UDC 621.311.1-523

RECENT COMPUTER CONTROL SYSTEM FOR ELECTRIC POWER NETWORK

Tsuneyoshi Oboshi
Isamu Suzuki

I. FOREWORD

The social demands for labor saving, energy saving, and higher efficiency are also essential themes in the field of electric power network operation. The functions of supervisory control and data acquisition system (called telecon hereinafter) have consequently exhibited more complex functions from the age typified by the word "automation" and operation as a system in which maintenance and improvement of the environment are combined has been planned.

The heart of such a system is the computer. Recently, equipment utilizing microprocessors have taken over a part of such systems. The use of such equipment is not unrelated to expansion and growth of power networks themselves, and the need for operation of automated equipment capable of quick, complex judgement has arisen.

However, a computer and its peripheral equipment has come seriously to occupy a position as the center of power network control only in the past 10 years. Therefore, remarkable changes in system configuration and operation functions are expected in the future. However, based on recent experience, the current situation is introduced and some observations are made.

II. DEVELOPMENT AND FEATURES OF SYSTEM

Table 1 is a simple summary of the development of control systems. It can be seen even from this table, that the development of computer control systems for electric power networks has been extremely noticeable.

Specifically, from the functional standpoint, its driving force was inquiries into the lightening and accuracy of fixed form jobs. It has been considerable what was judged to present no danger of introducing major obstructions to network operation even if it stops.

Therefor, even from the standpoints of scale and configuration, equipment matched only to the necessary functions have been selected. On the other hand, such a system has not had so many functions.

However, automatic operation has been promoted, and expanded functions have been steadily studied. Since the equipment supplied with a power network control system must be safe and responsive because of its importance, it must not merely satisfy the demanded funcitons, but must also be studied from all points of view and have a latitude of applications. The range of investigation is also widened from this background.

Taken laterally, the features of such systems are:

1) Functions: Expansion of processing work that is limited to the capacity of the computer.
2) Scale: Expansion of the kinds of connectable peripheral devices to satisfy the number of channels and functions.
3) Expandability: Use of a large capacity memory is a precondition.
4) Serviceability: Flexibility, especially in software maintenance, is necessary.
5) Operability: The adoption of multiple CRT displays and the securing of speed are necessary.
6) Reliability: A system configuration that does not cause stoppage is a precondition.
7) Processing ability: Clear evaluation of the specifications at peak business time in the objective power network.

III. SYSTEM CONFIGURATION FEATURES

Fig. 1 is a configuration example of a system built by taking the characteristic parts of the devices used in recent systems.

Usage forms that use the computer system not only for a centralized system configuration with unmanned electric stations as the objective, but that also use it organically with associated organizations have appeared. The trend is also toward inquiry into larger and faster computer systems.

A duplex system is used because of the demands for enhancement of reliability and maintainability and continuity of operational form. A duplex system employs a hot-standby method, and considerations are given so that the connection with the data transmission equipment is always maintained and operational data storage is not lost due to

