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Mikio Funatani, Teruhide Sugaya, Busei Takoshima

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Mikio Funatani
Staff General Manager, System Planning & Coordination Sec., Information Systems Dept.

Teruhide Sugaya
Staff General Manager, Planning Sec., Planning & Coordination Dept., Engineering & Construction Divisional Group

Busei Takoshima
General Manager, Business Systems Integration Div., Technology Dept., Kawasaki Steel Systems R&D Corp.

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1 Introduction

Speeding up the business cycle has become an important concept for strengthening corporate competitiveness, requiring that information systems play an increasingly important role. On the other hand, reductions in the cost of information systemization are also strongly required.

Kawasaki Steel considers open systems and decentralization technologies for information systems to be means of achieving these goals, and has therefore energetically promoted their application. Based on an analysis of the current state of information systemization and trends in technology, a fundamental company-level policy for this field was established in April 1992, and with the approval of top management, a company-wide response was promoted. The key points were to put the right computing resources in the right place as determined by the special features of business activities, and to create an infrastructure which would support this effort.[1)]

Together with promoting the installation and expansion of campus LANs, including departmental LANs, and the creation of a company-wide WAN, application to a number of systems was also promoted, taking advantage of the opportunity of new plant construction and system revamping.

The diverse technical tasks arising in each field of application, including measures to realize a 24-hour-a-day uninterruptible operational control system, were arranged and managed by establishing a system of arrangement as a development and operation technology through a cooperative division of labor among the various divisions, based on experience with mainframe computer systems.[2)]

This paper presents an outline of the fundamental policy and system of arranging technologies adopted in this effort, and evaluates the current conditions and results achieved in the application of open systems and decentralization technology.

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2 Policy for Open Systems and Decentralization Technology

2.1 Aims of Open Systems and Decentralization Technology

The effectiveness of open system technology had already been confirmed in a number of fields such as planning simulation systems, but in this effort, the targets were clarified once again for development at the corporate level.

(1) Contribution to Business Speedup

Together with promoting the application of information technology and networking to planning, evaluation, and management tasks, efforts will also be made to create an EUC/EUD (end user computing/end user development) environment which allows the actual user to make full use of information, and thus to improve administrative work and speed up the business cycle. Specifically, efforts will be made to improve the information literacy of users. The division of system functions and computer architecture will be reviewed to make it possible to strengthen system functions, which will expand as a result of enhanced literacy, and to cope with the needs of the practical application of information.

(2) Strengthening of System Response Capabilities and Technical Capabilities

System technology capabilities will be strengthened to make it possible to meet the needs of higher business efficiency at an early date. The systemization of open systems will be promoted as an axis for standardizing various types of protocols in order to respond to wide area business operations and networking and to properly meet separate new needs.

(3) Promotion of Information Systemization at Appropriate Cost

A wide-ranging examination of object technologies will be made when hardware architecture is decided and software is selected. Decisions will be made based on a full evaluation and careful selection in order to reduce the cost of information processing system construction. Existing systems will also be reviewed to reduce costs.

(4) Promotion of Total Systemization through Appropriate Decentralization of Functions

Aiming at improved operability, including improved user convenience and limitation of the range of effect during malfunctions, the centralized system architecture based on the mainframe computer will be changed to a decentralized computer system architecture.

2.2 Fundamental Policy for Promotion of Open Systems and Decentralized Architecture

Information system technology has made remarkable progress, and it is necessary to respond flexibly on an individual basis, but considering that a clear approach to the overall direction should be taken, the following was established as the basic policy for mid- and long-term development:

(1) Promotion of Right Resources in the Right Place Computing

Considering the special features of individual business operations and trends in technology, proper allocation of application functions and computers will be promoted based on an adequate arrangement of the fields of application of open systems and the aims of application. In particular, the creation of an EUC/EUD environment will be given priority so that staff members themselves can promote greater work efficiency.

