Simultaneous Operation of Two International Wireless Standards on a Single Radio Unit: Wi-SUN HAN and Wi-SUN FAN

—Enabling In-Home and Outdoor Communications with One Radio Unit for Smaller, Lower-Cost Next-Generation Smart Meters—

Overview

A research group led by Professor Hiroshi Harada and doctoral student Reo Gakumi of the Graduate School of Informatics, Kyoto University (hereafter referred to as "Kyoto University") has developed and demonstrated common firmware that enables two international wireless communication standards to operate concurrently using a single radio transceiver: Wi-SUN FAN, which is applicable to the outdoor-side communications between electric power smart meters and electric utilities (Route A), and Wi-SUN HAN, which is used for the in-home communications between smart meters and home energy management systems (HEMS) (Route B). The technology adds two new functions to the common firmware for both standards announced in May 2026: a "radio sharing arbiter" that allocates radio time between the two standards, and "fast PHY switching," which switches the communication scheme in approximately 1 millisecond for a complete FAN-to-HAN-to-FAN switching cycle while maintaining the connection state of both standards. Using a wireless module running the developed firmware, the group conducted demonstration experiments in two use cases involving smart meters and HEMS devices. In the smart meter application, the group confirmed that the module can both transmit meter-reading data to the electric utility via Wi-SUN FAN and respond to electricity usage data requests from HEMS devices via Wi-SUN HAN. In the HEMS device application, the module read electricity usage data from a smart meter via Wi-SUN HAN while connected to an independent IoT wireless network using Wi-SUN FAN, achieving a data delivery rate of 99.99% or higher on the Wi-SUN FAN side and an on-time response rate of 99.95% for power-value reads at 10-second intervals on the Wi-SUN HAN side. These results are expected to help reduce the cost and size of the wireless communication units in smart meters and HEMS devices, and are expected to find application not only in next-generation smart metering systems but also in joint metering of electricity, gas, and water utilizing electric power smart meter networks, as well as in wide-area energy management systems.

Key Points

- Developed common firmware that operates Wi-SUN FAN and Wi-SUN HAN simultaneously on a single radio unit. Implemented a "radio sharing arbiter," which coordinates the radio usage time of the two standards, and a "fast PHY switching" function, which switches the communication scheme in approximately 1 millisecond per complete switching cycle while maintaining the connection state of both standards.
- In a demonstration of the smart-meter use case, confirmed that a single radio unit can both transmit meter-reading data to the electric utility via Wi-SUN FAN and respond to power-value read requests from HEMS devices via Wi-SUN HAN.
- In a demonstration of the HEMS use case, achieved both the reading of electricity usage data from a smart meter via Wi-SUN HAN and connection to an independent IoT wireless

network using Wi-SUN FAN. Confirmed a data delivery rate of 99.99% or higher on the Wi-SUN FAN side and an on-time response rate of 99.95% on the Wi-SUN HAN side.

1. Background

Electric power smart metering systems use two communication routes: Route A, which connects the smart meters that the electric utility installs in each household to the utility's systems, and Route B, which connects the smart meters to home energy management systems (HEMS) and other in-home equipment. For next-generation smart meters being deployed from fiscal year 2025, the international wireless communication standard Wi-SUN FAN is under consideration as the wireless multi-hop communication scheme for Route A, while Route B continues to use the international wireless communication standard Wi-SUN HAN, which has been employed to date. Both standards adopt IEEE 802.15.4g in the 920 MHz band as their physical layer, but they differ in network joining procedures, authentication methods, frequency usage schemes, and other respects. Consequently, it has conventionally been necessary either to use a separate wireless module for each standard or to switch the standard running on a single wireless module.

