Special Article on Operation System
Network Element Management Operation Systems (NDOPS, HOPS, POPS)

We have developed operation systems called NDOPS (for NMLS/6PBS), HOPS (for NMSCP), and POPS (for PDC-P) for managing new nodes. The architectures of these new network-element-management operation systems and their specific functions are discussed, along with our development objectives.

Kazuhide Takahashi, Atsushi Kato, Yuji Ishida, Hideyuki Sakuramoto, Haruo Mizumoto, Katsuyuki Tsumita, Hideyuki Mori and Kazuaki Terunuma

1. Introduction

As the number of subscribers has exponentially increased and a broader variety of mobile service have been provided, it has been becoming extremely difficult to provide a sufficient level of service to our customers via conventional NE (Network Element) such as MLS (Mobile Local Switches) and MSCP (Mobile Service Control Point).

To meet this challenge, we need to develop NMLS (New Mobile Local Switch) and a NMSCP (New Mobile Service Control Point). These network elements are called "new nodes". To manage them, we developed maintenance and OPS (Operation Systems) aimed at reducing the maintenance workload, expediting failure recovery, and improving service quality. Specifically, we developed an NMLS/6PBS NDOPS (New Digital Operation System), an NMSCP (HOPS : HLR (Home Location Register) operation system), and a

