Standardization and Certification Process for "Wi-SUN" Wireless Communication Technology

Toyoyuki Kato

[Summary] The Wi-SUN alliance was established in January 2012 under the initiative of the National Institute of Information and Communications Technology (NICT) as a standards organization targeting creation of technical specifications for short-range wireless communications in the 920-MHz band based on the IEEE802.15.4 standard to assure interoperability and establish a certification process. Anritsu has been an active contributing member of this alliance right from the start and along with Anritsu Engineering and Anritsu Customer Support has helped plan test standards, execute interoperability tests, and develop certification test systems. This article outlines the Wi-SUN alliance standardization activities and reference standards. It also explains the Wi-SUN ECHONET profile adopted as the communications method for smart electricity meters in Japan.

1 Introduction

The increasing spread of communications networks is driving the need for faster network applications in parallel with faster and larger capacity communications. On the other hand, a great deal of attention and expectations are focused on so-called Machine to Machine (M2M) and Internet of Things (IoT) technologies in revolutionizing social and industrial infrastructure and well as lifestyles through addition of communications functions to "things". Communications equipment for these markets must not only be fast and have large capacity but also requires the following:

(1) Compact size
(2) Low cost
(3) Low power consumption
(4) Support for low speeds and small capacity
(5) Autonomous operation

To standardize wireless specifications supporting these requirements, the Institute of Electrical and Electronics Engineers, Inc. (IEEE) started discussions in January 2009 on a new standard called IEEE802.15.4g that added new specifications for the PHY layer to the existing IEEE802.15.4 standard. Subsequently and simultaneously another new standard called IEEE802.15.4e, which added specifications about a suitable Media Access Control (MAC) layer for this, was completed and standardized jointly in 2012.

At the same time that these standards were completed, the Wireless Smart Utility Network (Wi-SUN) alliance was established as an industry group playing a key role in standardization work; it proceeded with activities to establish and promote technology standards based on IEEE802.15.4.

Subsequently, ECHONET Lite (ECHONET: Energy Conservation and HOmecare NETwork) was adopted as the data exchange protocol for smart electricity meters in Japan, and IEEE802.15.4g/e was adopted as one of the communication technologies for the protocol transmission. In response, the Wi-SUN alliance drew-up plans for the technical specifications and test standards for the Wi-SUN ECHONET Profile as communications specifications for smart electricity meters in Japan; these plans established the equipment certification process, and many Wi-SUN certified products are already now on the market. Additionally, in parallel with the above, the technical specifications and test standards for the Wi-SUN FAN (Field Area Network) profile targeted mainly as the communications technology for smart electricity meters in north and south America were also developed. Lastly, plans were developed for Wi-SUN technical standards in a variety of fields, including healthcare, home area network (HAN), and factory automation (FA).

2 Wi-SUN Alliance

The main activities of the Wi-SUN alliance are as follows:

(1) Plan technical standards based on IEEE802.15.4 and related standards
(2) Establish and manage the certification process based on the same technical standards
(3) Plan and hold interoperability testing (IOT) events
(4) Run promotion activities

At January 2015, there were more than 70 organizations undertaking various activities, including 9 promoter members, 58 contributor members, and 5 observer members. The member classes and the respective authority are as follows:

- Promoter members
  Membership to be in charge of comprehensive decisions on the alliance.
- Contributor members
  Membership to participate in various activities for standardization, as a member of working groups.
- Observer members
  Generally, these members are certification organizations or test laboratories, and will devote to establish and operate the certification program rather than product development.

2.1 Planning Wi-SUN Technical Standard

Figure 1 shows the process used by the Wi-SUN alliance for planning technical standards.

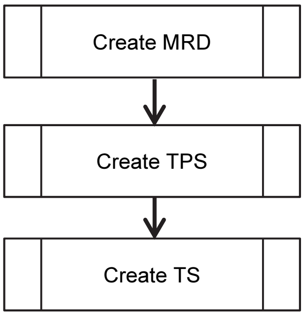


Figure 1 Technical Standards Development Process

(1) MRD (Marketing Requirement Document)
This document determines the target market, application range, uses, and objectives to clarify the needs for the technical standards plan; it defines the required standards such as the relevant conditions, implementation feasibility, implementation range and execution plans.

(2) TPS (Technical Profile Specification)
This is the specification defining the details of the technology to support the requirements in the MRD.

(3) TS (Test Specification)
This specification defines the test standards for equipment designed and developed based on the test specifications defined in the TPS.
Usually it is composed of two types: the Conformance Test Specification document for each layer of the communication layers forming the TPS, and of the Interoperability Test Specification document on interoperability.

Normally, these documents are created individually for each Technical Profile described later.

