Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: What Japan Utility Telemetering Association (JUTA) has done and will do on the next-generation gas metering system in Japan

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Abstract: Smart Metering in Japan

Purpose: Tutorial Session

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What Japan Utility Telemetering Association (JUTA) has done and will do on the next-generation gas metering system in Japan

September 19, 2011

Hajime Furusawa

Director

Japan Utility Telemetering Association,
Non-Profit Organization in Japan

Profile of Japan Utility Telemetering Association

Mission

- To contribute to the realization of low carbon society through the dissemination of modern utility telemetering system, which leads to the visualization of consumption of utilities
- To contribute to the prevention of the occurrence of accidents as well as assurance of consumer's safety and security through the dissemination of modern utility telemetering system
- To assure the safety and security of aged citizens living alone through the modern telemetering system
- To contribute to the improvement of productivity and efficiency of business through the dissemination of modern utility telemetering system

Profile of Japan Utility Telemetering Association

- History
  - Founded as Japan LP Gas OA Association in April, 1994
  - Changed the name to LP Gas IT Association in June, 2003
  - Changed the name to Japan Utility Telemetering Association in February, 2010
- Member enterprises
  - Total number: Over 70

Initiatives of Japan Utility Telemetering Association

- Standardization of specifications of common telemetering infrastructures
- Promotion of “ Mimamori service “,Keeping-watch service for aged citizen living alone
- Conducting the contract projects for governments
  - Ministry of Internal Affairs and Communications (2010)
  - Agency of Natural Resources and Energy (2003 and 2004)

Dissemination of Telemetering System in Japan

- Automatic meter-reading introduced in 1987
- Dissemination level at present
  - LP Gas: 6 millions (24%)
  - City gas: 2 millions (7%)
  - Water: 100,000

Distinctive Situations for Telemetering in Japan

- Use of customer's telephone line
- Two-way communication system
- Customers' demand for multi-services including "monitoring of occurrence of any abnormality" and "remote shut-off"
- Battery-driven transceiver for more than 10years

Introductions of smart gas meters in Japan

"Micom Meter" =

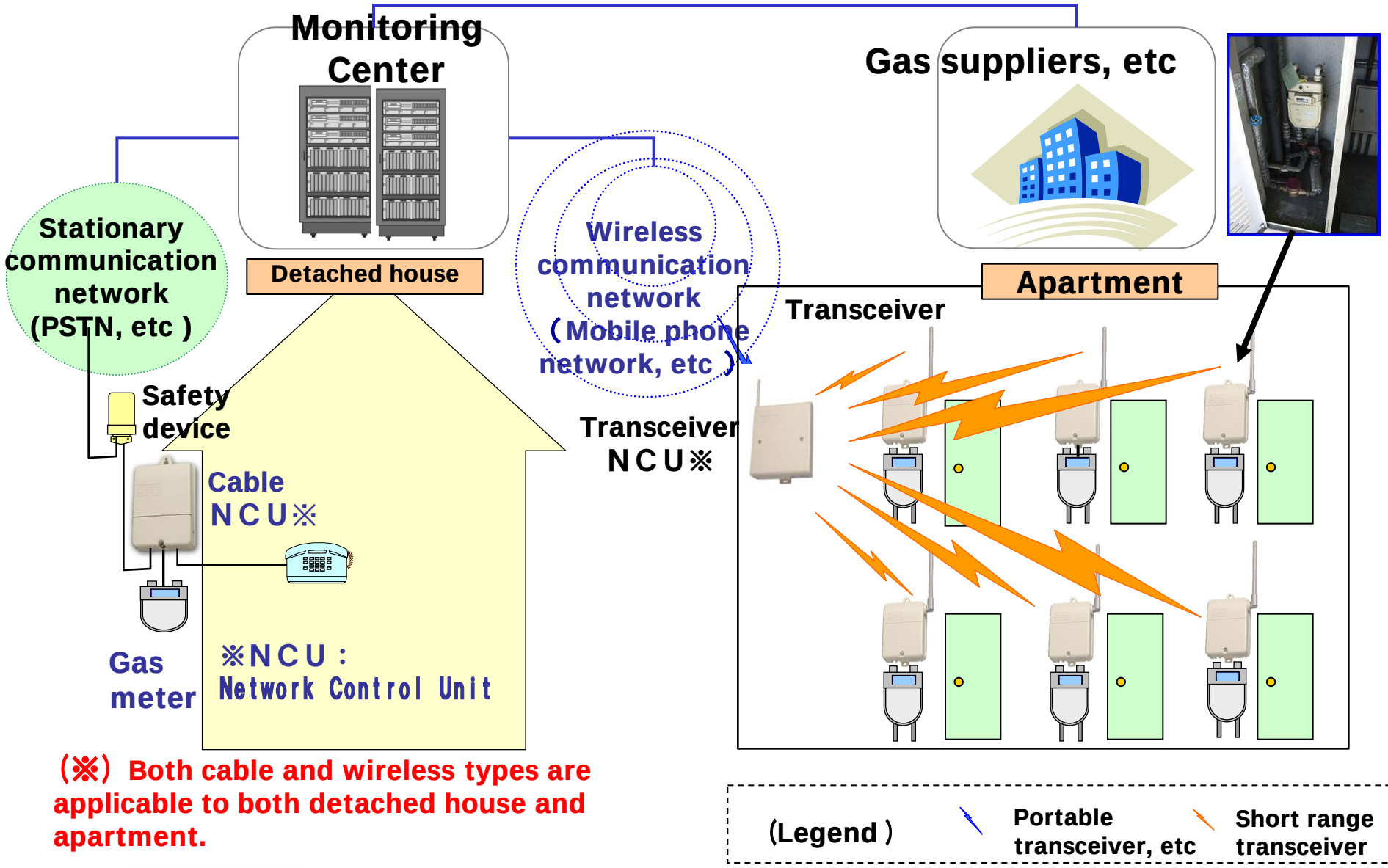
Micro Computer controlled gas Meter

- With microcomputer
  (City gas 1983-, LP gas 1985-)
  - One-way shut-off valve,
    Pressure switch,
    Seismic sensor
- With communication function
  (City gas 1987-, LP gas 1988-)
  - AMR, Paid services
  - Tow-way shut-off valve,
    Pressure sensor, etc.
- Ultra sonic gas meter
  (City gas 2005-, LP gas 2009-)
  - Measuring instantaneous flow rate
  - Standard specification for City and LP gas.

City gas

LP gas

Basic System of Present Telemetering system



Problems of Telemetering System in Japan

- Customer's communication infrastrucure
  - Decrease of analog telephone lines and diversification of them (shift to IP and broadband)
- Increase in customer's demand for multi-services:
  - Visualization of energy consumption
  - Security and safety
  - Mimamori service, etc
- Increase in security-oriented housing that makes meter-reading by a metering person difficult
  - Apartments with auto lock system
  - Houses protected with a sophisticated security system

Projects that JUTA accomplished and focusing on

- Standardization of specifications of a state-of-the-art telemetering (U-Bus Air) infrastructure
  (Duration: from November of 2009 to April of 2011)

