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# Series G

**Supplement 57**

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

## Smart home profiles for 6LoWPAN devices

ITU-T G-series Recommendations – Supplement 57

ITU-T G-SERIES RECOMMENDATIONS

**TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS**

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# Supplement 57 to ITU-T G-series Recommendations

## Smart home profiles for 6LoWPAN devices


**Summary**

Supplement 57 to ITU-T G-series Recommendations addresses Internet protocol version 6 (IPv6) adaptation layers for smart home systems, where embedded devices communicate with each other over low power and lossy networks (LLNs) for the purpose of sensor data collection and equipment control by using IPv6 over low power wireless personal area network (6LoWPAN) technology. Devices in smart home systems include home appliances, home energy equipment and various sensors within and around the home. Assumed applications for the communication include energy management, healthcare, home security and smart metering, while excluding broadband applications or mobile applications.

This Supplement addresses both IP-based wired and wireless low-power communications for smart home, and provides supplemental information to Recommendations ITU-T G.9903 and ITU-T G.9959. Additional information on other ITU-T G-Series Recommendations may be provided in future revisions of this Supplement.



**History**

| Edition | Recommendation | Approval | Study Group | Unique ID* |
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# Supplement 57 to ITU-T G-series Recommendations

# Smart home profiles for 6LoWPAN devices

## 1 Scope

This Supplement addresses Internet protocol version 6 (IPv6) adaptation layers for smart home systems, where embedded devices communicate with each other over low power and lossy networks (LLNs) for the purpose of sensor data collection and equipment control by using IPv6 over low power wireless personal area network (6LoWPAN) technology. Devices in smart home systems include home appliances, home energy equipment, and various sensors within and around the home. Assumed applications for the communication include energy management, healthcare, home security and smart metering, while excluding broadband applications or mobile applications.

The Supplement addresses both IP-based wired and wireless low-power communications for smart home systems, and provides supplemental information to [ITU-T G.9903], [ITU-T G.9959], as well as [TTC JJ-300.10] and [TTC JJ-300.11].

Communication devices for the smart home are generally embedded systems with constrained resources, and use low-power link technologies; thus it is common to implement a specific set of options from a given protocol. This set of options is called a "profile". Specification of a profile facilitates the implementation of integrated embedded equipment that supports multiple low-power links. This Supplement clarifies which adaptation layer functions for carrying IPv6 frames are supported by the 6LoWPAN-based adaptation layers, for example, those specified in [ITU-T G.9903], [ITU-T G.9959], as well as [TTC JJ-300.10] and [TTC JJ-300.11]. Additional information on other G-Series Recommendations and standards may be provided in future revisions of this Supplement.

## 2 References


[ITU-T G.9903] Recommendation ITU-T G.9903 (2014), *Narrowband orthogonal frequency division multiplexing power line communication transceivers for G3-PLC networks*.

[ITU-T G.9959] Recommendation ITU-T G.9959 (2015), *Short range narrow-band digital radiocommunication transceivers – PHY, MAC, SAR and LLC layer specifications.*

[IEEE 802.15.4] IEEE 802.15.4 (2006), *IEEE standard for local and metropolitan area networks – Specific requirements – Part 15.4: Wireless medium access control (MAC) and physical layer (PHY) specifications for low rate wireless personal area networks (WPANs).*

[IEEE 802.15.4e] IEEE 802.15.4e (2012), *IEEE Standard for Local and metropolitan area networks – Part 15.4: Low-Rate Wireless Personal Area Networks (LR WPANs) Amendment 1: MAC sublayer*.

[IEEE 802.15.4g] IEEE 802.15.4g (2012), *IEEE Standard for Local and metropolitan area networks – Part 15.4: Low-Rate Wireless Personal Area Networks (LR WPANs) Amendment 3: Physical Layer (PHY) Specifications for Low Data-Rate, Wireless, Smart Metering Utility Networks*.

[IETF RFC 2460] IETF RFC 2460 (1998), *Internet protocol, version 6 (IPv6) specification*.

[IETF RFC 2462] IETF RFC 2462 (1998), *IPv6 stateless address autoconfiguration*.

[IETF RFC 2466] IETF RFC 2466 (1998), *Management information base for IP version 6: ICMPv6 Group*.

[IETF RFC 4193] IETF RFC 4193 (2005), *Unique local IPv6 unicast addresses*.

[IETF RFC 4291] IETF RFC 4291 (2006), *IP version 6 addressing architecture*.