3 IEEE802.15.4 Standards

IEEE802.15.4 is a technical standards document defined by 802.15 WG which is a working group organized in IEEE802 Committee. IEEE802 is a standardization committee which is sponsored by the IEEE Computer Society. It mainly is in charge of standardization on technical specification for Local Area Networks (LAN), Metropolitan Area Networks (MAN), and Personal Area Networks (PAN). As shown in Table 1, IEEE802 have working groups (WG) or technical advisory groups (TAG) for each theme respectively.

Table 1 IEEE802 Working Groups and Technical Advisory Groups

Section	Working Groups	Responsibility
802.1	Higher Layer LAN Protocols WG	MAC Layer and related protocol technical standards
802.3	Ethernet WG	Ethernet technical standards
802.11	Wireless LAN WG	W-LAN technical standards
802.15	Wireless PAN WG	Wireless PAN technical standards
802.16	Broadband Wireless Access WG	Wide area wireless broadband access (Wi-MAX, etc.)
802.18	Radio Regulatory TAG	Radio regulations and rules
802.19	Wireless Coexistence WG	Coexistence of various communication technologies
802.21	Media Independent Handover Services WG	Handover between different communication technologies
802.22	Wireless Regional Area Networks WG	White-space wireless communications
802.24	Vertical Applications TAG	IEEE802 Cross-sectional themes supporting M2M. IoT, etc.

The 802.15 WG is responsible for Wireless PAN technical standards and Table 2 shows its revision and standardization work.

Table 2 IEEE802.15 Wireless PAN WG Standardization Work

Standard Name	Outline	Status
802.15.1	Wireless PAN PHY・MAC Layer (Bluetooth)	Completed
802.15.2	Sharing with Unlicensed Bands	Completed
802.15.3	High-speed Wireless PAN	Completed
802.15.4	Low-speed Wireless PAN	Completed
802.15.5	Mesh Topology	Completed
802.15.6	Wireless BAN (Body Area Network)	Completed
802.15.7	Short-range Visible Light Optical Networks	Completed
802.15.8	Peer-to-Peer (P2P) Communications	On going
802.15.9	Key Exchange Protocol	On going
802.15.10	Layer-2 Routing	On going

The IEEE802.15.4 standards are related to short range wireless networks called low-speed wireless PAN and is based on the Wi-SUN standard. The IEEE802.15.4 standards family is as follows:

(1) IEEE802.15.4

The first version of IEEE802.15.4 was standardized in 2004 as a specification for low-cost, low-power, short-range wireless communications. Amendments were subsequently issued in 2007 and 2011 to extend and update the performance. The current version is in the process of being updated again to reflect new extensions and updates. At the present time, the latest version is IEEE802.15.4-2011 and the main specifications are shown in Table 3.

Table 3 Main IEEE802.15.4 Specifications

Item	Application
Frequency band (MHz)	780, 868/915, 950, 2450
Modulation	ASK, BPSK, DQPSK, GFSK, MPSK, O-QPSK
Spreading	DSSS*1
Data Rate (Kbps)	20, 40, 100, 250, 1000
Access Control	TDMS or CSMA

*1: Can use either O-QPSK or BPSK together at DSSS-PHY

(2) IEEE802.15.4g

IEEE802.15.4g was standardized in 2012 as an amendment to add PHY layer specifications (SUN-PHY) for the Smart Utility Network (SUN) to the existing IEEE802.15.4 standard. It promoted definition and examination of conditions required by SUN such as low power consumption, low data rate, outside use, multi-region support, etc., and specified the following three SUN-PHY modulation methods:

- MR-FSK PHY (Multi-rate and multi-regional frequency keying)
- MR-OFDM PHY (Multi-rate and multi-regional orthogonal frequency division multiplexing)
- MR-O-QPSK (Multi-rate and multi-regional offset quadrature phase-shift keying)

Multiple frequency bands from 169 MHz to 2450 MHz are supported, and multiple data transfer rates are defined. The optimal combination can be selected matching the usage application and purpose as well as regional regulations.

(3) IEEE802.15.4e

This amendment standardized in 2012 strengthens and revises the MAC layer specifications of IEEE802.15.4 to expand the usage range and application range. Like IEEE802.15.4g standardized at the same time, it strengthens and updates the MAC layer specifications assuming SUN-PHY usage.

IEEE802.15.4 defines two access control methods: the asynchronous Carrier Sense Multiple Access (CSMA), and the synchronous beacon control. In the IEEE802.15.4e expanded MAC specifications, another synchronous method called channel hopping has been added along with two beacon control methods called DSME superframe and LLDN network.