In May 2026, Kyoto University developed and announced common firmware capable of running Wi-SUN HAN (Enhanced HAN) and Wi-SUN FAN 1.1 on a single wireless module, with the operating standard to be used selected at startup. However, using a single radio unit for both Route A and Route B of a smart meter at the same time requires a mechanism for sharing the radio unit while maintaining the connection state of both standards. Because each standard is designed on the assumption that it has exclusive use of the radio unit, simply switching the radio unit between them could cause communication interruptions or loss of connection state. The challenges were therefore to develop a mechanism for time-sharing a single radio unit while maintaining the connection state of both standards, and to verify the impact on the communication performance of both standards using actual hardware.

2. Research Results

Kyoto University has extended the common firmware for Wi-SUN HAN and Wi-SUN FAN announced in May 2026 to develop firmware that enables both standards to operate simultaneously using a single radio transceiver (**Figure 1**).

This firmware newly implements a "radio sharing arbiter," which coordinates the time each standard uses the radio unit, and a "fast PHY switching" function, which rapidly changes the radio unit settings while maintaining the connection state of both standards.

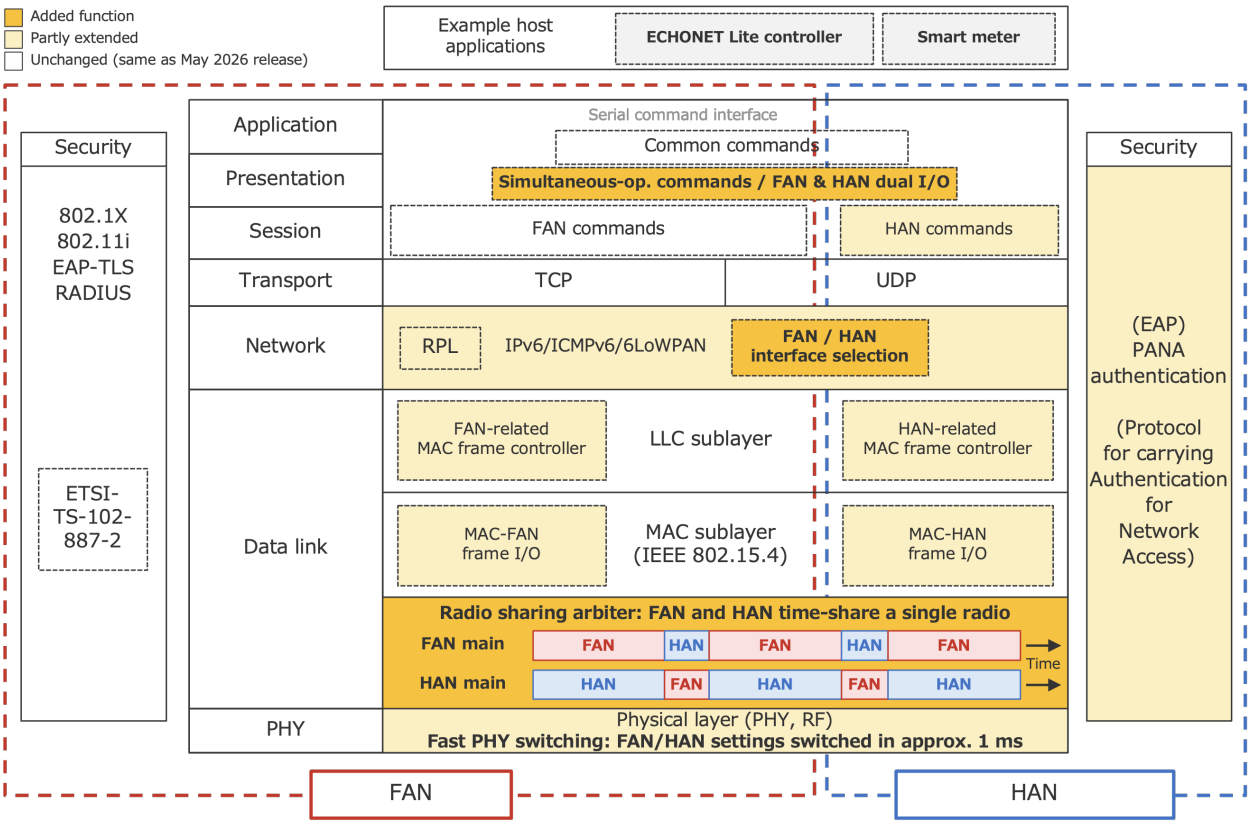


Figure 1 Functional configuration of the developed common firmware

As a result, Wi-SUN HAN and Wi-SUN FAN communications can now be executed in parallel on a single radio unit.

