New Electric-power Management System with Ubiquitous Solutions

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OVERVIEW: Hitachi integrated the various proven application software for the "electric-power management system" to cope with advanced power system operation. The application software are conventionally decentralized planning support subsystem that support energy scheduling and outage scheduling, online monitoring control subsystem that perform automatic generation control, network operation and control, training simulator subsystem that provide operational training. Development of the system, it applied the ubiquitous solution technologies which Hitachi has, enabled to catch ever-changing information visually and ensure seamless business linkage.

INTRODUCTION

SUPERVISORY Control and Data-acquisition/Energy Management System (SCADA/EMS) have produced 2nd-generation systems, which distribute their functions to servers and realize high functionality and high performance via open distributed system technologies, following the 1st-generation systems that performed centralized control and monitoring via dedicated servers. Now, the SCADA/EMS systems are shifting to third-generation systems, which utilize the state-of-the-art information/communication technologies.

Integration of the multi SCADA systems is the background to the shift to the 3rd-generation systems that could meet from utilities' needs to reduce a number of operators by integrated operation under circumstances of electricity deregulation and maturing of electric-power facilities.

The SCADA/EMS system of The Okinawa Electric Power Company, Incorporated (OEPC), which is presented here, is a highly integrated system consisting of an EMS for power-generation control and a SCADA system for controlling and monitoring power delivery to the distributed stations through its 132-kV trunk network. The system is equipped with high-functionality application software developed by Hitachi and already installed in other systems.

Hitachi has also delivered information/communication systems such as an LCOS (liquid-crystal-on-silicon) projector system, which is one of its products for "ubiquitous solutions," to OEPC. Furthermore, terminal server technology, which realizes seamless connection of functions as well as maintenance of system security by keeping the advantages of multi-operation system (OS) platforms composed of UNIX*[1], Linux*[2], and Windows*[3], has been applied for the first time to the SCADA/EMS system.

This paper describes various features of the first 3rd-generation SCADA/EMS system delivered to OEPC.

SYSTEM CONFIGURATION

The SCADA/EMS system consists of the following four subsystems as shown in Fig. 1.