Table 4 Media Access Control Methods

Access Control		Method	Standard
Asynchronous		CSMA	IEEE802.15.4-2011
Synchronous	Beacon control	Superframe	
		DSME superframe	IEEE802.15.4e-2012
		LLDN network	
	Channel Hopping	TSCH network	

CSMA: Carrier Sync Multiple Access
DSME: Deterministic and Synchronous Multichannel Extension
LLDN: Low Latency Deterministic Network
TSCH: Time Slotted Channel Hopping

4 Wi-SUN Technical Standards

The Wi-SUN technical standards basically use IEEE802.15.4/4g for the lower PHY layer and IEEE802.15.4/4e for the MAC layer. The higher layer uses different protocols depending on the equipment and system application field; a technical profile is specified for each application field and a TPS (Technical Profile Specification) is created describing the detailed specifications for the technical requirements and protocol set. Figure 2 shows the structure of the Wi-SUN technical standard and technical profile; there is an application layer, interface layer, MAC layer and PHY layer. The application layer ([1] in Figure 2) is defined by other Standards Developing Organization (SDO) dedicating to each application areas and markets. The interface layer ([2] in Figure 2) defines the existing standards defined by other SDOs, such as IEEE and IETF (Internet Engineering Task Force) as well as application methods as a technical profile.

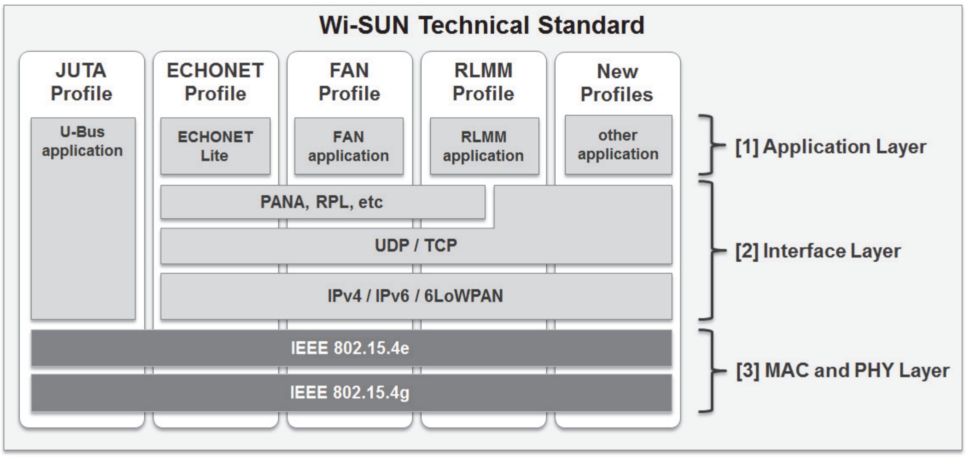
The MAC and PHY layers ([3] in Figure 2) define the application range for IEEE802.15.4/4e corresponding to each of the technical profile requirements as well as the technical profile specifications, such as parameters.

Table 5 lists the completed technical profiles and those which are still under development at December 2014.

Table 5 Wi-SUN Technical Profiles

Profile Name	Outline	Status
ECHONET Profile	Technical standards for sending ECHONET Lite protocol messages by Wi-SUN wireless communications	Completed
JUTA Profile	Communications standards for smart gas meters based on U-Bus Air standard of Telemetering Promotion Committee	On going
FAN Profile	Multihop communications specifications used by N and S American smart electricity meters	On going
RLMM Profile	Communications profile for industrial uses such as FA, healthcare, sensor networks, etc.	On going

The Wi-SUN technical profile uses a combination of technical standards already defined by other SDOs, such as IEEE and IEFT (Internet Engineering Task Force), and especially IEEE802.15.4. Selectable option functions and parameters are specified for the existing standards and any insufficient points are supplemented to specify a technology standard to implement a wireless network matching the applications and objectives.



PANA: Protocol for carrying Authentication for Network Access (RFC 5192)
RPL: IPv6 Routing Protocol for Low-Power and Lossy Networks (RFC 6550)

Figure 2 Wi-SUN Technical Standard and Technical Profile Structure

5 Wi-SUN ECHONET Profile

This section introduces Wi-SUN ECHONET, which has already started certification testing after completing technical standardization, as an example of a Wi-SUN technical profile.

The Wi-SUN ECHONET profile uses the 920-MHz wireless band as the Route-B communications specification for Tokyo Electric Power Company (TEPCO) smartmeters. The TTC JJ-300.10 "ECHONET Lite" home network communication Interface is specified as methods A and C (IEEE802.15.4/4e/4g 920 MHz wireless band).

5.1 Smartmeter Route-B Specifications

Smart electricity meters (smartmeters) have data-processing functions as well as communications functions for sending data about electricity usage to the power utility. These smartmeters have two communications interfaces; one is used by the power utility for remote monitoring and demand-response functions, while the other is used for communicating with the homeowner's Home Energy Management System (HEMS) to monitor and manage instantaneous usage and trends. The first interface is call the

Route-A and the second is the Route-B, which is a short communication path between the smartmeter and HEMS. Figure 3 shows the assumed location and usage environment of the smartmeter as well as the location of the Route-B.