(2) Steady Promotion Taking Advantage of Opportunities for Improvement

From the practical viewpoint, total changes in existing systems are difficult. Because trends in technology are also unstable, application studies will be carried out while continuing to promote reviews of technology, taking advantage of the opportunities of new system construction and revamping. Other targets will include expansion and the accumulation of technologies by application to new fields such as staff support, network monitoring, etc.

(3) Use of Conventional Hardware and Software Assets and Maintenance of Cooperation

The role and positioning of the host computer will be reviewed while, on the other hand, efforts will be made to realize effective use in open type systems of already-developed host information system assets. Concretely, the common use of total integrated data bases and dictionaries, etc., in general-purpose machines and open environments will be made possible.

(4) Positive Use of Commercial Software and Standard Software

Emphasis will be given to the adoption not only of middleware but also of application software to minimize the writing of new software.

(5) Promotion of Simultaneous Creation of Networks and Other Infrastructure

In order to promote an appropirate decentralization of functions, speedup of campus LANs, strengthening of branch lines, and the creation of a company-wide WAN will be promoted simultaneously with the application and expansion of individual systems.

2.3 Philosophy of Fields of Application and Configuration of Computer Functions

Fundamentally, all business operations are objects of this effort, but it is difficult to say that conditions allow immediate application to the main system as a whole. A policy was adopted under which application will be promoted from fields with appropriate technical fea-

tures, including processing which requires ease of use in planning and simulation and trial-and-error work, and mini-host processing in systems with a high level of independence. The challenge of basic business and fields with high volume processing requirements will then be taken up based on subsequent technical progress. The object functions in each field are shown in **Fig. 1**. The sections circled with single lines are the initial fields of application expansion, and those circled with double lines are challenge function fields.

In order to implement right-resource right-place computing steadily, the computer system functional configuration and division of responsibilities were established in the four layers shown in **Fig. 2**, and efforts were made to unify the image company-wide.

