Wide-area Integrated SCADA System Designed to Improve Availability and Flexibility

—SCADA and Operation Training Simulator System Supplied to Electric Power Development Co., Ltd.—

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OVERVIEW: The SCADA and OTS of Electric Power Development Co., Ltd. combines a simulator used for operational training with centralized SCADA system based at three regional control centers that monitor and control the operation of hydro power plants, substations, and converter stations scattered across Japan. The upgrade to this system described here involved the development of a wide-area integrated SCADA system designed to improve availability and flexibility. The system utilizes wide-area IP networking and server virtualization technologies and links the regional control centers and training center together via a wide-area IP network.

INTRODUCTION

IN the past, Electric Power Development Co., Ltd. (J-Power) managed the operation of its hydro power plants, substations, and converter stations scattered across Japan from four sites; namely its North, East, Middle, and West regional control centers. The upgrade to its SCADA (supervisory control and data acquisition) and OTS (operation training simulator system) reduced this number to three by merging the Middle and West regional control centers (into the Middle & West Regional Control Center) and linked the regional control centers and an OTS located at its Kawagoe Training Center via a wide-area IP (Internet Protocol) network to achieve organic system operation.

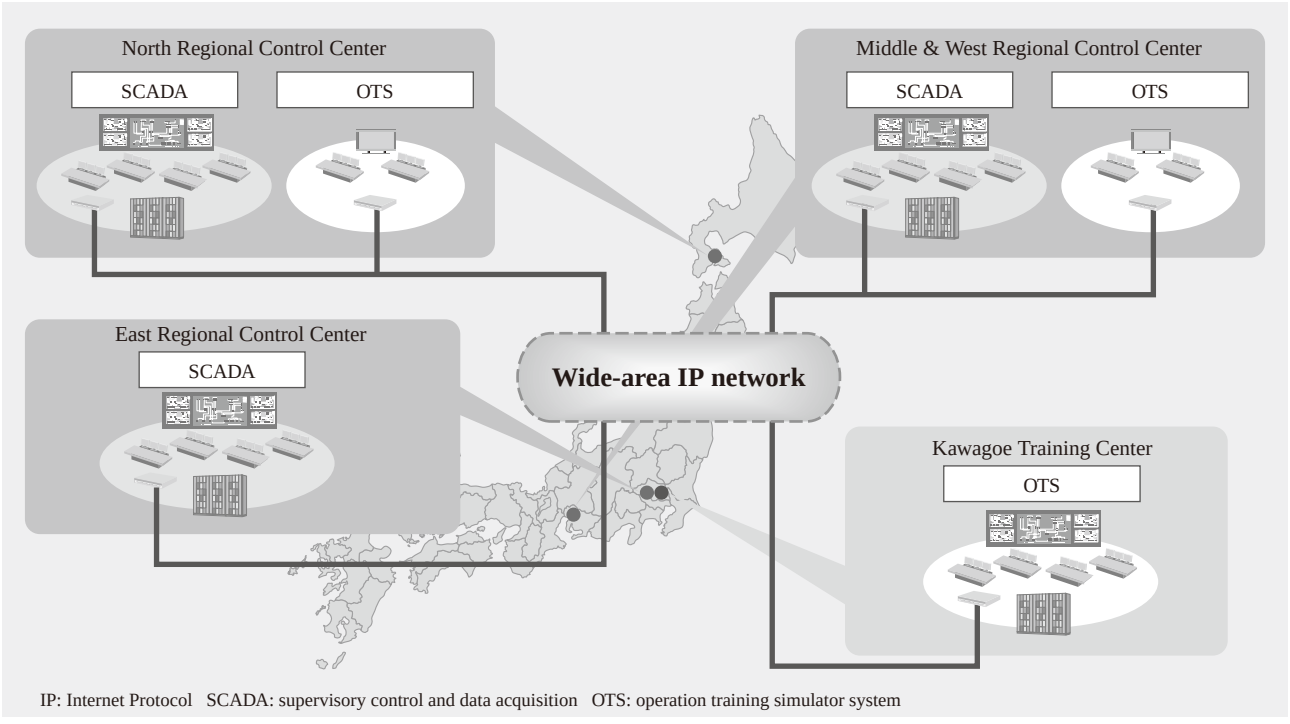

Fig. 1—Block Diagram of SCADA and OTS.
The wide-area SCADA system consists of a training simulator system and three regional control centers that monitor and control the operation of power system equipment located in different parts of Japan, all of which are linked together with via a wide-area IP network.