[IETF RFC 4443] IETF RFC 4443 (2006), *Internet control message protocol (ICMPv6) for the Internet protocol version 6 (IPv6) specification*.

[IETF RFC 4861] IETF RFC 4861 (2007), *Neighbor discovery for IP version 6 (IPv6)*.

[IETF RFC 4862] IETF RFC 4862 (2007), *IPv6 stateless address autoconfiguration*.

[IETF RFC 4944] IETF RFC 4944 (2007), *Transmission of IPv6 Packets over IEEE 802.15.4 Networks*.

[IETF RFC 5095] IETF RFC 5095 (2007), *Deprecation of type 0 routing headers in IPv6*.

[IETF RFC 6282] IETF RFC 6282 (2011), *Compression format for IPv6 datagrams over IEEE 802.15.4-based networks*.

[IETF RFC 6550] IETF RFC 6550 (2012), *RPL: IPv6 Routing Protocol for Low-Power and Lossy Networks*.

[IETF RFC 6775] IETF RFC 6775 (2012), *Neighbor discovery optimization for IPv6 over low-power wireless personal area networks (6LoWPANs)*.

[IETF RFC 7428] IETF RFC 7428 (2015), *Transmission of IPv6 packets over ITU-T G.9959 networks*.

[TTC JJ-300.10] Standard TTC JJ-300.10 (2015), *Home network communication interface for ECHONET Lite (IEEE 802.15.4/4e/4g 920MHz-band wireless)*.

[TTC JJ-300.11] TTC Standard JJ-300.11 (2014), *Home network communication interface for ECHONET Lite (ITU-T G.9903 Narrow band OFDM PLC)*.

# 3 Definitions

## 3.1 Terms defined elsewhere

None.

## 3.2 Terms defined in this Supplement

This Supplement defines the following terms:

**3.2.1 integrated device**: A network device in a smart home system that communicates with multiple smart home devices for smart home applications, such as home security and home energy management system (HEMS).

**3.2.2 low power and lossy network** (based on the definition given in [IETF RFC 6550]): Low power and lossy networks (LLNs) are made up of many embedded devices with limited power, memory, and processing resources. They are interconnected by a variety of links, such as IEEE 802.15.4, Bluetooth, low power WiFi, ITU-T G.9959, PLC (powerline communication), or other wired low power links. LLNs are transitioning to an end-to-end IP-based solution to avoid the problem of non-interoperable networks interconnected by protocol translation gateways and proxies.

**3.2.3 profile**: A specification of a set of options of existing protocols for use in a particular condition.

**3.2.4 smart home**: A system that consists of embedded communication devices, including home appliances, home energy equipment, and various sensors within and around the home, for the purpose of data collection and equipment control.

**3.2.5 smart home device**: An end device in a smart home system that equips a single communication profile.

## 4 Abbreviations and acronyms

This Supplement uses the following abbreviations and acronyms:

| | |
|---|---|
| 6CO | 6LoWPAN Context Option |
| 6LBR | 6LoWPAN Border Router |
| 6LR | 6LoWPAN Router |
| 6LoWPAN | IPv6 over Low power Wireless Personal Area Network |
| ABRO | Authoritative Border Router Option |
| AH | Authentication Header |
| ARO | Address Registration Option |
| DAC | Duplicate Address Confirmation |
| DAD | Duplicate Address Detection |
| DAR | Duplicate Address Request |
| DLL | Data Link Layer |
| ESP | Encapsulating Security Payload |
| EUI-64 | 64-bit Extended Unique Identifier |
| HEMS | Home Energy Management System |
| ICMP | Internet Control Message Protocol |
| IPHC | Internet Protocol Header Compression |
| IPv6 | Internet Protocol Version 6 |
| LLN | Low power and Lossy Network |
| MAC | Media Access Control |
| MIB | Management Information Base |
| MTU | Maximum Transmission Unit |
| ND | Neighbour Discovery |
| NHC | Next Header Compression |
| NS | Neighbour Solicitation |
| PHY | Physical layer |
| PIO | Prefix Information Option |
| RA | Router Advertisement |
| SAA98 | Stateless Address Autoconfiguration (in accordance with [IETF RFC 2462]) |
| SAA07 | Stateless Address Autoconfiguration (in accordance with [IETF RFC 4862]) |
| SLLAO | Source Link-Layer Address Option |

TCP Transmission Control Protocol

UDP User Datagram Protocol

## 5 Introduction

In smart home systems, embedded communication equipment with constrained resources is commonly used. In such an environment, only a part of the standardized communications protocol is often to be implemented in order to optimize the performance and cost of the embedded equipment. To achieve interoperability in such an environment, it is necessary to specify a set of selected options for standardized protocols. A specification that contains an option selection for a specific context is called a profile. The equipment using the same communication protocol cannot communicate if the profile is different.