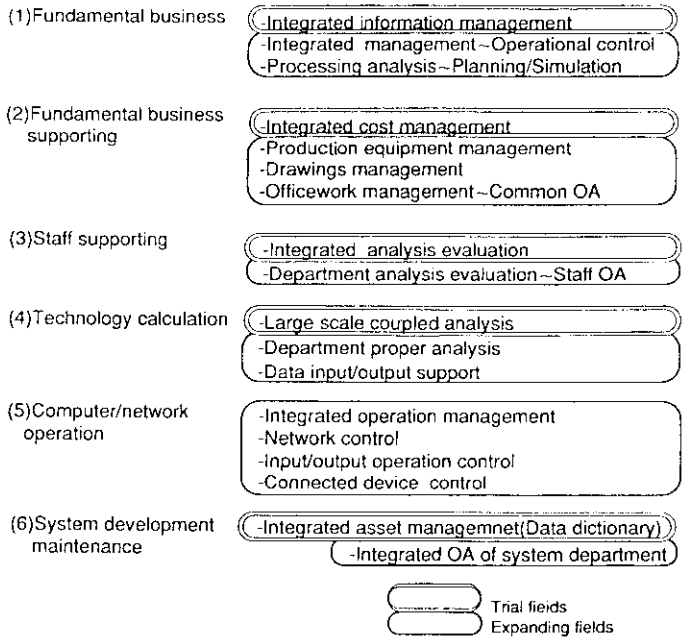

Fig. 1 Configuration and application fields of system functions

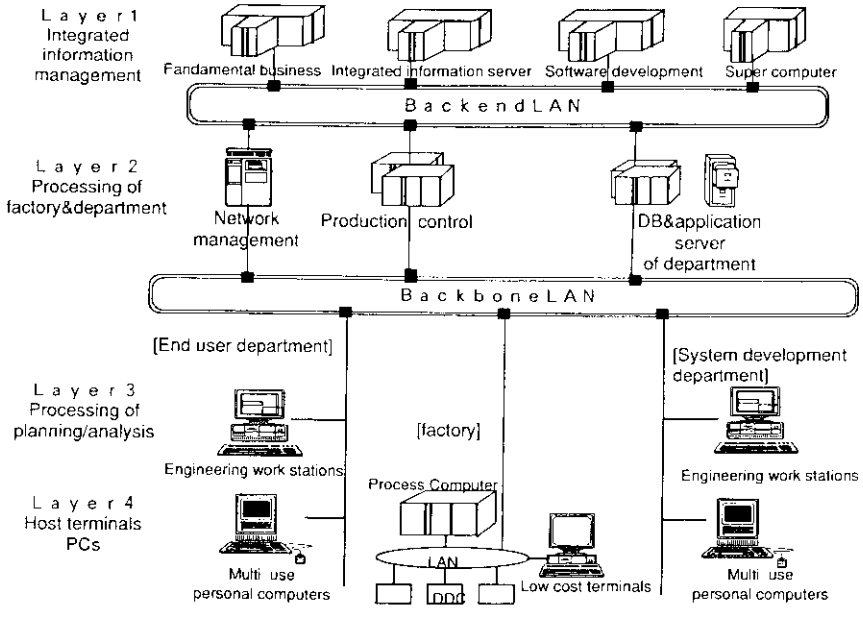

Fig. 2 Scheme of computer/network arrangement

3 Preparation of Base and Foundation for Promotion of Open Systems and Decentralization

Because the tasks in promotion include many different fields of application and object technologies, efforts were made to combine these in the development topics of each office and plant and to divide the work and solve the problems based on the following large categories:

(1) Preparation of infrastructure and basic technologies
(2) Preparation of control and operation technologies
(3) Preparation of development and application technologies
(4) Preparation of the development environment and training of technical personnel

In preparing the infrastructure, as mentioned previously, the principle adopted was advance response, by preparing the infrastructure simultaneously with application planning in each division. In the preparation of each technology, the aim was high practical utility based on the technology and know-how with the mainframe computer, but fundamentally, the policy was to minimize software writing. In addition, because sharp fluctuations in technology were foreseen, Kawasaki Steel struggled with the above based on a policy of flexible response which would not place early limitations of platforms such as hardware, software, etc.

3.1 Infrastructure and Basic Technology

To enable a decentralization of functions by an appropriate distribution of equipment, the establishment of company-wide and divisional networks and the expansion of branch LANs within divisions were promoted. In addition, aiming at smooth movement and development, the preparation of an environment for coexistence between existing mainframe computers and open system equipment was promoted.

3.1.1 Preparation of network environment

The points in the preparation of campus LANs are responding to higher speeds in the trunk LAN and expanding the branch LANs. An FDDI backbone LAN was installed for common use with the conventional optical fiber network (which was replaced in some offices), and Ethernet was laid as a divisional branch LAN. In large offices, a backend FDDI LAN was also constructed in combination with the above for large volume data transmissions between host computers and between various types of servers.

Further, together with the preparation of campus LANs, the preparation of a company-wide WAN has also been promoted to enable a response to wide area OA and company-wide development of client/server systems, and is substantially complete (**Fig. 3**).

3.1.2 Preparation of environment for coexistence of existing mainframes and open equipment

IBM and Fujitsu emulators capable of common use as host terminals via LANs with Macintosh and Windows personal computers, which have been provided to improve staff work efficiency, were developed in-house and are marketed as products handled by Kawasaki Steel Systems R&D Corp.[3,4]

In regard to asynchronous real communication software in business computers and between process computers at Kawasaki Steel, a TCP/IP version was developed for use with Fujitsu host and UNIX machines. By these means, an environment for the coexistence of existing equipment and open equipment has been prepared and is contributing to the smooth development of open systems.