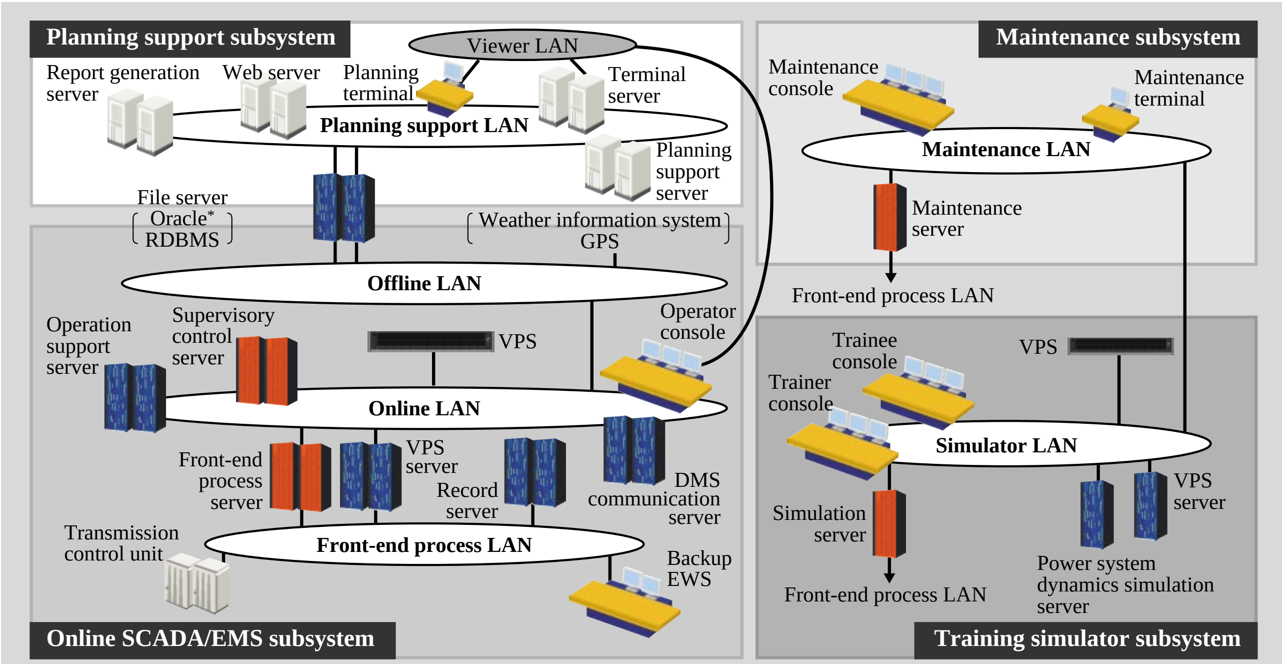
(1) Online SCADA/EMS subsystem

The subsystem supervises the states of the power system in real time, adjusts outputs of generators, and operates the power system. This subsystem is the most important for power supply and operation of the power system. UNIX is adopted at "servers," and Linux is adopted at "clients." And Hitachi's dependable, open, reliable middleware for power system is installed. Many task applications are installed for central dispatching center and control center (see Table 1).

(2) Planning-support subsystem

Aiming at improving economical performance, stability, and efficiency, the subsystem supports for the daily, weekly, monthly, and yearly planning of power-system apparatus and generators. Planning data made by this subsystem is sent to the online SCADA/EMS subsystem and used for scheduling and limitations of optimization calculations (see Table 2). Data created by the subsystem can be connected with the inter-information systems and can be applied among the system task applications by the terminal server techniques.

*1 UNIX is a registered trademark in the United States and other countries, licensed exclusively through X/Open Company Limited.
*2 Linux is a trademark of Linus Torvalds.
*3 Windows is a registered trademark of Microsoft Corporation in the U.S. and other countries.



* Oracle is a registered trademark of Oracle Corporation.

LAN: local area network
RDBMS: relational database management system
GPS: global positioning system
VPS: video projection system

DMS: distribution management system
EWS: engineering work station
EMS: emergency management system

Fig. 1—Configuration of SCADA/EMS System.
The new automatic power-supply system comes with a highly functional application that applies ubiquitous solutions, and it sets a precedent for generation electric-power information control systems.

TABLE 1. SCADA/EMS applications
Main functions are monitoring, controlling, operating, and reporting in realtime.

SCADA	Data acquisition, faulty device detection,
Generation control	Automatic frequency control, economic load dispatch
Network operation and control	Device control, switching-order automatic execution, voltage reactive power control
Power application	Automatic fault restoration, contingency evaluation, dispatcher power flow, state estimation, short-circuit analysis
Record & report	Operation summary report, generation report

(3) Training-simulator subsystem

The subsystem is the total simulation system by which operation training called "online SCADA/EMS" and each training evaluation can be executed. The power-system dynamics simulation server executes the simplified stability calculation in real time that is almost the same as the under real-time power system.

(4) Maintenance subsystem

This is the subsystem for maintaining a power

TABLE 2. Scheduling Application
Main functions of application groups for working out operation plans and forecasting-results information needed for performing online operation are shown.

Energy scheduling	Load forecasting, unit commitment
Outage scheduling	Outage scheduling, switching-order generation

system facility database and for testing to verify correct performance before the operation of the system. By the variety of testing functions of the system, the effect of maintenance and reliability of power system facility data would be improved. The training simulator subsystem and maintenance subsystem can be performed as an alternative system for online SCADA/EMS in time of emergency, therefore, this system has highly performed function.

