Next-Generation Communications Network Systems

Background and Objective

Utility communication network systems have been well implemented for the automated operation of power generation and delivery, but have yet to be developed for customer communications such as smart metering, and maintenance and diagnosis of power delivery assets. In addition, communications for power system protection and control are still proprietary and legacy (not IP-based).

This project integrates the fundamental technologies developed in the previous project into practical ones and develops design methods and tools for distribution and customer-side communications networks, sensor networks for power delivery asset condition monitoring, and IP-based wide-area monitoring, protection and control networks.

Main results

1 Communication characteristics evaluation of multi-hop wireless system using 920 MHz band for smart meters

The wireless system using 920 MHz band which draws attention as a candidate for a multi-hop wireless system* for smart meters, needs an efficient communication method to collect data from a large number of meters due to its low transmission rate, though has an advantage in its radio propagation characteristics. We developed a simulation program to evaluate commun ication characteristics in the case of using an open international standardized communication protocol. We showed that the limit of the number of waits for transmission dominantly influences the communication performance due to the random access scheme upon connecting to nearby equipment, and also that the limit of the number of retries for transmission is due to the radio interference from distant equipment upon connecting to faraway equipment (Fig. 1). In order to improve the communication performance, it is important to adjust certain parameters, such as transmission timing, waiting time for transmission, and the number of retries, suited to the environments where the communication equipment is implemented.

2 Development of a new sensing system using remote optical power supply connectable to wireless sensors

We proposed new multi-point optical sensing system using a remote optical power supply for power transmission line monitoring to achieve efficient use of facilities. In our previous work, the prototype system with wired sensors was developed and demonstrated. This time, we have developed an extended system connectable to wireless sensors which enables us to expand the monitoring area (Fig. 2). In the case of driving the radio receiver with large power consumption, supplied power is charged in the capacitor and the receiver is driven in a short time using its energy. An efficient data collection method was created for simplex sensors that the monitoring station surveys data sending timing of the sensors and controls the timing to start charging of capacitors. We successfully developed and examined a demonstration system applying the above technologies and practical wireless sensors to show that on-site monitoring facilities with no power equipment is feasible.

3 Examination of the applicability of a precise time synchronization scheme to wide-area IP networks

In order to measure and process power system state data precisely for protection and control, their measurement timings must be synchronized throughout the power system. To achieve simple timing synchronization, a time synchronization scheme standardized as IEEE 1588** was evaluated with respect to its expansive applicability to wide-area IP-related networks. While the time synchronization was degraded or not achieved for some cases in conventional networks (Table 1), a time synchronization error of around 1μs sufficient for protection and control was experimentally achieved in Ethernet-based networks dedicated to time synchronization (Fig. 3).

* A wireless system transmitting meter reading data from each smart meter like a bucket brigade, connecting neighboring smart meters.
** A time synchronization error less than 1 μs is achieved for a local area network.

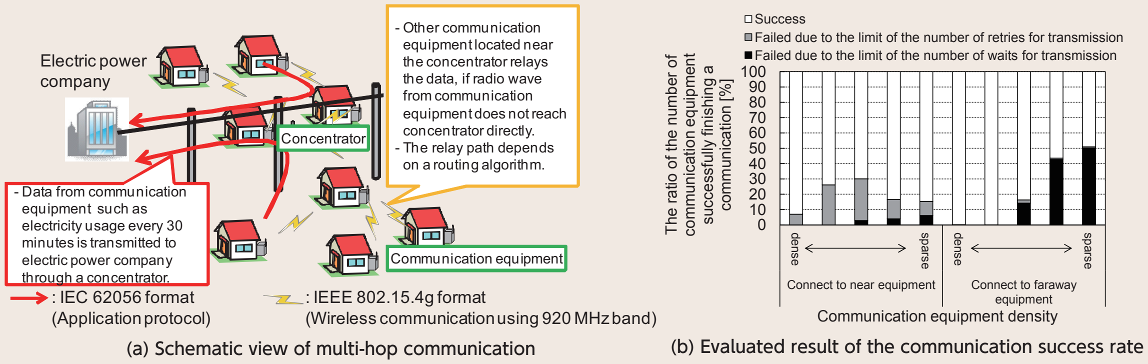

Fig. 1: Communication characteristics evaluation of the multi-hop wireless system using 920 MHz band for smart meters

