and a function to transfer frames and packets received at one port to the other by using a media access control (MAC) forwarding table (e.g., Ethernet bridge). The AGW has two kinds of function: the home network side and the access network side, while it contains L2 or layer 3 (L3) functions. This Recommendation only covers configuration management on the home network side functions of the AGW. Moreover, even if the AGW contains an L3 function, such as an IP routing function, this Recommendation only covers the functions necessary for identifying L2 home network topology.

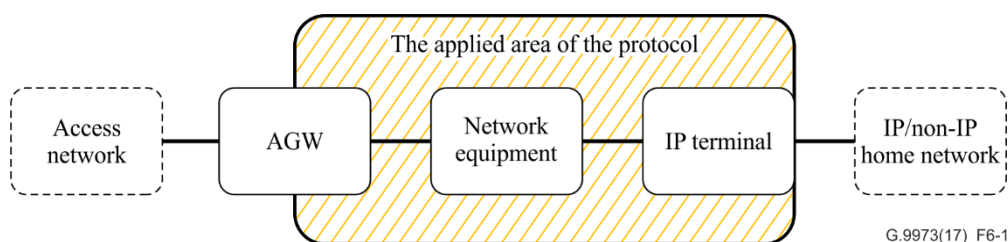


Figure 6-1 – The applied area of the protocol

7 Functional requirements of the protocol for identifying the home network topology

The protocol is mainly used for identifying the home network topology. It is also used for checking the connectivity between the local manager (LM) and the LA, the specifications of which are given in clause 11.1 of [ITU-T G.9971]. This Recommendation specifies the protocol that meets some of the requirements listed in clause 11.3 of [ITU-T G.9971]. The functional requirements, as well as their relationship with those in [ITU-T G.9971], are given below. Figure 8-1 is also helpful for understanding these requirements.

R1 (based on R11-C1 and R11-C2 in [ITU-T G.9971]): The local L3 agent must be able to acquire the IP and MAC addresses of the device where the local L3 agent resides. The local L3 agent must also be able to transmit the IP and MAC addresses to the LM in the manner described in clause 8.2.

R2 (based on R11-C3 in [ITU-T G.9971]): The local L2 agent must be able to acquire the MAC forwarding table retained by the device where the local L2 agent resides. The local L2 agent must also be able to transmit the MAC forwarding table to the LM in the manner described in clause 8.3.

R3 (based on R11-C4 in [ITU-T G.9971]): The local L3 agent must be able to acquire and transmit its device information to the LM in the manner described in clause 8.2.

R4 (based on R11-C5 in [ITU-T G.9971]): The local L2 agent must be able to acquire and transmit its device information to the LM in the manner described in clause 8.3.

R5 (based on R11-L2 in [ITU-T G.9971]): The local L3 agent should be able to respond to a connectivity check command from the LM in the manner described in clause 9.1.

R6 (based on R11-L2 in [ITU-T G.9971]): The local L2 agent should be able to send packets periodically to the LM for checking connectivity in the manner described in clause 9.2.

R7: The local L2 agent must be able to acquire the MAC address of the device where the local L2 agent resides. The local L2 agent must also be able to transmit the MAC address to the LM in the manner described in clause 8.3.

R8: The local L2 agent must be able to acquire the IP address of the device where the local L2 agent resides. (Required when the local L2 agent supports the function to transmit a link layer discovery protocol data unit (LLDPDU) encapsulated in an IP packet in the manner described in clause 8.3)

8 The protocol for identifying home network topology

This clause describes the interaction between the LM and the local L3 agent, as well as the LM and the local L2 agent.

Management information to identify the IP home network topology falls into two areas: device information and MAC forwarding table information. One example of device information is the device category, such as the network equipment or PC. Device information resides in the local L3 agent or the local L2 agent, while the MAC forwarding table information resides in the local L2 agent of the network equipment or the AGW.

