Development of Reliable Communication Architecture Suited to Power System Control in the Liberalized Electric Power Industry

Background

Control and communication systems for power system operation and maintenance have long been constructed individually and exclusively for each application. With the liberalization of electricity markets, however, not only increasing interconnectivity between different control systems and devices but also cost cutting of system construction and operation are required. While widely applied, off-the-shelf and standardized techniques are preferable with respect to the interconnectivity and cost cutting, they struggle to ensure real-time features, reliability and security required for power system control.

Objectives

To develop and demonstrate the techniques for ensuring real-time features, reliability and security of power system communications when off-the-shelf and standardized methods are applied.

Principal Results

1. Development of reliable communication techniques for power system control

Table 1 shows requirements for power system control and communication networks; real-time features, reliability, security, interconnectivity, efficiency of information transmission and processing. By making use of off-the-shelf and standardized techniques, we developed Distributed Real-time computer Network Architecture (DRNA) as a framework that meets those requirements.

DRNA consists of three layers; 1) standardized power device information model, 2) communication middleware ensuring communication process efficiency and reliability, and 3) IP-based communication network in conjunction with security measures. Fig. 1 shows an example of DRNA implementation for substation telecontrol system where each of the functionalities is embedded in control and communication devices. Standardized information models facilitate information exchanges between systems and devices.

2. Performance verification of DRNA middleware

The DRNA middleware conducts parameter settings and transmitter/receiver processing for prioritized and redundant transmissions in IP-based network. Even when communication load increases to a congested state, the middleware controls transmission delay increase to make the important information transferred and processed within one second as shown in Fig.2. The priority setting scheme has been adopted for a standard protocol of the Japan Electrical Manufacturer's Association (JEMA).

3. Comprehensive demonstration test of DRNA

In order to examine the operations of DRNA comprehensively almost under the circumstance of actual power system operation, distributed and cooperative voltage reactive power control system was constructed employing the DRNA functions in CRIEPI's power system simulator. The test showed proper operations of each function coordinated with others for the information exchanges among control devices and the control performance against load changes even in the states of communication network failures and congestions as well as mal-operations of power system devices. This study was conducted jointly with TM T&D, Inc.

Future Developments

The applicability of DRNA to power company's actual fields will be reviewed, and migration techniques from existing systems to DRNA-based ones will be developed.

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Reference

Y. Serizawa, et al., 2005, "Development of Distributed Real-time Computer Network Architecture, DRNA (Part 9) - Cooperative Functions of DRNA and their Examination -", Technical Report 04A123 (in Japanese)

Table 1 Requirements and Applicable Techniques for DRNA

Requirements	Contents (Applicable techniques)
Real-time feature	Assured transmission of information within about 1 second (Bandwidth management, prioritized transmission)
Reliability	No interruption of information transmission (Redundant route, receipt acknowledgement, re-transmission)
Security	No eavesdropping, modification, or insertion of information (Network isolation, authentication and encryption)
Interconnectivity	Enabling information exchange among different systems (Unified information formats and protocols)
Efficiency	Efficient utilization of control/communication devices (Software agent*, information flow control, etc.)

Note: *Software agent is software that consists of a program and data and can move throughout a network