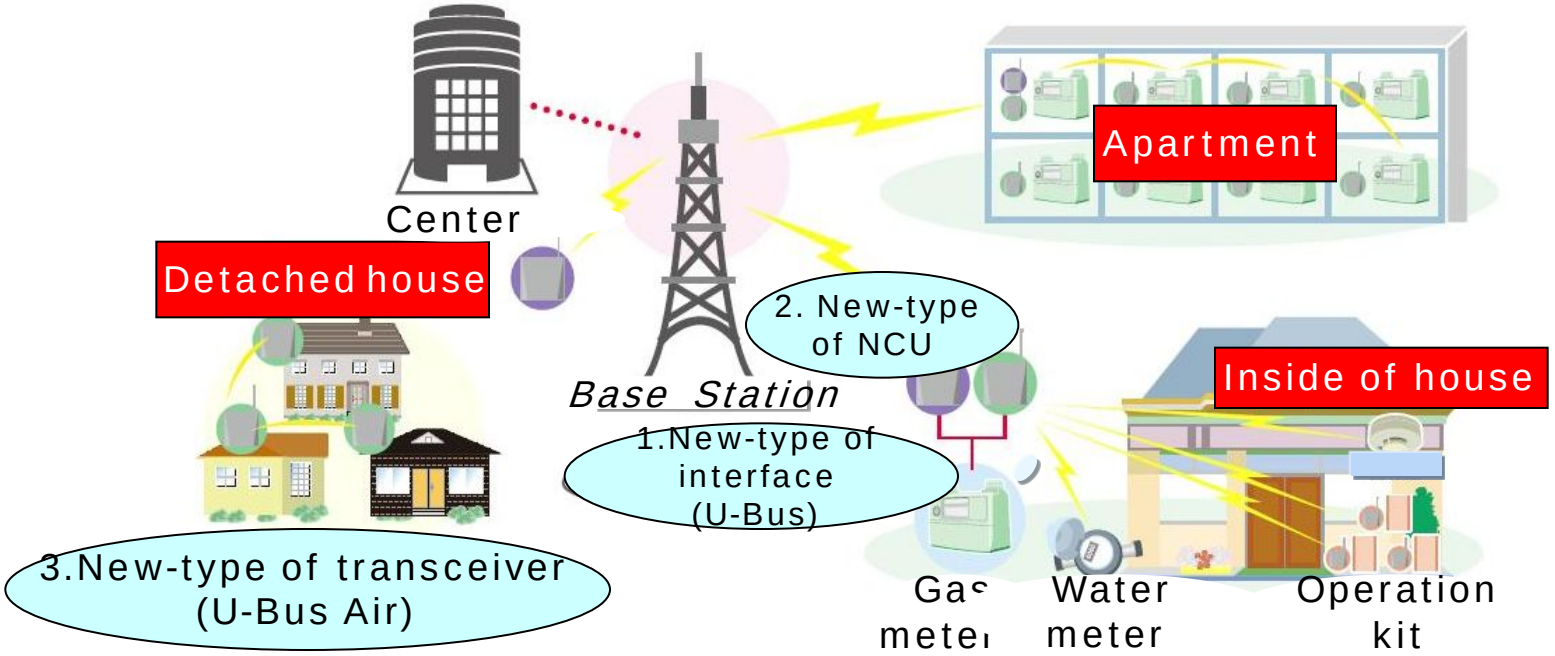
- Development of test system for the use of U-Bus Air metering infrastructure
  (Duration: from June of 2010 to March of 2011)

- Acceleration of standardizations
  - Support of standardizations in the domestic relevant industries
  - Offering to the overseas standardization body (IEEE802.15.4e/g)

Note: The above projects had been carried out with the supplementary budget of Ministry of Internal Affairs and Communications

Newly-Developed U-Bus Air Metering System

- U-Bus Air metering system consists of only battery-driven meters, devices and transceivers
  - Specifications of U-Bus (Common communication interface), each NCU (Applicable to various access networks) and U-Bus Air (Short range transceiver) have been standardized already.
  - U-Bus Air is a core component in U-Bus Air metering system.



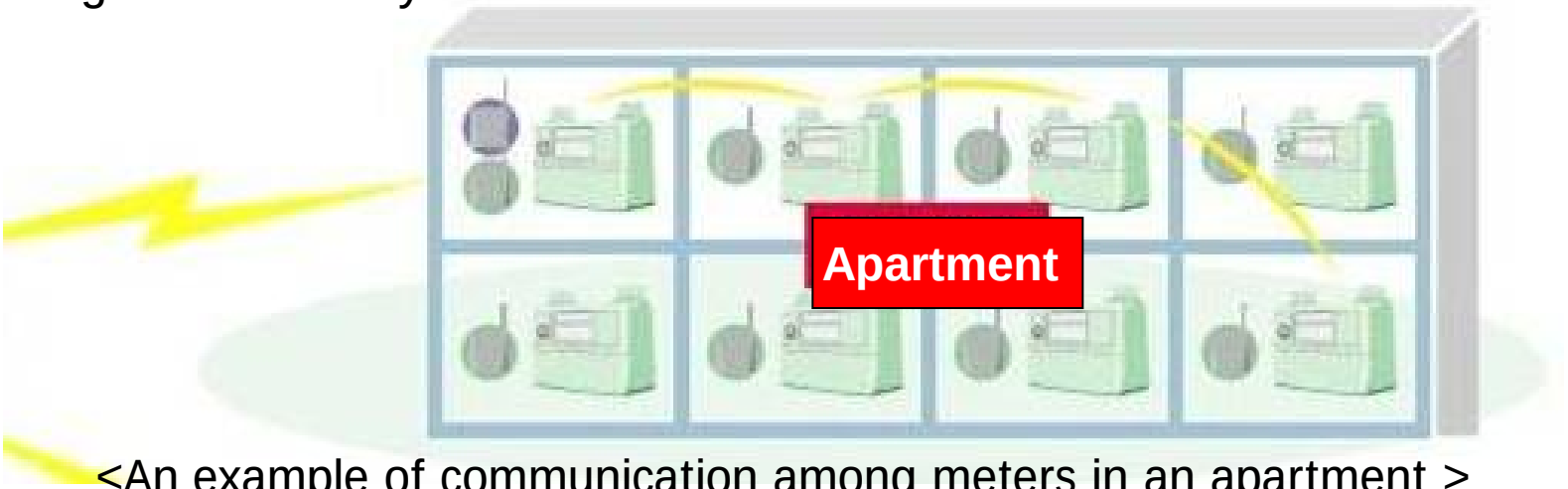
U-Bus Air

What is the U-Bus Air ?

- A new-type of 950 MHz-band transceiver※ that enables multi-hopping communication and the drastic reduction in consumption of electric power for communication
- The PHY specs is based on IEEE 802.15.4g Draft, and the MAC uses RIT Mode written in IEEE 802.15.4e Draft of Low Energy.

Benefits and Advantages

- Its self- network function makes the installation simple and easy
- Its self- selection-function can provide customers with the higher reliability



