Dependable, Open and Real-time Architecture for Power Systems — DORA-Power —

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OVERVIEW: To improve operating efficiency for deregulation and for other changes in the operating environment, electric power utilities in Japan are integrating information and control systems to support a stable supply of power and strengthening their connections. For that reason, the demand for the reliability in information and control systems, is even greater than before. Furthermore, from the viewpoint of the interconnectability and expandability of systems, there is a need to implement open systems that are based on industrial standard specifications. Under those requirements, Hitachi, Ltd. developed DORA-Power (Dependable, Open and Real-time Architecture for power systems), which conforms to the open platform that is rapidly being standardized and builds in the technology for achieving high reliability and high responsiveness that has been developed for information and control systems. DORA-Power makes it possible to incorporate the state-of-the-art technology to achieve superior functionality and operability in information and control systems for power systems, where reliability and real-time operation are required.

INTRODUCTION

IN response to deregulation, lower rates in charges for electric power and other such changes in the operating environment, electric power utilities in Japan are grappling with the problem of improving operating efficiency. Rationalization in the operation of the monitoring and control systems that support the stable supply of power is proceeding through system integration and the strengthening of cooperation among systems. For that reason, the increasing scale of monitoring and control makes it more necessary than ever to improve processing efficiency and reliability in information and control systems; to achieve efficient cooperation with other systems and system expansion, it is necessary to implement open systems based on industrial standard specifications.

In response to such needs, Hitachi, Ltd. developed DORA-Power, which conforms to the open platform that is rapidly being standardized and incorporates the technology for implementing highly reliable and highly responsive information and control systems that we have developed while incorporating highly functional commercial software.

DORA-Power DEVELOPMENT POLICY

Future information and control systems for power systems must achieve high reliability, connectivity, and expandability by combining highly functional components that are based on industrial standard specifications. To that end, the development policy for DORA-Power included the following points.

(1) Achieving high reliability (dependability)

"Conventional high reliability" takes the approach of attaining high reliability in individual components. As a result, highly reliable functions often do not conform to standard specifications and there are restrictions on the components that can be employed, leading to bottleneck to system construction.

For that reason, the development goal should be dependable technology, which realizes high reliability in the overall system with component based on industrial standard specification.

(2) Achieving portability and connectability (open system)

To increase interconnectability with other systems, it is necessary to conform to a standard interface, and commercial middle-ware shall be adopted with the UNIX*[1] and Windows NT*[2] OS (operating system). In addition, to facilitate software portability when the system is expanded, a middle-ware layer is established to make the OS, distributed system configuration, and redundant system configuration invisible to the application software.

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*1: UNIX is a trademark registered in the United States and other countries, licensed exclusively by The Open Group.
*2: Windows NT is a registered trademark of Microsoft Corporation in the United States and other countries.

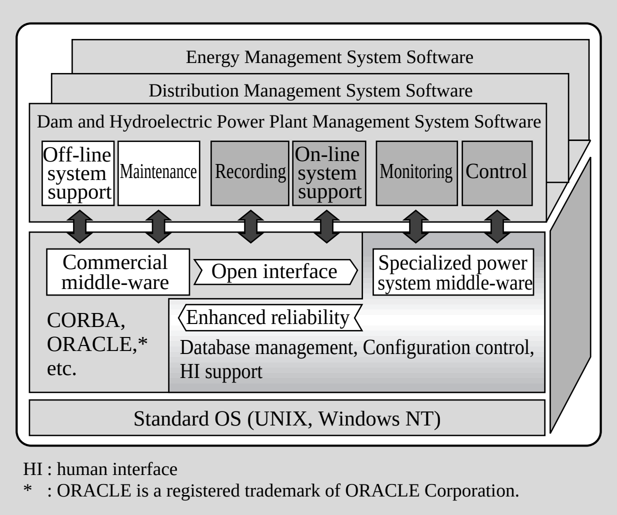

Fig. 1— DORA-Power Configuration.
The open interface commercial middle-ware and the specialized electrical power middle-ware that serves to enhance reliability are fused and serve as the development and execution platform for the application software of the information and control system and run under a standard OS.