The North Regional Control Center handles the operation of hydro power plants in Hokkaido and the transmission link between Hokkaido and the Mainland and the East Regional Control Center handles hydro power plants and substations in the Tohoku and Kanto regions. The Middle & West Regional Control Center, meanwhile, handles hydro power plants, substations, and frequency converter stations over a wide area of Central Japan (Chubu, Hokuriku, and Kinki) and Western Japan (Kyushu and Shikoku).

The OTS, on the other hand, provides a training environment for operators at each of the regional control centers (see Fig. 1). The upgrade project was intended to make the system easier to use through functions such as displaying the electrical status of the power system and fault sections, telop message processing, and tagging. These were implemented by adopting a distributed architecture for key computing equipment and using projection for the large-screen display. The upgrade also adopted the use of smartcards for operational security to control access to system operations.

This article describes Electric Power Development Co., Ltd.'s wide-area integrated SCADA system, which uses a wide-area IP network to link SCADA and OTS equipment.

CONFIGURATION OF INTEGRATED WIDE-AREA SCADA SYSTEM NATIONWIDE

SCADA System Overview

The SCADA performs remote monitoring and control of hydro power plants, substations, converter stations, and other facilities to ensure that they operate efficiently and to recover quickly from equipment faults, while also preventing such faults from cascading. Table 1 lists the main functions of the SCADA equipment.

SCADA System Features

(1) Standardize practices at the regional control centers.

The upgrade development project undertook a standardization of practices based on a clear demarcation between practices common to all the regional control centers and those specific to a particular center. Additionally, database and HMI (human-machine interface) specifications were standardized to reduce development and operating costs by expanding the degree of overlap among the three regional control centers.

(2) Use of smartcards for security

Security measures were put in place in which smartcards were used to manage client operation permissions based on roles such as "system administrator," "operator," "support staff," and "training." The operational functions that each of these roles were permitted to use were defined and the system was designed so that users could only perform operations for which they had permission.

(3) Wide-area IP network adopted for system administration of SCADA

The upgrade provided the ability to perform centralized management of the programs and maintenance databases at the three regional control centers via the wide-area IP network. Whereas administration of master data and updating of the maintenance data at the regional control centers was normally carried out using maintenance clients located at each center, a maintenance management server was installed at the Kawagoe Training Center (which served as the administration center) to allow the centralized management of the maintenance data for all the regional control centers.

After switching to the online system, it became possible to unify the maintenance data from the regional control centers in the maintenance management server via the wide-area IP network.

TABLE 1. SCADA Applications

The table summarizes the applications used for power system operation.

Name	Function
Data acquisition and processing (for power system)	Status and operating parameter monitoring of power plant and substation equipment, catchment and weather monitoring, etc.
Supervisory control (of electrical equipment)	Supervisory control of power plant and substation equipment, switch order management, and automatic execution, etc.
Schedules and operation management	Operation of generation equipment and Hokkaido-Mainland DC transmission link, startup and shutdown instructions to power plants, and automatic issuing of output setpoint commands based on planned output schedules for each power plant prepared by operational schedule planning
Automatic supply of power	Power allocation to power units, setting the number of operating units, setpoint output control to power units, PSS control of Sakuma Frequency Converter Station, and other supervisory control of generators to ensure efficient operation based on instructions from Central Load Dispatching Center
Operator support	Fault management and system restoration, operational data maintenance, etc.
Historical data retrieval and reporting	Automatic collection and reporting of various logs
Data exchange with other systems	Exchange of data with other power systems and other sites such as dam management centers, weather information, distribution of information to other departments (OA information).