<An example of communication among meters in an apartment >

※ To be scheduled to shift to 920 MHz-band

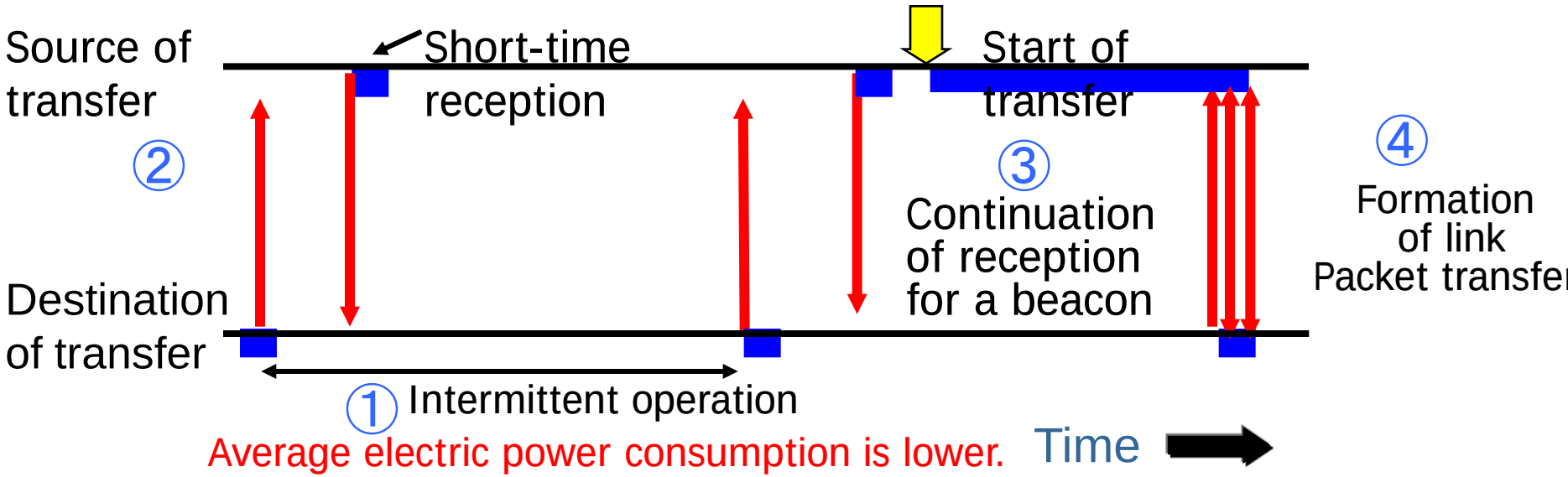
Specifications of U-Bus Air

Items	Specifications
Specification of transceiver (ARIB STD-T96)	Frequency :950MHz(*) Output :1mW/10mW Transmission velocity:100kbps
Network	Max. 50 (Mesh type) Max. 240 (Cluster tree type)
Connections of NCU	Max. 5 per network
Hopping	Max. 15 per network
Theoretical network	17 millions
Packet size	100 bytes
Operating mode	Intermittent operation: 3 seconds (Standard)
Interface	U-Bus
Setup	Self-registration and self-elimination

※To be scheduled to shift to 920MHz-band

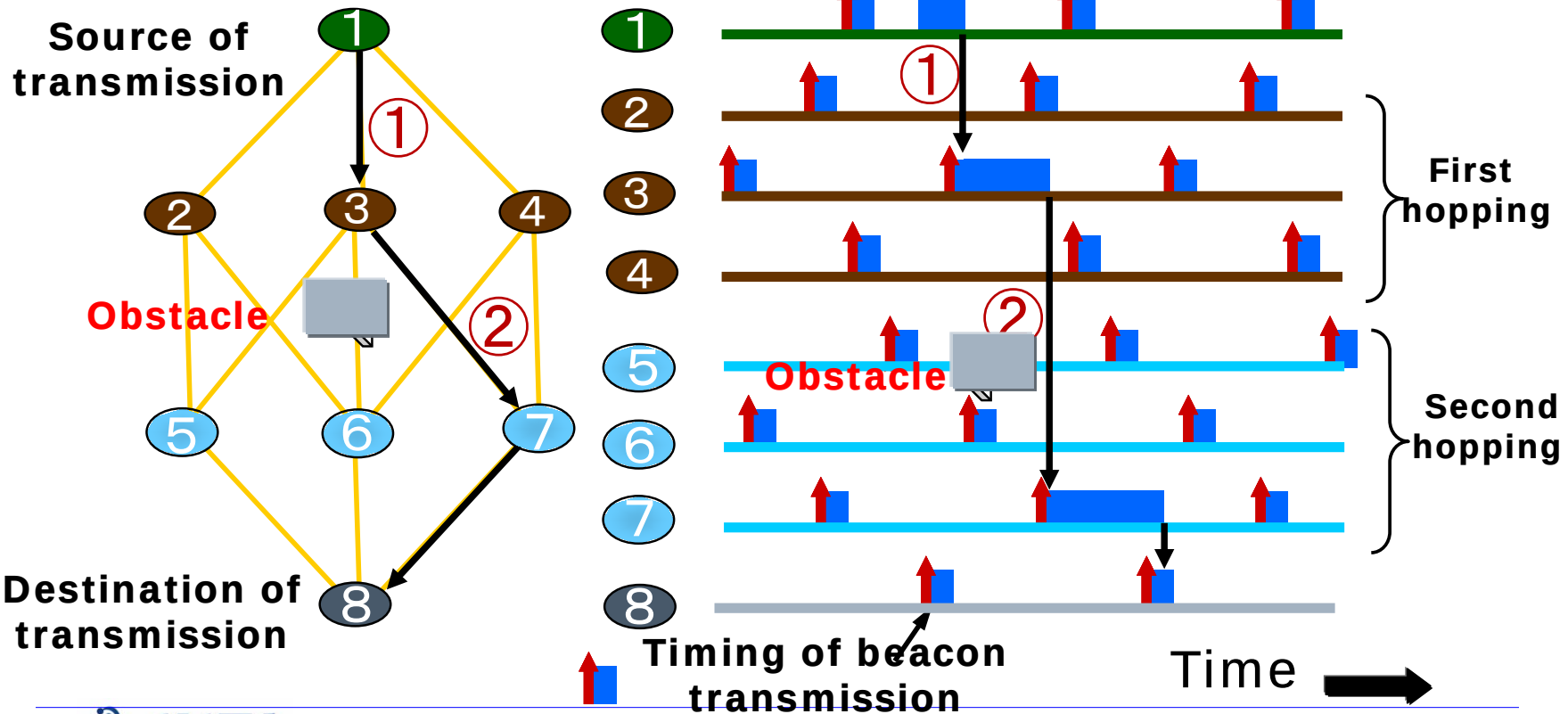
Features of U-Bus Air(1)

- Asynchronous access
  - ① All the transceivers operate intermittently.
  - ② Short-packet transmission and short-time reception are repeated periodically
  - ③ Source of packet transfer continues reception for a beacon
  - ④ Link is set up between source of transfer and destination of transfer on receiving beacon



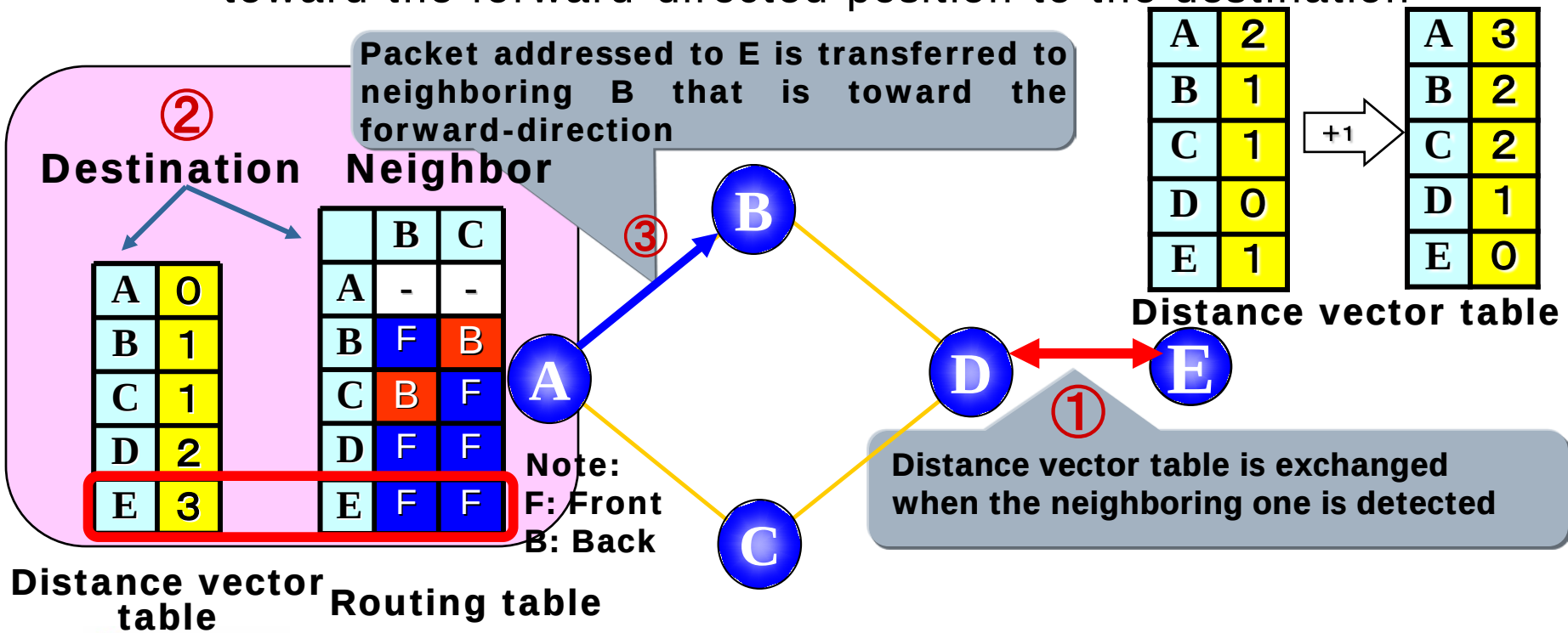
Features of U-Bus Air (2)