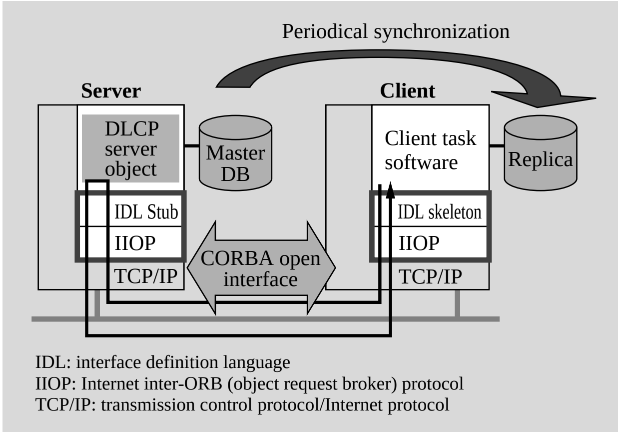

Fig. 2— Implementation of Real-time, Distributed Database in DORA-Power.
The client task software remotely accesses the master DB that is on the server by means of CORBA. If there is a local replica of the database, the software automatically accesses the replica instead. The replica is periodically synchronized with the master DB.

(3) Ensuring real-time operation

To maintain processability and display update response, even under severe performance conditions in which multiple changes in the status of power system apparatus occur over a short period of time, a high-performance distributed database suitable for distributed system shall be implemented.

(4) Improving ease of use

To implement a human interface that has advanced functionality and is easy to use for a high-performance monitoring and control system, the Windows NT GUI (graphical user interface), which is rapidly advancing as personal computers are coming into wider use, shall be adopted.

ARCHITECTURE AND FEATURES OF DORA-Power

On the basis of the development policy outlined above, we chose for DORA-Power an architecture in which commercial middle-ware that has an open interface is fused with electrical power middle-ware for enhanced reliability and that middle-ware is run under the standard OS like UNIX and Windows NT (Fig. 1). This architecture has the features listed below.

(1) Application of distributed object technology

As part of the middle-ware, a commercial software that is based on CORBA (common object request broker architecture),*3 an international standard for distributed objects, is employed to implement an open interface with respect to other systems. And the CORBA marshalling function (conversion processing for the exchange of information among different types of systems) is used to absorb the differences in format for storing information in memory among the computer processors in the system to facilitate the coexistence of different computers within the system.

(2) Database

To prevent the decrease in processability and the decrease in the responsiveness of screen update that accompanies centralized information access, a real-time, distributed database, DLCP (Data Life Cycle Program), is run under CORBA (Fig. 2). In this scheme, a replica of the power system apparatus database is placed on each computer and the various replicas are synchronized with respect to the status data, which changes from moment to moment. This makes it possible for computers that are not running DLCP to access the database that is under DLCP management by using Java*4 or other such means. In addition, commercial software that is based on standard specifications is employed for the maintenance database (DB) and recording DB to facilitate information sharing and cooperation with other systems.

(3) Support for redundant multi-computer systems and high-reliability configurations

The mutual monitoring of multi computer systems

*3: CORBA is a registered trademark of Object Management Group in the United States.
*4: Java and all Java-based trademarks and logos are trademarks or registered trademarks of Sun Microsystems, Inc. in the United States and other countries.

is adopted to improve the reliability of the system as a whole by implementing a system of multiple computers and LANs. This is accomplished using a standard LAN and without assuming special hardware such as memory or disk storage that is shared among computers by adopting the “free-running dual” scheme as the basis for multi-computer operation, in which each computer performs the same processing on the basis of the same input information in the CORBA distributed environment. Because the CORBA standard specifications for high system reliability premised on multiple disposition of objects are still being formulated, system implementation proceeded while keeping an eye on the standardization proposals so as to make the effect of decisions on the final standard specifications very small. Through the multi-computer support described above, even if a failure occurs in a computer or LAN, speedy switch-over to a backup computer with no loss of information can be achieved. Also, by equipping computers that do not have a multi-computer configuration with a mechanism in which information is saved periodically on another computer and, after recovery from a failure, the information is restored, high overall operability of the system can be achieved.

(4) Human interface

The screen construction components required for power information and control and the execution environment are installed on Windows NT, which has a high-level development environment and abundant screen construction components. The components are ActiveX*5 controls, which conform to an industry standard component interface, and advanced human interfaces can be implemented easily by using a commercial programming environment such as Visual Basic*6 to assemble the components. This also effectively deals with EUC (end user computing).

SPECIALIZED POWER SYSTEM MIDDLE-WARE FUNCTIONS AND FEATURES

As the fundamental technology for constructing the DORA-Power architecture, three types of specialized middle-ware for use in power systems were developed. The functions and features of that middle-ware are described below.

