INVESTIGATION OF WIRELESS TELECOMMUNICATION FOR AMI

Tatsuya NAKAMURA
Chubu Electric Power Co., Inc., – Japan
Nakamura.Tatsuya@chuden.co.jp

Shinji TAKEUCHI
Chubu Electric Power Co., Inc., – Japan
Takeuchi.Shinji2@chuden.co.jp

Atsushi OTOGAWA
Chubu Electric Power Co., Inc., – Japan
Otogawa.Atsushi@chuden.co.jp

Yukio IWASHIMA
ChubuSeiki Co., Ltd., – Japan
yukio-iwashima@chubuseiki.co.jp

Yasuhisa MATSUSHITA
ChubuSeiki Co., Ltd., – Japan
yasuhisa-matsushita@chubuseiki.co.jp

Hitoshi KUBOTA
Mitshubishi Electric Corporation– Japan
Kubota.Hitoshi@da.MitsubishiElectric.co.jp

Toshihiro INOUE
Mitshubishi Electric Corporation– Japan
Inoue.Toshihiro@da.MitsubishiElectric.co.jp

ABSTRACT

In order to investigate the feasibility of smart meter networks, the radio propagation characteristics of three types of wireless media, 2.4GHz-band wireless LAN, 950MHz and 429MHz-band low power radio, were evaluated in conditions similar to smart meter use.

INTRODUCTION

It is expected that Advanced Metering Infrastructure (AMI), which realizes two-way communication between central server computers and smart meters, is useful for efficiency of meter reading and efficient operation of power distribution under condition in which distributed power source are widely spread. Figure 1 shows a typical model of an AMI system. In the AMI system, servers operated by power supplier perform two-way communication with more than ten millions of smart meters (SMs) via wide aria network (WAN), gate ways (GWs), and smart meter networks (SMNs). Although various kinds of communication media, such as low power radio, power line communication (PLC), are proposed, in terms of simplicity and cost of installation and maintenance, the authors believe that multi-relay network with license free wireless communication is one of the most appropriate communication media for SMN.

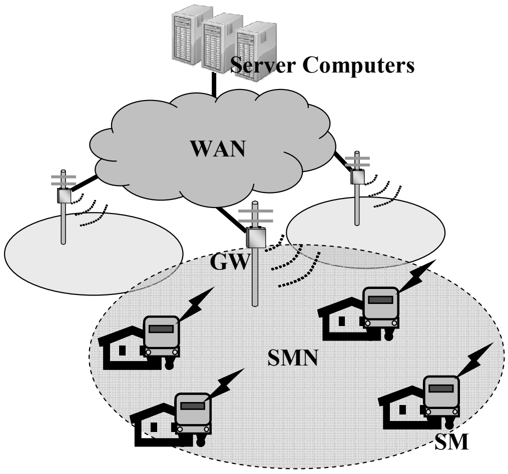

Fig. 1. A Model of AMI System.

In order to evaluate the feasibility of SMN, the authors measured the radio propagation characteristics of three types of Japanese license free wireless communication media, 2.4GHz-band wireless LAN, 950MHz and 429MHz-band low power radio, under conditions similar to smart meter use.

EVALUATED WIRELESS MEDIA

The specifications of 2.4GHz wireless LAN physical layer are defined in IEEE 802.11 and ARIB STD-T66. They define several types of physical layers with different modulations and different data transfer rates [1,2]. Because of its high sensibility, IEEE802.11b 1Mbps physical layer which uses Direct Sequence Spread Spectrum (DSSS) modulation was selected as an object of the measurement.

There are two types of 950MHz low power radio physical layer specified in IEEE 802.15.4 and ARIB STD-T96 [3,4]. In consideration of usability in AMI, 950MHz low power radio 100kbps physical layer which employs Gaussian Frequency Shift Keying (GFSK) modulation was evaluated.

Although 429MHz low power radio physical layer is specified in ARIB STD-T67, there aren't nether any data transfer rates nor modulations definition [5]. 429MHz low power radio 4.8kbps physical layer with GFSK modulation, was evaluated since it is commonly used.

