An Overview of Recent Distribution Management Systems

Kazuhiro Oohashi
Jinpei Kuwayama
Hiroshi Horiguchi

1. Introduction

The advancement of information communications and the sophistication and diversification of city functions have led to larger and more complicated distribution systems. Ten years have passed since the full-scale introduction of computers into these distribution systems. The goals were to improve supply reliability and efficiently operate the equipment.

Recently, accompanying the trend of worldwide deregulation of electrical enterprise lows, the preservation of the global environment, and new information processing systems backed by open system technology in accordance with international standards, distribution automation technology has developed from the viewpoint of different evaluation and framing.

Fuji Electric has been involved in this field from the early stages. Excerpts from the results were published in two special issues of the Fuji Electric Journal which featured distribution automation tech-

Fig.1 Developments of distribution automation systems and changes in required specifications

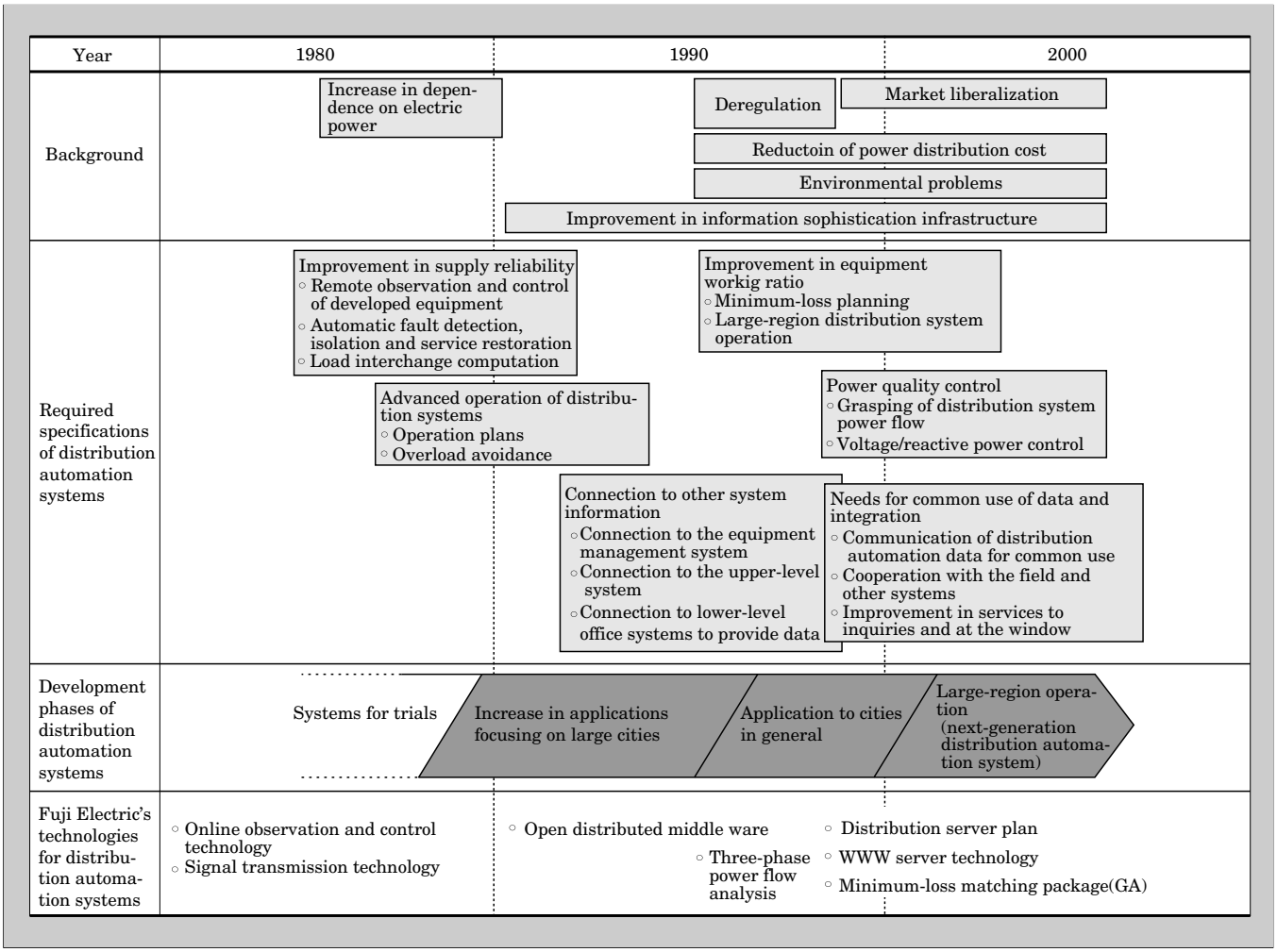
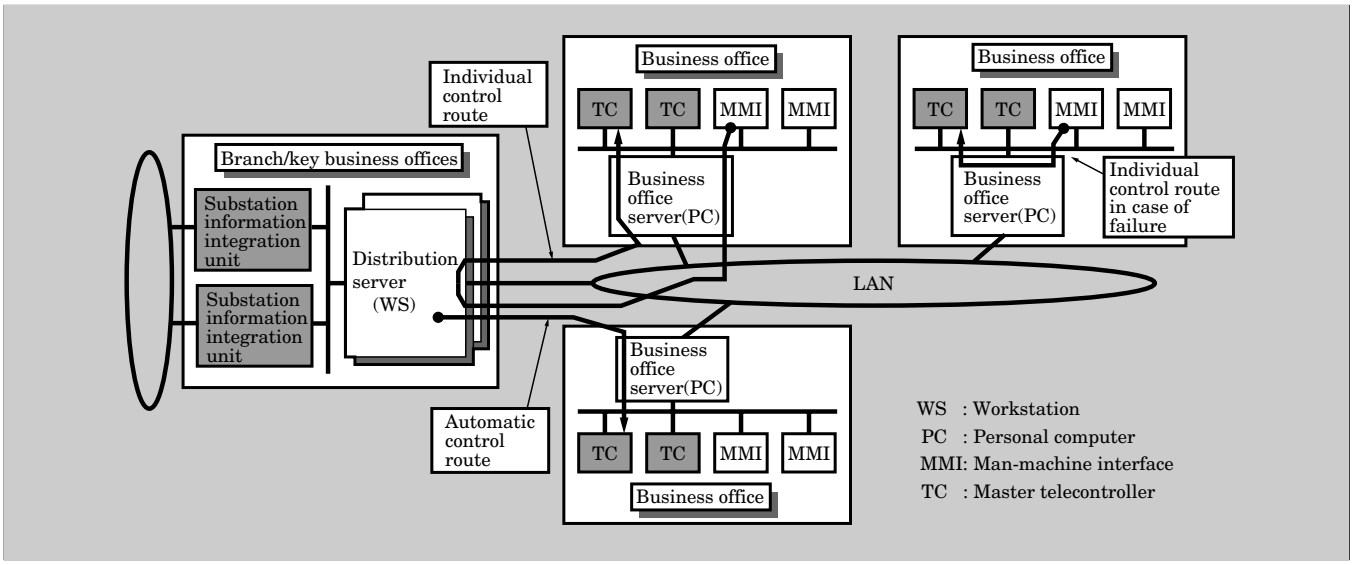