One of the key features enabling simultaneous operation is the newly developed "radio sharing arbiter" (**Figure 2(a)**). With this mechanism, Wi-SUN FAN normally uses the radio unit, and when Route B communication via Wi-SUN HAN is required, use of the radio unit is temporarily allocated to Wi-SUN HAN. There are two types of switching periods: periods set in response to communication requests on the Route B side, and periods set at regular intervals for reception on the Route B side. These periods are scheduled to avoid the broadcast reception periods of Wi-SUN FAN. In addition, even while the radio unit is switched over, the connection state of each standard is maintained by retaining its network membership, authentication information, communication schedule, and other state.

The other key feature is the "fast PHY switching" function (**Figure 2(b)**). Because Wi-SUN HAN and Wi-SUN FAN differ in data rate, modulation scheme, frequency usage, and other respects, sharing a radio unit requires changing the settings of the radio IC according to each standard. The developed firmware therefore realizes a mechanism that switches the communication scheme solely by changing the physical layer settings and controlling MAC layer timers, without reinitializing the radio unit or rejoining the network. As a result, measurements confirmed that switching from Wi-SUN FAN to Wi-SUN HAN is completed in approximately 0.4 milliseconds, and switching from Wi-SUN HAN to Wi-SUN FAN in approximately 0.5 milliseconds.

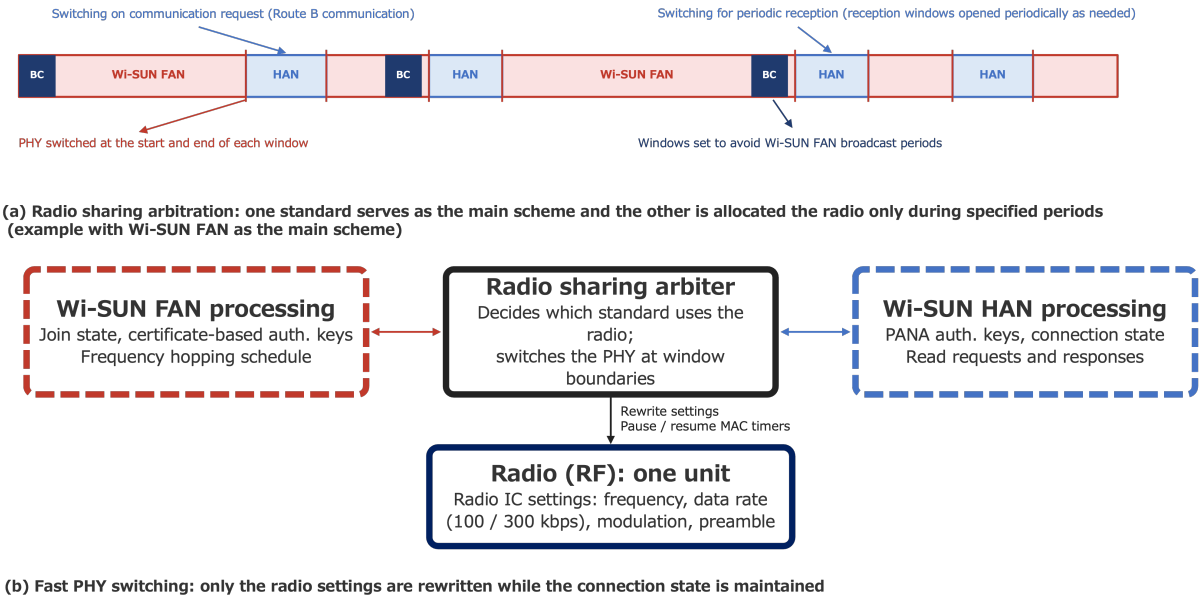


Figure 2 Mechanism of simultaneous operation of Wi-SUN FAN and Wi-SUN HAN on a single radio unit

Next, to verify the effectiveness of a wireless module running the developed firmware, demonstration experiments were conducted for two usage models assuming application to smart meters and to HEMS devices.