- Exceptional reliability of communication
  - ① Transferring to the transceiver which is closed to the terminating destination in order of link formation)
  - ② Detouring obstacle since the appropriate destination of transfer can be selected from multiple destinations of transfer



Features of U-Bus Air(3)

- Effectively-use of the routs
  - ① Distance vector table for every destination is compiled by exchanging with the neighboring one
  - ② Every routing table is determined in comparison with the neighboring one
  - ③ Packet is transferred to the neighboring transceiver that is toward the forward-directed position to the destination

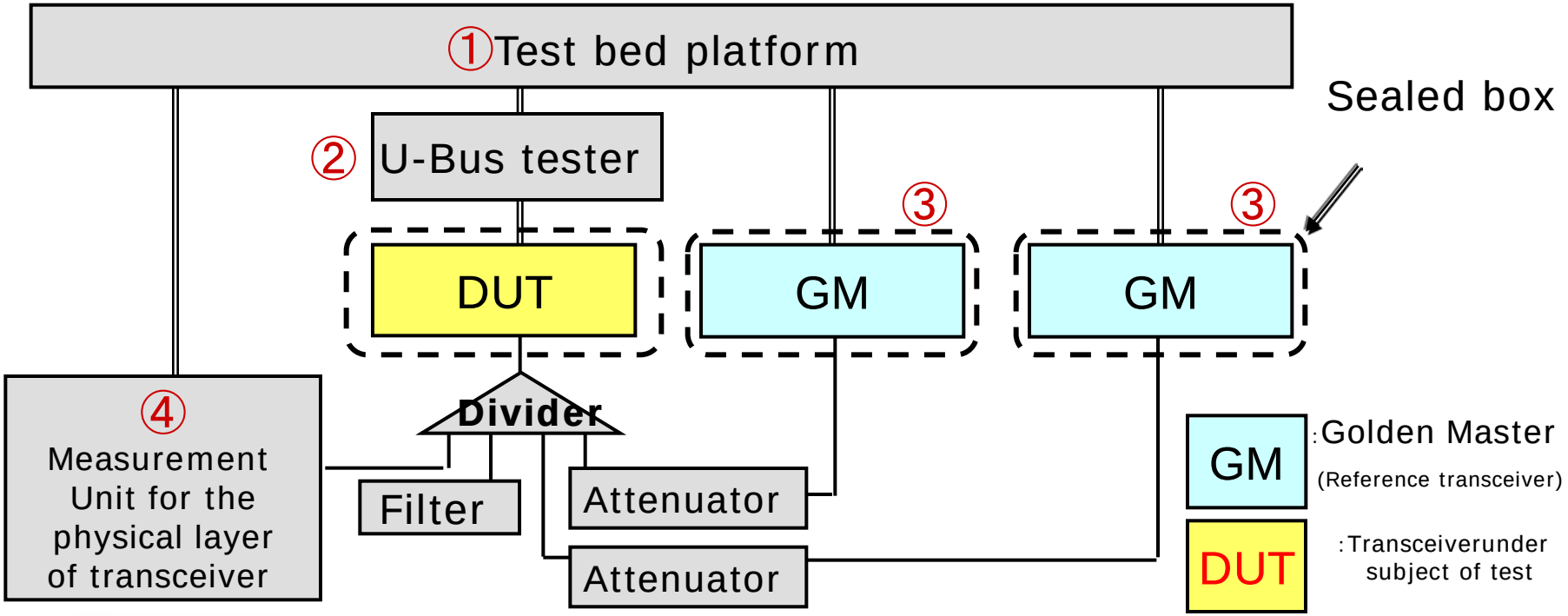


Test System for U-Bus Air Metering Infrastructure

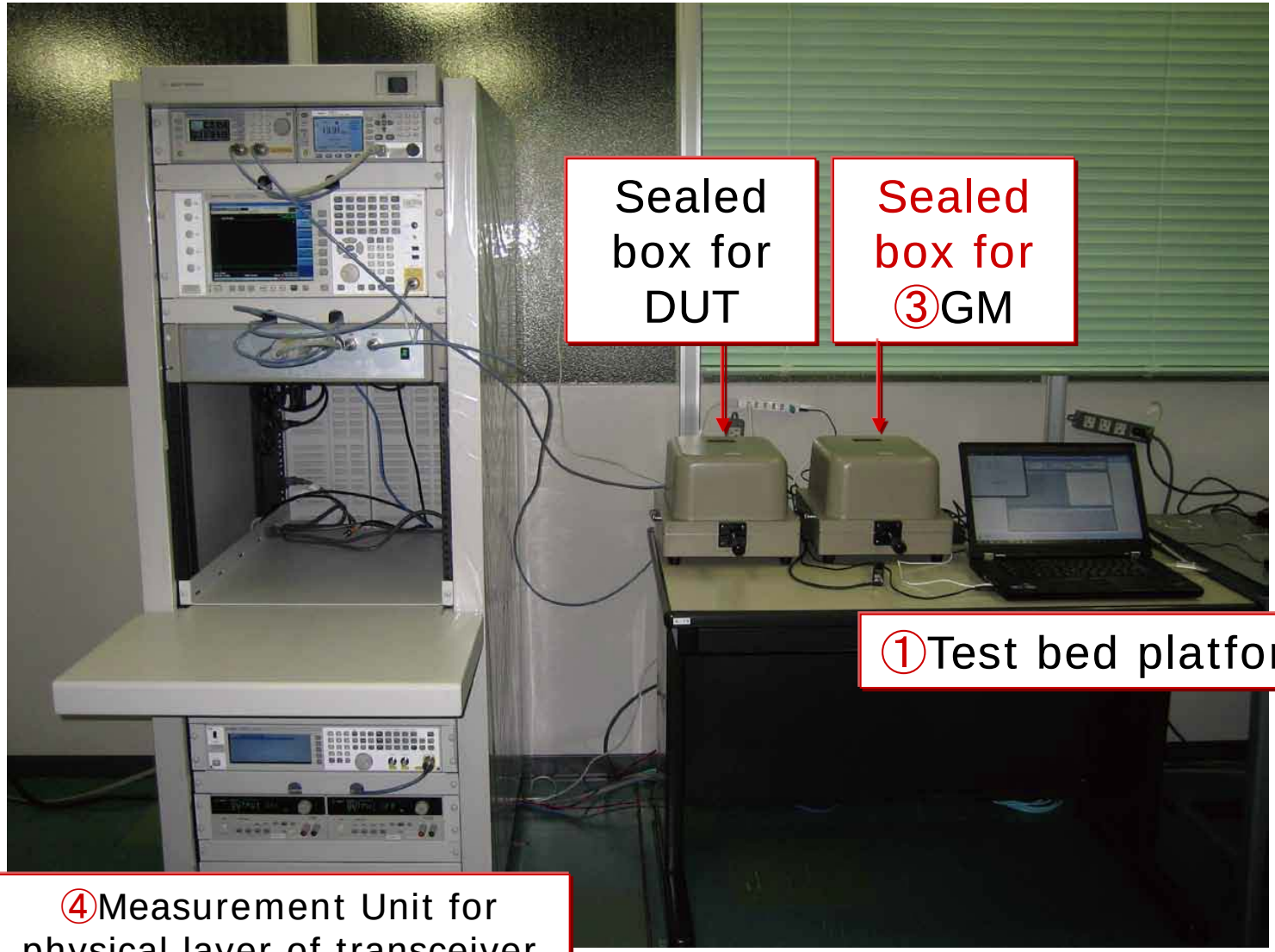
- Test system has been developed for the users to be able to introduce the devices necessary for U-Bus Air metering system without anxiety.
  - Interconnectivity testing system (Test Bed)
    Connectivity between devices made by different makers is tested.
    ① Physical layer of transceiver
    ② MAC layer and NET layer
  - Operation simulator
    Various performances are assessed under the practical environment
    ① Delayed time in communication
    ② Battery life of U-Bus Air