Table 1 Development of control system

Item \ Period	Up to the mid 70's	Up to the end of the 70's
Function	• Selective control by pushbutton • Accident and operation recording • Reporting (daily report, monthly report)	• Control using a CRT • Automatic operation • Automatic recovering • Automatic supervision • More efficient processing • Edited operational accident recording • More complex report business • Multiplex connection between CPU • Multiple processing of MSG lines • Operation plan calculation • Hydraulic system calculation • Forecast calculation • Simulation • On-line testing
Scale — Objective facility	• Distribution electric station center • Partial, primary substation • Small hydroelectric power stations • Limited to total 30 channels of telecon	• Telecon 200 channels or more without regard to scale of electric station • Pointing of ultra-high voltage electric stations • Including large pump-up PS
Scale — CPU system	• Main storage capacity 64 kB • Auxiliary storage 512 kB • Program mode I/O is the mainstream • Paper tape base	• Faster, more functional hardware • Main storage capacity 2MB • Auxiliary storage (1) Fixed head disk 2.4 MB (2) Moving head disk 50 MB • MT + DISK base • Application of DMA access to all I/O • Filing equipment which automatically detects change of incomming status • Multiplexed systems
Expandability	○ Hardware • Main storage capacity limit 64 kB • Auxiliary storage units restriction • Peripheral devices Kinds: Small Number of units: Several ○ Software • Mainly assembler language • Development by function • Few I/O support functions	○ Hardware • Expansion of main memory area • Auxiliary storage (1) Expansion of area (2) Relaxation of limits on number of connectable units (3) Increase in kinds • Peripheral devices (unification of interface) Kinds: Expanded Number: Increased ○ Software • Strengthening of basic software • Exhaustive modularization • Adoption of data base • Strengthening of easy data insertion tools
Maintainability	• CPU stopping essential for maintenance (However, included special back-up functions) • Software maintenance by programming techniques • Special knowledge necessary	• Stopping of CPU system unnecessary (Development by off-line side computer) • Standardization of documentation • Application of high level languages • Application of structural programming techniques • Application of interactive type software maintenance techniques
Operability	• Man-machine interface (1) Lighted pushbutton switches (2) Lamp type display (3) Slide display • Restriction on multiplex operability	• Man-machine interface (1) Use of multiple high density CRT (2) Selective control by light pen (3) Light pen shared input board with maintenance functions • Expansion of multiplex operating functions • Unitary management of display functions by CRT
Reliability	• Simplex main equipment • Backup devices with limited functions	• Multiplexing of main equipment • Elimination of affect of single unit accident • Multiplexing of power equipment
Processability	• Low multiplexing depth • Low processing capacity	• Planned processing of multiplexing depth • Utilization of system availability evaluation analysis methods