Management information can be retrieved by the LM, which can reside in any device in the IP home network, according to the last paragraph of clause 11.1 of [ITU-T G.9971]. Figure 8-1 shows a typical case where the LM resides in the AGW. The AGW has both the local L2 and L3 agents. The network equipment has the local L2 agent, and there are two types of the IP terminal which has the local L2 agent and the local L3 agent, respectively. The local L3 agent of the IP terminal sends device information by using the UPnP device architecture (UDA), while the local L2 agent of the network equipment sends both device information and MAC forwarding table information by using the link layer discovery protocol (LLDP). Note that the local L2 and L3 agents of the AGW locally send device information to the LM. The LM can identify the IP home network topology by analysing the collection of this management information. By utilizing this IP home network topology information, some applications can perform fault localization in response to the failure of network services.

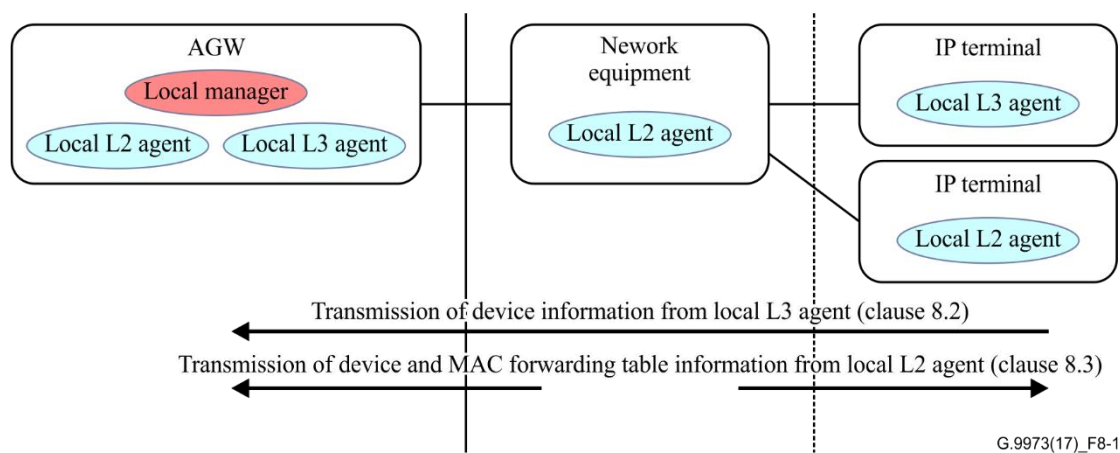


Figure 8-1 – The protocol for identifying home network topology

8.1 Management information

Each LA of the device, such as the IP terminal, the network equipment or AGW, manages device information representing the device. It consists of at least the following four kinds of management information. Fault management information may be added to the device information as described in clause 6.1 of [TTC JJ-300.00]. The string length of the management information is described in clause 6.1 of [TTC JJ-300.00].

- a) Device category: represents the category of each device, such as TV or digital versatile disk (DVD) recorder.
- b) Manufacturer code: represents the company that produced the device. It is a company identifier (ID) [organizationally unique identifier (OUI) code] registered by IEEE.
- c) Model name: represents the device's brand or series name assigned by the manufacturer.
- d) Model number: represents the device's model number assigned by the manufacturer.

MAC forwarding table information is specified for the network equipment. It represents the pair of the network equipment port and one or more MAC addresses of devices, such as the IP terminal or the network equipment or the AGW, connected to this port.

8.2 Interaction between the local manager and the local L3 agent

The local L3 agent must send device information to the LM by utilizing the universal plug and play- (UPnP-) controlled device function described in [ISO/IEC 29341-1] (UDA). Note that it uses the "basic device information" part of the device description document (DDD) message per the local L3 agent. The detailed methods and timing for the LM to retrieve device information from the local L3 agent must comply with clause 2 "Description" in the UDA, while that for IPv6 must comply with Annex A in the UDA. Each element of the basic device information, such as device category, manufacturer code, model name and model number, must comply with [TTC JJ-300.00]. Moreover, detailed specifications of each element, such as the name space and the character length, must follow clause 6.2 of [TTC JJ-300.00].

When the local L3 agent transmits the device information to the LM, the IP and MAC addresses are set in the packet header. Therefore, the IP and MAC addresses can be transmitted to the LM.

The LM may transmit setting information by utilizing the UPnP-controlled device function to the local L3 agent. The local L3 agent that receives the setting information then responds with the updated result by reflecting the setting information.