Table 1 New concept of next-generation distribution automation systems

Category	Distribution needs	New concepts		Contents/features
Distribution system operation	Reduction of power distribution cost	Large-region distribution control system plan	○ Large-region distribution system operation with information interconnection between distribution automation systems (interconnection between branch and business offices)	○ Increase in the distribution line working ratio ○ Reduction in night duty
			○ Distributed system configuration with open architecture	○ Facilitated data transmission between systems and function expansion ○ Reduction in initial structuring cost using personal computers
			○ Interconnection with other/upper-level systems	○ Advanced system operation due to data unification ○ Efficient data maintenance
Distribution business	Improvement in equipment working ratio	Distribution system planning support systems		○ Improvement in equipment working ratio by minimum-loss matching computation ○ Designing efficiency enhancement
	Equipment modernization	Compatibility with 22kV/400V direct distribution and 400V low-voltage trunk lines		○ Combination optimized with diversified supply forms
	Improvement in information amenity	System having distribution automation system data for common use		○ Enhanced efficiency in filling in forms and data editing ○ Improvement in services in responding to inquiries and at the window
Power quality control	Power quality observation and compensation to meet diversified power sources and loads	Functions of power quality measurement, analysis, and compensation		○ Power flow computation, imbalance/harmonic analyses, and compensation for systems that include dispersed generation, static var generators and static voltage regulators

Fig.2 Conceptual diagram for a next-generation distribution automation system based on the large-region distribution server concept plan



nologies (Vol. 61, No. 12 of 1998 and Vol. 66, No. 2 of 1993). Although it has been five years since the last issue, this paper will describe recent trends and Fuji Electric's developments and results, focusing on distribution automation and customer automation.