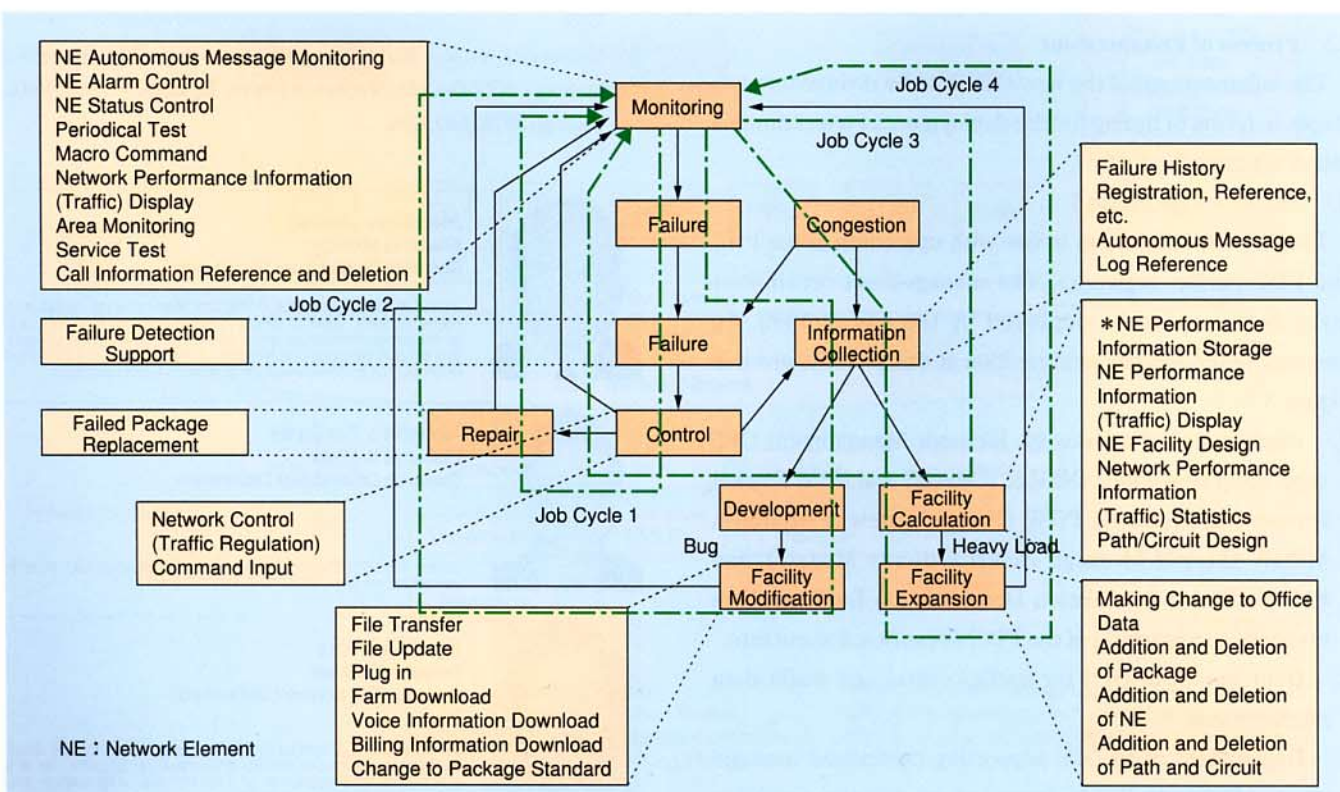


Figure 1 Maintenance and Operation Job Cycles

PDC-P (PDC Mobile Packet Communication System) management operation system.

We will discuss the architecture of these NE management operation systems, our development objectives, and the functions provided by these new systems.

2. Tasks Performed by Operation Systems

As Figure 1 shows, four job cycles are involved in the maintenance and operation of network elements. Job cycle 1 starts when the NE monitoring function detects a device failure. The detection function localizes the failure, after which countermeasures are taken and the failed device is repaired. If the device is only temporarily recovered, information about the failure is gathered and analyzed to begin development and facility modification in job cycle 2. In job cycle 3, the congestion status of the network is inspected and controlled. In the final cycle, cycle 4, information is collected, the facility is calculated, and the facility is enhanced. Maintenance operation is required to efficiently keep these cycles.

3. Common OPS Architecture

The OPS architecture, illustrated in Figure 2, contains common functional blocks serving the three types of tasks mentioned above. The software was shared as much as possible during development to reduce the development cost. This architecture consists of three functional blocks. Interface function block, a data-management function block, and an operational application function block. The interface function block provides functions for communicating with