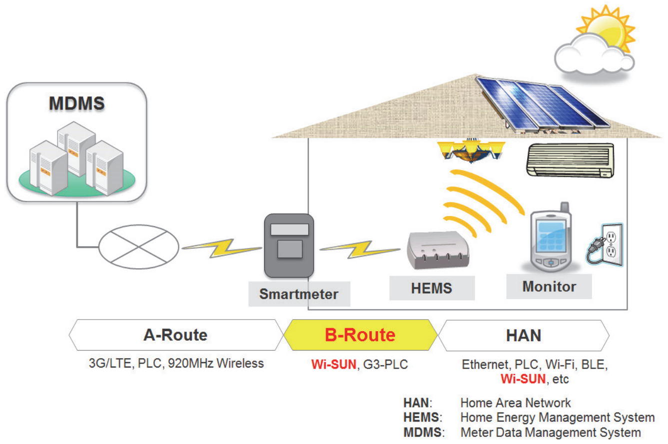


Figure 3 Smartmeter Installation and Usage Environment

This Route-B uses the ECHONET Lite Standard developed by the ECHONET consortium as the protocol for exchanging data about electricity usage, etc. Additionally, there are two communications methods for transferring these data: either using the 920-MHz wireless band, or narrowband communications over the household power wiring. These are defined by the technical standards of the Wi-SUN ECHONET profile and G3-PLC (Power Line Communication) standard, respectively. The Wi-SUN alliance has drawn-up the Wi-SUN ECHONET profile as the technical specifications for data exchange using ECHONET Lite.

As well as defining the structure of the PHY and MAC layers characterized by transmission of ECHONET Lite protocol messages and defining the parameter usage, the Wi-SUN ECHONET profile also defines the User Datagram Protocol (UDP) and Internet Protocol (IP) used by the higher layers as well as related protocols and their usage, etc. Figure 4 shows the structure of the SUN ECHONET profile protocol layers.

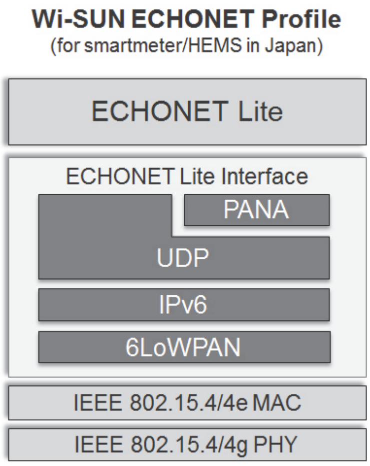


Figure 4 ECHONET Profile Protocol Layer Structure

5.2 Structure of Reference Standard

Figure 5 shows the structure of the standards for the Wi-SUN ECHONET profile. As described previously, it makes use of pre-existing standards and defines concrete uses. Additionally, the result is use of the TTC JJ-300.10 A and C routes.

The rest of this article introduces the contents of each reference standard and each definition in the Wi-SUN ECHONET profile.

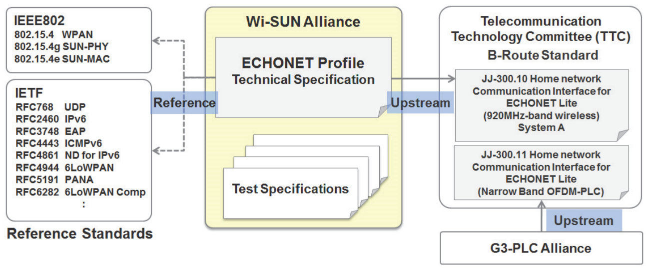


Figure 5 Wi-SUN ECHONET Profile Standard Structure

5.3 IEEE802.15.4 Reference Standard

5.3.1 PHY Layer

The PHY layer has multiple functions and components defined based on the reference standards in IEEE802.15.4-2011 and IEEE802.15.4e-2012; Table 6 lists the items, method and parameters used by the Wi-SUN ECHONET profile.

Table 6 Wi-SUN ECHONET Profile PHY Layer Specifications

Function/Method	Selected Specification
Modulation Method	MR-FSK
Frequency Band	920 MHz
PSDU (PHY Service Data Unit) Size	255 octets
FCS (Frame Check Sequence)	2 octets
ED (Energy Detection)	Yes
LQI (Link Quality Indication)	Yes
CCA (Clear Channel Assessment)	Yes
Data Whitening	Yes

5.3.2 MAC Layer

Like the PHY layer, the MAC layer is based on the reference standards defined in IEEE802.15.4-2011 and 802.15.4e-2012 and has various items to be selected from the option functions and components defined in both standards; these are defined as the MAC layer specifications for the Wi-SUN ECHONET profile and are listed in Table 7.