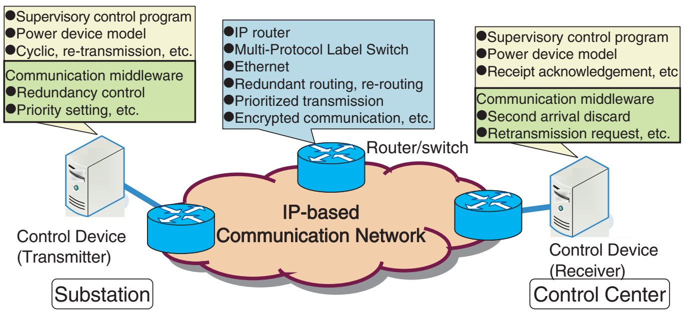

Fig.1 Functional structure of DRNA

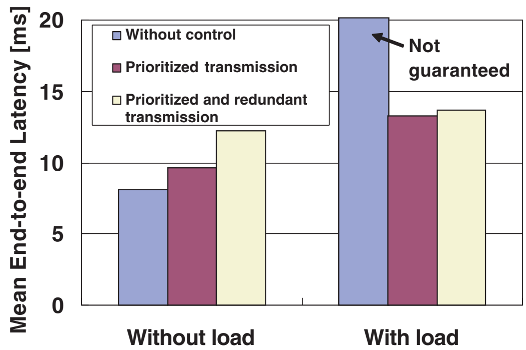

Fig.2 Performance of the DRNA middleware

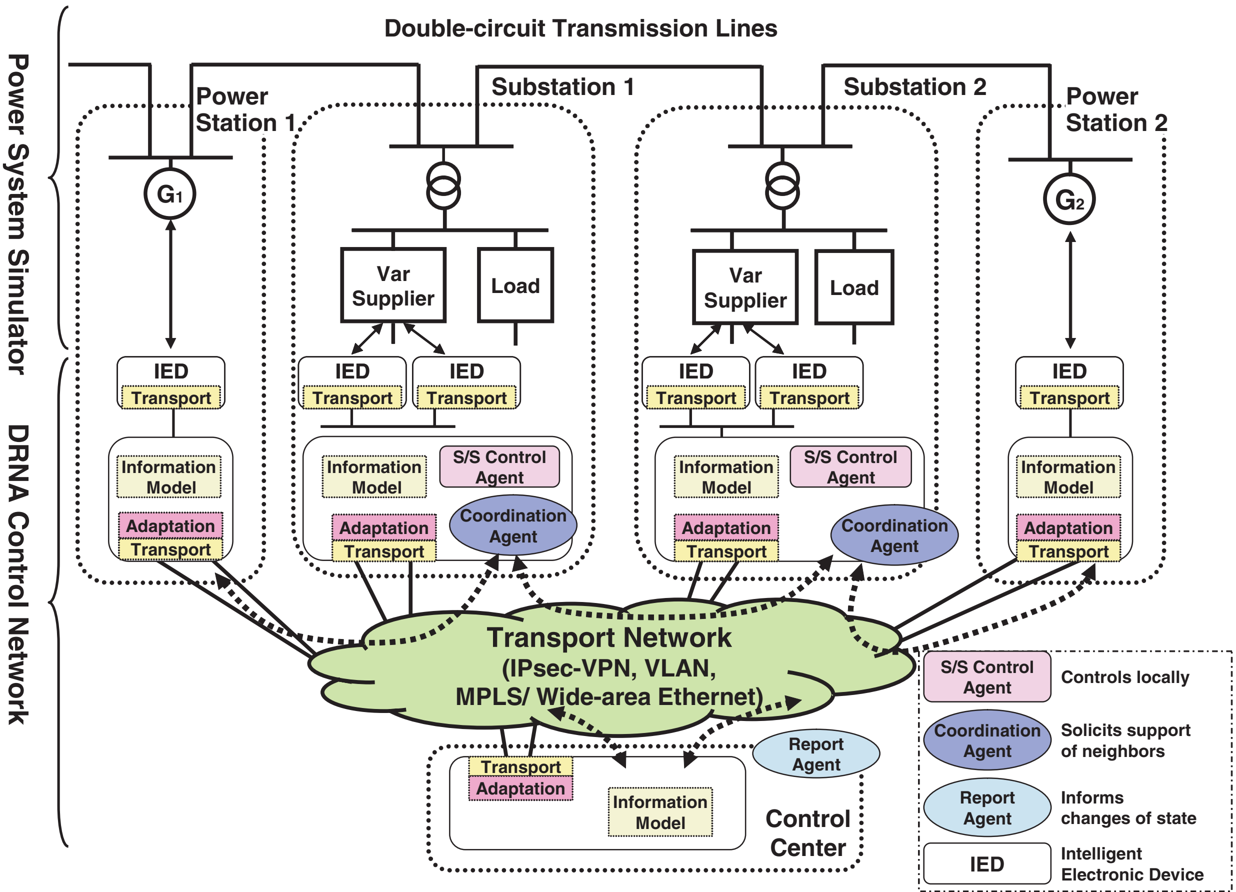

Fig.3 Demonstration system of distributed and cooperative VQC