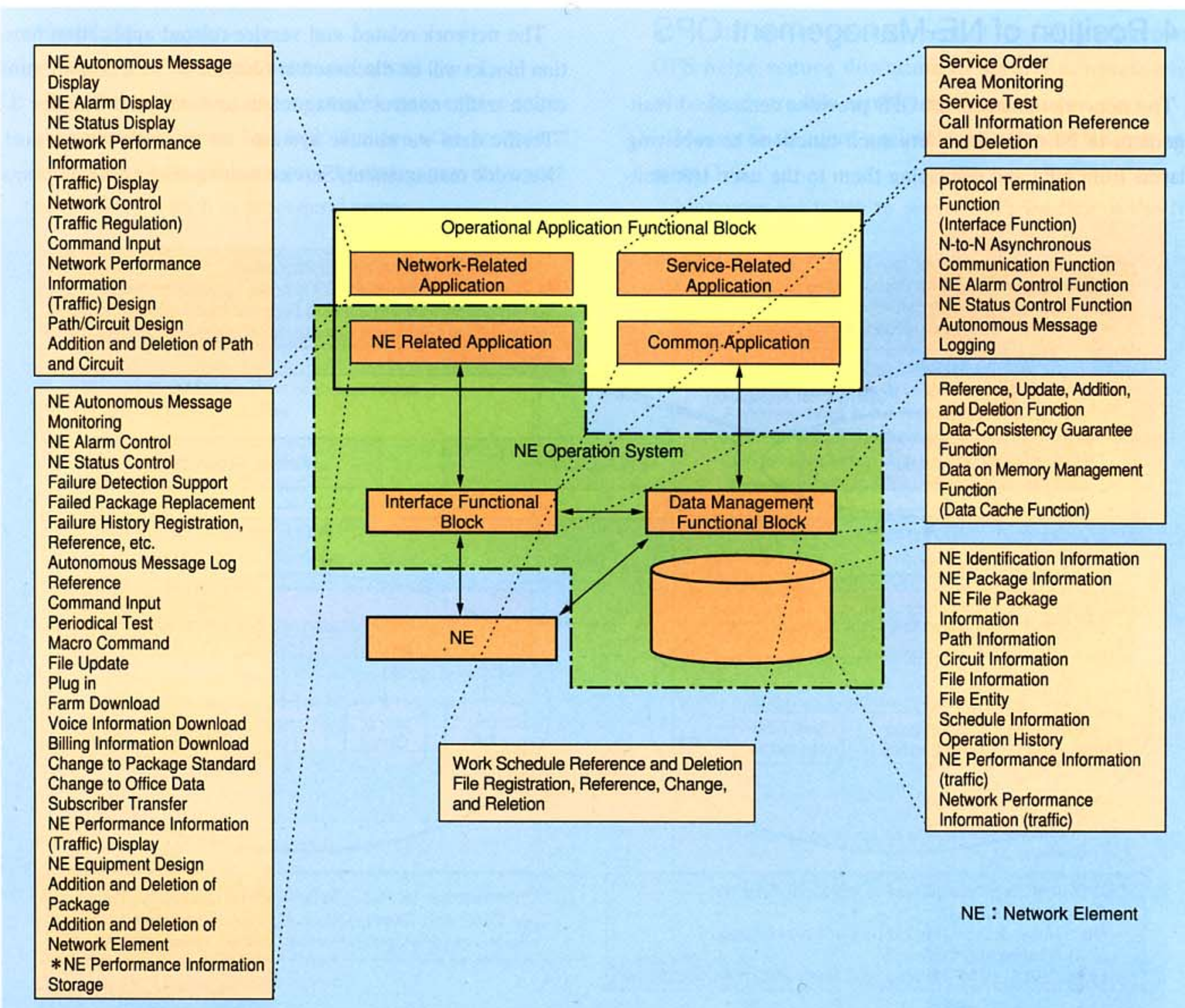


Figure 2 Grouping of Maintenance and Operation Tasks and OPS Architecture

and centralizing the NEs. The data-management function block manages the operational data (e.g., status of NE equipment) and files (e.g., system files supplied to NEs). The operational application function block uses both the interface function block and the data-management function block to perform various types of maintenance tasks.

The maintenance tasks, see Figure 1, can be categorized into three groups based on the objects they manage : The tasks in the first group are those for managing the NEs, such as alarm monitoring. The tasks in the second group serve the whole network, such as traffic monitoring. Call-information management (call-processing alarm management) and other mobile network service related tasks form the third group. In line with this categorization, three types of applications, NE related, network related, and service related, form the application function block.

4. Position of NE-Management OPS

The network-management OPS provides centralized management to NEs. It also offers such functions as receiving alarms from NEs and displaying them to the user, transmitting commands from users to NEs, and returning replies from the NEs to the users.

To perform these functions, the NE-management OPS is positioned with the NE-related application function block, the interface function block and the data-management function block.

5. Objectives of NE-Management OPS

The new NE-management OPS (NDOPS) was developed to reduce maintenance overhead (Objective 1), prevent operational errors (Objective 2), reduce the cost of the NE-management OPS hardware (Objective 3), and improve the reliability of the NE-management OPS (Objective 4). As indicated in Figure 3, setting four specific targets based on the three function blocks achieved Objectives 1 and 2.

The network-related and service-related application function blocks will be discussed in Chapter 2 "Mobile communication traffic control management system" and Chapter 3 : "Traffic data warehouse system" of the following report, "Network management/Service management operation sys-