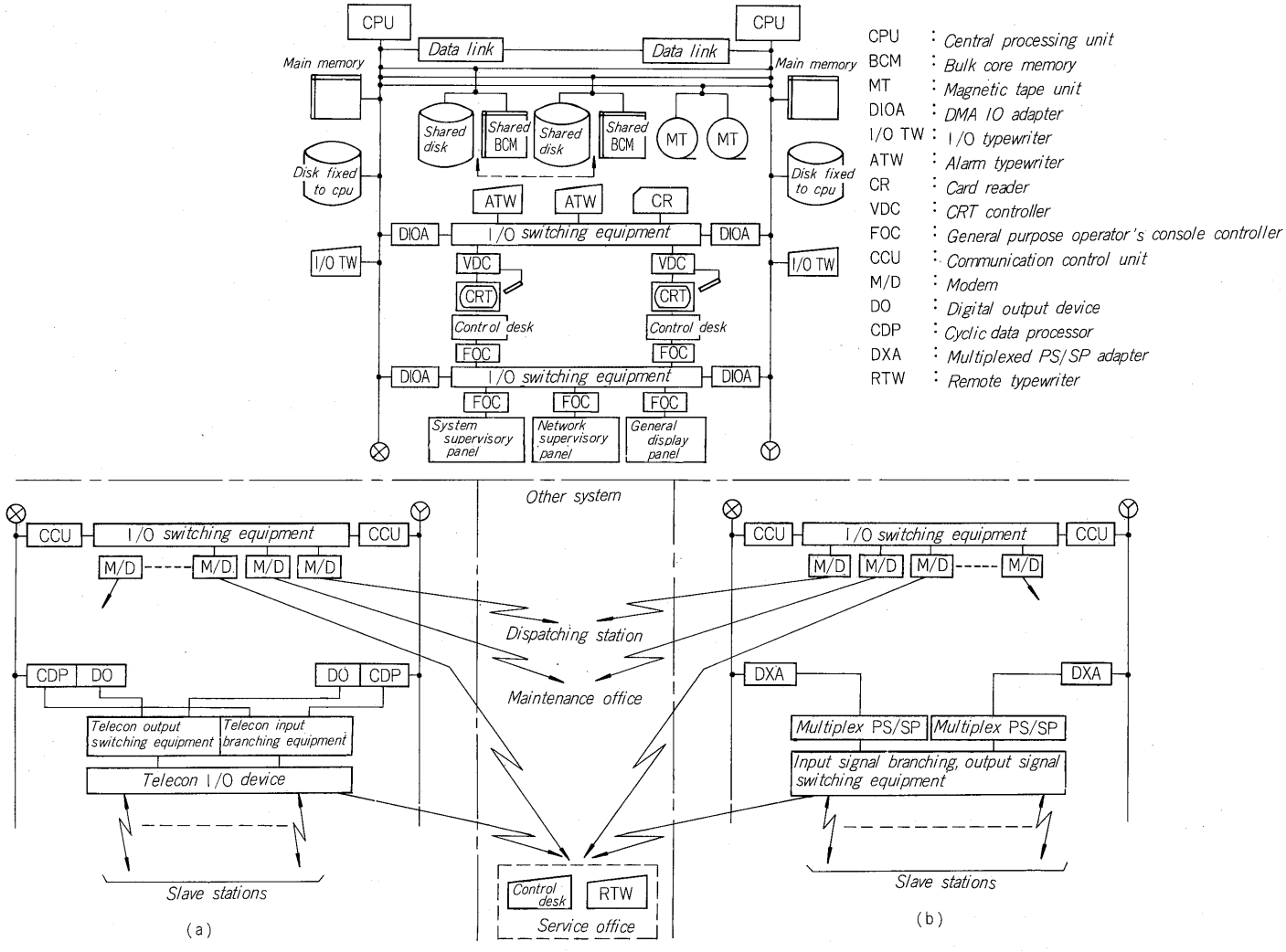

Fig. 1 Model of computer control system for electric power network

system switching.

A storage medium (shared file) that can be cross-call-accessed is installed as shown in the figure for this purpose. Bulk Core Memory (BCM) is selected when the system needs a large volume of frequently accessed data to improve the processing speed and reduce the accumulated access time loss. The adoption of sophisticated CRT display equipment as the man-machine interface is also becoming popular.

Moreover, the trend is toward multiple installation for functional use according to the purpose. For this reason, expansion of the main memory of the computer and faster response by considering the memory layout have become more important. Of course, special consideration of the software that supports this is also necessary.

In a Computer Based Supervisory Control (CBSC) system, I/O devices have been installed for each channel as the control station data transmission equipment interface, and telecon I/O devices (so-called TCI/O) that limit the affect when trouble occurs have been used for some time [*Fig. 1* (a)]. However, in addition to this, the use of a configuration that permits handling of the I/O of one kind of computer system by a multiplex PS/SP that has been made smaller and more integrated by means of a microprocessor multiplex system is beginning. [*Fig. 1* (b)] Both use DMA accessed devices with a status change detection automatic files function to lighten the access load on the computer at incoming data processing. Especially, the DMA access method is also used as the interface of the latter even in outgoing data processing.

The adoption of the microprocessor does not stop at this kind of device, and control desks, system supervisory panels, and other devices having multipurpose application in I/O processing are being developed and applied, and the system configuration is changing to a distributed processing system comprised of independent functions for each purpose instead of centralized equipment for matching with various processes as so-called process I/O devices (PI/O), and improved reliability and maintainability are expected.

IV. SOFTWARE FEATURES

From inquiry into the forms in which multiple functions closely related with operation and organization are processed by a computer, the need for efficiently processing:

1) Increased application functions
2) Increased opportunity for congestion among functions
3) Increased frequency of access accompanying strengthening of I/O and opportunity for collision

has arisen naturally.

In this, a suitable priority level must be assigned and the memory layout considered to obtain data arrangement suited to the process. On the other hand, since power networks are constantly growing, its conditions must be reflected in the program. Since the rise and fall of fixed form data is usually represented by a table, changes in the state of the network are in the form of table modification and addition. This is not unrelated to inquiry into the ease or difficulty of maintenance and processing efficiency for tables, and ? construction in which these are considered as a uniform is necessary. At the same time, this also poses a problem when planning expansion of functions.

In other words, expansion of functions might be scaled out up to reconstruction of the system due to a tenporary data construction by addition and modification of the program body. From this, a highly flexible data layout in which power network operation has been amply considered has become necessary at a large scale system. Specifically, this is called together with the power network system oriented data base. On the other hard, adoption of a construction having a good response and a configuration that minimizes the linkage use control tables which are accessed at real-time for on-line off-line or generation data, etc. is the main point.

Obtaining a knowledge of software may not necessarily be a precondition for maintenance accompanying the arrangement of the methods of handling data. That is, support utilities by which data can be generated interactively with the CRT display used by the system can be supplied according to the method of representing the data which are handled within the planning, operation and implementation technology range of conventional power network systems. Of course, maintenance by means of conventional programming techniques is also possible.