Several standards have been published on communication interfaces for the smart home: [TTC JJ-300.10] for IEEE 802.15.4/4e/4g 920MHz-band wireless and [TTC JJ-300.11] for [ITU-T G.9903] narrowband OFDM PLC. [TTC JJ-300.10] specifies three methods. Method A is for one to one link IP communication, method B is for multi-hop IP communication and method C is for non-IP communication. This Supplement addresses IP communication for methods A or B of [TTC JJ-300.10], [TTC JJ-300.11] and [ITU-T G.9959].

## 6 General description

### 6.1 Smart home characteristics

In smart home systems, home appliances, energy equipment, housing facilities, various sensors are connected via a home network. In order to reduce power consumption, communication devices are typically equipped with a sleep operation and limited transmission power. Such a communication network is called a low power and lossy network (LLN) and protocols for LLNs have been studied in various standardization bodies including IETF.

Since communication is not a primary purpose for smart home devices, those devices are commonly equipped with the minimum functions in order to reduce computing and memory resources. In order to achieve interoperability in such conditions, in addition to the selection of communication protocols, option selection arrangements are necessary. A selected set of options for a particular purpose is called a profile in this Supplement. A wired or wireless communication medium is selected for a smart home device depending on its characteristics. Therefore, it is necessary to assume the coexistence of multiple LLNs in a smart home.

Thus, a framework for a smart home network composed of multiple communication media with multiple profiles is considered.

### 6.2 A smart home infrastructure

Figure 1 is an example of a smart home infrastructure. A "smart home device" is an end system that equips a single communication profile. An "integrated device" communicates with multiple smart home devices for smart home applications, such as home security and HEMS. In this example, one integrated device and three home devices equipped with different communication profiles are assumed in a system. The integrated device needs to implement multiple communication media with multiple profiles. For the design of an integrated device to accommodate more than one similar protocol, it is desirable to have a unified basic framework for the reduction of equipment resources and for ease of development. The implementation can be facilitated by minimizing the difference between each profile based on similar technology, and this will help the spread of smart home applications.

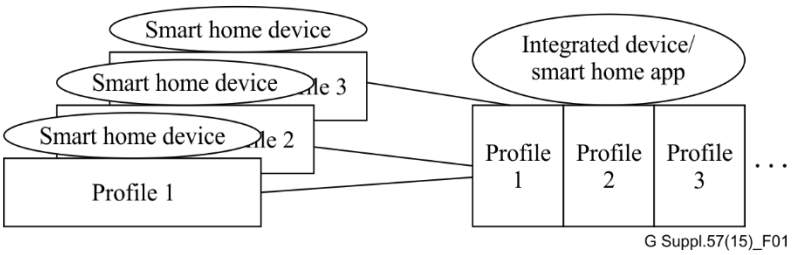


**Figure 1 – An example of a smart home infrastructure**

For dealing with smart home equipment in a unified manner, the use of IPv6 is common. IP communication for LLN has been standardized [IETF RFC 6550], but still a choice of options exists, even if communication is IP based. Figure 2 is an example for the implementation of an integrated device. As illustrated on the left hand side of Figure 2, it is common to implement similar protocol stacks separately in parallel. However, several of the protocols the profiles apply to are the same for an IP-based LLN communication standard as shown in Figure 2. By organizing the options of common protocols used in smart home networks into a communication profile, the design of the integrated device is facilitated. As a result, the degrees of freedom of smart home applications are extended.

IP and transmission control protocol/user datagram protocol (TCP/UDP) are common for most communications media and applications, and 6LoWPAN adaptation layer has various profiles depending on the communication medium and applications.

