Priority Subjects — **Development of a Supply/Demand Infrastructure for Next-Generation Electric Power**

Next-generation Communications Network Systems

Background and Objective

Utility communication network systems have already been satisfactorily implemented for the automated generation and delivery of power, however these are yet to be developed for customer communications including smart metering, power asset maintenance and diagnosis. In addition, communications for power system protection are still proprietary and legacy (not IP-based).

This project deals with the integration of fundamental technologies developed in the previous project, along with the development of design methods and tools for demand area secure communications network interconnecting customers and distributed energy resources, a sensor network for power asset condition monitoring, and IP-based wide-area and high-speed control networks.

Main results

1 Development of network design assisting technologies for the demand area wireless multi-hop network

We developed a tool which estimates radio propagation losses to assist concentrator allocation design for multi-hop wireless smart meter networks taking into account the type of area and impact on the surrounding buildings (Fig. 1) (R13014). We also developed a propagation loss estimation method for smart meters which are placed in the pipeshafts of apartment buildings. For the estimation, experimental results of radio wave propagation characteristics and electric field analisys software are used (R13006). These results can be used for effective design of a wireless multi-hop network and to assist in determining whether wiress multi-hop communication can be used for apartment buildings or not.

2 Construction of a prototype sensor network for facility maintenance in substations

In the sensor network system that we are developing for facility maintenance, easy and speedy installation of sensors is important for improving efficiency of maintenance work. We have constructed a prototype of the sensor network system for facility maintenance that is equipped with the plug-and-play (PnP) function and the wireless sensor network as elemental technologies. We have also confirmed a series of operations from starting up the sensor to collecting the data on the prototype (Fig. 2) (R13020).

As an elemental technique for stabilizing data collection with a wireless sensor network, we have proposed a method to estimate the cause of data loss occurrence (R13011). Additionally, as an elemental technique for associating a sensor with equipment measured by it, we have proposed a location estimation method of wireless nodes by using sound sensors and broadcasting sampling synchronization data (R13005).

3 Verification of a wide area monitoring, protection and control (WAMPAC) network using power system simulator

A WAMPAC network system associated with applications of wide area current differential protection and load shedding stabilizing control was integrally constructed, employing wide area Ethernet and time synchronization as well as functionally modular control devices that had been individually developed previously. The appropriate operations and effectiveness of the network system were verified using CRIEPI's power system simulator (Fig. 3) (R13012).

Time synchronization to simultaneously sample voltages and currents is required for a WAMPAC system with a large scale communication network consisting of subnetworks. We developed an inter-subnetwork time synchronization scheme and evaluated the accuracy to be less than tens of microseconds* even with network failures to obtain a prospect of large-scale and highly-reliable time synchronized networks (R13023).

* Accuracy of time synchronization for sampling is required to be less than 100 microseconds.

Other reports: (R13003), (R13007), (R13010)

	items
Input data	• Type of area (residential, urban, suburban or rural(flatland and mountain)) • Location of the transmitter station (Concentrator), longitude, latitude or appoint on the map • Transmitted power (dBm) • Frequency bands (400 MHz, 920/950 MHz, 2.4 GHz) • Communication ranges (Concentrator to meter or meter to meter, antenna height above ground to be considered) • Receiver sensitivity (dBm) • Meter installation environment (metal or plastic)
Output data	• Location of the transmitter station (on the map) • Distance between concentrator and buildings • Number of obstructions between concentrator and buildings • Building density of the estimation area • Propagation area on the map • Received power of buildings • Number of buildings inside the propagation area • A square measure of the propagation area