Test Bed (Interconnectivity test system)

- Test bed is composed of each measuring unit and automatic test program
  - ① Test bed platform: Input of information on test, Output of test results
  - ② U-Bus tester: Test for U-Bus (Cable)
  - ③ GM: Verification of communication procedure for U-Bus Air
  - ④ Measurement Unit for the physical layer of transceiver: Measurement of radio wave of U-Bus Air



Outlook of the Test Bed



Measurement of Physical Layer of Transceiver

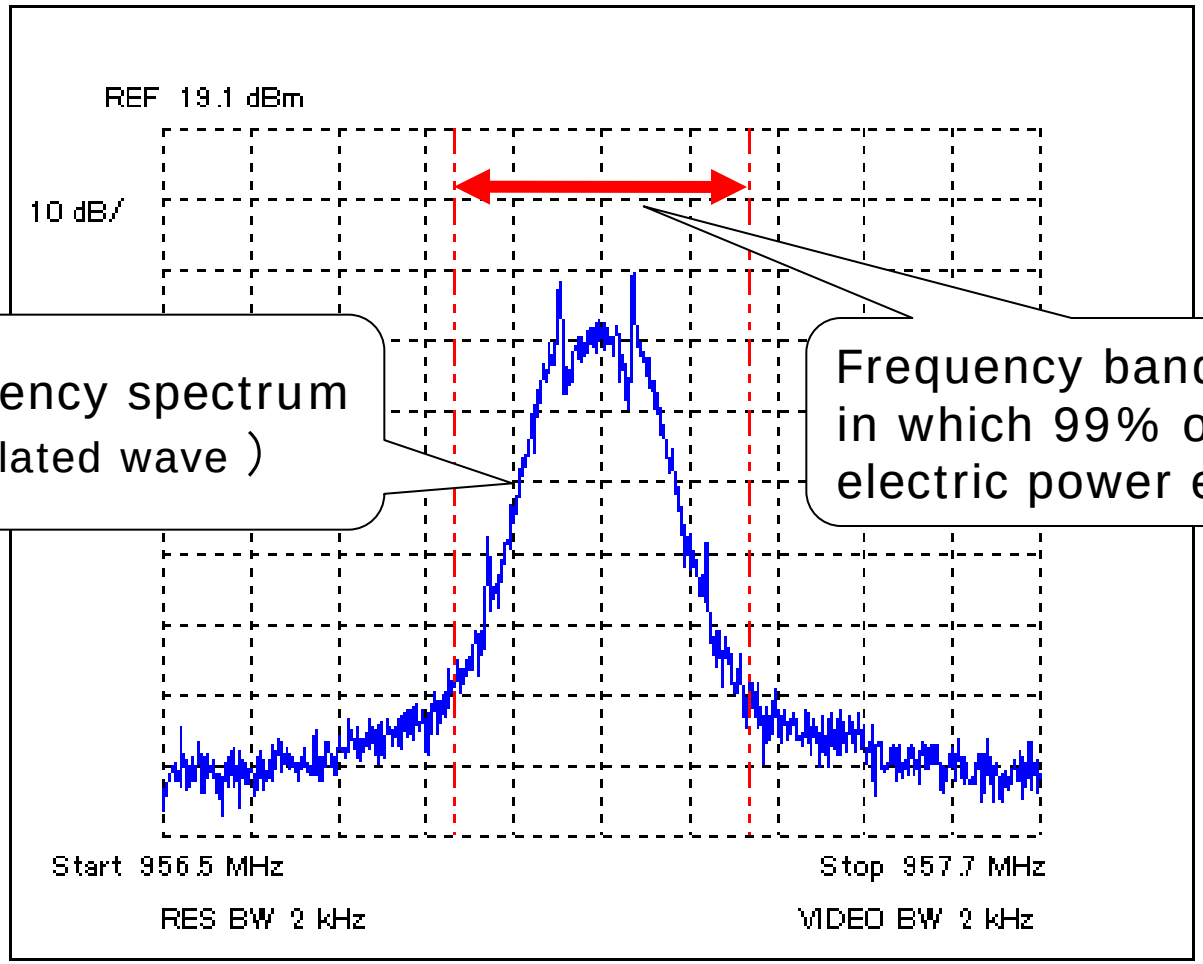
Test Items		Specifications
Quality of wave	Frequency	950MHz band (※)
	Occupied bandwidth	400kHz
	Output	10mW
Unwanted wave	Out-of-band emission	- 55dBm/100kHz
	Leakage wave to neighboring channel	- 26dBm/100kHz
	Emission wave in a state of reception	- 55dBm/100kHz
Radio function	Continuous transmission time at maximum/Quiescent time at minimum	100/100
	Confirmation of function not to emit any waves by itself when there is other wave	−75dBm
Reception performance	Response	−90dBm PER＝1% or less
Transmission performance	Degree of modulation, etc by observation of waveform	GFSK(BT=0.5) 100%

※To be scheduled to shifted 920MHz band

Measurement of MAC Layer and NET Layer

	Measurement Items		Details of measurements
MAC layer	Intermittent operation	Intermittent operation period	3 seconds (Example)
		Measurement of reception time after intermitting	2ms
	Transfer of neighboring data	Normal/Abnormal sequences	Procedure, frame composition, timing
		Quiescent time	100ms or more
	Transfer of division data	Normal/Abnormal sequences	Procedure, frame composition, timing
	Data exchange	Normal/Abnormal sequences	Procedure, frame composition, timing
NET layer	Construction of network	Detection of neighboring transceiver	- 80dBm or more
		Exchange of network information	Exchanging and editing of distance vector table
	Transfer of data	Transmission/hopping/reception of data	Function of multi-hopping
		Treatment of abnormality	Exceeding of time-limit for packet existence, etc

Test Results of Physical Layer of Transceiver (Example)



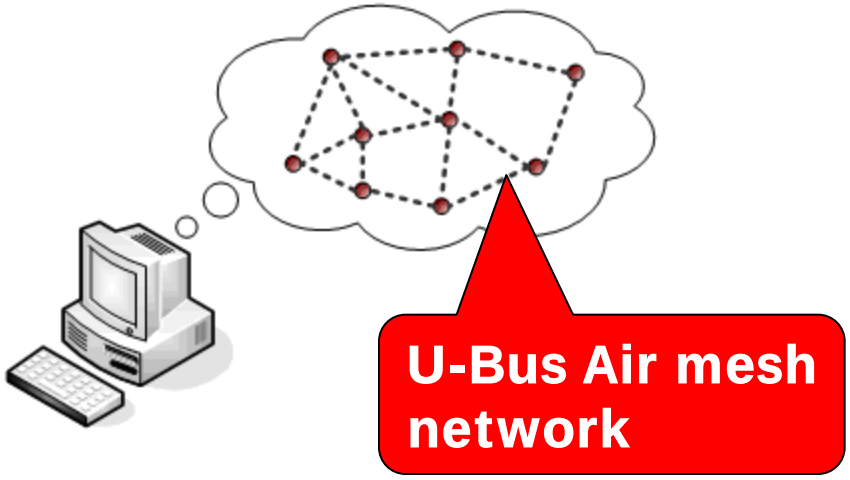
Radio frequency spectrum (GFSK modulated wave)

Frequency bandwidth in which 99% of total electric power exists

Measurement of physical layer of transceiver (Occupied bandwidth)

Operation Simulator

- Simulation under the practical environment
  - Simulation tests
    - Parameters (Input): Layout of U-Bus Air Devices, Operation conditions, obstacle (attenuation), etc
    - Comparison (Output): Communication delay time, battery life, etc.