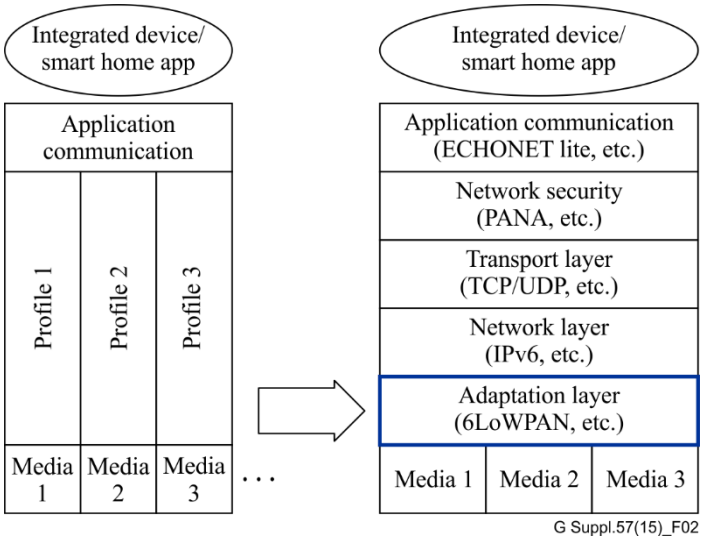


**Figure 2 – Example of a smart home architecture**

### 6.3 IPv6 Adaptation layer functions and their mapping to some existing standards

An adaptation layer is placed between the network layer and data link layer, and optimizes the network layer protocols in accordance with the characteristics of the data link. Organizing the adaptation layer in some profiles, depending on the characteristics of the data link, is useful for building effective home networks.

Figure 3 illustrates the scope of standardization. Underlying physical layer/media access control (PHY/MAC) layer technologies are assumed to be LLN communications media and may include [IEEE 802.15.4, [IEEE 802.15.4g, [IEEE 802.15.4e, ITU-T G.9959, narrowband PLC [ITU-T G.9903] and other LLNs that 6LoWPAN can support.

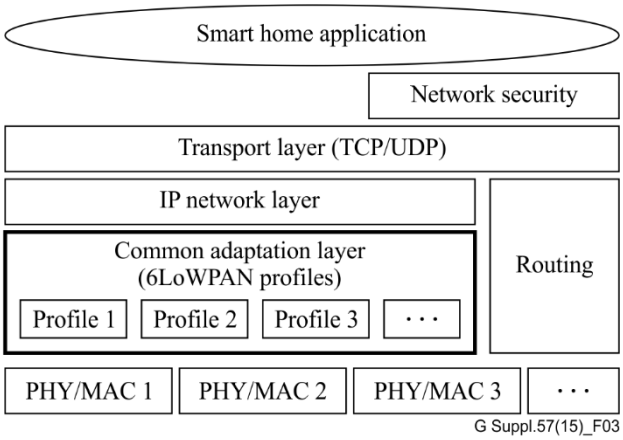


**Figure 3 – An example of architecture of smart home devices**

Table 1 lists adaptation layer profiles based on the following specifications and shows which adaptation layer functions are supported:

- One to one link IP communication based on [TTC JJ-300.10] (IEEE 802.15.4/4e/4g 920 MHz-band wireless) method A.
- Multi-hop IP communication based on [TTC JJ-300.10] (IEEE 802.15.4/4e/4g 920 MHz-band wireless) method B.
- Narrowband PLC [ITU-T G.9903] based on [TTC JJ-300.11].
- Multi-hop IP communication based on [ITU-T G.9959], [IETF RFC 7428].

**Table 1 – Adaptation-layer profiles**

| No. | Functions | Reference | Adaptation-layer profiles | | | | Note |
|---|---|---|---|---|---|---|---|
| | | | [TTC JJ-300.10] method A | [TTC JJ-300.10] method B | [TTC JJ.300.11]/ [ITU-T G.9903] | [ITU-T G.9959] | |
| 6LP1.1 | Addressing mode (64-bit extended unique identifier , EUI-64) | Clause 3 of [IETF RFC 4944] | M-HL | M-physical layer/data link layer M-PHY/DLL[a] | M-PHY/DLL | N | [a]Short address shall be used for data communication |
| 6LP1.2 | Addressing mode (short address) | Clause 3 of [IETF RFC 4944] | N | M-PHY/DLL | M-PHY/DLL | M-PHY/DLL | |
| 6LP2 | Frame format | Clause 5 of [IETF RFC 4944] | O[b] | O | M-PHY/DLL | M-PHY/DLL | [b]Header Type = LOWPAN_HC1 shall not be used. Header Type = LOWPAN_BC0 and clause 5.2 of [IETF RFC 4944] are optional. |
| 6LP3 | Stateless address autoconfiguration | Clause 6 of [IETF RFC 4944] | M-HL | M-PHY/DLL | M-PHY/DLL | M-PHY/DLL | |
| 6LP4 | IPv6 link local address | Clause 7 of [IETF RFC 4944] | M-HL | M-PHY/DLL | M-PHY/DLL | M-PHY/DLL | |
| 6LP5 | Unicast address mapping | Clause 8 of [IETF RFC 4944] | M-HL[c] | M-PHY/DLL | M-PHY/DLL(*) | M-PHY/DLL | [c]16-bit address (short address) shall not be used |
| 6LP6 | Multicast address mapping | Clause 9 of [IETF RFC 4944] | N | N | N[d] | M-PHY/DLL | [d]M for the use case other than one-to-one link. |

