DEVELOPMENT OF DISTRIBUTION AUTOMATION SYSTEM THAT ATTENMPTS THE FUNCTIONAL ENHANCEMENT BY THE SYSTEM COOPERATION

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ABSTRACT

We have introduced the Distribution Automation System (DAS) for " Efficient operation of power distribution " and "Early recovery after the power failure occurs", etc. DAS achieved economical system construction and efficient business management by optimizing the function cooperation with other system (Substation Automation System (SAS) and Distribution Management System (DMS)). DAS is constructed by object oriented programming. As a result, we can control the wide area distribution network, because DAS can cooperate mutually.

I. INTRODUCTION

In the early phase of the development, we introduced a method of automatic detection and automatic separation of breakdown section that use a relay function of the section switch mounted on power distribution lines, and later, we further introduced a system that enabled remote monitoring from customer service offices and remote control by operator's individual instructions. And now, more advanced functions (automatic control by the system, etc) have been introduced in DAS.
This paper reports the overview of the latest DAS and the main features, including associated systems.

II.SYSTEM OVERVIEW

A. Systems overall configuration

Figure 1 shows the overview of a whole DAS unit and its associated systems (SAS and DMS). Figure 2 shows the appearance of the DAS. A UNIX computer is adopted in the server calculator, and TCP/IP is basically used in the system-to-system network, for example, and commercial products and general-purpose technologies are positively adopted to ensure rapid and rational development. A two-fold and redundant structure is used in the server and the system-to-system network, which has realized high reliability (only the communication network of remote terminal unit is a single structure).
A DAS unit performs remote monitor and control of automated switches via the remote terminal unit, and it also makes cooperation with other systems in order to exercise different functions efficiently.

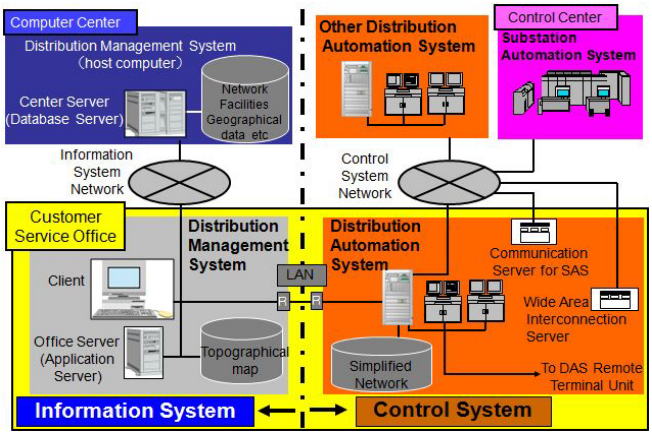


Figure 1: Systems overall configuration

Figure 2: Appearance of DAS

B. Cooperation between DAS and SAS

SAS governs and controls those systems that are upper than substations. DAS has cooperation with SAS via the communication server, and exercises remote monitoring and control of substations. Figure 3 shows the scope of monitoring and control by SAS and DAS.

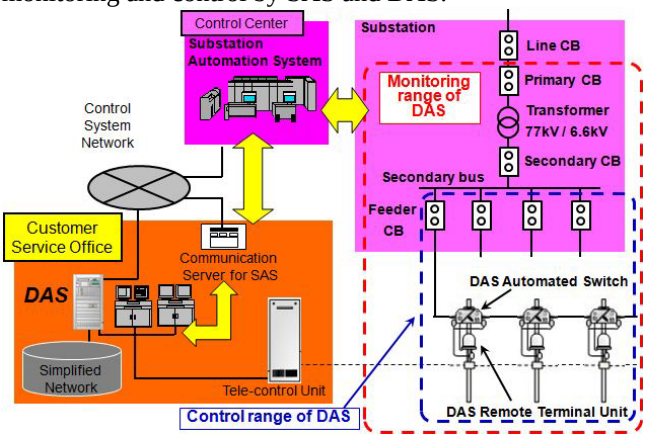


Figure 3: Range of monitoring and control

C. Reciprocal DAS cooperation

Each of our customer service offices, which carry out power distribution system operation, has a DAS unit (at 60 places in total), and they are all autonomous distributed systems. To control the distribution line across two or more customer service offices, two or more DAS must be operated cooperatively. Therefore, our DAS units are structured so that they can have reciprocal cooperation via wide area interconnection server (Figure 4). We use object-oriented software technology and distributed object technology for system cooperation.
For more details, refer to Sections III.A and III.B below.