APPLICATIONS SUPPORTING STABLE POWER SUPPLY

The electrical power system of OEPC is isolated and stand alone in Japan. Moreover, operation of high-capacity generators along with enlargement of system scale started, and this operation becomes more

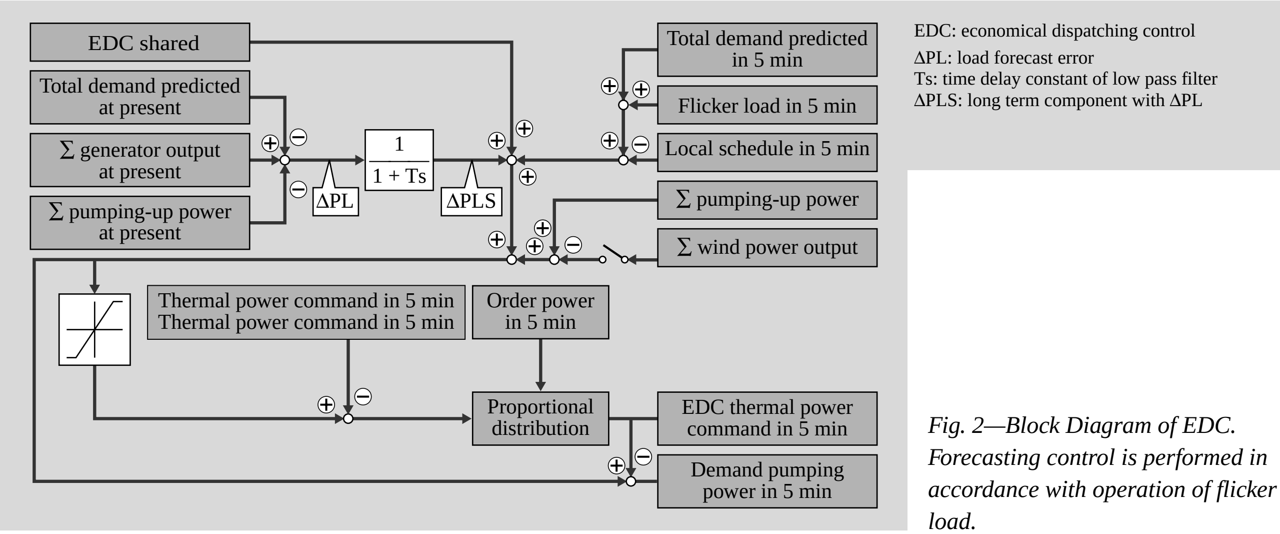


Fig. 2—Block Diagram of EDC. Forecasting control is performed in accordance with operation of flicker load.

complicated in accordance with variations in the lineup of power sources (such as high growth rate of coal-fired generators in order to handle installed capacity).

In addition, increase in the complexity of operation owing to large-capacity flicker load becomes a factor in accordance with system scale. And on top of increased speed and improved power-saving, the needs for seamless applications and operation-data coordination are extremely required.

An example application of a power-generation-information control system developed by Hitachi as a new automatic power-dispatch system is described as follows.

Supply-and-demand Control System Using Flicker-load Prediction

Under rapidly changing flicker load (non-confirming load), if supply-and-demand adjustment for flicker load (whose fluctuation band is relatively large in correspondence with system capacity) is failed, a large fluctuation of frequency would be occured. As for countermeasures against this fluctuation, the following two ideas have been advanced:

(1) Increase the capacity for generators capable of handling the rate of change of load

(2) Operate oil-fired generators with large rate of change of power output.

As a result of these measures, however, the output power of efficient coal-fired generators with large capacity is decreased, leading to increased fuel costs.

Accordingly, on introducing this new automatic power-dispatching system, in addition to improvement of supply-and-demand systems that could perform future predictions by applying quadratic programming method (which have accumulated successful results under the central supply-and-demand command-center system), namely, methods for optimizing mathematical planning problems expressed as inequalities with a second-order objective function and first-order constraint condition, future prediction (including flicker load) was developed, and lightening of operator burden by automatic operation during flicker-load adjustment and reduction of fuel costs were achieved.

As for flicker load, since power demand changes greatly in accordance with operation under or not under flicker load and operation start-up time, the prediction of whole power demand for independent systems is not easy. As a result, in the case of supply-and-demand operation planning, an operation plan for flicker load is added to the forecast result of power demand (excluding flicker load), and economical load dispatching and a start-up/shutdown schedule for generators is put in place.