**Table 1 – Adaptation-layer profiles**

| No. | Functions | Reference | Adaptation-layer profiles | | | | Note |
|---|---|---|---|---|---|---|---|
| | | | [TTC JJ-300.10] method A | [TTC JJ-300.10] method B | [TTC JJ.300.11]/ [ITU-T G.9903] | [ITU-T G.9959] | |
| 6LP7 | Encoding of IPv6 header fields | Clause 10.1 of [IETF RFC 4944] | N[e] | N | N | N#3 | [e]Internet protocol header compression (IPHC) [IETF RFC 6282] shall be used for header compression. [IETF RFC 4944] HC1, HC2 not supported. |
| 6LP8 | Encoding of UDP header fields | Clause 10.2 of [IETF RFC 4944] | N[f] | N | N | N#4 | [f]IPHC [IETF RFC 6282] shall be used for header compression. [IETF RFC 4944] HC1, HC2 not supported. |
| 6LP9 | Non-compressed fields | Clause 10.3 of [IETF RFC 4944] | M-HL | N | N | N | |
| 6LP10 | Frame delivery in a link-layer mesh | Clause 11 of [IETF RFC 4944] | N | N | N | N | |
| 6LPF1 | Fragmentation type and header | Clause 5.3 of [IETF RFC 4944] | M-HL | M-HL | M-HL | N[g] | [g][ITU-T G.9959] has its own segmentation. |
| 6HC1.1 | LOWPAN_IPHC (base format) | Clause 3.1.1 of [IETF RFC 6282] | M-HL | M-HL | M-HL | M-HL | |
| 6HC1.2 | Context identifier extension | Clause 3.1.2 of [IETF RFC 6282] | N | M-HL | N[h] | M-HL | [h]M for the use case other than one-to-one link. |
| 6HC2.1 | Stateless multicast address compression | Clause 3.2.3 of [IETF RFC 6282] | M-HL | M-HL | M-HL | M-HL | |

**Table 1 – Adaptation-layer profiles**

| No. | Functions | Reference | Adaptation-layer profiles | | | | Note |
|---|---|---|---|---|---|---|---|
| | | | [TTC JJ-300.10] method A | [TTC JJ-300.10] method B | [TTC JJ.300.11]/ [ITU-T G.9903] | [ITU-T G.9959] | |
| 6HC2.2 | Stateful multicast address compression | Clause 3.2.4 of [IETF RFC 6282] | N | M-HL | N[i] | N | [i]M for the use case other than one-to-one link. |
| 6HC4 | LoWPAN_ next header compression (NHC; IPv6 extension header compression) | Clause 4.2 of [IETF RFC 6282] | N | M-HL | M-HL | M-HL | |
| 6HC5 | LOWPAN_NHC (UDP Header Compression) | Clause 4.3 of [IETF RFC 6282] | N | M-HL | M-HL | M-HL | |
| 6ND1 | DHCPv6 address assignment for 6LoWPAN border router (6LBR), 6LoWPAN router (6LR) and host | Clause 3.2 of [IETF RFC 6775] | O | N | N | O | |
| 6ND2 | DHCPv6 prefix delegation for 6LBR | Clauses 3.2, 7.1 of [IETF RFC 6775] | O | O | N | O | |
| 6ND3 | DHCPv6 prefix delegation for 6LR and host | Clauses 3.2, 7.1 of [IETF RFC 6775] | O | N | N | O | |
| 6ND4 | Static IPv6 address configuration on 6LBR | Clause 5.4.1 of [IETF RFC 6775] | O | M-PHY/DLL | N | N | |