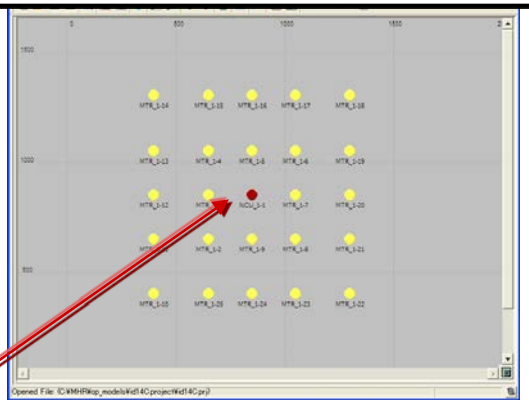


Operation simulator

Test Results of Operation Simulator (Example-1)

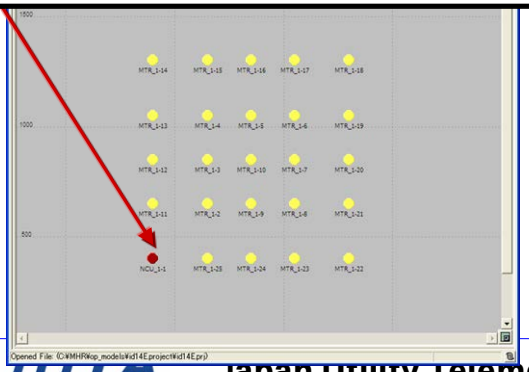
- Influence of layout of NCU on communication delay time
  - Average communication delay time is shorter in case that NCU is laid out in the center while maximum one does not change

NCU laid out in the center

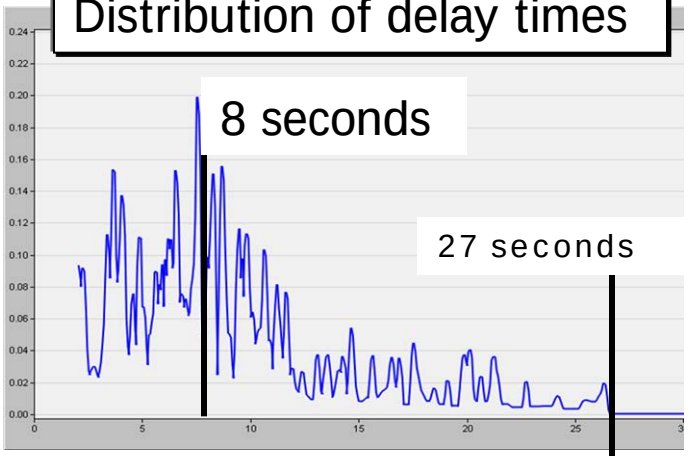


NCU

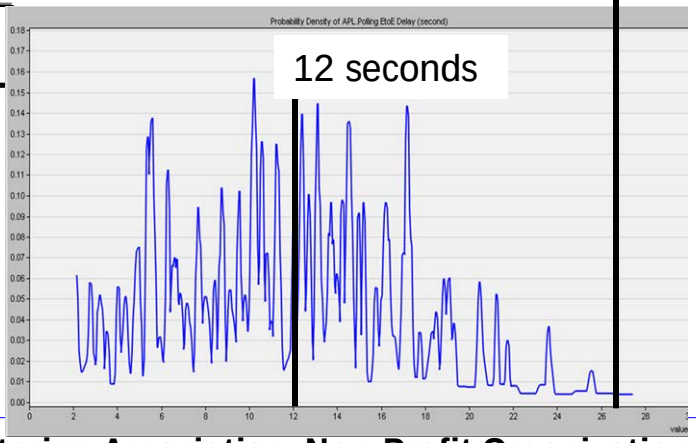
NCU laid out at the corner



Distribution of delay times



Average delay time : 8 seconds
Maximum delay time : 27 seconds

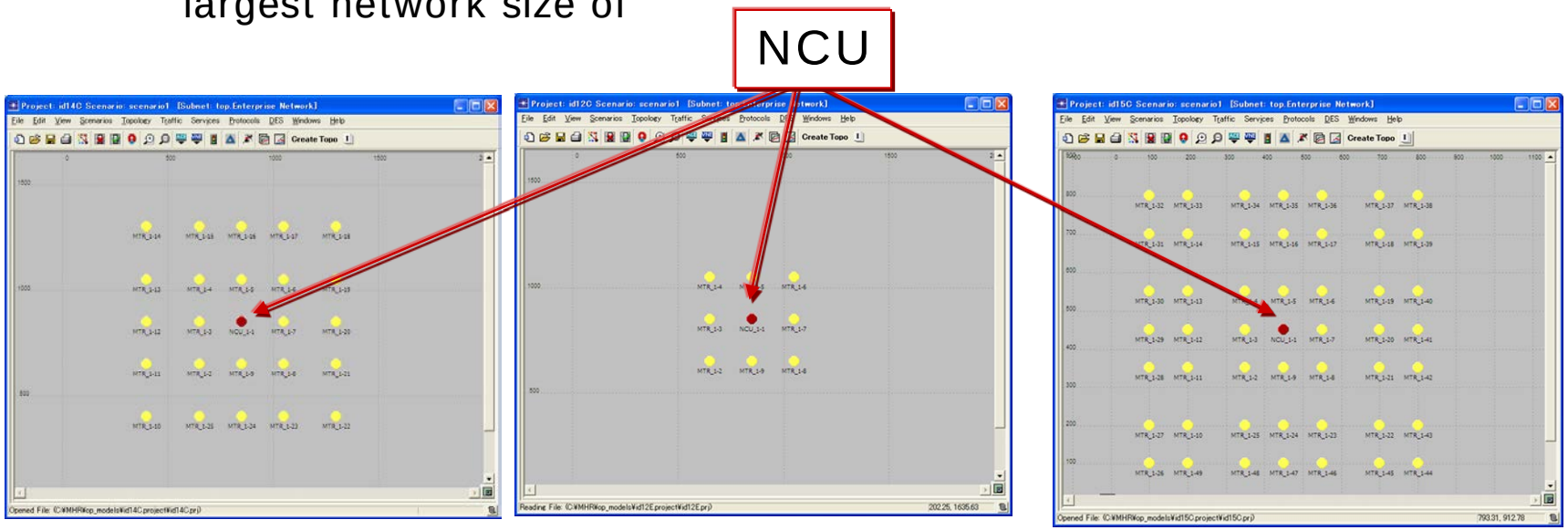


Average delay time : 12 seconds

Maximum delay time : 27 seconds

Test Results of Operation Simulator (Example-2)