V. MAINTAINABILITY IMPROVEMENT MEASURES

Expansion of a system with the growth of the power network is necessary. The software was alluded to in the preceding section. However, hardware expansion work must be made easy also. Moreover, shutting down of the system for this purpose must, of course, not be allowed.

Usually, the above work is not difficult with a duplexed system and, therefore, it is clearly taken up as one of the system functions.

As a result of strengthening these, proof that there were no obstructions after on-line operation was entered must be first confirmed by performing operation identical

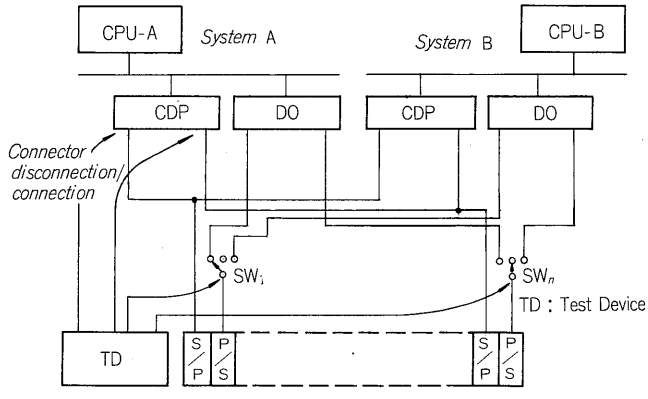

Fig. 2 Application of simulator for example

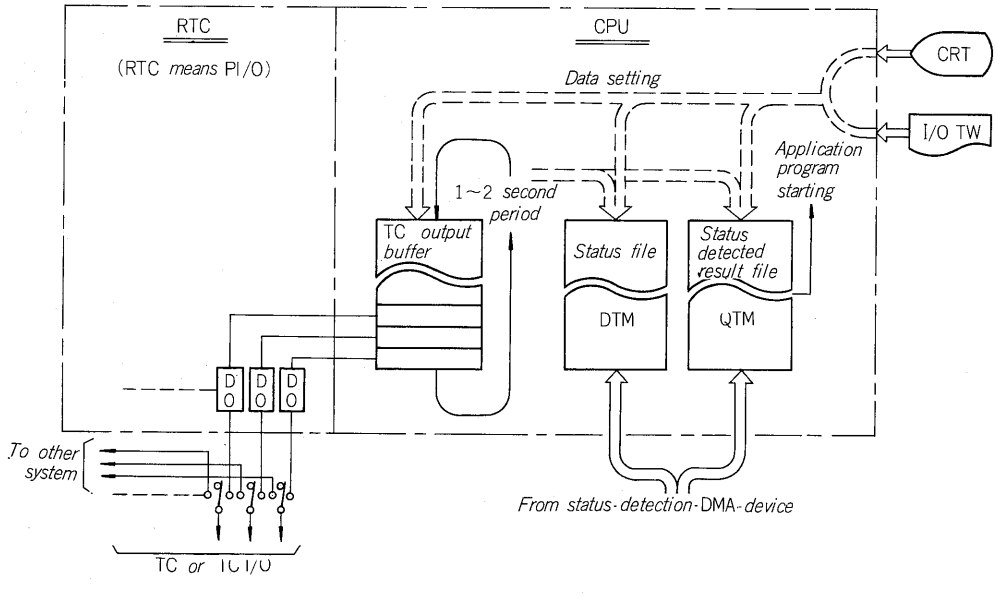

Fig. 3 Simulation method for TC facilities by software

to the on-line state. The technique for this approval method must be amply considered. We can cope with this problem from both the standpoint of test devices and test programs encompassing simulation.

Fig. 2 corresponds to the case of adoption of an interface in *Fig. 1* (a). The test device is represented by TD. In addition to having all the functions of a telecon, the TD also permits input from cassete tape, and the automatic status changes that occur in the power network can be simulated and input periodically. This eliminates the corresponding need for people each time and contributes towerd labor saving of system experiments and permits future automation.

