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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 10 years
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.
Basic System of Present Telemetering system

Stationary communication network (PSTN, etc)

Detached house

Gas suppliers, etc

Wireless communication network (Mobile phone network, etc)

Transceiver

Portable transceiver, etc

Short range transceiver

Monitoring Center

Gas meter

Safety device

 ※ NCU: Network Control Unit

 ※ NCU:

 Both cable and wireless types are applicable to both detached house and apartment.

(Legend)
Problems of Telemetering System in Japan

- Customer’s communication infrastructure
  - 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

※ To be scheduled to shift to 920 MHz-band
### Specifications of U-Bus Air

<table>
<thead>
<tr>
<th>Items</th>
<th>Specifications</th>
</tr>
</thead>
</table>
| 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.

Average electric power consumption is lower.
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.

Distance vector table is exchanged when the neighboring one is detected.

Packet addressed to E is transferred to neighboring B that is toward the forward-direction.

Distance vector table

<table>
<thead>
<tr>
<th>Neighbor</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>F</td>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>1</td>
<td>F</td>
<td>F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>2</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>3</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
</tr>
</tbody>
</table>

Routing table

<table>
<thead>
<tr>
<th>Destination</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>B</td>
<td>F</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>C</td>
<td>1</td>
<td>B</td>
<td>B</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>D</td>
<td>2</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>E</td>
<td>3</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
</tr>
</tbody>
</table>

Note: F: Front, B: Back
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

Diagram:

1. Test bed platform
2. U-Bus tester
3. GM
4. Measurement Unit for the physical layer of transceiver
   - Divider
   - Filter
   - Attenuator
   - Golden Master (Reference transceiver)
   - Transceiver (under subject of test)
Outlook of the Test Bed

① Test bed platform

② Sealed box for DUT

③ Sealed box for GM

④ Measurement Unit for physical layer of transceiver
# Measurement of Physical Layer of Transceiver

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

※To be scheduled to shifted 920MHz band
# Measurement of MAC Layer and NET Layer

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

<table>
<thead>
<tr>
<th>NCU laid out in the center</th>
<th>NCU laid out at the corner</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average delay time:</strong> 8 seconds</td>
<td><strong>Average delay time:</strong> 12 seconds</td>
</tr>
<tr>
<td><strong>Maximum delay time:</strong> 27 seconds</td>
<td><strong>Maximum delay time:</strong> 27 seconds</td>
</tr>
</tbody>
</table>

![Distribution of delay times](image)
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 NCU

Battery life in network consisting of nine transceivers: 12.51 years
Battery life in network consisting of twenty five transceivers: 11.17 years
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

Internal of pipe-shaft

Apartment used for test
(10 households × 10 floors)
### 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

#### Diagram:

<table>
<thead>
<tr>
<th>The eighth room</th>
<th>The seventh room</th>
<th>The sixth room</th>
<th>The fifth room</th>
<th>The fourth room</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image-url" alt="Diagram" /></td>
<td><img src="image-url" alt="Diagram" /></td>
<td><img src="image-url" alt="Diagram" /></td>
<td><img src="image-url" alt="Diagram" /></td>
<td><img src="image-url" alt="Diagram" /></td>
</tr>
</tbody>
</table>

*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.

Note: F: Floor  
R: Room
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).

Note: F: Floor  
R: Room
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