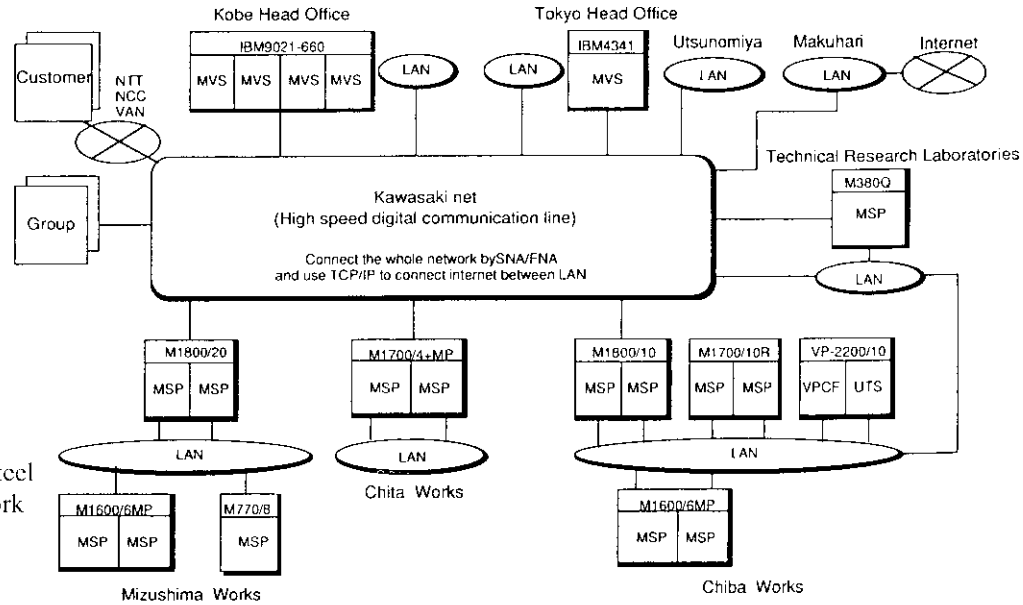

Fig. 3 Kawasaki Steel Corp. network

3.2 Control and Operation Technologies

As the largest task for the promotion of open systems, operational technology is far behind in comparison with mainframe computers, and it is not possible to withstand heavy operation. The following control and operation technology was prepared with the targets of realizing 24-hour operation of the core business control system, automatic operation of batch systems, and independent control of networks.

3.2.1 Operating technology for core business control system

Preparation of this technology was promoted with the abnormality monitor and rehabilitation function for UNIX computer real system hard and software malfunctions and application software as the main items. Object equipment is regularly monitored from a monitoring workstation by way of the networks, and an alarm notification is indicated, together with the content of the abnormality, when a malfunction occurs. In case of fatal malfunctions such as CPU error, automatic switchover to a standby host computer is made in a required time of approximately 10 min, and work is continued. Further, automatic backup of the data base by tape equipment and other automatic operation have been realized.

In addition to the above, an execution control mechanism for suppressing negative effects during transaction concentrations (simple TP monitor which performs multiprogramming priority control) and an operation analysis function for grasping application response time distribution and for CPU load control have been prepared, giving adequate consideration to performance guarantees.[5]

The Chiba Office of Kawasaki Steel Systems R&D Corp., Steel Systems Div. is mainly promoting the development of these functions based on the Fujitsu UNIX computer server DS Series OS and Informix.**

3.2.2 Batch system operation and control technology

On the other hand, the Mizushima Office is promoting from various viewpoints a study of the possibility of realizing batch systems in an open system environment, with Sun-UNIX computers and SYBASE*** as preconditions. The following and other knowledge has been obtained as a result of benchmark tests of multiprogramming performance with set model jobs:

(1) Even in multi-programming performance with 2 or 3 jobs, the elapsed time for each job is increased by 1.2 to 5.1 times that when running single jobs.
(2) CPU consumption capacity increases become greater above the increase ratio of multiprogramming, and CPU bottlenecks tend to occur more easily.
(3) The above tendencies remain unchanged even if a number of cases are performed under various job processing priority orders.

A job execution control function was judged essential in the core batch system operation, which has a large load, and independent development was carried out in the company in line with the following operational functions.

Timed Starting: Processing is started automatically at a set time.
Interrupted Processing Assurance: Automatically restarts processing which has been interrupted by equipment abnormalities, etc.
Operating Result Control: Gathers and controls operating result logs of batch jobs.
Mill Sheet Output Control: Stores and transmits mill sheet data and restarts after abnormalities.