In Usage Model 1, the developed wireless module was used as the communication unit of an electric power smart meter, with Route A, the communication route to the electric utility, implemented by Wi-SUN FAN, and Route B, the communication route to in-home HEMS devices, implemented by Wi-SUN HAN (**Figure 3**).

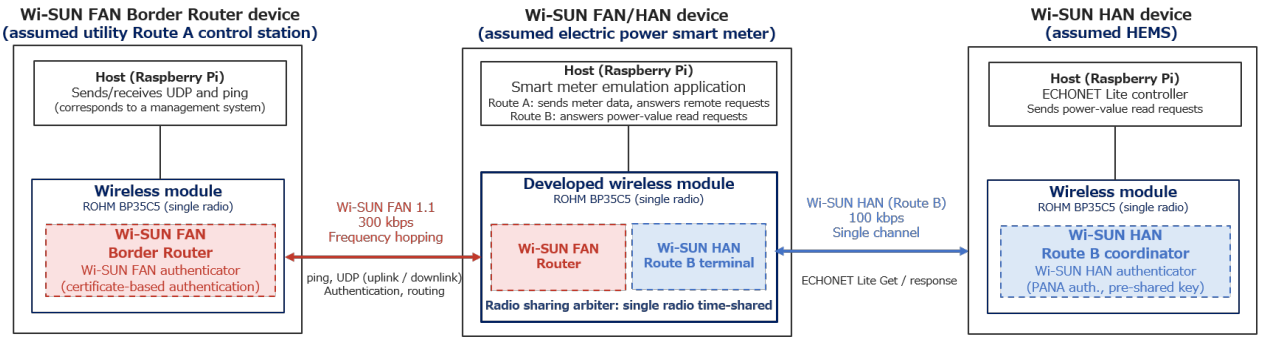


Figure 3 Usage Model 1: System configuration of the demonstration test assuming application to an electric power smart meter

In this model, a device representing a smart meter connects to the electric utility's network via a Wi-SUN FAN border router while responding, as a Wi-SUN HAN Route B terminal, to electricity usage data requests from a HEMS device. The developed firmware was implemented on a ROHM BP35C5 wireless module, which was combined with a device equipped with Wi-SUN FAN border router functionality and a device emulating a Wi-SUN HAN-compatible HEMS device to construct the demonstration test environment (**Figure 4**).