(1) Database management middle-ware

This middle-ware allows application software to transparently access the information that is distributed over the system and implements the automatic access to standby computers that is necessary for redundant systems operation. In addition to the allocation of database replicas and implementation of high-speed information synchronization processing to guarantee the responsiveness of screen operation even when many changes in status have occurred, this middle-ware also provides for flexibility at the time of system expansion because it allows changes in the information allocation in accordance with performance requirements. This middle-ware also provides multi-aspect information management, in which the simulated information for test when facilities are updated and the information for training use are managed separately from the on-line data, high-speed switching of currently-used facilities information and facilities information for future use data, and other such basic functions that are required by information and control system for power systems. Furthermore, it provides basic information models for electrical power technology, data transfer format, time series data, etc. and realizes highly expandable software by support for a data-oriented approach to application software design.

(2) Configuration control middle-ware

This software provides functions for system start-up and shutdown, monitoring for abnormalities in computers and LANs, failure management, changes in operating mode and other such functions that are related to computer system operation (Table 1).

(3) Human interface support middle-ware

This software comprises the human interface (HI) manager and the HI components for power system use (Fig. 3). The HI manager has functions for menus and

TABLE 1. Functions of the Configuration Control Middle-ware
The configuration control middle-ware supports functions that are related to the operation of distributed multi-computer systems.

Function	Description
Operating mode management	Mutual failure monitoring by computers and automatic system shut-down and switching to the back-up system when a failure occurs
LAN management	LAN failure monitoring and automatic switching and load distribution management when a failure occurs
Failure management	Task program. OS and hardware failure management and journal keeping
Timing management	Makes time corrections and maintains timing consistency among computers
DB management	DB version management and main memory information back-up and recovery
System monitoring console operation management screen	Computer operation halting and mode changing and DB switching. Display of system status, failure journal, etc.

*5: ActiveX is a trademark of Microsoft Corporation in the United States and other countries.
*6: Visual Basic is a registered trademark of Microsoft Corporation in the United States and other countries.

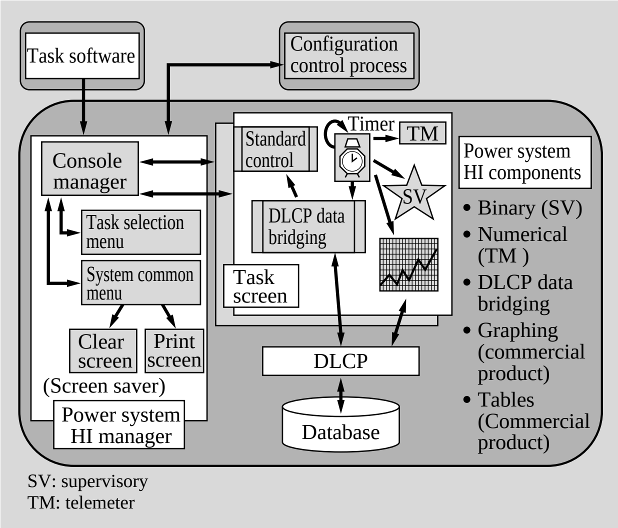

Fig. 3— HI Support Middle-ware Configuration.
The HI support middle-ware comprises the HI manager, which supports management of the task screens and common processing for menus and other screen elements and the power system HI components, which are used to create the task screens.

printing. It also has functions for monitoring memory use and terminating programs before failure due to a memory leak occurs to prevent the propagation of such failures and to prevent a decrease in reliability when general-purpose components are used. For the power system HI components, on the other hand, the components for bridging DLCP and commercially available components and the components that are required for special power system expressions are implemented as ActiveX controls so as to allow effective use of the numerous commercially available Visual Basic components.

This approach makes it possible to realize a highly-functional and highly reliable human interface in a short time through component-based development.

APPLICATION EXAMPLE

The “Integrated Dam Management System,” an application of DORA-Power, has been delivered. That system is designed to achieve safe and sure management of multiple dams through centralized management and remote monitoring and control from an integrated control room.

System Configuration

The system configuration is shown in Fig. 4. The integrated control room is equipped with a host computer that performs monitoring and control, a remote monitoring operation console for remote dam monitoring and control, a report server, video projector