PSS: power system stabilizer OA: office automation DC: direct current

COMPREHENSIVE OPERATIONAL TRAINING ENVIRONMENT WITH WIDE-AREA DISTRIBUTED CONFIGURATION

Overview of OTS

The OTS is used to train operators in the skills required. It consists of simulation functions that replicate the behavior of the power system being monitored and controlled, its generation and substation equipment, catchment information (dam inflows, river water levels, etc.), and weather information (warnings and alerts, rainfall figures, etc.) as well as a functional model of the regional control centers (SCADA). The OTS management server that provides the simulation functions and functional model of the regional control centers is located at the Kawagoe Training Center.

Training can be conducted either as group training involving a team of operators or as individual training for a single operator. To provide an environment equivalent to that of the actual regional control centers, the equipment used for the HMIs during group training has the same configuration as the SCADA. This includes the large-screen display and OTS clients. The group training equipment is located at the Kawagoe Training Center. Meanwhile, equipment for training individual operators is provided at each of the regional control centers and consists of a OTS client and large display screen. The OTS management server provides training services across the wide-area IP network, via which it connects to the OTS clients, and large display screens in each regional control center.

OTS Features

The OTS incorporates the following features to improve training efficiency and cut operating costs:

(1) The replication of regional control center functions is structured in a way that runs the SCADA applications (which were developed on the SCADA). Operations and functions equivalent to the SCADAs at the regional control centers are replicated by using online data processing to input and output the results of modeling by each simulation function. This allows for practical hands-on training that is more realistic than was possible in the past (see Fig. 2).

(2) Running the actual SCADA applications makes it easy to update the training simulation to match any modifications made to the SCADA (changes to the applications or maintenance data).

(3) The OTS management server needed to be installed at a single location (on a single computer). Accordingly, a multi-site configuration using server virtualization technology was adopted to allow training to take place at six locations at once (corresponding to simultaneous group training and individual training at the three regional control centers). Server virtualization technology provides an environment in which multiple independent virtual servers can coexist on a single physical server. This improves training efficiency by simplifying the use of training services, switching the training site between the various places where training is performed (training center and the regional control centers) (see Fig. 3).

(4) By connecting to the wide-area IP network, the same training services that are used for group training can be accessed from the regional control centers without being limited to particular times or places.

(5) Data can be shared between the SCADA and OTS via the wide-area IP network. The online network status at each regional control center (current data about equipment status and similar matters) can be passed to the OTS and used as the OTS initial status for a training exercise.

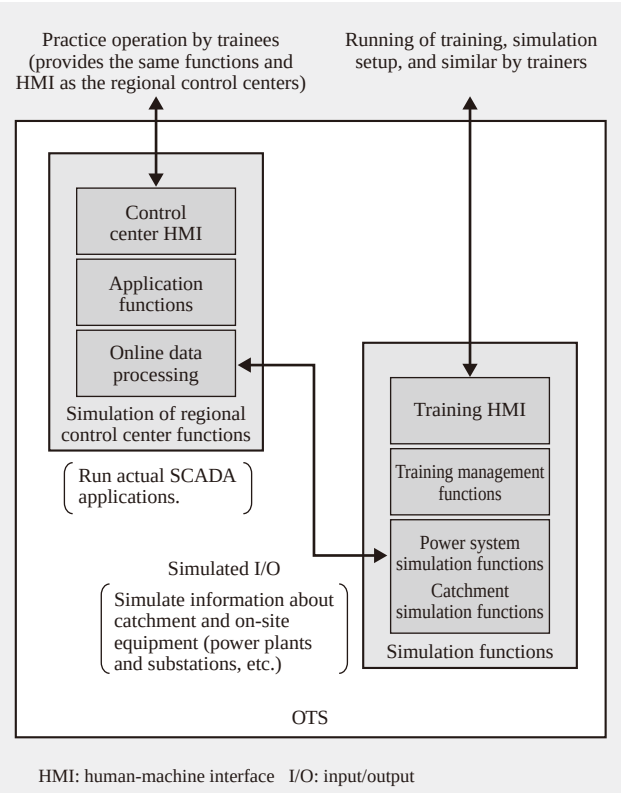

Fig. 2—Functional Configuration of OTS.
The OTS contains functions for modeling the regional control centers and simulation functions. The functions for modeling the regional control centers run actual SCADA applications.