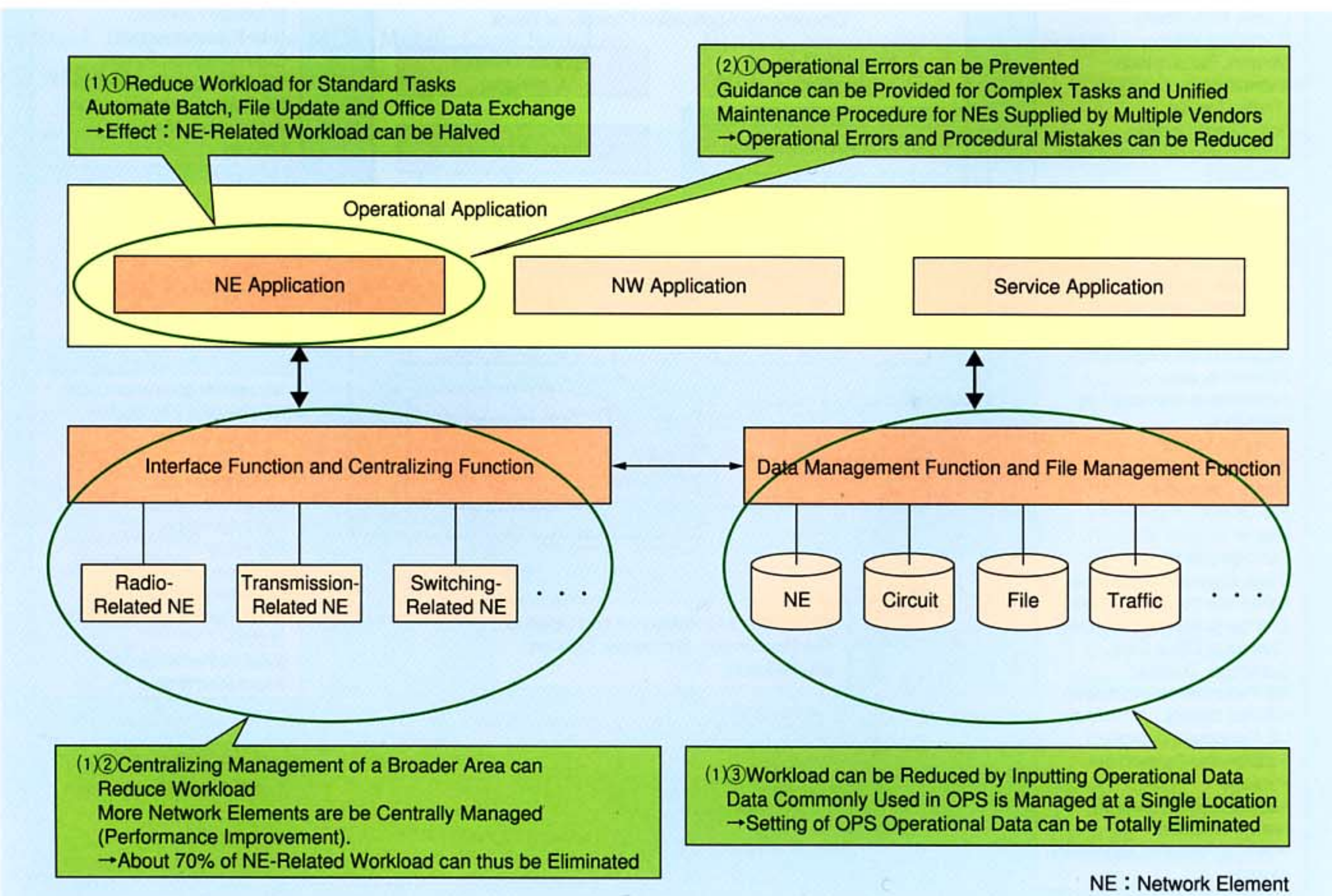


Figure 3 OPS Architecture and Challenges

tem (MTCS).

(1) Objective 1 ··· Reduce maintenance overhead

① Reduce workload related to standard operations

Because standard operations are conducted using the same control for all NEs, conducting them on multiple NEs in parallel can reduce the workload. By automating standard operations in this way, we can reduce the total workload for maintenance operations as much as 50%.

② Centralize management of a broader area

By covering more NEs with centralized management, the workload for alarm monitoring can be significantly reduced. Centralized management should eliminate 70% of the workload related to monitoring and controlling related operations.

③ Reduce workload related to operational data input

If the same operational data does not need to be input to multiple NE-management OPS, the workload can be reduced.

(2) Objective 2 ··· Prevent operational errors

① Provide operation guide for complex maintenance work

Operational screens that look similar to the procedural instructions help maintenance operator prevent operational mistakes such as procedural errors.

② Streamline maintenance operation for NEs supplied by multiple vendors

The NE-management OPS absorbs the interface differences among NEs supplied by different vendors, so that maintenance operator can manage them the same way on the screen, helping to prevent operational errors.