**Table 1 – Adaptation-layer profiles**

| No. | Functions | Reference | Adaptation-layer profiles | | | | Note |
|---|---|---|---|---|---|---|---|
| | | | [TTC JJ-300.10] method A | [TTC JJ-300.10] method B | [TTC JJ.300.11]/ [ITU-T G.9903] | [ITU-T G.9959] | |
| 6ND5 | Static IPv6 address configuration on 6LR and host | Clause 5.4.1 of [IETF RFC 6775] | O | M-PHY/DLL | N | N | |
| 6ND6 | EUI-64 based IPv6 address generation | Clause 5.4.1 of [IETF RFC 6775] | M-HL | M-PHY/DLL | N | N | |
| 6ND7 | 802.15.4 16-bit short address | Clause 1.3 of [IETF RFC 6775] | O | M-PHY/DLL | N | O | |
| 6ND8 | 802.15.4 64-bit extended address | Clause 1.3 of [IETF RFC 6775] | M-HL | M-PHY/DLL | N | N | |
| 6ND9 | Duplicate address detect | Clause 4.4 of [IETF RFC 6775] | O | M-PHY/DLL | N | N | |
| 6ND10 | Duplicate address request (DAR) and duplicate address confirmation (DAC) messages | Clause 4.4 of [IETF RFC 6775] | O | M-PHY/DLL | N | N | |
| 6ND11 | Support source link-layer address option (SLLAO) | Clauses 4.1, 5.3 of [IETF RFC 6775] | M-HL | M-PHY/DLL | N | M-HL | |
| 6ND12 | Support address registration option (ARO) | Clause 5.5 of [IETF RFC 6775] | M-HL | M-PHY/DLL | N | N | |
| 6ND13 | Support authoritative border router option (ABRO) | Clauses 3.3, 3.4, 4.3, 6.3 of [IETF RFC 6775] | O | M-PHY/DLL | N | O | |

**Table 1 – Adaptation-layer profiles**

| No. | Functions | Reference | Adaptation-layer profiles | | | | Note |
|---|---|---|---|---|---|---|---|
| | | | [TTC JJ-300.10] method A | [TTC JJ-300.10] method B | [TTC JJ.300.11]/ [ITU-T G.9903] | [ITU-T G.9959] | |
| 6ND14 | Support prefix information option (PIO) | Clauses 3.3, 5.4 of [IETF RFC 6775] | O | M-PHY/DLL | N | O | |
| 6ND15 | Support 6LoWPAN context option (6CO) | Clause 4.2 of [IETF RFC 6775] | O | M-PHY/DLL | N | O | |
| 6ND16 | Multihop prefix and context distribution | Clause 8.1 of [IETF RFC 6775] | O | M-PHY/DLL | N | N | |
| 6ND17 | Multihop duplicate address detection (DAD) | Clause 8.2 of [IETF RFC 6775] | O | M-PHY/DLL | N | N | |
| 6ND18 | Support router discovery | [IETF RFC 6775] | M-HL | M-PHY/DLL | N | N | |
| 6ND19 | Support router advertisement (RA) based address configuration on 6LR and host | Clause 5.4.1 of [IETF RFC 6775] | O | M-PHY/DLL | N | N | |
| 6ND20 | Support neighbour cache management | Clause 3.5 of [IETF RFC 6775] | M-HL | M-PHY/DLL | N | N | |
| 6ND21 | Support Address Registration | Clause 3.2 of [IETF RFC 6775] | M-HL | M-PHY/DLL | N | N | |
| 6ND22 | Support Address unregistration | Clause 3.2 of [IETF RFC 6775] | M-HL | M-PHY/DLL | N | N | |

**Table 1 – Adaptation-layer profiles**

| No. | Functions | Reference | Adaptation-layer profiles | | | | Note |
|---|---|---|---|---|---|---|---|
| | | | [TTC JJ-300.10] method A | [TTC JJ-300.10] method B | [TTC JJ.300.11]/ [ITU-T G.9903] | [ITU-T G.9959] | |
| 6ND23 | Support neighbour unreachable detection | Clause 5.5 of [IETF RFC 6775] | M-HL | M-PHY/DLL | N | N | |
| 6ND24 | Send multicast neighbour solicitation (NS) | Clause 6.5.5 of [IETF RFC 6775] | O | N | N | N | |
| 6ND25 | Send unicast NS | Clause 5.5 of [IETF RFC 6775] | M-HL | M-PHY/DLL | N | N | |
| IP1 | Header format | Clause 3 of [IETF RFC 2460] | M-HL | M-PHY/DLL | M-PHY/DLL | M-PHY/DLL | |
| IP1.1 | Extension headers | N/A | O | M-PHY/DLL | N | O | |
| IP1.2 | Extension header order | Clause 4.1 of [IETF RFC 2460] | O | M-PHY/DLL | N | O | |
| IP1.3 | Options | Clause 4.2 of [IETF RFC 2460] | O | M-PHY/DLL | N | O | |
| IP1.4 | Hop-by-hop options header | Clause 4.3 of [IETF RFC 2460] | O | M-PHY/DLL | N | O | |
| IP1.5 | Routing header | Clause 4.4 of [IETF RFC 2460] | O | M-PHY/DLL | N | O | |
| IP1.6 | Fragment header | Clause 4.5 of [IETF RFC 2460] | O | O | N | O | |
| IP1.7 | destination Options Header | Clause 4.6 of [IETF RFC 2460] | O | O | N | O | |
| IP1.8 | No next header | Clause 4.7 of [IETF RFC 2460] | M-HL | O | N | N | |