- Relationship between network size and battery life
  - Simulation was conducted on the condition that the frequency of polling and call-out is one time per two weeks respectively
  - Targeted battery life of ten years was attained even in case of the largest network size of



Battery life in network consisting of nine transceivers: 12.51 years

Battery life in network consisting of twenty five transceivers : 11.17years

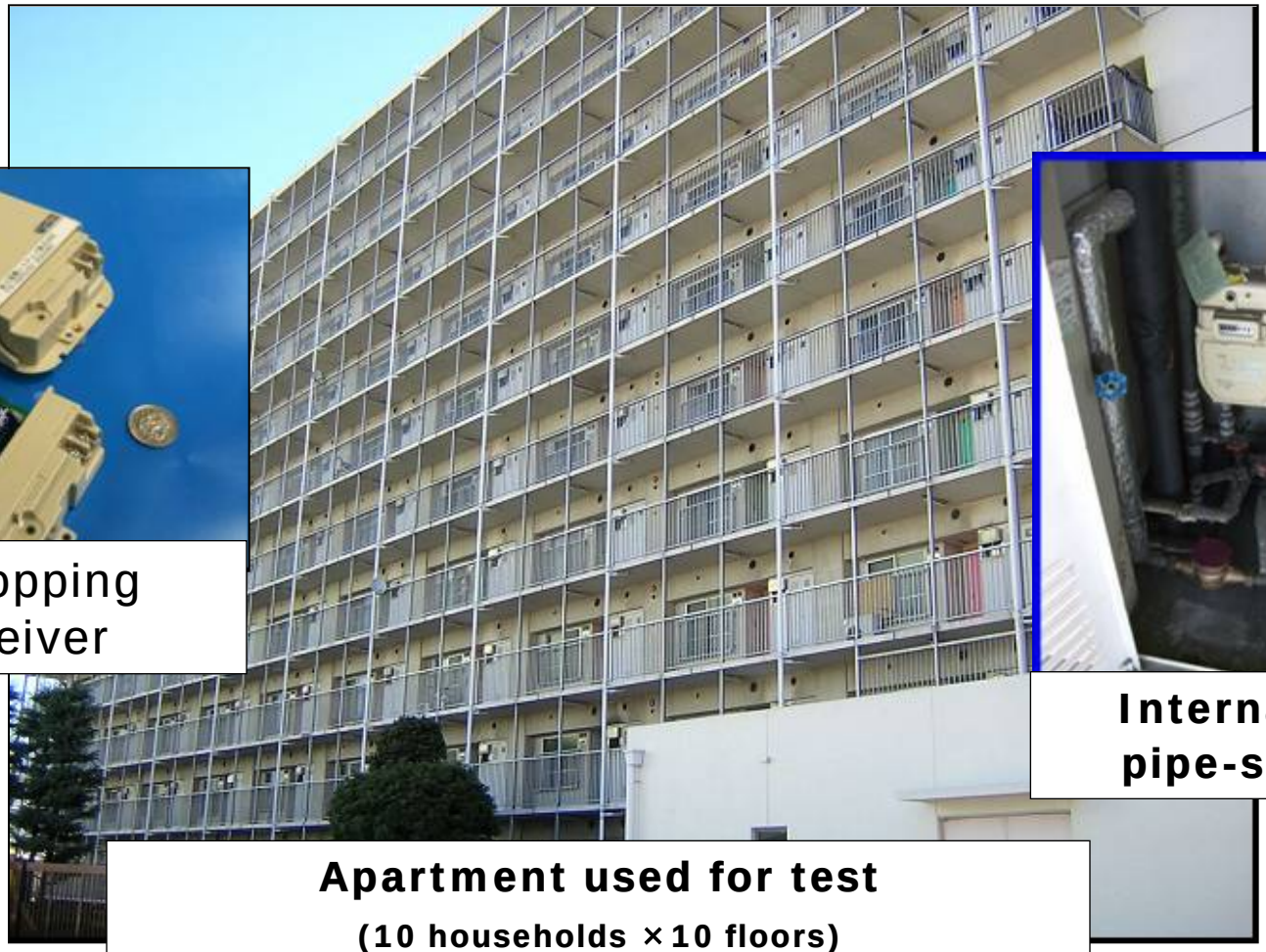
Battery life in network consisting of forty nine transceivers: 10.41 years

Battery life of U-Bus Air transceiver in a detached houses area in the suburbs

Field-test of U-Bus Air system

- Field-test for communication was carried out installing a U-Bus Air in pipe-shaft of every house in the apartment.

Multi-hopping transceiver



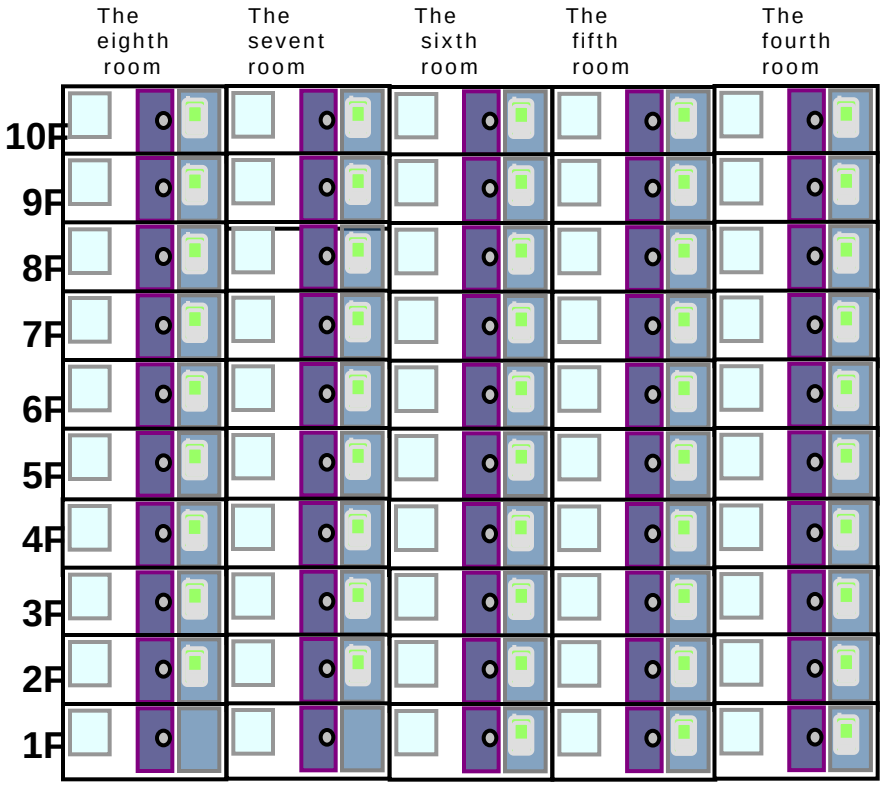
Apartment used for test

(10 households ×10 floors)