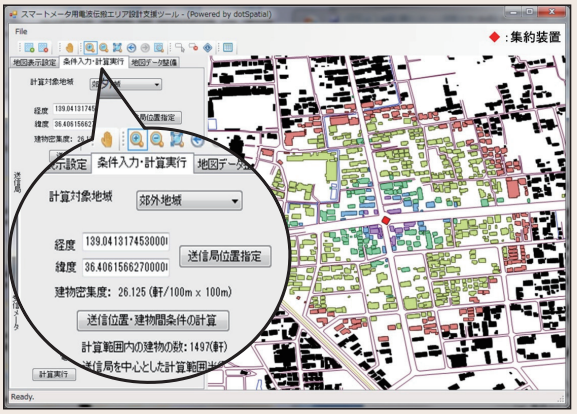
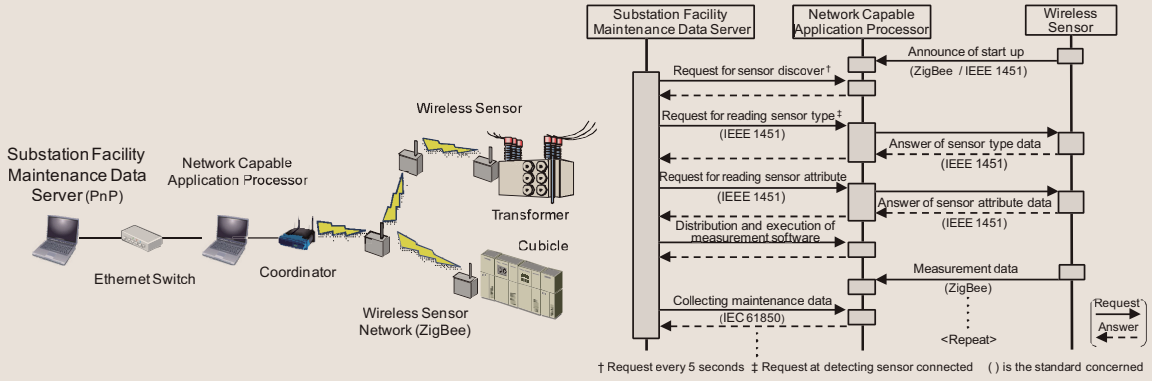


Fig. 1: Input/output data and an example of the display of the wireless multi-hop network design assisting tool

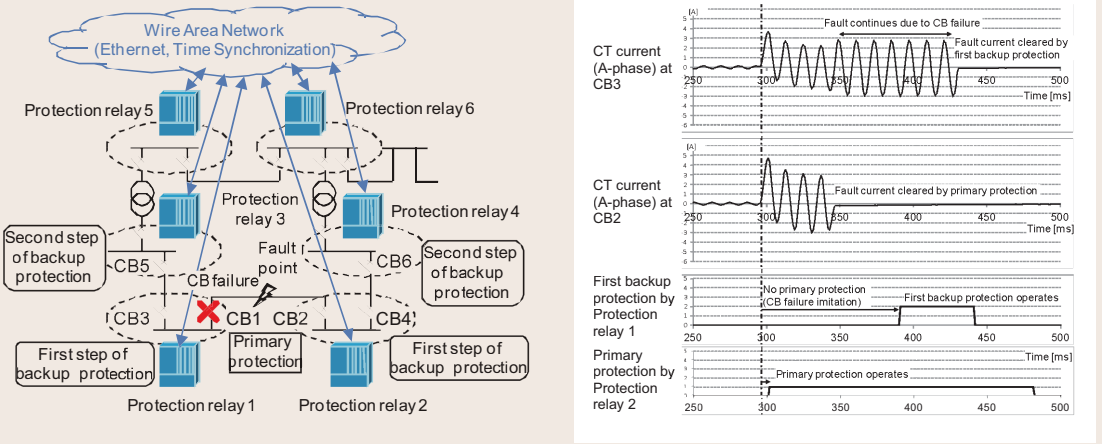
By inputting the type of area and other parameters, a color-coded coverage area is displayed on the area map. The receiving power level of each building and the condition of radio wave shielding around the building are evaluated and displayed also.



(a) Basic system configuration (b) Operations from sensor installation until start of measurement

Fig. 2: Basic configuration and operations of the facility maintenance sensor network

A series of functions from sensor start-up until data collection is performed according to the standardized method for sensor specification acquisition and data transmission as well as the PnP function for distributing measurement software.



(a) Verification system configuration (b) Verification results

Fig. 3: Performance verification of wide area current differential protection using power system simulator

Each control device, or protection relay, is connected to others via an Ethernet-type wide-area communication network equipped with a time synchronization scheme to clear a fault (primary protection) by processing currents simultaneously sampled for determining the faulty section. When the primary protection failures to operate due to CB (CB1, CB2, etc.) failures or similar, backup protections extend the protection zones with step 1 and step 2 to clear the faulty zone.