**Table 1 – Adaptation-layer profiles**

| No. | Functions | Reference | Adaptation-layer profiles | | | | Note |
|---|---|---|---|---|---|---|---|
| | | | [TTC JJ-300.10] method A | [TTC JJ-300.10] method B | [TTC JJ.300.11]/ [ITU-T G.9903] | [ITU-T G.9959] | |
| IP1.9 | Authentication header (AH) | Stateless address autoconfiguration (SAA98) [IETF RFC 2462] | O | N | N | N | |
| IP1.10 | Encapsulating security payload (ESP) header | Management information base [IETF RFC 2466] | O | N | N | N | |
| IP2 | Deprecation of type 0 routing headers | [IETF RFC 5095] | O[j] | M-PHY/DLL | N | N | [j]When IP1.5 is applied, IP2 shall be used. |
| IP3 | Path maximum transmission unit (MTU) discovery | Clause 5 of [IETF RFC 2460] | O | M-PHY/DLL | N | N | |
| IP4 | Flow labels | Clause 6 of [IETF RFC 2460] | M-HL | M-PHY/DLL | N[k] | N | [k]Specification in clause 6 of [IETF RFC 2460] is not supported. |
| IP5 | Traffic classes | Clause 7 of [IETF RFC 2460] | M-HL | M-PHY/DLL | N[l] | N | [l]Specification in clause 7 of [IETF RFC 2460] is not supported. |
| ICMP1 | Message format | Clause 2.1 of [IETF RFC 4443] | M-HL | M-PHY/DLL | M-PHY/DLL | M-PHY/DLL | |
| ICMP2 | Message source address determination | Clause 2.2 of [IETF RFC 4443] | M-HL | M-PHY/DLL | M-PHY/DLL | M-PHY/DLL | |
| ICMP3 | Message checksum calculation | Clause 2.3 of [IETF RFC 4443] | M-HL | M-PHY/DLL | M-PHY/DLL | M-PHY/DLL | |
| ICMP4 | Message processing rules | Clause 2.4 of [IETF RFC 4443] | M-HL | M-PHY/DLL | M-PHY/DLL | M-PHY/DLL | |

**Table 1 – Adaptation-layer profiles**

| No. | Functions | Reference | Adaptation-layer profiles | | | | Note |
|---|---|---|---|---|---|---|---|
| | | | [TTC JJ-300.10] method A | [TTC JJ-300.10] method B | [TTC JJ.300.11]/ [ITU-T G.9903] | [ITU-T G.9959] | |
| ICMP5 | Destination unreachable message | Clause 3.1 of [IETF RFC 4443] | M-HL[m] | M-PHY/DLL | M-PHY/DLL | M-PHY/DLL | [m]Code = 4 only. |
| ICMP6 | Packet too big message | Clause 3.2 of [IETF RFC 4443] | O | M-PHY/DLL | M-PHY/DLL[n] | O | [n]Transmission function may not be supported. |
| ICMP7 | Time exceeded message | Clause 3.3 of [IETF RFC 4443] | O | M-PHY/DLL | M-PHY/DLL | O | |
| ICMP8 | Parameter problem message | Clause 3.4 of [IETF RFC 4443] | M-HL | M-PHY/DLL | M-PHY/DLL | M-PHY/DLL | |
| ICMP9 | Echo request message | Clause 4.1 of [IETF RFC 4443] | M-HL | M-PHY/DLL | M-PHY/DLL | M-PHY/DLL | |
| ICMP10 | Echo reply message | Clause 4.2 of [IETF RFC 4443] | M-HL | M-PHY/DLL | M-PHY/DLL | M-PHY/DLL | |
| IPAD1 | IPv6 addressing | [IETF RFC 4291] | M-HL[o] | M-PHY/DLL | M-PHY/DLL | M-PHY/DLL | [o]Some features are not used. |
| IPAD1.1 | Global unicast address | Clause 2.5.4 of [IETF RFC 4291] | N | M-PHY/DLL | N | M-PHY/DLL | |
| IPAD1.2 | Link local Unicast Address | Clause 2.5.6 of [IETF RFC 4291] | M-HL[p] | M-PHY/DLL | M-PHY/DLL | M-PHY/DLL | [p]Link local address based on EUI-64 shall be used. |
| IPAD1.3 | Unique local unicast address | [IETF RFC 4193] | N | M-PHY/DLL | N | M-PHY/DLL | |
| IPAD1.4 | Anycast address | Clause 2.6 of [IETF RFC 4291] | N | N | N | N | |
| IPAD1.5 | Multicast address | Clause 2.7 of [IETF RFC 4291] | M-HL[q] | M-PHY/DLL | M-PHY/DLL[q] | M-PHY/DLL | [q]FF02::1 shall be used for transmission. |
| IPAD1.6 | Prefix length | | /64 | /64 | /64 | /64 | |