Further, one feature is a central monitoring system from the host computer console for the UNIX computers, which are in a decentralized arrangement.

In a batch system with computers in a decentralized arrangement, cooperation among dissimilar machine types and dissimilar systems is essential, and it is necessary to guarantee the mutual processing execution order including file transfer. The general tool for file transfer is the FTP (file transfer protocol), but the the lack of an interrelated means of confirmation is a problem. Therefore, an automatic file transfer system having the following features was developed[6] on an FTP base:

(1) Batch processing cooperation among dissimilar machine types taking file transfer as an opportunity
(2) Guarantee of processing order of continuously generated transferred files
(3) Automatic start of file transfer and subsequent batch processing following circuit malfunctions, etc.

Because the results of application were extremely effective, the above was put into package form under the trade name OPENWAY-FT.

3.2.3 Decentralized system control and network operation technology

The above real and batch operation functions substantially solved the application server control tasks. Enabling independent response to the operation and performance control of networks and network-subordinate decentralized systems in a multi-vendor environment was therefore adopted as a further target. Various types of tools for the essential network control functions of equipment, architecture, malfunctions, performance, and secrecy control were introduced, and this target was realized (**Fig. 4**).[2]

In the present circumstances, in which these systems are primarily used in-company, no active response is

** Informix is the registered trademark of Informix Software Inc.
*** SYBASE is the registered trademark of Sybase Inc.

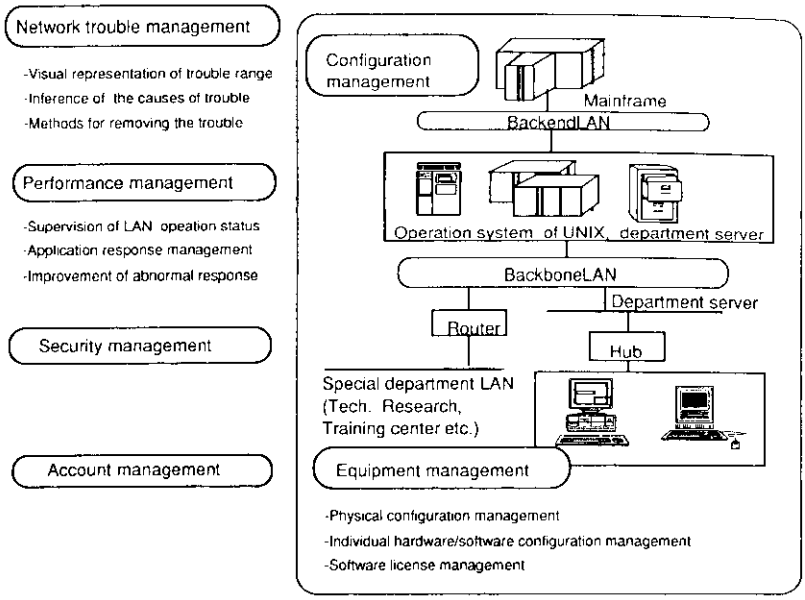

Fig. 4 Function structure of open system operation management

made to the rate control function. As part of the equipment control function, a feature is the enforcement of licensing control limiting the maximum number of persons using software at one time, with the aims of reducing personal computer software costs and monitoring improper use.

In addition, countermeasures for guaranteeing reliability are important, aiming at stable operation. These include the optimization of network architecture and standardization of technology and equipment adopted. The total balance of function and cost, etc., involves many difficult problems, but positive incorporation is necessary from the viewpoint of early discovery and handling malfunctions and limiting the range of performance abnormalities. We consider the promotion of subnetworks to be a concrete and effective means of preventing the creation of unwieldy size and are therefore promoting an architecture review and response whenever networks are expanded.

3.3 Development and Application Technology

For the efficient development and application of open systems, it is necessary to adopt the most appropriate technology in each object field. Attention must be paid to the fact that there are differences in technical features in all fields of the core business DB architecture and application development, staff support system development, centering on the use of information, the development of planning simulation and other trial and error processing systems, and simple small-scale systems.