EVALUATION OF RADIO PROPAGATION

Conditions of Mesurments

Received signal strength (RSS) and packet error rate (PER) were measured under three conditions that reproduce communication between GW on a utility pole and SMs of detached houses, communication between GW on a utility pole and SMs in an apartment building, and communication among SMs in an apartment building

The measurements were executed in and around a 5-storied apartment building in a residential quarter in suburbs.

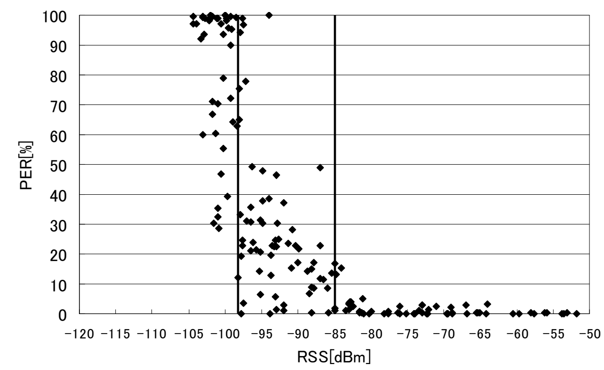

Fig. 2. Scatter Plot of Measured RSSs and PERs of Wireless LAN.

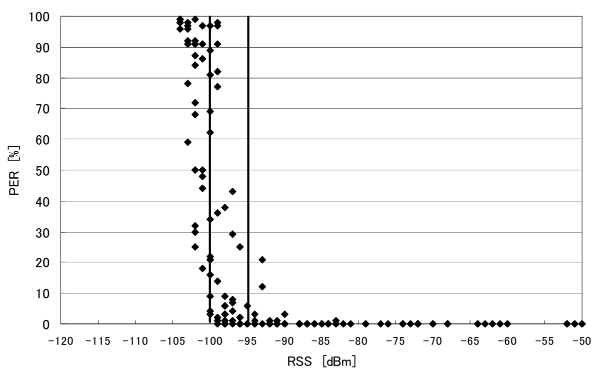

Fig. 3. Scatter Plot of Measured RSSs and PERs of 950MHz low power radio.

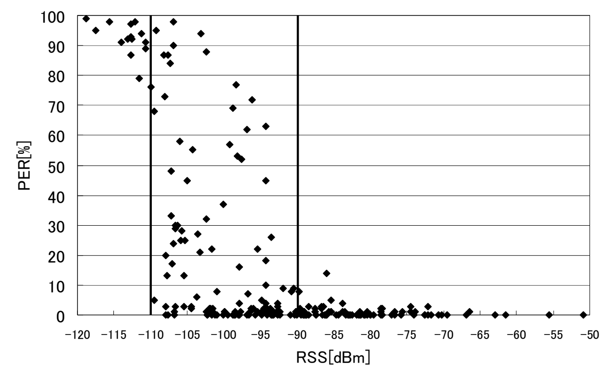

Fig. 4. Scatter Plot of Measured RSSs and PERs of 429MHz low power radio.

Table 1. Classifications of measuered.RSS

	Serviceable Area	Fringe Area	Unserviceable Area
Wireless LAN	RSS >= -85dBm	-85dBm > RSS >= -98Bm	-98Bm > RSS
950MHz Radio	RSS >= -95dBm	-95dBm > RSS >= -100dBm	-100dBm > RSS
429MHz Radio	RSS >= -90dBm	-90dBm > RSS >= -110dBm	-110dBm > RSS

PER were measured with 184Byte-length-packet (including header) for 2.4GHz wireless LAN and with 144Byte-length-packet (including header) for 950MHz and 429MHz low power radio.
The installation situations of measuring equipments are described in the following sections.

Communication between GW and SM of Detached House
Transmitter was placed on a handrail of outside stairs of the apartment building, instead of being placed on a utility pole. The height above the ground was about 6m, which is equivalent to the height if the GW would be installed in normal AMI operation.
Receivers were placed by utility poles around the apartment building, instead of being placed on walls of detached houses. The height above the ground was about 1.8m, which were equivalent to the height of a common SMs.

Communication between GW and SM in Apartment Building
Transmitter was placed by utility poles around the apartment building. The height above the ground was about 1.8m.
Receivers were placed in pipe shafts of the apartment building. In the pipe shaft, SMs were surrounded by reinforced concrete walls in three sides, and the other side was sealed by a steel door without any ventilation holes.