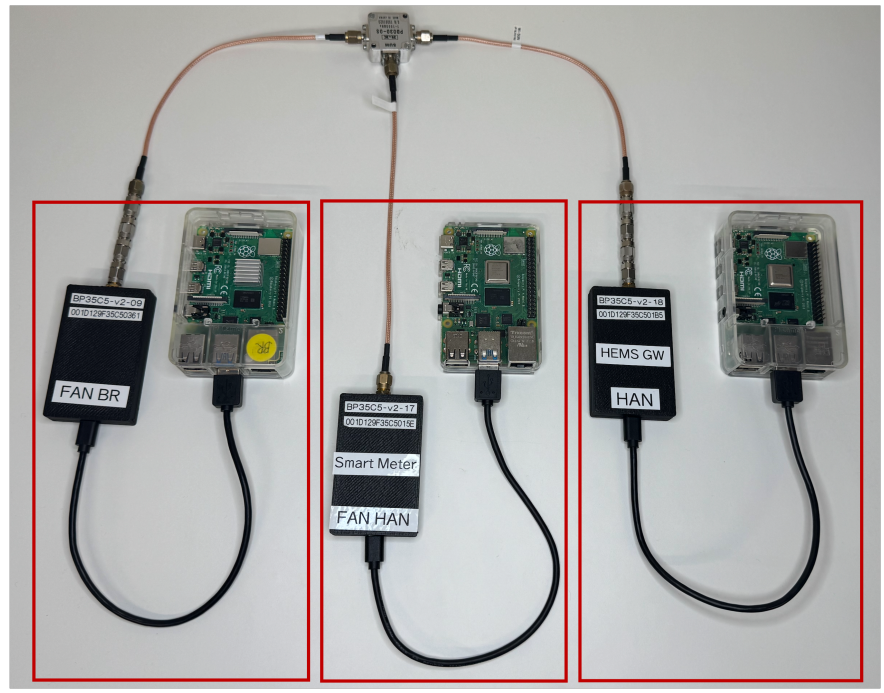


Figure 4 Usage Model 1: Demonstration test environment assuming application to an electric power smart meter

In this usage model, in order to respond to electricity usage data requests from the HEMS device, the proportion of time during which the radio unit is allocated to the Wi-SUN HAN side was varied among 10%, 30%, and 45%, and the communication characteristics of Route A and Route B were evaluated (**Figure 5**).

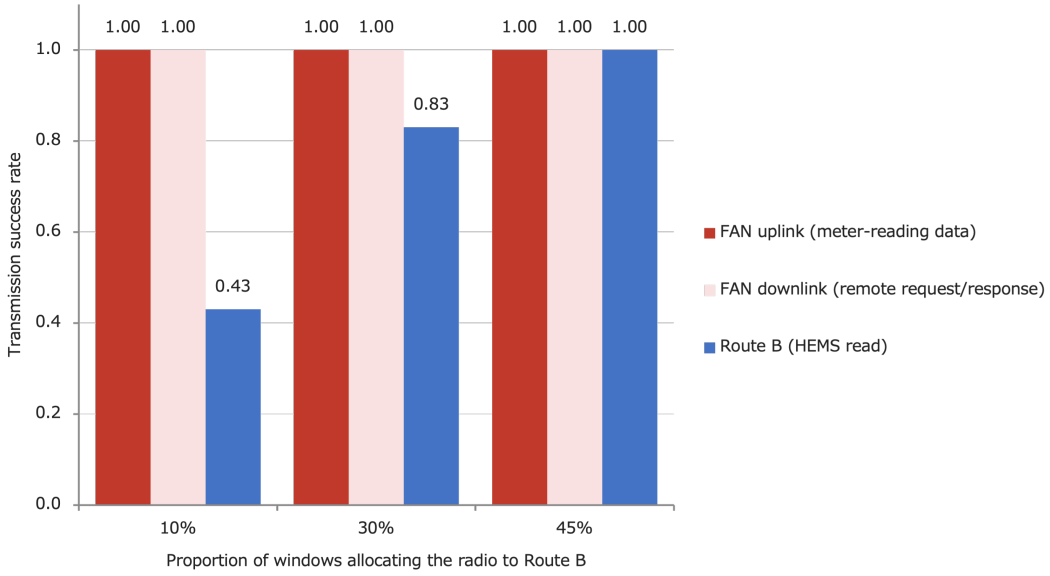


Figure 5 Usage Model 1: Transmission success rates of Route A and Route B versus the proportion of radio usage time allocated to Wi-SUN HAN

As a result, when the allocation ratio to the Wi-SUN HAN side was set to 10%, 30%, and 45%, the response success rate for electricity usage data requests sent from the HEMS device at 10-second intervals was 43%, 83%, and 100%, respectively. In particular, it was confirmed that at an allocation ratio of 45%, all read requests were successfully answered. For Route A communication via Wi-SUN FAN, assuming the transmission of meter-reading data to the electric utility, all data were transmitted successfully even when 200-byte data packets were transmitted once per minute. Furthermore, for downlink communication assuming remote requests from the electric utility, a transmission success rate of 100% was confirmed at the application level, including retransmissions.