Table 7 Wi-SUN ECHONET Profile MAC Layer Specifications

Function/Method	Selected Specification
MAC Address	64-bit Expanded Address
Access Control	Non-Beacon Mode (Asynchronous communications)
Security	Security Level 5
Network Topology	Star (1 to 1 for B route)

5.4 IETF Reference Standard

As shown in Figure 2, the Wi-SUN ECHONET profile uses IPv6 and UDP as the protocols for the network layer and transport layer to transfer the ECHONET Lite protocol messages. IPv6 packets reduce the size of the data communications by compressing the headers using IPv6 over Low Power Wireless Personal Area Networks (6LoWPAN) as implemented in the IEEE802.15.4 standard for low-speed wireless PAN. Additionally, to achieve secure communications in MAC layer, the profile uses the Protocol for carrying Authentication for Network Access (PANA) as the authentication mechanism and key exchange method.

The next section outlines these 6LoWPAN and PANA technologies and introduces how they are applied in the Wi-SUN ECHONET profile.

5.4.1 6LoWPAN

6LoWPAN is defined in Request For Comments (RFC) 4944 as an Adaptation sub-layer between the IPv6 and MAC layers to support exchange of IPv6 packets on low-speed networks with a short maximum frame length. The main items defined in RFC 4944 and RFC 6282 are as follows:

(1) IPv6 Stateless Address Allocation
(2) IPv6 Header Compression/Expansion Method
(3) UDP Header Compression/Expansion Method
(4) IPv6 Packet Fragmentation/Defragmentation Method
(5) Message Header Definition

Additionally, RFC 6282 defines updated specifications for IPv6 header compression and expansion.

The Wi-SUN ECHONET profile uses the IPv6 stateless address allocation, IPv6 header compression and expansion and IPv6 packet fragmentation/defragmentation definitions from these 6LoWPAN specifications.

IEEE802.15.4 presumed that the main usage applications would be on sensor networks configured with several hundreds to several thousand network nodes. Consequently IPv6 is implemented by dynamic allocation of multiple network addresses in the network layer. On the other hand, the IPv6 address length of 128 bits (16 octets) is very much longer than the IPv4 length of 32 bits (4 octets) and the protocol header size forms a large part of the overall packet length. Moreover, since most data transfers are relatively small amounts, the Wi-SUN ECHONET profile defines the maximum length of the PSDU as 255 bytes and if the size of the data to be transferred exceeds this length, some measures are required. As a result of this, the Wi-SUN ECHONET profile not only uses IPv6 as the protocol for the network layer but also uses 6LoWPAN for IPv6 header compression and fragmentation/defragmentation.

5.4.1.1 6LoWPAN IPv6 Header Compression

The first version of IEEE802.15.4 defines a maximum frame size of 127 bytes. When transferring IPV6 packets using this IEEE802.15.4 standard, after adding the 40-byte minimum size of the IPv6 packet header plus the PHY and MAC headers, about half of the entire frame length is composed of header information. In particular when sending small data sizes, half of the frame content is header information. Consequently, the 6LoWPAN header compression is used to reduce the 40-byte header length to a minimum of about 3 bytes.

However, although the 2011 amendment to IEEE802.15.4 increased the maximum frame length to 2047 bytes, since it is important to shorten the time that the band is occupied from the perspective of conflict resolution and better usability on an IEEE802.15.4 low-speed wireless PAN, the Wi-SUN ECHONET profile still uses 6LoWPAN header compression.

Figure 6 shows the IPv6 packet structure. From this, the following two fields can be omitted for use on IEEE802.15.4 networks.

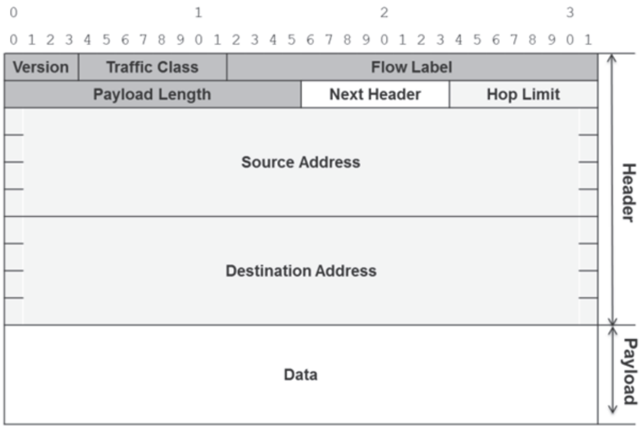


Figure 6 IPv6 Packet Structure

- Version Field
  Since this is self-evidently IPv6, there is no need for this to be specified.
- Payload Length
  There is no need for this to be specified because the frame length is detected and distinguished by the lower layer at frame receiving.

Moreover, the following five fields can be shortened, partially omitted, or omitted under some conditions, as described below.