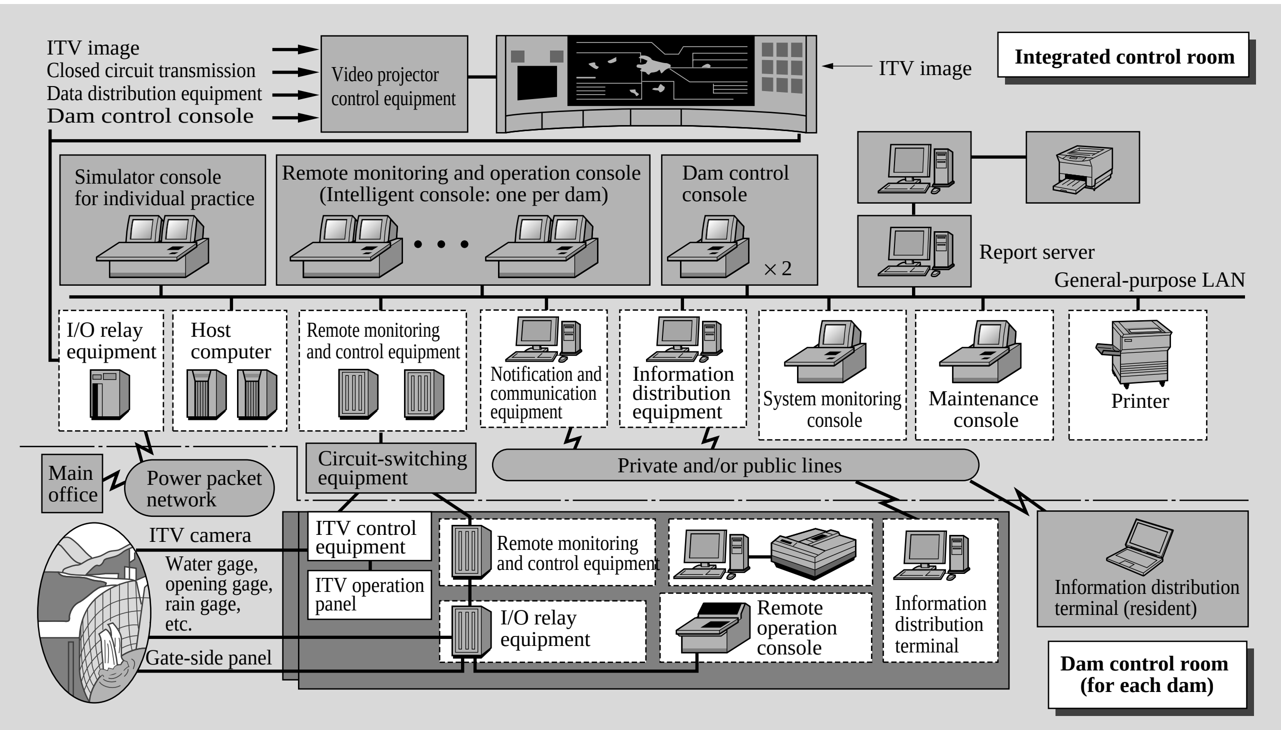

Fig. 4— Configuration of the Integrated Dam Management System.
The host computer has a dual-machine redundant configuration. In addition, even when the host computer fails, the remote operation console can be used independently to monitor and control each dam, thus increasing reliability.

control equipment for displaying ITV (industrial television) image, etc. and dam remote monitoring and control equipment for communicating with the dams. In addition, the dam control offices have remote monitoring and control equipment for communication with the integrated control room, remote monitoring equipment for monitoring the dam status, ITV control equipment and input/output relay equipment for connecting the control equipment to the on-site devices. For the host computer, remote monitoring operation console, and other such monitoring and control equipment, a high-reliability control server is used. For report server and other equipment for providing information, a general-purpose personal computer is used. For the input/output relay equipment that interfaces with on-site devices, the H-7000 controller is used. In this way, a balance between reliability on one hand and expandability and maintainability on the other is achieved in the system.

Merits of Applying DORA-Power

The advantages obtained by employing DORA-Power are described below.

(1) Because the same software can run on both the high-reliability server and the general-purpose personal computer, a system that has a high degree of selectivity of component and function allocation can be constructed.

(2) By taking advantage of the middle-ware functions to implement dual host computers, dam operation from the operation console in the event that both of the redundant host computers fail, and information backup by the host computer when the report server (single system) fails, it has been possible to construct a high-reliability system by incorporating commercial products.

(3) The monitoring and control screen can be constructed easily from components, and because the actual screen can be displayed during specifications meetings, finely detailed screen design based on user needs can be accomplished in a short time. Also, by combining the special power system HI components with commercially available components, a highly visible and easy to operate HI can be achieved.

(4) A system that has an open interface has been realized by bridging DLCP and the World Wide Web server of the information distribution equipment to send image information concerning dam information and weather reports to information distribution terminals at residences, etc.

CONCLUSIONS

We have described the features of DORA-Power and explained an application example.

By using DORA-Power, it is possible to achieve a high degree of expandability in a system that incorporates the latest computer technology and features of superior functionality and operability in the application field of power system information and control, where high reliability and processing performance are required. In future, we will proceed to consider other applications, such as electric power distribution system monitoring and power line monitoring.

REFERENCE

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