Communication among SMs in Apartment Building
Both transmitter and receivers were placed in pipe shafts of the apartment building.

Classification of Measurment Results

Figure 2 – Figure 4 show scatter plots of entire measured RSSs and PERs. PER increases rapidly when RSS falls below a certain level. In the 2.4GHz wireless LAN's case, as an example, when RSS is larger than -85dBm, PER is small enough to expect establishing steady communication. And when RSS becomes smaller than -98Bm, PER is too high to expect steady communication. In this paper measured RSSs are classified into Serviceable area, Unserviceable area, and Fringe area.
Table 1 shows the RSS classification of three measured wireless media.

Results of Evaluations

Communication between GW and SM of Detached House
Figure 5 shows classified RSS measured under simulated condition of communication between GW and SM of

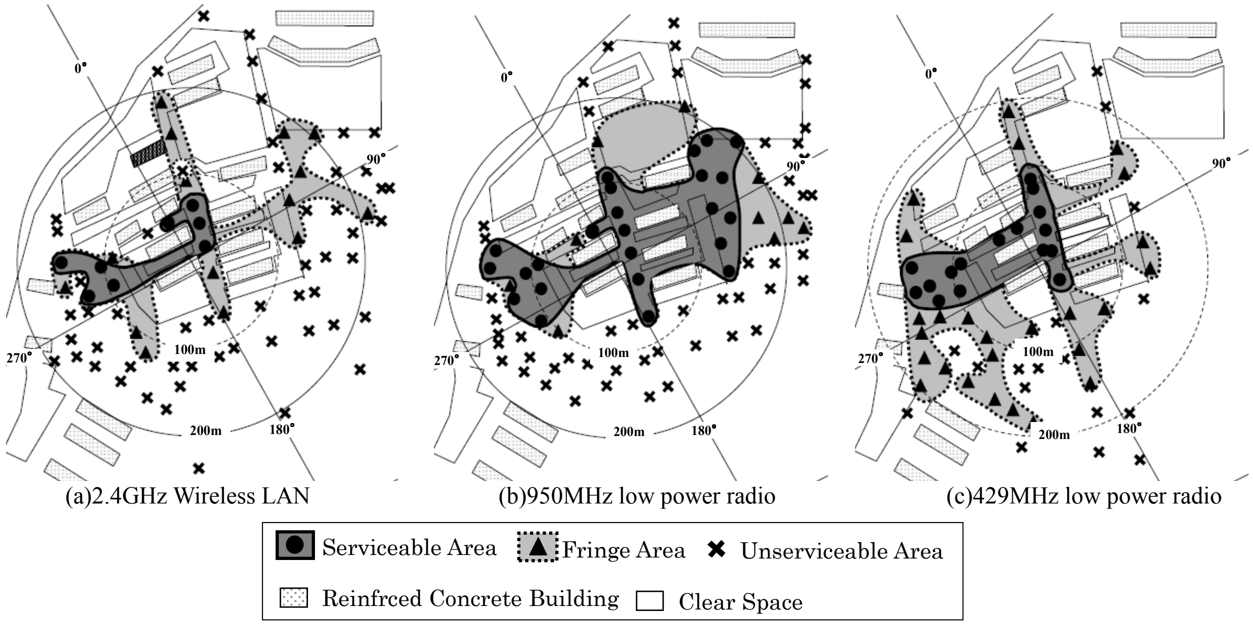

Fig. 5. Measured RSSIs of Communication between GW and SM of detached houses in a Suburban Residential Area.