- Traffic Class and Flow Label
  Usually, these are used to implement the priority control (8-bit precision) and band control (24-bit precision) for transferring IPv6 packets using priority control protocol and/or resource reservation protocol, together with transfer control mechanism provided by the lower layer. It is difficult to achieve high-accuracy priority control and band classification on IEEE802.15.4 networks, so these are hardly ever used. Consequently, the Traffic Class and Flow Label are shortened to a small number of bits.
- Next Header
  Usually, this cannot be omitted because it is used to indicate the higher protocol classification, but it can be omitted when this is not necessary.
- Hop Limit
  Usually, upper limit of IPv6 packet router hop count is specified as 8 bits, but this value can be expressed as 2 bits by classification into four types: 1, 64, 255, and Other. However, when Other is specified, it must be added without omitting the 8-bit value.
- Source Address
  The IPv6 address length is 128 bits, but for a link local address, FE80:0000:0000:0000 is used for the most significant 64 bits and since Extended Unique Identifier (EUI-64) generated from the MAC address is used as least significant 64-bits of the IPv6 address, it can be regenerated as long as the MAC header keeps existing. Consequently, all 124 bits can be omitted only in case of unicast addresses. However, in case of multicast addresses, only the unique part which length is varied according to its multicast scope can be shortened.
- Destination Address
  As similar to the case of Source Address above, the destination address may be either omitted or shortened.

Figure 7 shows the format for the IPv6 header compression (IPHC: IP Header Compression) defined by RFC 6282. In addition the definitions for each of these IPHC fields is listed in Table 8. As an example, by using these header compression methods, IPv6 header of unicast packet to be 128-bit long can be compressed into 3 bytes consisting of 2 bytes of IPHC and 1 byte of Next Header field.

In addition, when all of or part of the original value are used without compression, or when substitute values are used, these values are added in the specified sequence after IPHC. This subsequent header part following to IPHC is called in-line header.

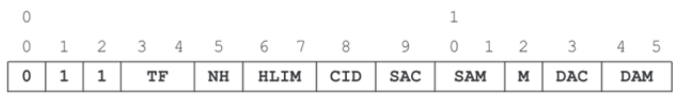


Figure 7 6LoWPAN IPHC Format

Table 8 6LoWPAN IPHC Field Definitions

Abbre-viation	Name	Bits	Outline
TF	Traffic Class and Flow Label	2	Specify the compression method
NH	Next Header	1	Indicate "omitted" or not
HLIM	Hop limit	2	Specify the compression method
CID	Context Identifier	1	Indicate "use" or not.
SAC	Source Address Context	1	Specify use/no use of context data for source address
SAM	Source Address Mode	2	Specify compression method for source address by combination with above described SAC
M	Multicast flag	1	Specify destination address type as unicast or multicast
DAC	Destination Address Context	1	Specify use/no use of context information for destination address
DAM	Destination Address Mode	2	Specify destination address compression method using combination of above-described M and DAC values

Figure 8 shows the compressed header format when the IPv6 unicast packet is compressed using this method.

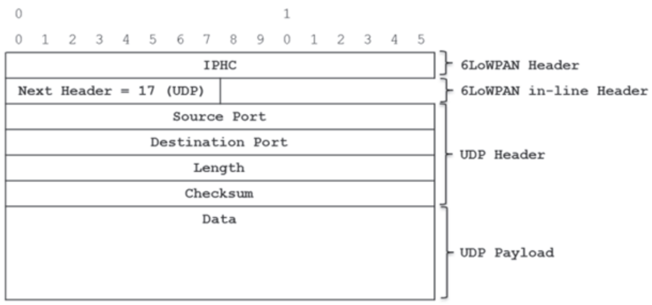


Figure 8 Packet Structure after IPv6 Header Compression with 6LoWPAN

5.4.1.2 6LoWPAN Fragmentation/Defragmentation Method

The Wi-SUN ECHONET profile uses a maximum PSDU length of 255 octets. Additionally, the IPv6 packet Maximum Transfer Unit (MTU) is 1280 bytes. Although most usual application data transfers almost never exceed 255 octets, some consideration is given to the possibility of this being exceeded depending on the implementation and behavior of the higher layer application. When a IPv6 packet frame exceeds 255 octets, its data are divided using the 6LoWPAN fragmentation and defragmentation method, then sent them out.

Using 6LoWPAN, the IPv6 packets are divided into multiple fragments and sent, requiring specification of a fragment header and its processing method. Figure 9 shows the form of the fragment header.

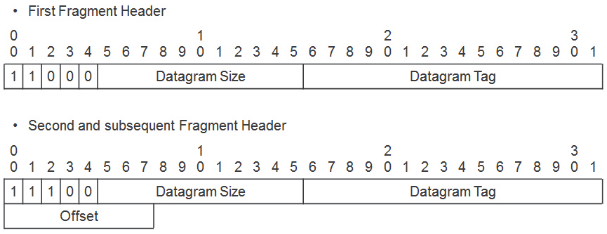


Figure 9 6LoWPAN Fragment Header

The Datagram Size field sets the IPv6 packet byte length before division. The Datagram Tag allows the fragments to be recognized as part of the same IPv6 packet at the receive side by setting the same value at all the divided fragments of the same IPv6 packet. Second and subsequent fragments have an offset field attached indicating which part of the original IPv6 fragment is included in that fragment.