Fig. 3 outlines the simulation method for telecon facilities by software. This function executes on-line processing only with the test state set. Concerning operation detecting process, the presence or absence of operation is scanned by a periodic program and if the specified data are set from a CRT display, I/OTW or other input device, the automatic status changes are connected to the associated application task by the program that detects that status.

VI. CONCEPTS OF HIGH RELIABILITY AND FAST RESPONSE SYSTEM

Of all the causes that generate abnormal states at a power network, the most important are thunderstorms and typhoons and are featured by an increase in the processing amount of the computer system and long-term continuation of that state. Of course automatic processing, but also a man-machine interface that permits rapid response and recovery of the abnormal state should be expected in a network control computer system that has the overall use of control functions as a precondition in this case also.

For this reason, the required functions being frequently used are to be grouped into jobs that require quick response and jobs that do not. Classification by clarifying the expected value for response even at the same kind of job or processing is necessary. As a result, specialization of the proceesor and a planning ability that permits a suitable data and program structure are necessary in the case of functions that require quick response. If this is possible, a system having the required response can be built.

A system is not complete with only superior response and, of course, must also satisfy various other performanses (For example, the Functions of *Table 1*).

Fig. 4 reaches this objective by adoption of a PFU-MAXS system.

This system can use up to four computers. Of these, one is used for high frequency processing and the others correspond to other job processing, and consideration has been given so that main/standby or partial restricted processing is performed by each system.

In the PFU-MAXS system, the I/O bus is expandable up to 16 busses. Moreover, since connection and disconnection are performed by executing an instruction from any

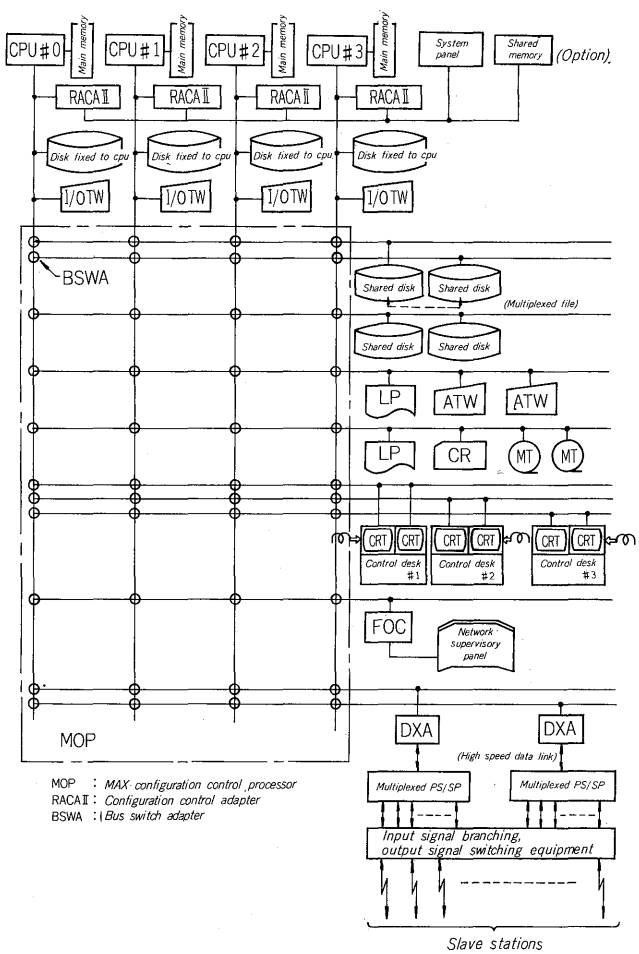

Fig. 4 PFU-MAXS applied computer control system for electric power network

computer and the files and I/O can be used synmetrically by any computer, processing to prevent a loss of data by partial trouble with a minimum number of I/O is possible. This system also has superior cost-performance for high reliability.

Electronizing of the bus switching part itself was planned. The biggest feature is the application of microprocessor applied displays and indicator panels so that contacts are only at the parts that use pushbutton switches, and all the other parts are completely contactless.

VII. CONCLUSION

Together with suitable development of computer system components, a systematic grasp of processing business at a power network control computer system can be outlined, and more stringent inquiry into greater response, reliability, maintainability and other improvements is being performed and recognized. The authors wished to introduce the present state and the corresponding posture of Fuji Electric based on our record of achievements.