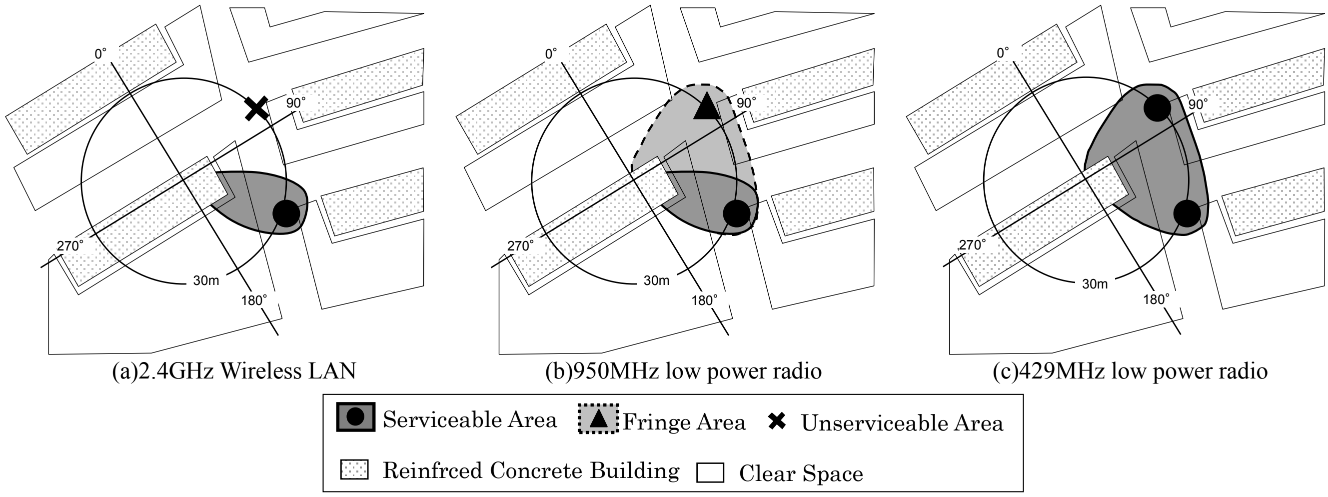

Fig. 6. Measured RSSIs of Communication between GW and SM in Apartment Building.

detached house. In Figure 5, 0degree indicates the direction of the steel doors of pipe shafts.

The results of measurement show that 950MHz low power radio had longest range in the three wireless media. 950MHz low power radio extended its level of service area over 200m in the direction of 75degree, while the service area of 2.4GHz wireless LAN and 429MHz low power radio were limited within about 150m.

All of the three wireless media had difficulty to establish communication across the apartment building nearby. Although GW was placed on a handrail of stairs of an apartment building, instead of being placed on a utility pole this time, GW located in the vicinity of a building will be in the condition similar to this. Since the result shows that all three wireless media evaluated were unable to establish communication across the building nearby, it must be necessary to employ multi-relay technology to stretch SMN to every corner effectively.

Communication between GW and SM in Apartment Building

Figure 6 shows classified RSS measured under simulated condition of communication between GW and SM of an apartment building. In Figure 6, 0degree indicates the direction of the steel doors of pipe shafts.

429MHz low power radio could establish communication between inside of a pipe shaft and utility poles on both steel door's side and its opposite side of the pipe shaft, that it is the equivalent to have the utility poles locates in direction of 80degree and 135degree in Figure 6 (4) respectively, while Wireless LAN and 950MHz low power radio had difficulty in communication between SM and GW on a steel door's side of the pipe shaft.

Considering gathering data from SMs in apartment buildings via GWs placed on utility poles, 429MHz low power radio is the most reliable communication media of those three.

Communication among SMs in Apartment Building

Figure 7 describes the dimensions of the apartment building where the measurements were executed. Figure 8 shows classified RSS measured under simulated condition of communication between SMs in an apartment building. In the three wireless media evaluated, 429MHz low power radio shows the finest results. It could establish communication not only between SMs in same pipe shaft or between SMs in adjacent pipe shafts on same floor but also between SMs in adjacent pipe shafts on different floors, whereas 2.4GHz wireless LAN could establish communication only between SMs in same pipe shaft, and 950MHz low power radio could communicate between a few limited SMs in adjacent pipe shafts.

CONCLUSION

Three kinds of licence free wireless communication media, 2.4GHz band wireless LAN, 950MHz band and 429MHz band low power radio, were evaluated to investigate the feasibility of smart meter network.

The results show that in view of serviceable area and communication speed 950MHz low power radio is the most suitable communication media for smart meter network among the evaluated three kinds of wireless media. However it may difficult to establish steady communication across buildings directly. It is expected that multi-relay network technology enables communication across building or to avoid other possible obstacles, and allows reducing installation cost of smart meter network.