In Kawasaki Steel, the systemization of development technology is being promoted as shown in **Fig. 5** in accordance with the guidelines of hardware and software selection standards. In all cases, together with aiming at

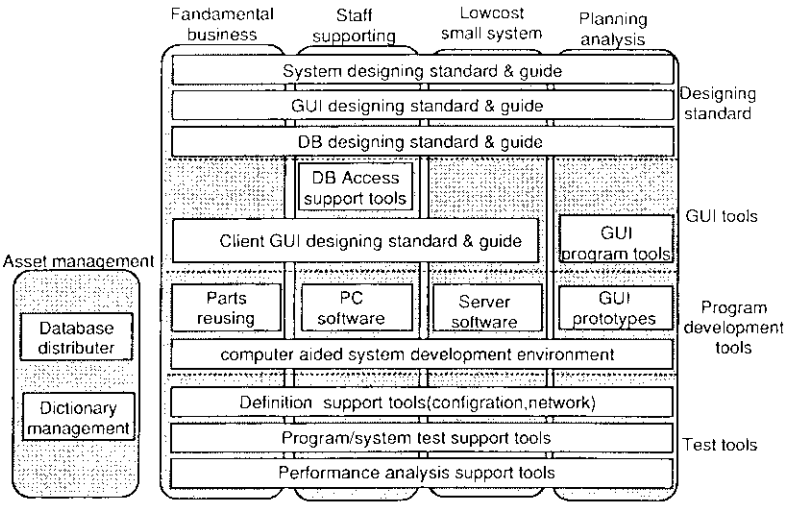

Fig. 5 Scheme of development technology

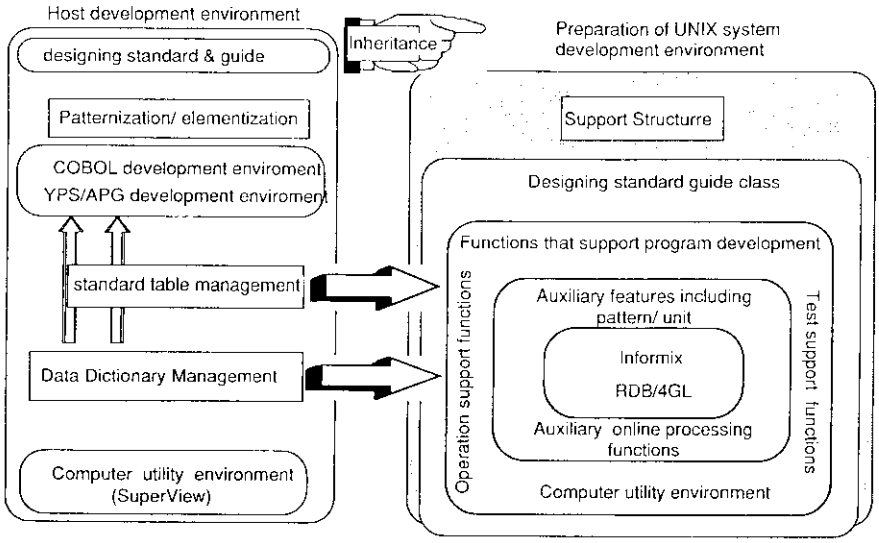

Fig. 6 Fundamental business system development environment of UNIX

the establishment of technology in an open-system independent environment, adequate care is given to mutual cooperation so as to enable effective utilization of host mainframe computer DBs and dictionary assets. In the particularly important core business information system development technology, the aim is to create the simplest possible technical system by eliminating redundancy while passing on the know-how related to mainframes. **Figure 6** shows the concept of preparation of the UNIX computer development technology in the Chiba basic system.

3.4 Preparation of Development Environment and Training of Technical Personnel

In advance of application of open system technology in a practical business division, test servers and personal computers were installed for preparation of an in-department LAN in order to make an evaluation in the system department and prepare an environment for development. The development of an emulator for coexistence with the host environment was promoted as part of this effort. The training of technical personnel to respond to the adoption of open systems, as mentioned previously, aimed at short-term training by providing a system development environment resembling a mainframe development environment, and a conversion from COBOL technicians was realized in 2 to 3 days of training.