(a) The elapsed time from the autonomous transmission of meter readings every 30 minutes by communication equipment to the reception of the said readings by an electric power company was calculated considering the use of the international standard protocol for automatic meter reading IEC 62056. (b) The limit of the number of waits for transmission dominantly influences the communication performance due to the random access scheme upon connecting to nearby equipment, and also the limit of the number of retries for transmission due to the radio interference from distant equipment upon connecting to faraway equipment.

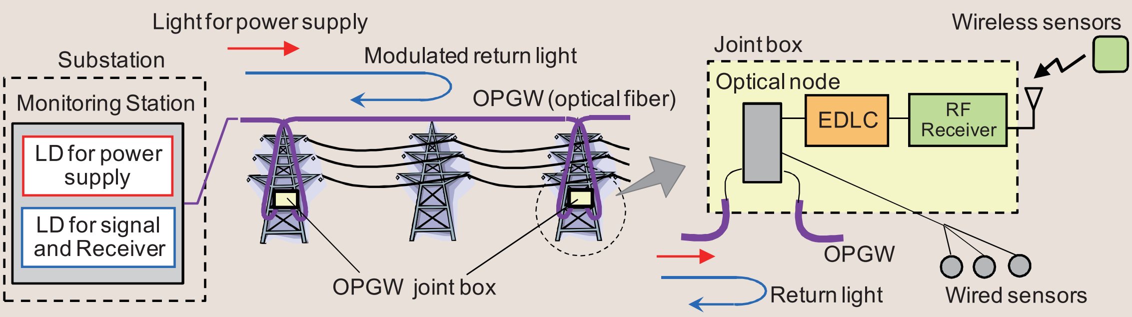

Fig. 2: Multi-point optical sensing system using remote optical power supply connecting to wireless sensors

The driving power of optical nodes is remotely supplied by a light source at the monitoring station, and no power equipment is necessary at sensing sites. Data from wireless sensors with large power consumption can be collected by driving the receiver in a short time using charged energy in EDLC (electric double-layer capacitor). Moreover, an efficient data collection method was achieved for simplex sensors that monitoring station surveys data sending timing of sensors and controls the timing to start the charging of EDLC.

Table 1: Examination of the time synchronism between master and slave clocks in combination with IP-related conventional communication equipment (A) and synchronization scheme-implemented one (B)

Since conventional wide-area Ethernet or IP network without time synchronization scheme implemented apply to actual wide-area networks, the applicability of communication patterns and synchronization schemes was examined from a regulation viewpoint and experimentally. Some cases showed the restriction of applicable synchronization schemes and the increase of time synchronization error to tens of microseconds or greater.

Communication pattern of A / Synchronization scheme of B	1:1	1:n
Centralized operation	✓	✓
Peer to peer operation	–	#
None (Conventional only)	✓	✓

Legend ✓: Synchronization operable
–: Inoperable
#: Operable only for Ethernet

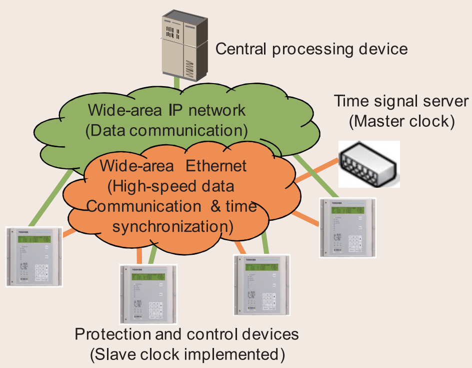

Fig. 3: Examination of the applicability of time synchronization scheme to stabilizing control system using wide-area IP-related communications

A network system for stabilizing control was constructed using communication equipment with time synchronization scheme implemented and protection and control devices with slave clocks. Even under heavy traffic conditions, the network maintained a time synchronization error of around 1μs (Contract research from NEDO).