In Usage Model 2, on the other hand, the developed wireless module was installed in an in-home HEMS device, which acquires electricity usage data from an electric power smart meter via Wi-SUN HAN while connecting to an outdoor multi-hop wireless network as a Wi-SUN FAN router (**Figure 6**).

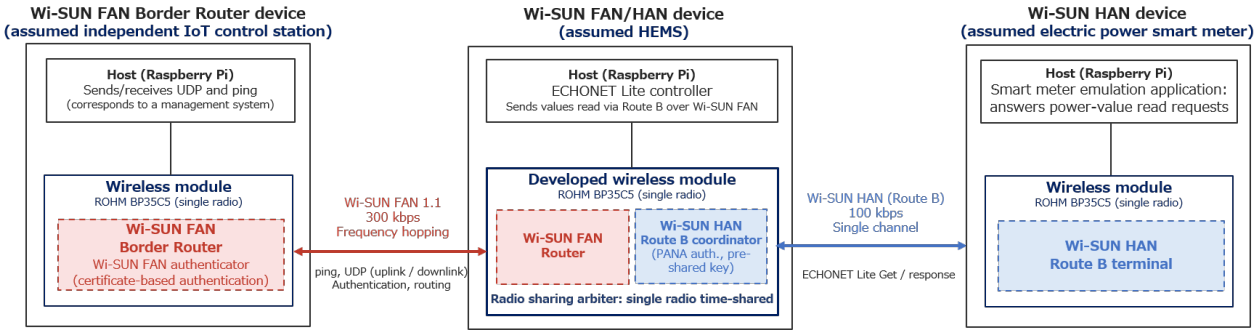


Figure 6 Usage Model 2: System configuration of the demonstration test assuming application to a HEMS device

This model assumes an independent IoT network built by an operator other than the electric utility, in which the electricity usage data acquired from the smart meter is transmitted to a Wi-SUN FAN border router. The demonstration test environment was constructed by combining a device emulating a HEMS device equipped with the developed wireless module, a device emulating a Wi-SUN HAN-compatible smart meter, and a device equipped with Wi-SUN FAN border router functionality (**Figure 7**).

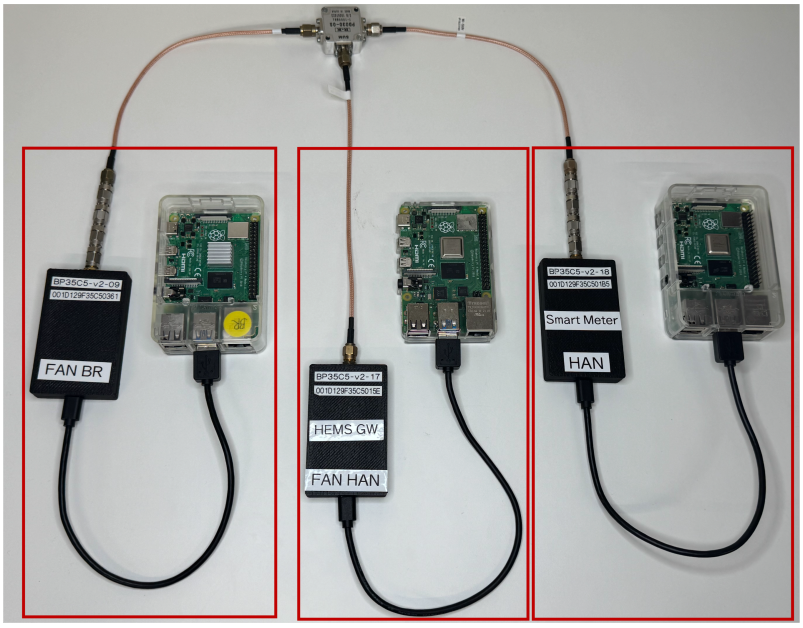


Figure 7 Usage Model 2: Demonstration test environment assuming application to a HEMS device

In this usage model, the communication performance of both standards was evaluated while varying the amount of data transmitted on the Wi-SUN FAN side and the interval at which electricity usage data are read via Wi-SUN HAN (**Figure 8**).