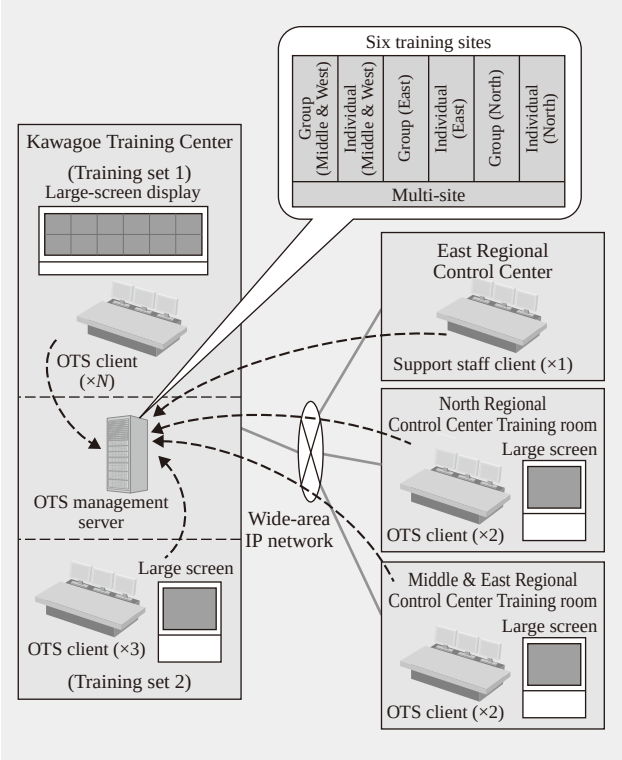

Fig. 3—Block Diagram of OTS.
The training sites connect via wide-area IP network to the simulation server located at the Kawagoe Training Center.

WIDE-AREA IP NETWORK

The various systems at the regional control centers located in different parts of Japan and the Kawagoe Training Center link together via the wide-area IP network. The network has a narrow bandwidth (in the Mbit/s range), operates over long distances, and has delays in the order of several tens of milliseconds. It was necessary to ensure that the system would be able to deliver the required performance levels (processing capacity and responsiveness) under these conditions, even when training was being conducted at six sites at once. Accordingly, the following techniques for wide-area distributed operation were adopted for communications over the wide-area IP network:

(1) Replication of current data and differential transmission

A replica of frequently referenced data is maintained on the clients and managed between client and server via the network. Replication is a technique for keeping master and replica copies of data synchronized. Fast data access is achieved when data is referenced at the client by accessing the local replica data. Also, by broadcasting only the updated data (difference between data before and after updating) to all of the clients, usage of communication capacity during normal operation is reduced while keeping the replica data up to date.

(2) Use of data update tags and data caching

This is a technique for optimizing the replication timing by checking the data update tag and data update time when the replica data is referenced to determine the synchronization between master and replica data. It is used when it is necessary to synchronize the master data and the volume of replica data managed between the server and clients via the network is large. Although data updated at the master copy is periodically sent to the replicas to ensure synchronization, the periodic nature of the process means there is a time lag. To prevent loss of synchronization between master and replica due to this time lag, the data update tag is used to check for loss of synchronization when replica data is referenced at a client. If loss of synchronization has occurred, the master data is accessed instead to maintain consistency.

(3) Dynamic compression of communication data

This technique is used when transferring large volumes of data between devices connected via a communication link and is implemented by the communication middleware in a way that is transparent to the applications. The communication middleware compresses data in its send buffer before transmission and decompresses it at reception to restore the data in the receive buffer. Compressing the data sent over the network reduces the bandwidth used.

By using these techniques, the required performance could be achieved even when the system is heavily loaded due to simultaneous status changes when conducting training at six sites at once.

CONCLUSIONS

This article has described Electric Power Development Co., Ltd.'s wide-area integrated SCADA system, which uses a wide-area IP network to link SCADA and OTS equipment.

Hitachi has developed a system that provides organic interoperation between a training center and regional control centers located in different parts of Japan by linking them together via a wide-area IP network. Hitachi believes that this has resulted in a system that makes possible new ways of operating and the provision of added-value functions.

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