Figure 10 shows an example of IPv6 packet division using the 6LoWPAN packet fragmentation method. In this example, one IPv6 packet is divided into three 6LoWPAN fragments. In the first fragment, an IPHC is added to follow immediate after the fragment header and followed by the beginning part of IPv6 payload header. The second and third fragments contain the IPv6 payload immediately after the fragment header.

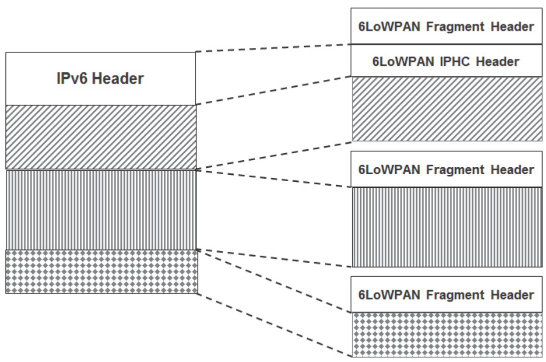


Figure 10 6LoWPAN Packet Division

5.4.2 PANA

Most of conventional access authentication protocols are defined in data link layer. Typical examples are the Point to Point Protocol (PPP) and the Extensible Authentication Protocol (EAP). In particular, EAP is divided into the access authentication protocol and the authentication method. It is easy to change and add authentication methods and has been used widely as the access authentication method for wireless LAN and was adopted by IEEE802.1X standard.

On the other hand, modern networks use a great variety of datalink layers, requiring an access authentication protocol that is independent of the types and structures of datalink layers.

The Protocol for carrying Authentication for Access Network (PANA) is a protocol implemented using network layer (UDP/IP) instead of data link layer, for transmission of access authentication protocol, such as EAP, which is normally implemented in the datalink layer. Using the network layer removes dependence on the datalink layer for the access authentication protocol (Figure 11).

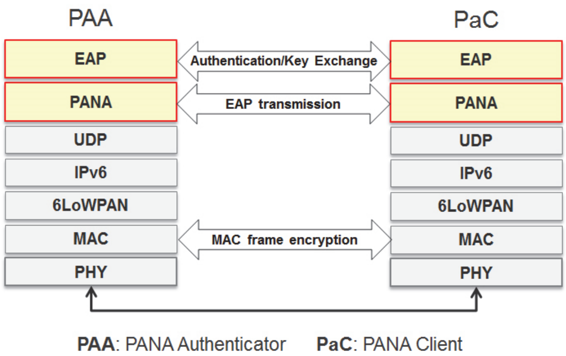


Figure 11 PANA Protocol Stack

PANA is a client/server model protocol. The client is called PANA Client (PaC) and the server is called PANA Authenticator (PAA). PAA takes the role of the Authenticator for PaC and a PANA session is established and started according to a request from PaC as the authenticator client (Supplicant). Next, Authentication data is exchanged during this PANA session and, after negotiating the various parameters and algorithm to be used, the authentication process and key exchange are performed using EAP based on the frame format and communication sequence specified in the PANA specifications.

In the Wi-SUN ECHONET profile, not only is the terminal connected to the network given access authentication using PANA EAP protocol authentication, but also the coding keys used for frame encoding and decoding are exchanged in the MAC layer.

5.4.3 Wi-SUN ECHONET Profile Extension

As previously described, the Wi-SUN ECHONET profile uses 920-MHz wireless band for the Route-B of electricity smartmeters and all power utilities in Japan are moving towards this method. Plans for technical specifications and tests standards have already been completed, and a certification test system has started with increasing numbers of devices obtaining certification.

The next step has been to expand the HAN specifications; plans for me technical specifications about using wireless communications in 920-MHz band to connect the HEMS with domestic electrical equipment are already complete, and creation of certification test specifications is progressing (at February 2015). In the first half of fiscal 2015, the final expanded HAN specifications will be added to the Wi-SUN ECHONET profile and the certification test process will also be established, supporting both an increase in the number of installed smartmeters as well as more domestic electric equipment supporting the Wi-SUN standard.

6 Certification System

6.1 Certification Tests

The key elements of the Wi-SUN alliance certification process are:

- Approval Certification Test Specification Documentation
- Certified Test Equipment (TE) and Certified Test Bed Unit (CTBU)
- Certified Test Laboratories

6.2 Certification Test Specifications

The Wi-SUN certification process is divided into a Conformance Test and an Interoperability Test.

The Conformance Test connects the Device Under Test (DUT) to the certified TE and runs tests based on the Conformance Test specifications.

The Interoperability Test connects DUTs and confirms normal communications in line with the Interoperability Test specifications to check normal operations on a network of mixed devices. The Wi-SUN certification tests use a CTBU at one side of the connection to monitor interoperability with the DUT.