Internal of pipe-shaft

Layout of U-Bus Air Transceivers in Field-test

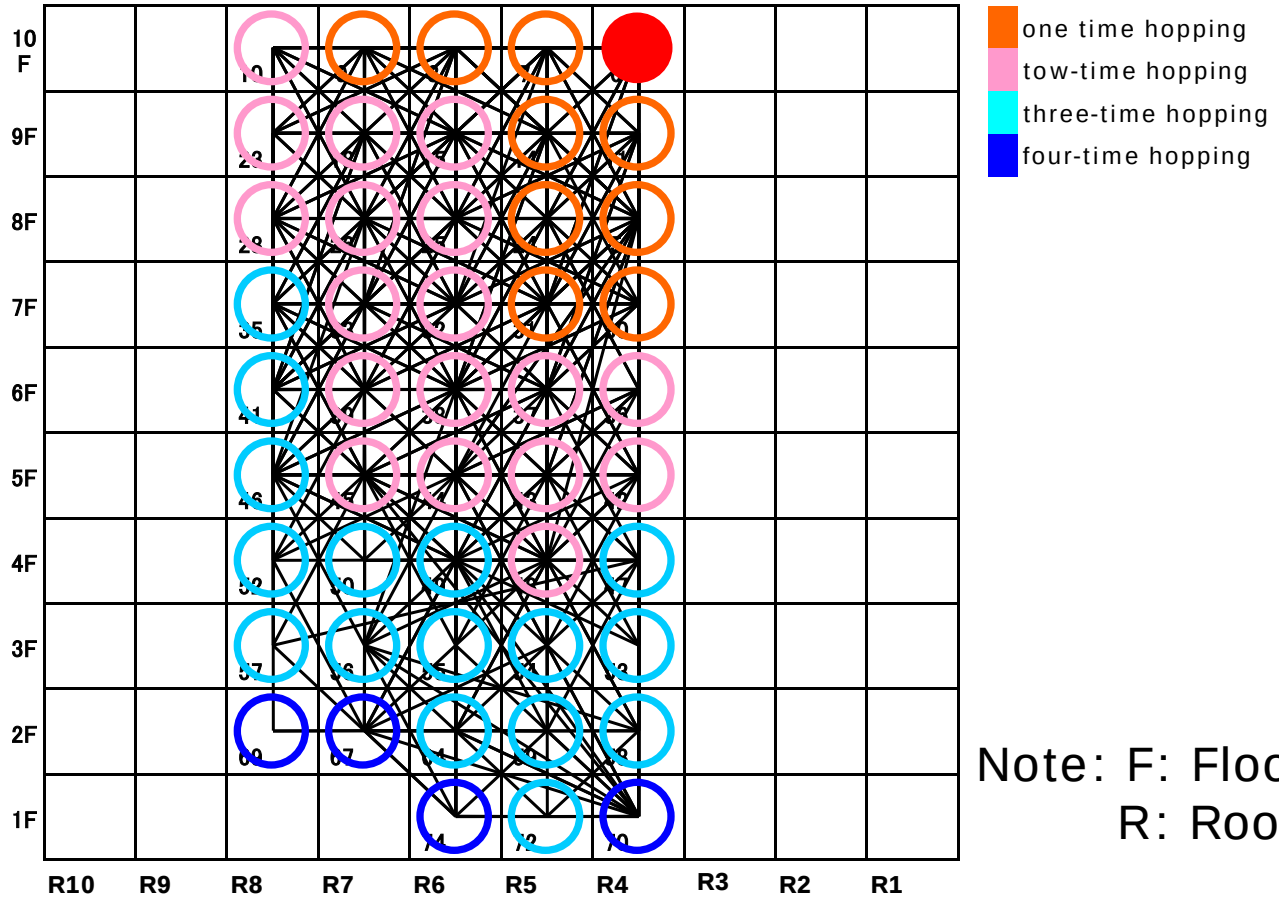
- Forty eight (48) U-Bus Air transceivers were installed in the layout of five (5) per floor × ten (10) floors
  - Information on network composition of U-Bus Air was obtained



Picture of apartment

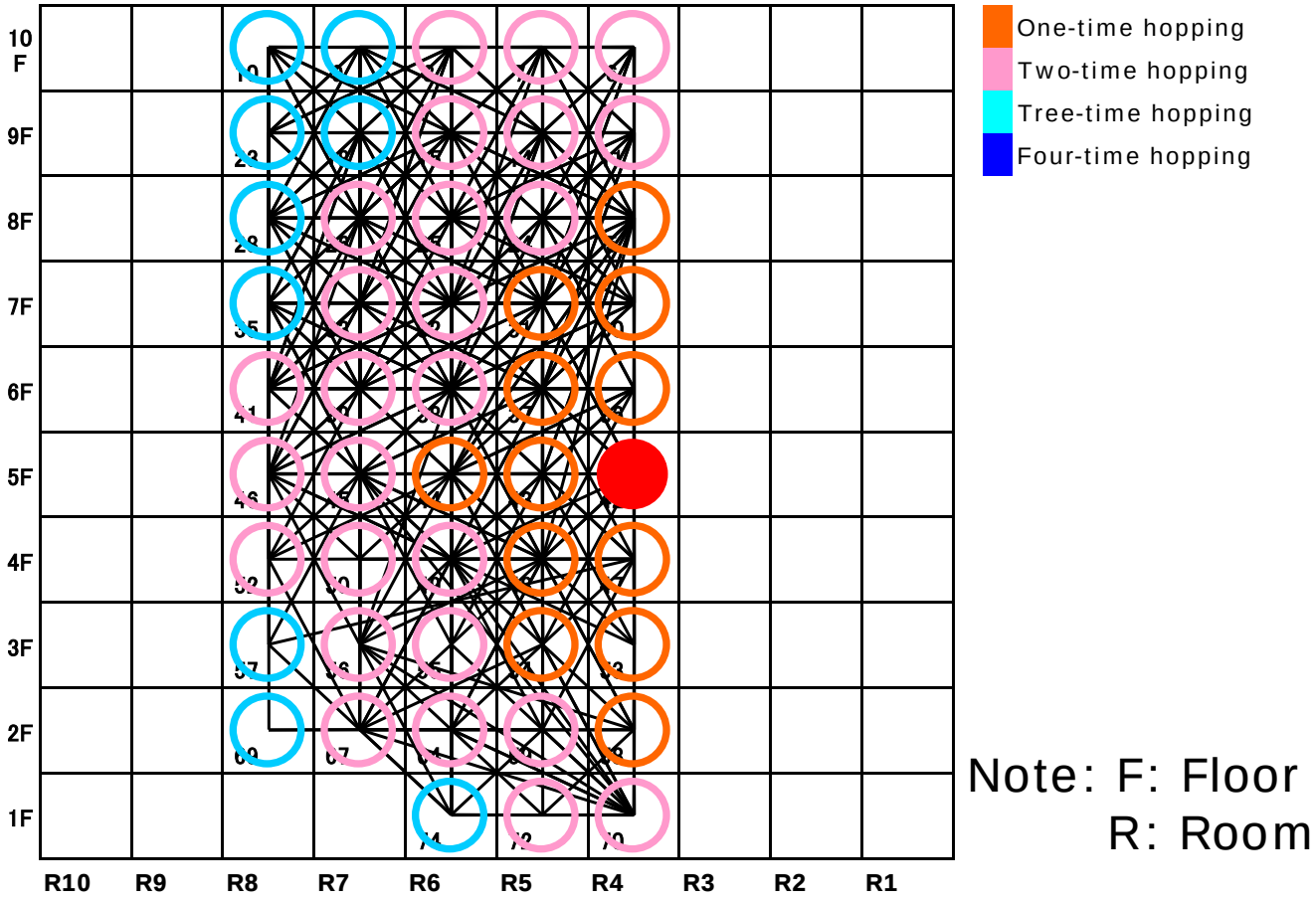
Results of Field-test of U-Bus Air (Example 1)

- Whole U-Bus Air transceivers within the network could be connected each other with four-time hopping in case that NCU was installed on the top floor



Results of Field-test of U-Bus Air (Example 2)

- Whole U-Bus Air transceivers within the network were perfectly connected each other with three-time hopping in case that NCU was installed on the middle floor (Fifth floor)



Acknowledgement

- A state-of-the-art telemetering infrastructure has just been development by Japan Utility Telemetering Association.

- We, at JUTA, are ready to offer this technology not only to the domestic users but also to the overseas ones, because we are very much confident that this next generation- type system could without doubt contribute to the realization of Smart Meter Systems and Home Energy Management Systems.

- We would like you to visit the exhibition corner where you will be able to understand our system in more detail.

Thank you so much for your attention