It is difficult, however, to set the operation start-up time under flicker load in minutes. Accordingly, power demand is forecast according to an operation start-up schedule for each generator designated in the plan, power demand excluding flicker load, and operation patterns under flicker load. At the same time, future-forecast-based control combining operation under flicker load is performed (see Fig. 2). In regards to a supply-and-demand control system, future systems and power demands spanning 14 sections could be predicted by quadratic programming based on this information, and command designation for the most economical generators is carried out.

Moreover, focusing on the periodicity of flicker load on pipe work of OEPC reveals the similarity of the variation patterns of flicker load in each period. Accordingly, by communicating the operation plan for flicker loads in advance, it is possible to attain uninterrupted automatic operation while each period is corrected by hand. Additional improvement of automatization ratio is being aimed at; that is to say, signal from flicker load in the future would be automatically captured, and the supply-and-demand system automatically corrects the period and pattern of flicker load.

Power-system Operation for Consistent Coordination of Operation Data

In regards to an "operation power stoppage support system" for performing automatic adjustment of monthly and yearly operation subjects while maintaining system reliability and electricity-supply reliability according to stoppage demands, construction of new equipment, or equipment shut-down by maintenance departments, formulation of the period in which operation can be executed and that best satisfies each constraint condition (such as power flow in each system's section) is performed automatically. Accordingly, it is necessary to simplify power-system equipment, express it in simple terms, and shorten computation times.

Meanwhile, the operation tag that performs system operation online according to the adjustment results operates on a platform composed of Hitachi's power-system-use middleware for electrical-power information control systems; therefore, detailed data on power-system equipment of online monitoring and control subsystems is needed.

As for the operation-application system (which applies to the operation stoppage support system for operation subjects, in order that there is no need to install it on an application in a terminal set up in the relevant department, in the case of a Windows platform, it is necessary to provide the system as a Web application.

In regards to the new automatic power-dispatch system, by using a presentation server, these contradicting technical factors can be satisfied, and operations and related data can be connected seamlessly. As a result, tasks from application for operation subject up to automatic adjustment of operation period, creation of operation tags based on operation subject, and automatic execution of operation tags online on the operation-execution day are performed consistently, thereby making operating efficiency exceptionally high (see Fig. 3).

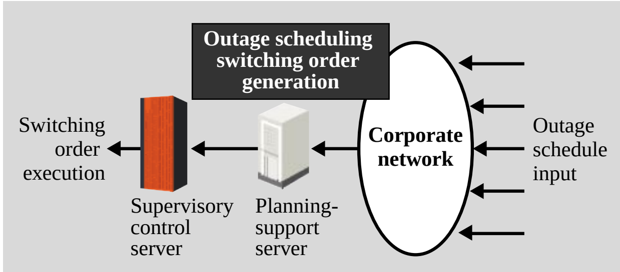


Fig. 3—Outline of Outage Schedule Data Flow.
Automatic execution of operation tags online is performed consistently.

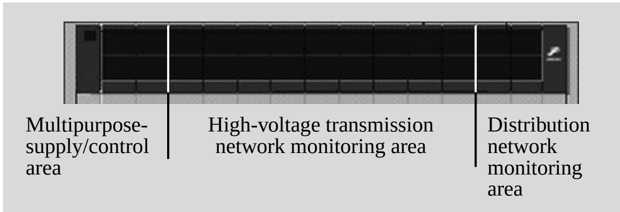


Fig. 4—Video-projection System for Online SCADA/EMS.
Information required for supply and demand, system, and distribution monitoring is presented as an image with dynamic visibility according to application by means of a rear projector.

UBIQUITOUS SOLUTIONS APPLIED TO NEW ELECTRIC-POWER MANAGEMENT SYSTEM

LCOS Rear-projection System

SCADA/EMS/DMS has been provided by Hitachi with a VPS (video-projection system), which is integrated in a large-scale system for monitoring the overall power network status and/or conditions.