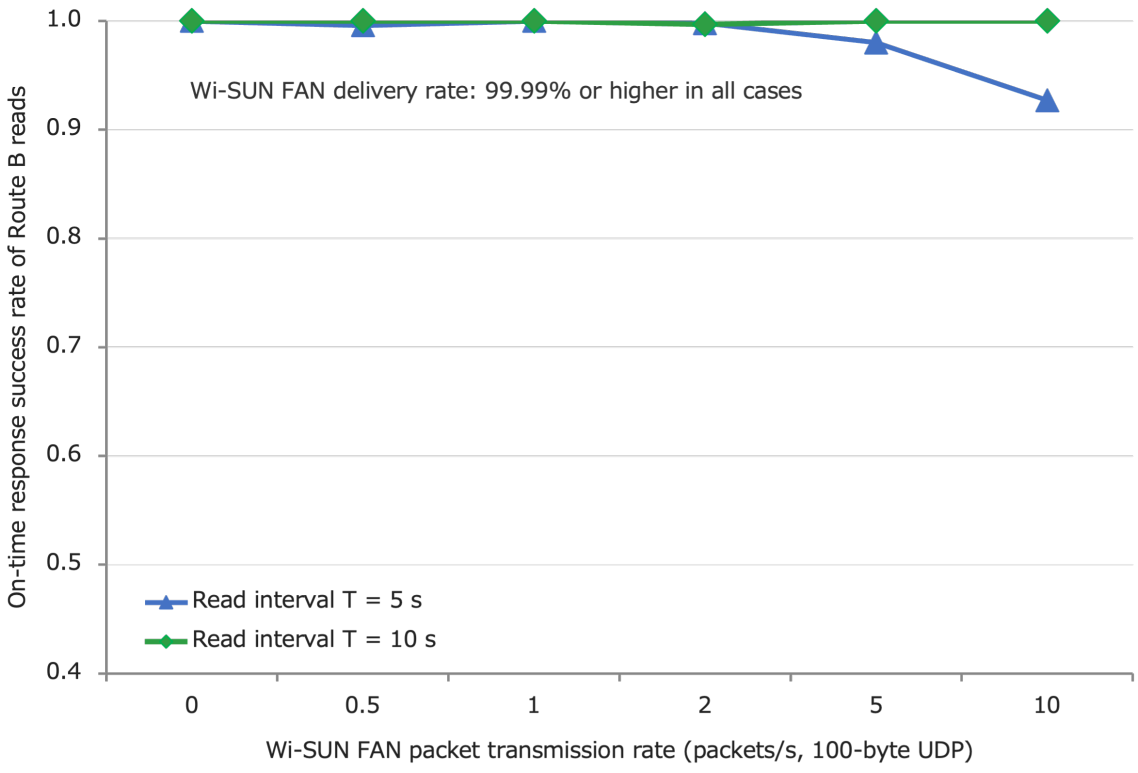


Figure 8 Usage Model 2: Relationship between Wi-SUN FAN transmission volume and the on-time response success rate of Wi-SUN HAN power-value reads

As a result, the Wi-SUN FAN side maintained a data delivery rate of 99.99% or higher under all evaluated conditions. It was also confirmed that even when the transmission volume on the Wi-SUN FAN side increased, electricity usage data responses could be obtained within the specified time by appropriately setting the read interval on the Wi-SUN HAN side. In particular, for reads at 10-second intervals, as assumed in the application communication interface specification for smart meters, an on-time response rate of 99.95% was confirmed across the evaluated conditions. Furthermore, during 48 hours of continuous operation, the connection state of both standards was maintained, and relay operation in Wi-SUN FAN multi-hop communication also continued without interruption.