Development technology having a client/server morphology was arranged for representative morphologies for covering a wide range of application platforms, and to create an environment where in-house mass education would be possible.

On the other hand, education and enlightenment activities were carried out based on the preparation of educational equipment and a curriculum for practical business departments with a view to enhancing the technical capability of practical business departments to use information. Persons in charge of systems were appointed in practical business departments, and organizational strengthening was promoted with the aim of enabling independent progress in the adoption of information, including the arrangement of individual topics.

4 Status and Evaluation of Promotion of Open Systems

4.1 Status of Promotion

First, open systems were promoted in line with the pace of the entire company to prepare a company-wide EUC/EUD environment for improvement of staff work efficiency. There are some variations by division, but we are approaching the target of allocation personal computers to all staff members, and are at the stage where we are endeavoring to promote application to near-to-hand work.

On the other hand, individual application systems have been put in place separately as the opportunity arose, in line with the circumstances of the division.

Taking the refurbishing of the upstream facilities at Chiba Works as an example, "cutting and dividing of staff work for everyday operational control work and improvement activities," "clarification of the division of labor between business computers and process computers," and "review of computer automatic processing and human judgment works" were carried out, aiming at development in line with the fundamental policy of promoting open systems and decentralization.[7] An outline of the division of functions is shown in **Fig. 7**. Here, the following and other items are aimed at system construction in the direction of an overall strengthening

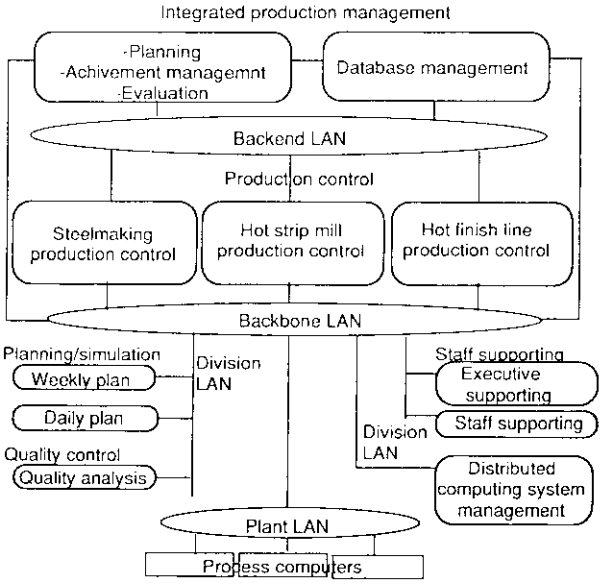

Fig. 7 Function arrangement of production management and control system of newly constructed steelmaking and hot rolling process

of front business support:

(1) Implementation of a total control function for the control of plans, progress, and results by the host, and unified control of the DB
(2) Implementation of plan evaluation, revision, and schedule plan drafting by workstations
(3) Instructions, execution coordination, actual product control, shipping and receiving control, and collection of results by operation control servers
(4) Analysis of the actual condition of operations and quality and study of improvement measures by personal computer

Each division is grappling with the adoption of open systems and decentralization with the same philosophy. Initially, the object was relatively small scale systems, but recently application to large scale systems has been promoted. An introductions to individual systems will be presented in subsequent papers, but recent examples worthy of special mention include, in addition to the previously mentioned operational control system for the upstream modernization at Chiba Works, PEGASUS domestic sales and production system, the Daiwa Steel bar mill production control system, and other WAN type client/server systems.