2. Trends of Distribution Automation Systems

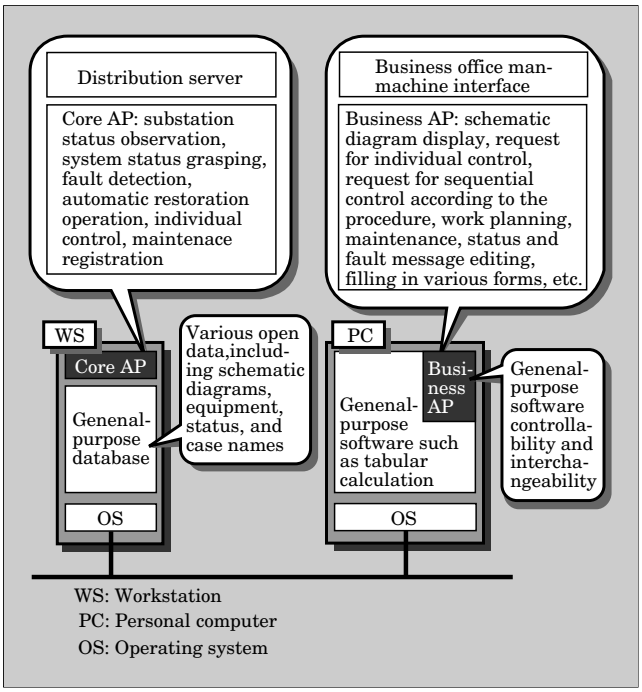
2.1 Present status and the next-generation concept of distribution automation systems

Figure 1 shows the developments in distribution automation systems and changes in required specifications.

In accordance with other distribution automation systems which have been positively introduced since the 1980s, Fuji Electric has adopted its own "online observation and control technology". This central technology has been widely used in various fields. Thus, we have structured and developed highly reliable systems with advanced functions that include use know-how in operating distribution systems.

In the meantime, we have made ceaseless efforts to

Fig.3 Software configuration for the large-region distribution control system plan



anticipate users' demands and changes in the environment in order to offer distribution automation systems utilizing the latest technology.

Now, in addition to technical innovations such as information amenity, rapid improvement in CPU performance, and open distributed systems, environments around electrical enterprises have changed greatly. Accordingly, demands for distribution automation systems have changed-from an emphasis on supply reliability to the adding of functions to include advanced operation and information amenity.

Fuji Electric has proposed a new concept shown in Table 1 for the next generation of distribution automation systems that will meet these trends.

2.2 Distribution automation systems based on the large-region distribution server concept

With the increasing use of distribution automation systems, investigations have been made into having the status of system equipment between business offices. This common use will realize automatic fault detection, isolation, and service restoration by any office. In the future, it is hoped that night duty at each business office will be abolished by centralized backup operation performed at night.

Future distribution automation systems will be required to reinforce interconnection with related systems and have functions for sophisticated analysis or decision based on more information. It is also important that each system's base structure has a standard open architecture using de facto or international standards. It should also be an environment

Fig.4 An example of a data system for common use

where timely information can be obtained from other systems.

Figure 2 shows the conceptual diagram of a distribution automation system based on Fuji Electric's large-region distribution control system plan. Figure 3 shows its software configuration.

This system consists of a distribution server in a branch office (or a key business office) and a local area network (LAN) interconnecting the business offices. Each business office contains a business office server, man-machine interfaces and master telocontrollers. The distribution server performs the integrated management of the facility's data of the distribution systems within its jurisdiction as well as centralized observation and control within the branch office. The business office server stores the entire facility's distribution system data in the distribution server and performs autonomous operation.

The distribution server uses a workstation to maintain reliability through efficient use of existing software. It uses a general-purpose database for free data transmission between systems and ensures sequential expandability for software. The use of personal computers for man-machine interfaces at the business office aims at reduced development cost and improvement in controllability and expandability using diverse general-purpose software.

