Project Research — Development of a Supply/Demand Infrastructure for Next-generation Electric Power

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 including smart metering, and 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 and the development of design methods and tools for: demand-area secure communications networks interconnecting customers and distributed energy resources, sensor networks for power asset condition monitoring, and IP-based wide-area and high-speed control networks.

Main results

1 Development of Transmission Performance Assessment and Design for a Demand-area Network

We measured radio propagation characteristics in both a "concentrator to meter" and "meter to meter" communication environment for smart meter multi-hop wireless communications and developed an empirical formula to estimate the propagation path loss, which can be applied in radio cell planning at different areas (residential, urban, suburban), along with propagation conditions (the number of obstructions and road width, etc.) (Fig. 1) (R11031).

kHz-band PLC (power line communication) is one of the most useful communication technologies for apartment buildings. We proposed a new simplified calculation method of transmission loss for multiple branching power lines. We also introduced an approximate equation that enables us to calculate loss easily using typical spreadsheet software and clarified that the equation has enough accuracy (approximation error is less than a few dB) (R11001) (R11015).

2 Demonstration of a New Sensing System Using a Remote Optical Power Supply for a Sensor Network

We have proposed a new multi-point optical sensing system using a remote optical power supply. This system enables facilities monitoring over wide areas such as power transmission lines to use no power equipment at sensing sites (Fig. 2). We developed the prototype system including low-energy optical nodes, and it was confirmed by laboratory experiments that the sensing data from the node located up to 23 km apart can be collected and that sequential data collection from several nodes is possible. Furthermore, it was shown that the system is applicable to remote monitoring for existing on-site ground fault indicators (R11014).

3 Development and Reliability Assessment of IP-based Wide-area and High-speed Control Networks

We have developed communication network technologies that enable the construction of low-cost and high-performance protection and control systems by utilizing the interconnectivity of off-the-shelf IP technology and by implementing the scheme of real-time features and reliability assurance. We have also evaluated the reliability of an IP-based protection system (Table 1) and showed that a redundant system configured with two separate fiber optic and microwave radio networks is required to meet the system reliability requirements (R11032).

Other reports: (R11024) and (R11029)

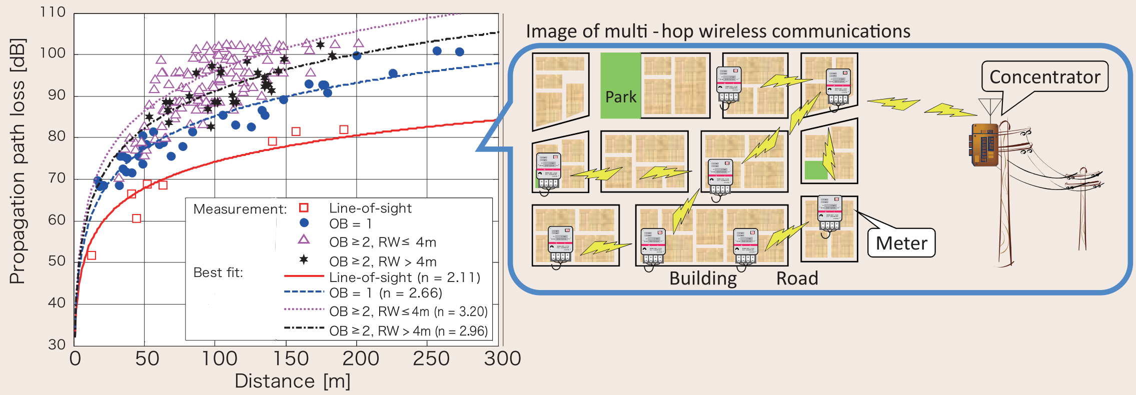

Fig. 1: Distance dependency of the propagation path loss with its best-fitting curves for the 950-MHz band and "concentrator to meter" paths

The propagation path loss can be represented by using the best-fitting curves with propagation path loss exponents (n) in terms of the number of obstructions (OB) and road width (RW).

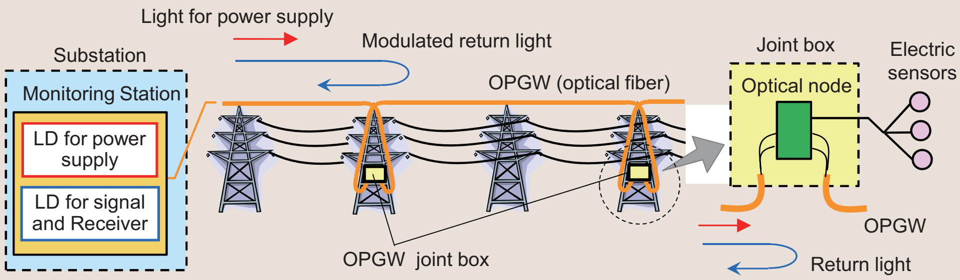

Fig. 2: Multi-point optical sensing system using a remote optical power supply (example for power transmission facilities monitoring)

Driving power for optical nodes is remotely supplied by a laser diode (LD) at a monitoring station, and no power equipment is necessary at sensing sites. In a monitoring station, a signal light to control the optical nodes is transmitted, and a return light modulated by sensor information is received.

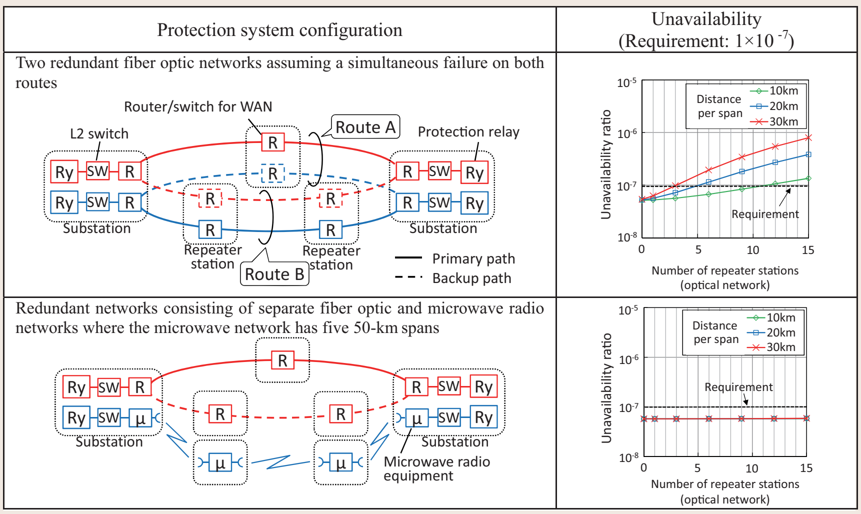

Fig. 3: Results of a reliability assessment for IP-based protection systems

Since two separate fiber optic networks are hard to construct, the number of applicable repeater stations and the end-to-end transmission path length are restricted. When one network is configured with a microwave radio, they meet the requirement since simultaneous failure occurs less.