The adoption of open systems and decentralization are progressing steadily in line with the staff support system which is now being developed company-wide. Among the new system development at Kawasaki Steel in 1994, open systems accounted for a share of more than 40%. However, considering the weight given to application to new fields, and in particular higher efficiency in white collar work, and the extremely large scale of existing systems, open systems make up only somewhat more than 5% of all the systems owned by the company. On the other hand, the share held by open system equipment in the total hardware budget is comparatively high considering the scale of the open systems, being about 15% at the end of fiscal 1994. The characteristic features of positive investment in open systems are manifest in this high figures, including, for example, the frequent need for advance investment in LAN, OA servers, and other infrastructural equipment, and use environments not accompanying software development.

4.2 Evaluation of Degree of Achievement of Targets

More than three years have already passed since we began to wrestle with the company-wide policy decision to adopt open systems and decentralization. As discussed above, the share of open systems in the total, including existing systems, still cannot be called large, but it is the evaluation of the authors that the initial targets are being steadily achieved.

(1) Coping with Business Speedup

Application to work which had in the past been resistant to the application of these technologies, such as plan evaluation and staff work, is being promoted, and a speedup of business is being realized. In particular, concrete form is being given to application to near-at-hand jobs with the preparation of EUC/EUD environments, and there is a consistent trend toward shortening of the work cycle. In the future, by realizing greater cooperation between jobs, further effects can be hoped for at the company-wide level.

(2) Strengthening of System Response Capabilities and Technical Capabilities

Initially, there were some doubts that the range of object technologies was too broad, but as the essential technical fields became clear, technical capabilities were steadily accumulated. However, it is difficult to say that there has been an adequate response to the standardization of international protocols which are necessary for the application of networks to business work. Further, there has been a problem of confusion by short-term technical movements due to changes in the strategy and tactics of vendors.

(3) Promotion of Information System Adoption at Appropriate Cost

Looking at individual systems, a trial calculation for the previously mentioned Chiba operational control system shows that the hardware cost of open systems is approximately 25% less than with the mainframe computer. The total hardware cost at Chiba Works was reduced 20% during the last three years by scaling down the functions of the mainframe, etc., in line with the promotion of right-sizing. Because the price of mainframes decreased last year, it is difficult to attribute this saving entirely to open systems, but even including the cost of preparing application technolo-

gies, it can be said that this effort was a reasonably rewarding one.

(4) Promotion of Total Systemization by Proper Division of Functions

In terms of improvement of operability by limiting the affected range when a malfunction occurs, it has been possible to achieve the expected benefits where operation and production control systems are concerned. However, in large-scale WAN client/ server systems and staff support systems, the need for data and information cooperation via networks has grown stronger and an apparent decentralization of functions has been possible, but operation-related problems tend to be conspicuous.

From the user's viewpoint, the convenience and response of each individual system have been greatly improved, but the fact that the design and fabrication load related to the system department's performance guarantees has increased can be called a new problem.

It is not possible to quantify development productivity, but it appears that there has been a corresponding improvement in productivity over the past, mainly in the preparation of mill sheets and preparation of plans. In line with the effect of the more tightly focused range of individual functions accompanying decentralization, it may be concluded that there has also been an overall improvement. However, care is necessary because, with the nonprocedural languages which feature GUI (graphic user interface) in personal computers, it is difficult to grasp the system structure systematically, and many problems arise in the maintenance stage.

5 Conclusions

The philosophy and status of promotion of open systems and decentralization has been introduced. Although this effort is still in stage of development, the results obtained to date are as follows:

(1) The systemization of planning, evaluation, analysis, and other work which had in the past been difficult to systematize has been promoted, contributing to a business speedup.

(2) Divisional DB servers and other EUC/EUD environments have been prepared, improving the system response capabilities of practical business departments.

(3) Application of decentralized servers to core operational control systems has improved independent operability in each shop.

(4) Scaling down of mainframe functions in line with the promotion of right-sizing and similar measures have reduced hardware costs.

It seems that increasingly high expectations are placed on information systems for improving the efficiency of corporate activities. Based on reviews of business by BPR (business process reengineering), the promotion of networking, including group companies and cooperation with other companies, is considered one effective direction, and open systems and decentralization are positioned as backbone technologies for this purpose.

In the future, we intend to work positively toward the promotion of application of the above at every opportunity.

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