With this configuration, two or more distribution systems within a business office are integrally managed, and the whole system is open to each business office and seamless operation is realized. In seamless operation, the staff is not conscious of the boundary between business offices due to the methods of automatic fault detection, isolation and service restoration utilizing the whole system.

2.3 Common use of information

Each division of electric power companies has been introducing computer systems that include distribution

Fig.5 Conceptual diagram for a customer automation system

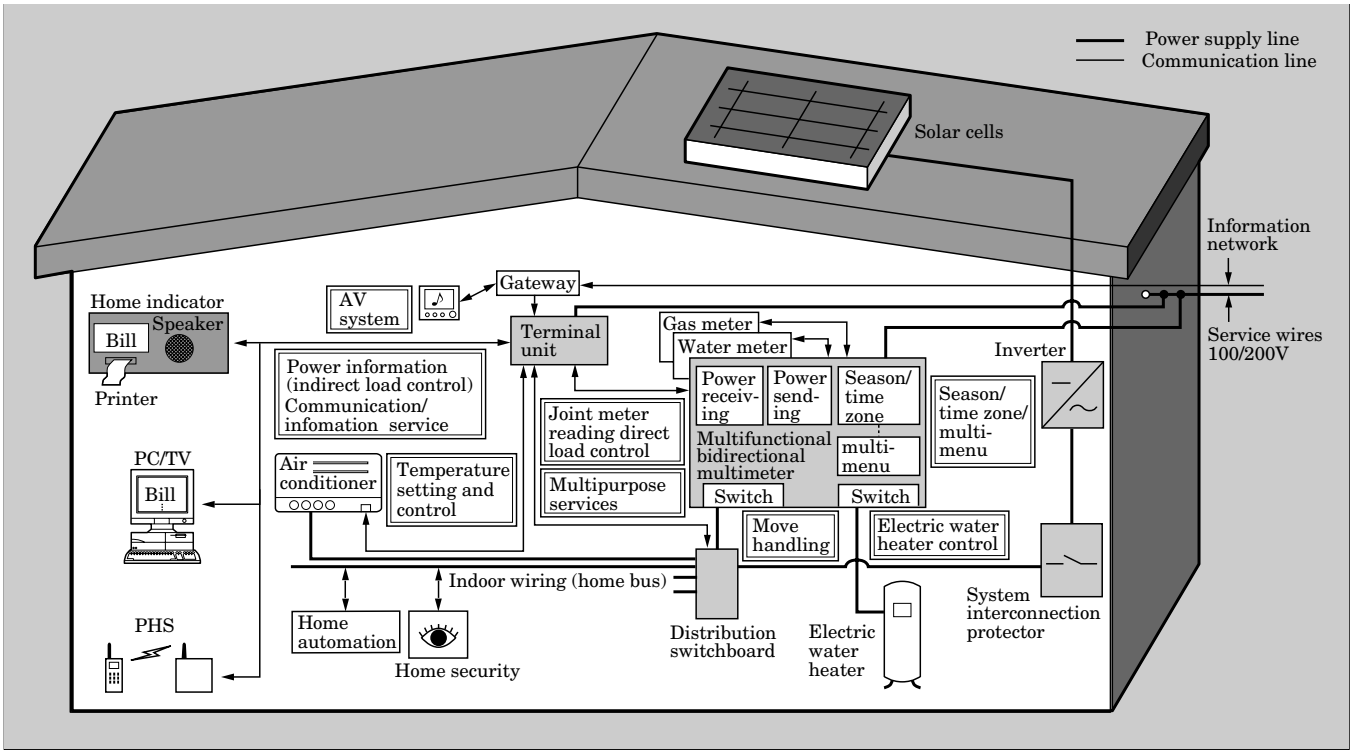
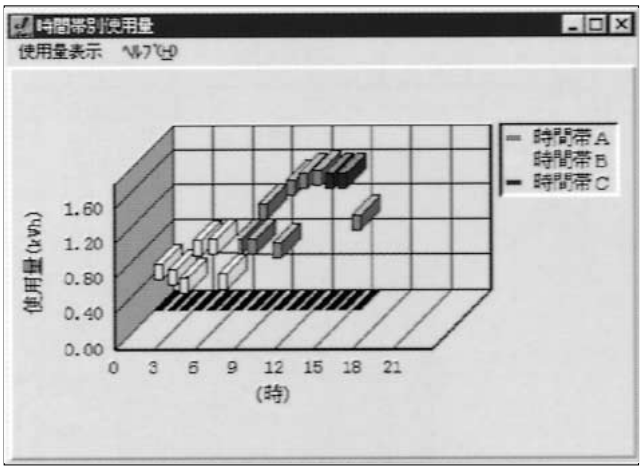


Fig.6 An example of information on power consumption



automation systems.