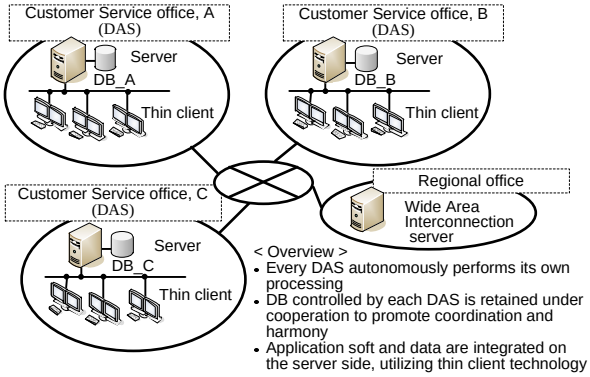


Figure 4: Form of DAS operation

D. Cooperation between DAS and DMS

DAS units and DMS units have reciprocal cooperation in a single customer service office (Figure 5). More specifically, a DMS unit consolidates the management of facility data, network data and similar information, which were independently possessed conventionally, in order to downsize the whole system, to rationalize the development and maintenance, to reduce the labor for daily operation of data maintenance, and to raise the efficiency of distribution operation. A firewall is mounted on the network boundary between the control system and the information system for the purpose of keeping security among reciprocal systems.
For more details, refer to Sections III.C below.

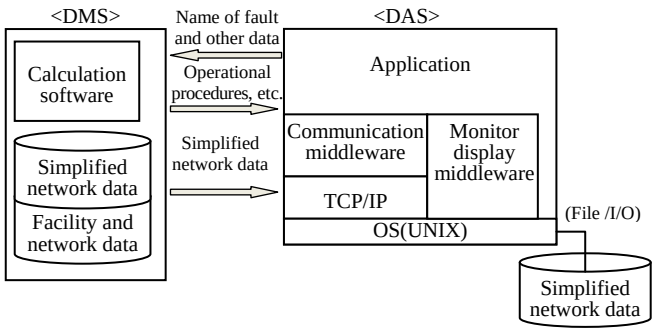


Figure 5: Image of software structure

III. MAIN FEATURES OF THE FUNCTIONS AND APPLICATION TECHNOLOGIES

A. Monitoring and controlling functions

According to the position on the map data controlled by DMS, DAS locates and arranges the facilities in the power distribution line so that users can monitor and control the screen of symbolized power distribution line diagram (Figure 6) as visible as indication by the power distribution line. Monitor and control of substation for power distribution can be performed also from DAS for higher efficiency of operation tasks (Figure 7).
For update of distribution status, Object Oriented Design (OOD) is adopted, and C++ is used as the software development language.
Figure 8 shows an image of internal action when a power distribution lines changes from feeding to power OFF caused by the change of FCB from ON to OFF in an actual distribution line.