(3) Objective 3 ··· Reduce cost of NE-management OPS hardware

① Accommodate multiple types of NEs

A function is provided to accommodate multiple types of NEs in the same OPS so that OPS hardware cost can be reduced.

(4) Objective 4 ··· Improve reliability of NE-management OPS

① Measure to guard against failure of NE-management OPS

Dual-configuration servers, dedicated lines, routers, hubs, and the other equipment of the NE-management OPS helps reduce downtime to several minutes, even when hardware fails completely.

② Measures to guard against congestion of NE management OPS

Measures are taken to prevent overloading of the NE

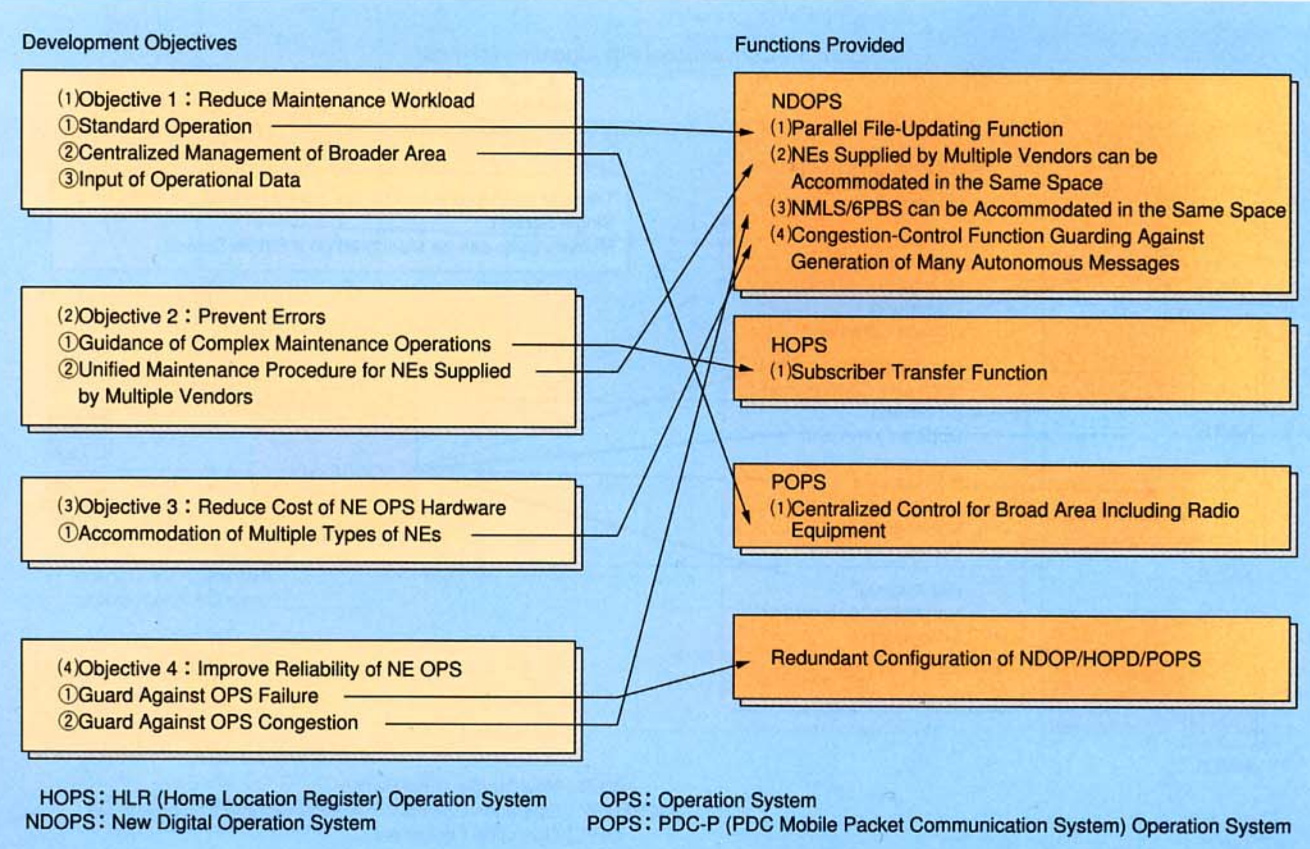


Figure 4 Development Objectives and Functions Provided

management OPS and consequent operation stoppage.