Even though the communication speed is limited, 429MHz low power radio has advantages over two other wireless media for communication in apartment buildings. With multi-relay network using 429MHz low power radio, server computers will be able to access any smart meters in an apartment building via gate way placed on a utility pole nearby under the evaluated condition.

From the results of this investigation it is reasonable to evaluate the possibility to adopt a multi-media SMN composed by two or more kinds of communication media, according to circumstances with the objective to build smart meter network effectively.

Since the propagation of radio signal is affected by several circumstances, the authors intend to execute similar investigations under variety of circumstances before starting full-scale operation of advanced meter infrastructure system.

The authors are also planning to evaluate the feasibility to apply multi-relay network for smart meter network

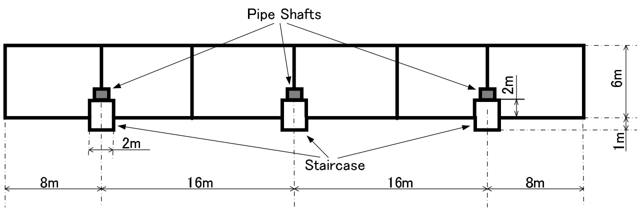

Fig. 7. Dimensions of the Apartment Building.
(5-storied building)

REFERENCES

[1] IEEE Computer Society, 2007, *IEEE Standard for Information technology— Telecommunications and information exchange between systems— Local and metropolitan area networks— Specific requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications,* IEEE

[2] ARIB Standards Assembly, 2010, *SECOND GENERATION LOW POWER DATA COMMUNICATION SYSTEM / WIRELESS LAN SYSTEM,* Association of Radio Industries and Businesses, Japan.

[3] IEEE Computer Society, 2009, *IEEE Standard for Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications,* IEEE

[4] ARIB Standards Assembly, 2009, *950MHz-BAND TELEMETER, TELECONTROL AND DATA TRANSMISSION RADIO EQUIPMENT FOR SPECIFIED LOW POWER RADIO STATION,* Association of Radio Industries and Businesses, Japan

[5] ARIB Standards Assembly, 2007, *TELEMETER, TELECONTROL AND DATA TRANSMISSION RADIO EQUIPMENT FOR SPECIFIED LOW-POWER RADIO STATION,* Association of Radio Industries and Businesses, Japan.

	Staircase			Staircase			Staircase	
Room 501	✖	Room 502	Room 503	●	Room 504	Room 505	✖	Room 505
Room 401	✖	Room 402	Room 403	Tx	Room 404	Room 405	✖	Room 405
Room 301	✖	Room 302	Room 303	●	Room 304	Room 305	✖	Room 305
Room 201	✖	Room 202	Room 203	●	Room 204	Room 205	✖	Room 205
Room 101	✖	Room 101	Room 103	●	Room 104	Room 105	✖	Room 105

(a)2.4GHz Wireless LAN

	Staircase			Staircase			Staircase	
Room 501	●	Room 502	Room 503	●	Room 504	Room 505	✖	Room 505
Room 401	▲	Room 402	Room 403	Tx	Room 404	Room 405	●	Room 405
Room 301	▲	Room 302	Room 303	●	Room 304	Room 305	▲	Room 305
Room 201	✖	Room 202	Room 203	●	Room 204	Room 205	✖	Room 205
Room 101	✖	Room 101	Room 103	●	Room 104	Room 105	✖	Room 105

(b)950MHz low power radio

	Staircase			Staircase			Staircase	
Room 501	●	Room 502	Room 503	●	Room 504	Room 505	▲	Room 505
Room 401	●	Room 402	Room 403	Tx	Room 404	Room 405	●	Room 405
Room 301	●	Room 302	Room 303	●	Room 304	Room 305	●	Room 305
Room 201	▲	Room 202	Room 203	●	Room 204	Room 205	▲	Room 205
Room 101	▲	Room 101	Room 103	●	Room 104	Room 105	▲	Room 105

(c)429MHz low power radio

● Serviceable Area ▲ Fringe Area ✖ Unserviceable Area

Fig. 8. Measured RSSIs of Communication between SMs in Apartment Building.