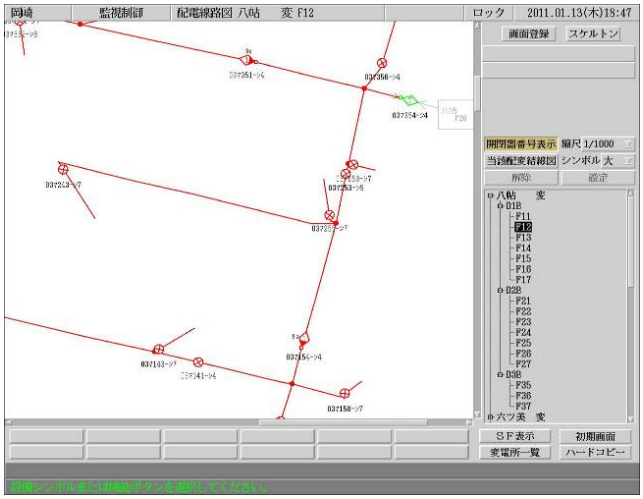


Figure 6: Screen of power distribution line diagram

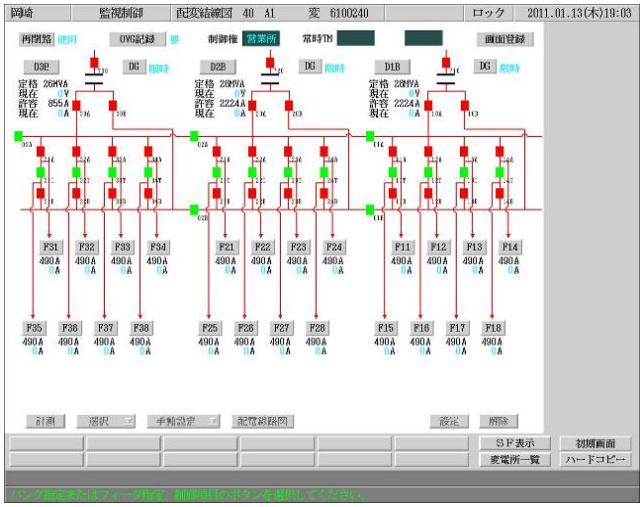
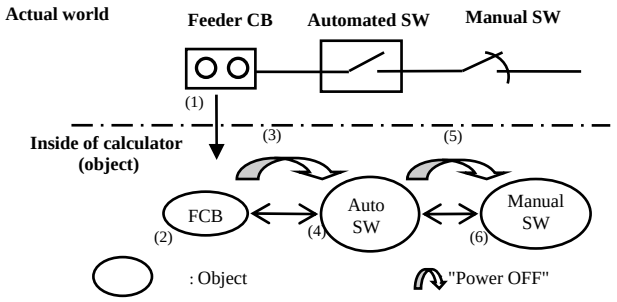


Figure 7: Screen of substation diagram



(1)Detects if the actual FCB changed its status from ON to OFF.
(2)Sets FCB object to the status of OFF.
(3)Sends "Power OFF" to Downside Auto SW object.
(4)Upon receiving "Power OFF", Auto SW object moves to the status of OFF.
(5)Sends a "Power OFF" message to the Downside Manual SW object.
(6)Upon receiving "Power OFF", Manual SW object retains the status of OFF.

Figure 8: Image of system processing when in power off

B. Wide area cooperation

DAS is an autonomous distributed system, and each DAS has the data of jurisdictional limits respectively. However, each DAS need to operate cooperatively to operate the distribution line across two or more offices.

Then, we developed the method of automatically exchanging data via virtual facilities on the borderline in the distribution line. As a result, two or more DAS can be operated easily cooperatively (Figure 9).

To achieve this mechanism, we adopted "Common Object Request Broker Architecture" (CORBA). CORBA controls the location of object, which is present on a network, using a naming service. On receiving a request for an object from application software, CORBA identifies the specific location using the naming service to obtain the object, and then passes it to the application software (Figure 10). As a result, the application software can obtain and process the object (network permeation) without being aware whether the necessary object is under competence of its own customer service office or of other office.

Each DAS operations are fully independent, and it can operate as if it had the data of other DAS. As a result, this wide area function has enabled automatic execution of switching operation of boundary-striding power distribution lines.

Because our system and network are made redundant as described previously, possibility of causing an impediment is low. However, there is a case where the network is cut in pieces by the wide-scale disaster etc. Then DAS is designed so that a single DAS unit may cover total operation to minimize the scope of effects even if cooperation between DAS units cannot be established.

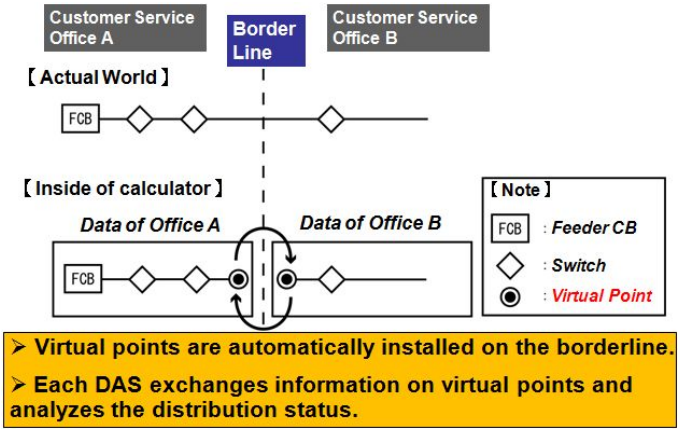


Figure 9: Data cooperation over virtual points

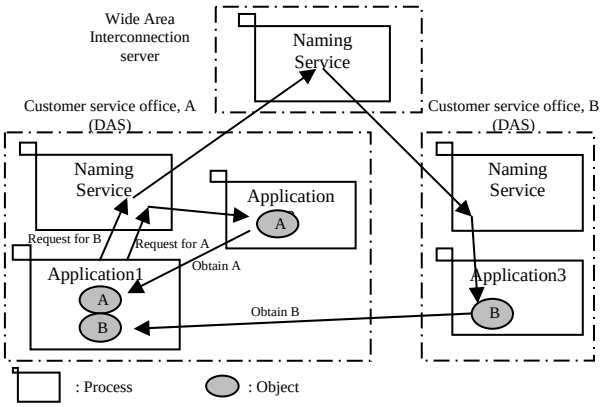


Figure 10: CORBA Naming Services

C. Automatic updating of data

DAS and DMS independently possessed facility data, conventionally. This allowed problems to take place, such as "repeated data maintenance work", "delayed data updating" and "mismatch due to misoperation". Our system unifies the management of master data of system facility using DMS, and DAS extracts the data necessary for system operation from that master data, and it only possesses a partial copy. In addition, a mechanism has been established that conducts real time and automatic update of DAS data if DMS data is updated by any work or the like. Thus the system may always maintain high-precision data in a most advanced state with minimum labor.