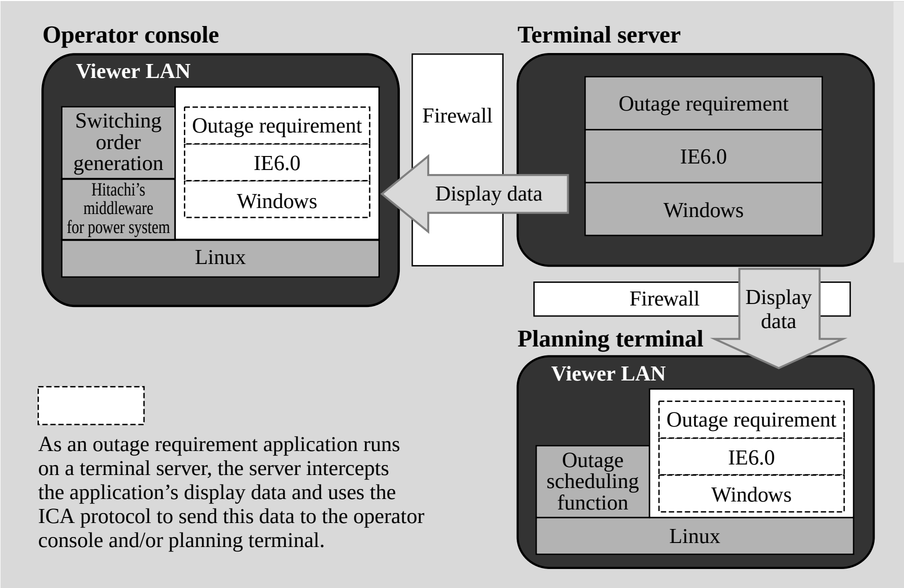
Hitachi has developed advanced VPS (see Fig. 4), called LCOS projector system, which has the following features:

(1) High definition, high resolution, and high quality
(2) High durability due to an ultra-lightfast alignment layers that prevent light deterioration, allowing a pure image to be sustained for a longer period and extending product life
(3) The running cost is half of that of the current module since the optical engine does not contain polarizing material or any other components.
(4) Patented optical-beam control

The system provided for OEPC has twenty-six 70-inch panels for online monitoring and twenty 50-inch panels for the dispatcher-training simulator.

VPS is divided into the following three areas:

(1) Multi-purpose-supply/control area,
(2) High-voltage transmission-network monitoring area, and
(3) A distribution-network monitoring area for easy



IE: Internet Explorer*
ICA: independent computing architecture

* Internet Explorer is a registered trademark of Microsoft Corporation in the U.S. and other countries.

Fig. 5—Realization of Windows-based Application under Linux Platform.
While security is maintained as is, an environment in which online services and planning-support operations can be performed freely via the control console is provided.

and reliable operation

VPS can dynamically display the follwoing images by a remote cursor function, and a projection controller.
(1) The same alphanumeric and graphical images could be shown on monitors
(2) Configurable display images as defined in the specification
(3) Images derived from video signal sources, such as a weather image

Terminal Server Provided for Operability with Network Security

This system features security management by which the highest security level is assigned to operator consoles used for on-line monitoring. However, the same operator consoles must be used for planning support function of Windows system on a Linux platform. Therefore, Hitachi provided terminal servers are shown in Fig. 5.

The operator or engineer can use various Windows application service menus either at remote consoles or operator consoles. In the mean time, network security has been kept by applying the terminal server.

CONCLUSIONS

Hitachi has supplied an electric-power management system as a "ubiquitous solution" to The Okinawa Electric Power Company, Incorporated (OEPC).

Future SCADA/EMS/DMS integration strategies will provide a unifying overall design and structure for utilities in order to support their productivity objectives. For example, system hardware will be installed at data centers but distributed functions can keep their reliability and security (i.e. location-free). Moreover, rapid growth of communication infrastructure, which will be faster and exchange huge volumes of information on IP-networks, can be accommodated.

This new automatic power-distribution system—which satisfies the above technical requirements—is suitable as a so-called "next-generation electric-power information management system."

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