Improvements in network technology and widely used office automation machines have produced multiple types as well as a large quantity of data. The mechanism of transmitting real-time operation data and analysis data from each system to personal computer terminal units connected to the internal LAN enables the data to be commonly and efficiently used, thus enhancing the efficiency of business management. As a result, this system for the common use of data aims at business interconnection between divisions for maintenance and planning and cooperation support between the field and control room. This system is presently being introduced.

Figure 4 shows a display example of this system using general-purpose software.

2.4 Development toward distribution system planning support

This functions of distribution system planning include developing an optimum power transmission plan to a new supply request and an equipment plan based on the estimated increase in future demand, avoiding supply failures such as overload.

The key is to device a plan that makes the most of existing distribution equipment and suppresses new installations. Solving a combination optimization problem with complicated operating conditions and elements among the vast quantity of distribution system patterns with a computer and showing the operator the most suitable solution was difficult.

Recent technical developments in computer capacity enhancement and man-machine interface enrichments such as graphical user interface (GUI) have led to proposals of various new solutions to the combination optimization problem and easy application of the these techniques to the distribution system planning problem. This has created an environment in which to develop the solution into a support function.

Fuji Electric has applied the genetic algorithm (GA), one of the modern heuristic techniques, to this combination optimization problem. We have realized the distribution system's planning support functions such as generating optimal network configuration and transferring load between substations.

3. Activities for Customer Automation

With regard to customer automation systems, studies and demonstrations in the field focusing on automatic meter reading and load control have been carried out for several years. Some have been put into practical use.

Recently, to improve load factor and reduce CO_2 exhaust, demand side management (DSM) for taking measures for load leveling and energy saving has been studied. Studies into power quality control aiming at multi-menu power service have also begun.

Fuji Electric has participated in this field from the early stages. We have made efforts to expand the product lines of electronic watt-hour meters and customer terminal units and to accumulate know-how in the field and operation/evaluation techniques for various data transmission technologies including a power line carrier system.

New topics for the future include measures for meeting the increase in system interconnections for dispersed generation that reflects relaxed regulation and market liberalization for meeting diversified power supply forms. Further development of non-electric enterprise fields such as information service, heat supply, and home security is also anticipated. Figure 5 shows a conceptual diagram of Fuji Electric's future customer system.

3.1 Trends in automatic meter reading

Backed by data transmission technology development, electronics application to watt-hour meters and diversification of power rate systems, automatic meter reading is being rapidly introduced to bulk customers with complicated meter readings and problematic areas of meter reading, such as apartments with an automatic locking system or mountainous districts. Fuji Electric has marketed a multifunctional electronic watt-hour meter with a load survey function to meet the demand regulation contract of bulk customers and a watt-hour meter and terminal units with the remote function of handling household moves.

3.2 Tackling DSM

The Agency of Natural Resources and Energy, the Ministry of International Trade and Industry has continuously demonstrated centralized load control since 1986 as a measure for load leveling. Fuji Electric has also anticipated.

In the beginning, centralized load control was studied, with a major focus on direct load control to control electric water heaters and air conditioners. However, recent improvements in the information communication infrastructure have reflected growing concern over indirect load control, which guides the power consumption pattern in standard homes and small shops. Customers receive information on rates and demand values from the electric power company.

Fuji Electric, commissioned by the Japan Electric Meters Inspection Corporation (JEMIC) developed and demonstrated a system for indirect load control. Figure 6 shows a display example of this system.

To meet the spread of dispersed generation, we are preparing a series of products and expanding applications for the protection system for dispersed generation interconnection in accordance with the system interconnection guidelines of the Ministry of International Trade and Industry.

4. Conclusion

The advancement of distribution automation systems will continue due to the backup of information communication infrastructure improvement, diversified customer needs, and continuous progress in related technologies.

Fuji Electric will ensure a future course and will contribute to the development of the distribution automation system.

In this special issue, we would like to acknowledge the cooperation of the electric power industry and would appreciate future guidance and support.