8.3 Interaction between the local manager and the local L2 agent

The local L2 agent must send device information and MAC forwarding table information to the LM by utilizing LLDP. Both types of information are broadcast from all ports via the LLDP agent specified in [IEEE 802.1AB]. According to [IEEE 802.1AB], the local L2 agent hands both types of information to the LLDP agent, which broadcasts it from all managed ports after attaching the device MAC address. The detailed mechanism must comply with clause 6.3 of [TTC JJ-300.00]. Instead of broadcasting both types of information, the unicast transmission may be used by the local L2 agent.

The local L2 agent must manage the device information, MAC forwarding table information of the device on which it resides and the chassis ID identifying the local L2 agent. Moreover, the local L2 agent may manage the list of its LLDP agents' MAC addresses. The detailed mechanism to specify the chassis ID lies outside the scope of this Recommendation.

The local L2 agent sends this management information periodically or when it is updated. The detailed specifications for timing or methods must comply with [IEEE 802.1AB].

The LM may transmit setting information by utilizing the LLDP message to the local L2 agent. The local L2 agent that receives the setting information then reflects the setting information.

Figure 8-2 shows the LLDPDU frame format used by the local L2 agent. The LLDPDU header consists of the destination MAC address, the source MAC address and the LLDP Ethernet type. The source MAC address must be one of the MAC addresses managed by the LLDP agent, while the Ethernet type for LLDP must be 88-CC. According to [TTC JJ-300.00], the destination MAC address must be set to FF-FF-FF-FF-FF-FF for broadcast. The destination MAC address may be set for the unicast transmission. Each network equipment that receives the LLDPDU must handle it according to [IEEE 802.1D].

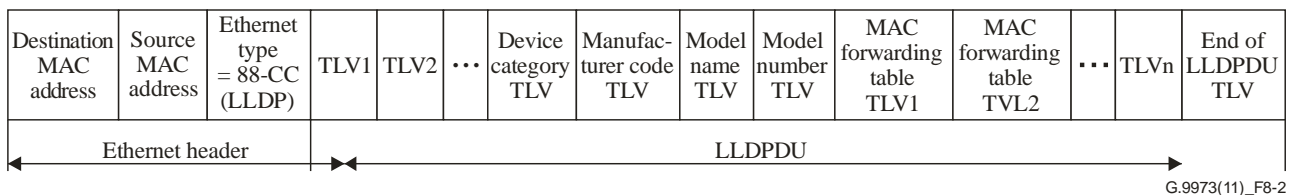


Figure 8-2 – LLDPDU format

The four instances of type, length, value (TLVs) (TLV type=0-3) that [IEEE 802.1AB] specifies as mandatory must be contained in the LLDPDU: TLV type=0 represents "End Of LLDPDU TLV"; TLV type=1 represents "Chassis ID TLV"; TLV type=2 represents "Port ID TLV"; TLV type=3 represents "TTL TLV" (where TTL is time to live). Note that the detailed specifications must comply with clause 6.3.1 of [TTC JJ-300.00].

Device information and MAC forwarding table information must be sent in TLV format with extended TLV fields. Detailed fields and values are provided in Annex A.

The local L2 agent may send the management information with the LLDPDU by using an encapsulation protocol over the IP in the data link layer that does not support the Ethernet frame. For this case, the device in which the local L2 agent resides must support generic routing encapsulation (GRE; see [IETF RFC 1701]) as an encapsulation protocol. Any other encapsulation protocols may also be supported. The detailed settings for GRE must comply with clause 6.3 of [TTC JJ-300.00].

9 Connectivity check between the local manager and the local agents

The connectivity checks between the LM and the LAs are executed in L3 and L2. The former is described in clause 9.1, while the latter is described in clause 9.2.

9.1 Connectivity check between the local manager and the local L3 agent

Two connectivity checks are possible in response to a fault. One is that the LM re-tries to retrieve device information from the local L3 agent (the number of re-tries lies outside the scope of this Recommendation). The other is that the LM sends an Internet control message protocol (ICMP) echo request message to the local L3 agent and receives an ICMP echo reply message. The former can be realized by referring to clause 8.2. The detailed specifications of the latter must comply with clause 7.1 of [TTC JJ-300.00].