Figure 12 shows Conformance Test and Interoperability Test system. Moreover, Conformance Test and Interoperability Test define the test specifications and items for each layer.

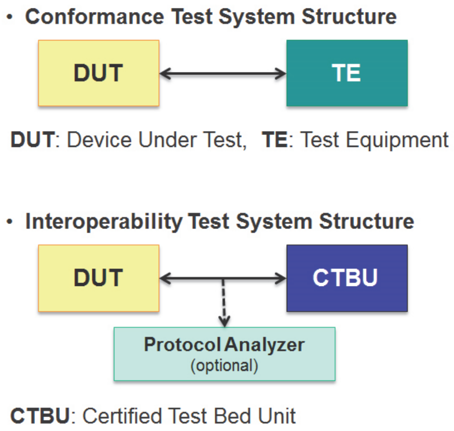


Figure12 Certification Test System Structure

6.2.1 Conformance Test Specifications

Separate Conformance Test specifications are defined for each of PHY, MAC, and interface layers. Tables 9, 10, and 11 list WI-SUN ECHONET profile Conformance Test items for each layer.

Table 9 PHY Layer Standards Compliance Test Items

Classification	Item
Transmitter Test	Modulation Quality
	Transmitter Frequency Offset
	Transmitter Adjacent Channel Power Ratio
Receiver Test	Receiver Sensitivity Test
	Adjacent/Alternate Channel Rejection Ratio
Frame Encoding	Packet Test

Table 10 MAC Layer Standards Compliance Test Items

Classification	Item
ED Scan	ED Scan
Active Scan	Active Scan with EBR command
Command Frame	Command Frame Reception
Data Transmission	Direct Mode Unicast Transmission
	Broadcast Frame Transmission
Data Reception	Direct Mode Unicast Reception
	Broadcast Frame Reception
Security	Direct Mode Unicast Transmission and Reception
	Broadcast Transmission and Reception

Table 11 Interface Layer Standards Compliance Test Items

Classification	Item
Adaptation Layer	6LoWPAN Header Compression /Decompression
	6LoWPAN Fragmentation /Defragmentation
Network Layer	ICMPv6
	Neighbor Discovery
	Multicast Packet Transmission
Security Configuration	PANA Authentication
	PANA Re-authentication

6.2.2 Interoperability Test Specifications

Interoperability Test defines two test specifications for PHY layer and higher layers (MAC and interface/adaptation layers).

Table 12 Interoperability Test Items

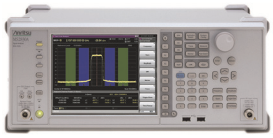
Layer	Item
PHY	Packet TRx Specified/Selected Parameters: ・Packet Size ・Transfer Rate ・Data Whitening ・FCS Mode ・Frequency Band
MAC and Interface	PANA Authentication
	ICMPv6 Echo Request and Response over 6LoWPAN
	UDP Unicast Packet Transmission over 6LoWPAN
	UDP Multicast Packet Transmission over 6LoWPAN
	Bi-Directional Data Transmission with MAC security
	PANA Re-authentication

6.3 Authentication Test Devices

The test equipment used for the Wi-SUN certification tests must also have received approval as a certified test device from the Wi-SUN alliance. Anritsu's MG3710A Vector Signal Generator and MS2830A Signal Analyzer have both received approval as Wi-SUN IEEE802.15.4g PHY certified test equipment.

Wi-SUN® certified
PHY Test Equipment

MG3710A Vector Signal Generator



MS2830A Signal Analyzer

Additionally, the ME7051 Wi-SUN Protocol Test System developed by Anritsu Engineering has also received approval as certified test equipment for the MAC and interface layers of the Wi-SUN ECHONET profile.

Wi-SUN® certified
Enet Protocol Test Equipment

ME7051 Wi-SUN Protocol
Test System

Wi-SUN ECHONET profile certification tests started from April 2014 and many certification organizations are using Anritsu Wi-SUN certified test equipment for Wi-SUN certification testing.

7 Summary

Anritsu, Anritsu Engineering and Anritsu Customer Support have participated actively right from the start in creation of the Wi-SUN alliance, making contributions to planning and editing certification test standards, etc., as well as in attending IOT events as a test equipment vendor. At the same time, Anritsu has pushed forward with developing and verifying certification test equipment such as the ME7051A. As a result of these activities, we hope that we have made some contribution, however small, to certification and introduction of B-Route communications tests. For the future, we are working actively on core technologies supporting M2M and IoT to assist widespread use of home and sensor networks, etc., by offering new measurement and test solutions for certifying the interoperability of Wi-SUN communications systems and furthering growth of the Wi-SUN standard.

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Author

Toyoyuki Kato
Anritsu Engineering Co., Ltd.
Market Development Division