These results demonstrate that the developed common firmware enables Wi-SUN FAN and Wi-SUN HAN communications to be executed in parallel on a single radio unit while maintaining the connection state of both standards, and that it is applicable to both smart meters and HEMS devices.

3．Potential Impact and Future Prospects

The Wi-SUN HAN/Wi-SUN FAN simultaneous operation technology developed in this work makes it possible to implement both Route A and Route B communication functions of a smart meter in a single wireless module, while keeping the networks logically separate. These results are expected to contribute to reducing the cost and size of the wireless communication units installed in smart meters and HEMS devices, and will lead to the construction of new IoT systems that collect and utilize power information acquired from smart meters via wide-area multi-hop wireless networks based on Wi-SUN FAN. Moreover, because communication can be carried out while keeping the networks of the two standards separate, the technology can be extended to a wide variety of energy management services while preserving the independence of each network.

Furthermore, next-generation smart metering systems are moving toward the introduction of an "IoT Route," which utilizes the electric power smart meter network to collect meter-reading data jointly from gas meters, water meters, and the like. Since Wi-SUN Enhanced HAN, which is employed in the system developed here, is used as a wireless communication standard for the IoT Route, the technology is also expected to be extended to joint meter-reading systems for electricity, gas, and water. This approach is expected to streamline data collection from multiple utility infrastructures through electric power smart meters, and to contribute to reducing system construction and operation costs through the shared use of communication equipment.

Going forward, in addition to monitoring household electricity consumption, the group will pursue applications to energy management systems that incorporate photovoltaic power generation equipment, storage batteries, EV charging equipment, and the like, as well as to joint meter-reading systems for electricity, gas, and water. The group will also proceed with evaluations of long-term stable operation including the renewal of authentication keys, interoperability with actual smart meters, and communication performance in real-world environments subject to radio attenuation and interference, aiming for practical implementation as an IoT communication platform supporting social infrastructure such as smart metering, energy management, and smart cities.

These research results are scheduled to be presented at the "Commemorative Forum Celebrating Professor Hiroshi Harada's Receipt of the Medal with Purple Ribbon," to be held on October 22, 2026.

4. Acknowledgments

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＜Terminology＞

1. Route A and Route B of smart meters

   The two communication routes provided by an electric power smart meter. Route A is the communication route to the electric utility's meter-reading and control systems, and uses one of 920 MHz band wireless multi-hop communication, cellular networks, or power line communication. Route B is the communication route to the customer's in-home equipment (such as HEMS), through which the customer can directly obtain values such as cumulative electricity consumption recorded at 30-minute intervals and instantaneous power.

2. Wi-SUN FAN (Field Area Network)

   A wireless communication standard developed by the Wi-SUN Alliance. It connects sensors, meters, and other devices through IPv6 multi-hop communication, and is used for smart metering, distribution automation, infrastructure management, intelligent transport systems, smart lighting, and more. It is characterized by its ability to build wide-area, highly reliable IoT networks; version 1.0 was established in 2016. Version 1.1 supports higher-speed communication, lower power consumption, and other enhancements.

3. Wi-SUN HAN (Home Area Network)

   A wireless communication standard for in-home use developed by the Wi-SUN Alliance. For Route B of low-voltage smart meters in Japan, the specification known as "Route B" is used, connecting a smart meter and a HEMS device on a one-to-one basis. The connection is established using an authentication method (PANA) based on a previously issued authentication ID and password, and values such as electricity usage data are exchanged in the ECHONET Lite format. Wi-SUN Enhanced HAN, the target of the common firmware announced in May 2026, is an extended specification that adds relay and power-saving functions to Wi-SUN HAN.

4. ECHONET Lite

   A communication standard developed by the ECHONET Consortium for controlling and monitoring home appliances and residential equipment. It is also used for communication between smart meters and HEMS devices, and has been standardized internationally as ISO/IEC 14543-4-3.