D. Automatic processing of control

For the function of calculating the operational procedures during the operation of planned switching and on-fault switching, the same facility data and algorithm are used regardless of in which system it is realized. Functions are properly shared between DMS and DAS: the function of creating switching operation procedures is given to DMS because DMS is provided with all data necessary for calculation, and created switching operation procedures

are transmitted to DAS for execution.
If any accident occurs in a power distribution line, for example, a DAS unit monitors the system status and identifies the "section involving the fault cause" and the "section that needs power transmission", and it reports the found conditions to DMS. DMS creates the switching procedures for power transmission to the section of power failure, and notifies it to the DAS unit. Then later, the DAS unit conducts the switching procedure while checking them. Thus both systems take actions in harmony for efficient achievement of functions.

E. Function of act-for-another operation

In ordinary customer service offices, a person on duty is posted for nighttime and holidays to wait on customers and/or perform tasks of power distribution system operation. In the case of small-scale customer service offices, however, those tasks of person on duty may be performed by neighboring customer service offices in place of that small office for the reduction of business load. Accordingly, a DAS unit is provided with act-for-another functions to execute operation of another DAS unit (Figure 11).
A DAS unit is provided with two or more operation desks to ensure management of plural operators during normal operation. Use of one of those desks for the tasks of input/output processing of another DAS unit may reduce the task load of other customer service offices. Fundamental functions are carried out by the main calculator unit of relevant offices, so there is no concern of reducing the performance of system monitoring or other processing.

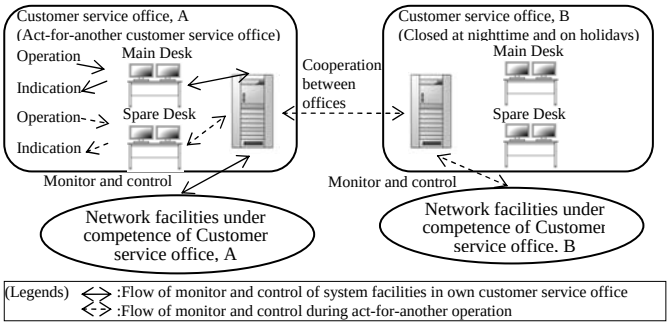


Figure 11: Function of act-for-another operation

F. Remote maintenance of systems

The DAS software needs updating for functions enhancement. A function of remote updating software is provided to ensure efficient and rapid execution of software updating in a number of business offices.
The software remote updating function is performed in the following two steps:
A manufacturer operator delivers new software from wide area interconnection server to the DAS unit of customer service offices.
The staffer in charge of the customer service office updates the DAS software by means of simplified operation.
To secure rapid treatment of system trouble, a mechanism is provided to read the system action log at a remote place. This mechanism enables prompt initial diagnosis after trouble occurrence, allowing us to determine "whether the trouble is solved or not" and "the cause of trouble is in the very DAS or coming from outside (associated system or network)".

IV. CONCLUSIONS

In 2009, latest DAS units were introduced into all customer service offices (at 60 places in total), and are now operated well. Various plans of function improvement are discussed also today, of which typical ideas are:

A. Development of new switches and remote terminal units having sensor functions

The current switches and remote terminal units can recognize voltage of only one phase, and therefore, new switches and remote terminal units that can measure three phase voltage, current and other factors are under development. If such devices are realized, they can tell the power factor through current and ultimate voltage in section switches, and therefore, more proper power quality control (retention of proper voltage, etc.) will be available.
Remote monitoring could not find a break in cables conventionally even if a break has occurred in a high voltage wire, which disables substation relays. However, three-phase voltage monitoring can positively detect a disconnection of Upside high-voltage wire in a remote terminal units, which will be effectively used for public security such as urgent power failure.

B. Measures for earthquake and other large-scale disaster

When under an earthquake or a large-scale typhoon, a break may arise in high-voltage wires or other faults simultaneously in multiple places. In such situation, we disable re-power in order to ensure public security.
A new mechanism is under construction that makes the system automatically disable re-power.