9.2 Connectivity check between the local manager and the local L2 agent

The LM can keep the chassis ID as well as TTL by interacting with the local L2 agent as described in clause 8.3. Therefore, the LM can perform the connectivity check by checking whether or not the next LLDPDU comes after the previous one within the TTL period. The detailed specifications must comply with clause 7.2 of [TTC JJ-300.00].

Annex A

Detailed fields and values of TLVs

(This annex forms an integral part of this Recommendation.)

This annex is extracted from [TTC JJ-300.00].

As shown in Figure A.1, the extension of type, length and value (TLV) fields is accomplished by setting TLV type = 127 in TLV header in accordance with [IEEE 802.1AB]. Moreover, the TLV information string must contain TTC OUI = E0-27-1A as well as TTC subtype, which is specified in Table 6-3 of [TTC JJ-300.00]. The TLV data represent device information in the case of TTC subtype = 1, while the TLV data represent MAC forwarding table information in the case of TTC subtype = 2.

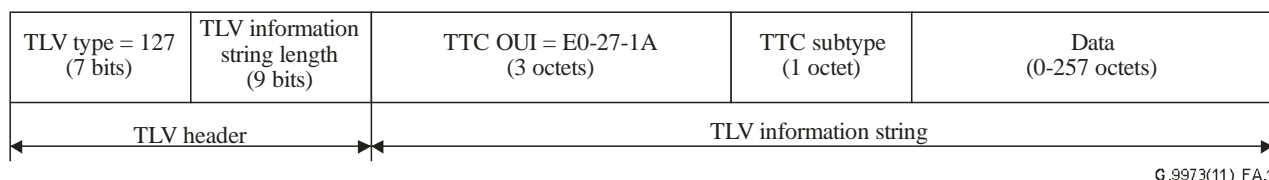


Figure A.1 – TLV format for device and MAC forwarding table information

In accordance with clause 6.3.2 of [TTC JJ-300.00], Figure A.2 shows the data part of device information, which consists of device information ID, string length and device information data. Device information IDs represent the device category, manufacturer code, model name and model number. It may include the additional device information ID for fault management that is described in clause 8.1. Device information data represent the value of device information for each device. The detailed specifications of device information IDs and device information data must comply with clause 6.3.2 of [TTC JJ-300.00].

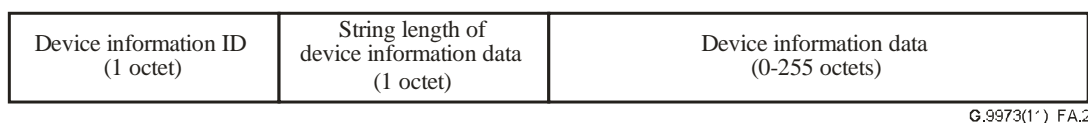


Figure A.2 – Data format in TLV for device information

In accordance with clause 6.3.3 of [TTC JJ-300.00], Figure A.3 shows the data part of MAC forwarding table information, which consists of the kind of interface, port number, the number of MAC addresses connected to the port, and MAC addresses, including each string length. Their detailed specifications must comply with clause 6.3.3 of [TTC JJ-300.00].

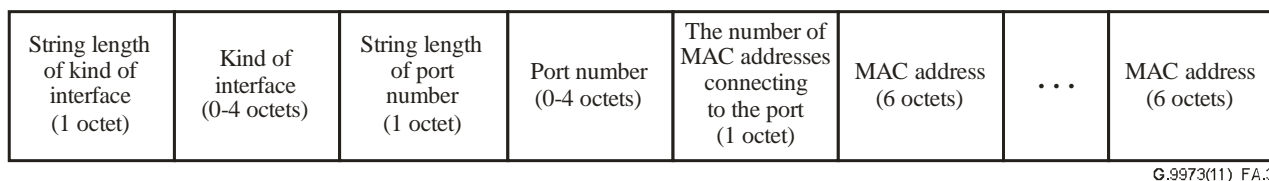


Figure A.3 – Data format in TLV for MAC forwarding table information

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- [b-IEEE 802.15.4] IEEE 802.15.4 (2015), *IEEE standard for low-rate wireless networks*.

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