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|---|---|---|---|---|---|---|---|
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| IPAD2 | Stateless address autoconfiguration (SAA07) | [IETF RFC 4862] | M-HL | M-PHY/DLL | M-PHY/DLL | M-PHY/DLL | |
| IPAD2.1 | Creation of link local address | Clause 5.3 of [IETF RFC 4862] | M-HL | M-PHY/DLL | M-PHY/DLL | M-PHY/DLL | |
| IPAD2.2 | Creation of global addresses | Clause 5.5 of [IETF RFC 4862] | N | M-PHY/DLL | N | M-PHY/DLL | |
| ND1 | Router and prefix discovery | Clause 6 of [IETF RFC 4861] | N | N | N | N | |
| ND2 | Address resolution | Clause 7.2 of [IETF RFC 4861] | M-HL | N | N | N | |
| ND3 | Neighbour unreachability detection | Clause 7.3 of [IETF RFC 4861] | N | N | N | N | |
| ND4 | Duplicate address detection | Clause 5.4 of [IETF RFC 4862] | O | N | N | N | |
| ND5 | Redirect function | Clause 8 of [IETF RFC 4861] | N | N | N | N | |
| ND6 | Router solicitation message | Clause 4.1 of [IETF RFC 4861] | N | N | N | N | |
| ND7 | Router advertisement message | Clause 4.2 of [IETF RFC 4861] | N | N | N | N | |
| ND8 | Neighbour solicitation message | Clause 4.3 of [IETF RFC 4861] | N/A[r] | N | N | N | [r]See clauses 8.1, 8.2, 8.3 of [IETF RFC 4861] |

**Table 1 – Adaptation-layer profiles**

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|---|---|---|---|---|---|---|---|
| | | | [TTC JJ-300.10] method A | [TTC JJ-300.10] method B | [TTC JJ.300.11]/ [ITU-T G.9903] | [ITU-T G.9959] | |
| ND8.1 | NS transmission | | O[s] | | | N | [s]At least one of clause 8.1 or clause 8.2 of [IETF RFC 4861] shall be used. |
| ND8.2 | No NS transmission | | O[t] | | | N | [t]At least one of clause 8.1 or clause 8.2 of [IETF RFC 4861] shall be used. |
| ND8.3 | NS reception | | M-HL | | | N | |
| ND9 | Neighbour advertisement message | Clause 4.4 of [IETF RFC 4861] | N/A[u] | N | N | N | [u]See clauses 9.1, 9.2, 9.3, 9.4 of [IETF RFC 4861] |
| ND9.1 | Solicited NA transmission | | M-HL | | | N | |
| ND9.2 | Solicited NA Reception | | ND8.1: M-HL ND8.2: N | | | N | |
| ND9.3 | Unsolicited NA transmission | | N | | | N | |
| ND9.4 | Unsolicited NA reception | | N | | | N | |
| ND10 | Redirect message | Clause 4.5 of [IETF RFC 4861] | N | N | N | N | |
| ND11 | Source/target link-layer address option | Clause 4.6.1 of [IETF RFC 4861] | M-HL | N | N | N | |
| ND12 | PIO | [Clause 4.6.2 of [IETF RFC 4861] | N | N | N | N | |

**Table 1 – Adaptation-layer profiles**

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| ND13 | Redirected header option | Clause 4.6.3 of [IETF RFC 4861] | N | N | N | N | |
| ND14 | MTU option | Clause 4.6.4 of [IETF RFC 4861] | N | N | N | N | |
| M-PHY/DLL: support for function is specified as mandatory at PHY and/or DLL<br>M-HL: support for function is specified as mandatory at higher layers (above PHY/DLL)<br>O: support for function is specified as optional<br>N: function is not supported | | | | | | | |

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