6. Functions Provided by Operation Systems for New Nodes

We have developed several specific functions for NDOPS, HOPS, and POPS. OCSE-SW (Operation Control Information Storage Equipment-SW), OCSE-H (Operation Control Information Storage Equipment-H), and OCSE-P (Operation Control Information Storage Equipment-P). The relationships between Objectives 1 and 4 and these functions are indicated in Figure 4. Objectives 1 to 3 will be discussed in Section(4) "Remote file updating system" of the following article, "Network management/service management operation system (MTCS)", and Objective 4 will be discussed later.

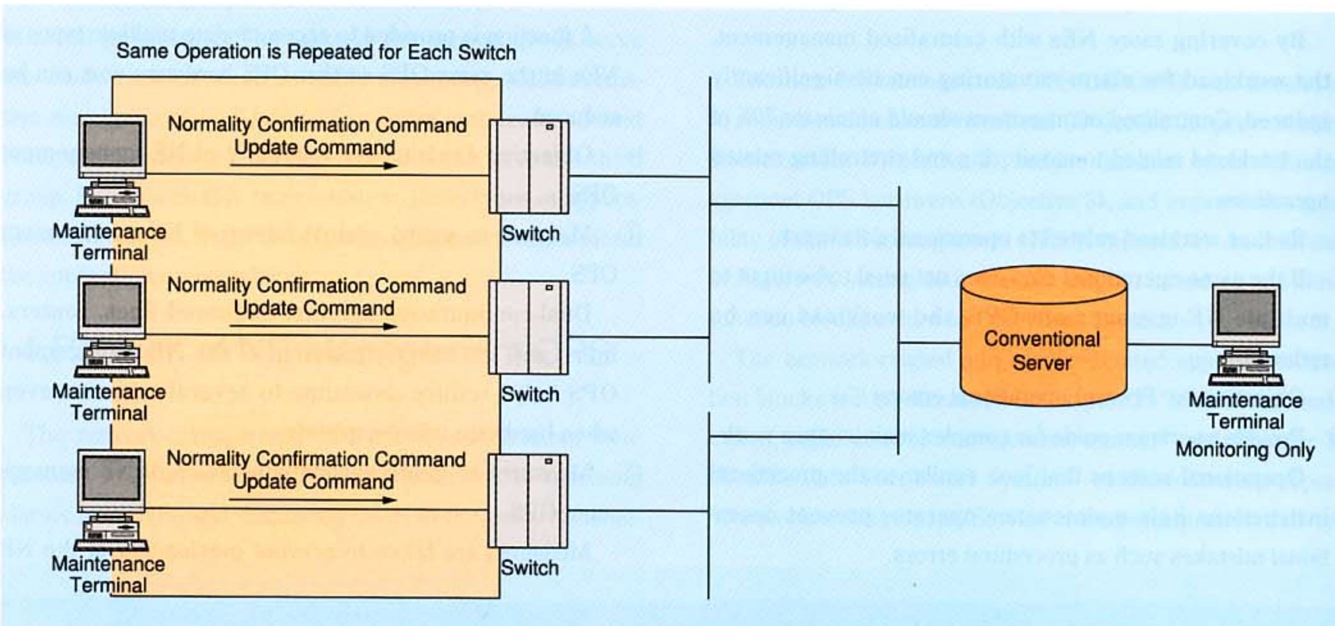


Figure 5 Conventional File-Updating Method

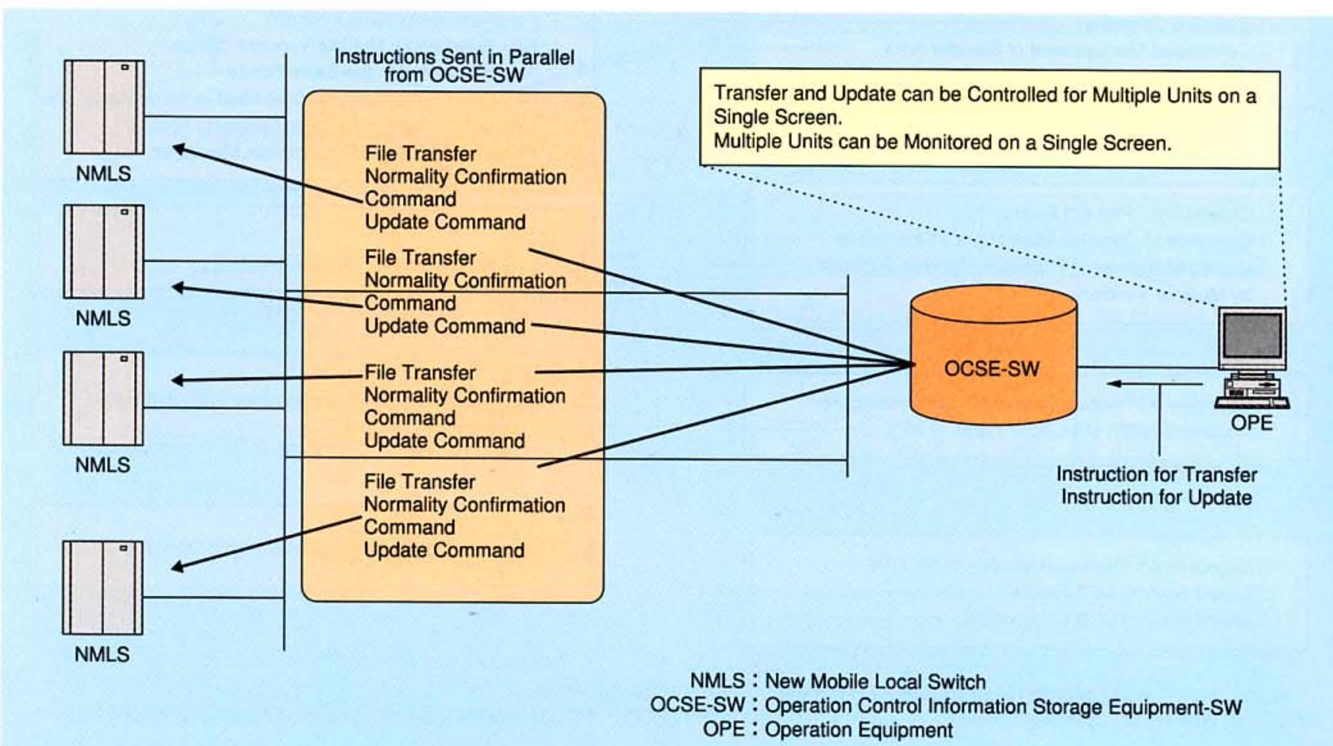


Figure 6 Parallel File-Updating Method

6.1 NDOPS

(1) Parallel file updating function

To serve the increasing number of mobile subscribers, several hundred switching units are currently in operation. With a conventional system, the same command has to be input to each of these units to update a file, plug in a module, or make a change to office data.

When a file is to be updated, for example, a maintenance operator has to update it at a maintenance terminal directly connected to a switch. This creates a tremendous amount of work because operator has to perform the task in the office where the file is located and additional effort is required at each switching unit. The workflow of the conventional approach is illustrated in Figure 5.

The use of NDOPS has significantly reduced the workload imposed by this task because it automates the commands used for file-updating operations, such as the command to confirm normal operation of a switching unit and the update command, and also because it controls several NEs in parallel.

Figure 6 shows the parallel updating mechanism of NDOPS. The maintenance operator can now execute the entire task simply by updating the file only once on a terminal located at the central office. A task status list on the screen makes it possible to monitor the progress of the updating operation at each switching unit at a single glance.

(2) Accommodation of NEs supplied by different vendors

The same hardware specifications were used by suppliers to develop conventional D60 switches (MLS), there are no differences in the NE-OPS interfaces of the switches, including their commands and messages. In the development of NMLS, however, we encouraged price competition among vendors, which led them to use different hardware components and different interfaces to reduce cost. Operational errors by the maintenance operator are thus a concern. In the development of NDOPS, we thus implemented three features.

① The alarm levels are unified so that the maintenance

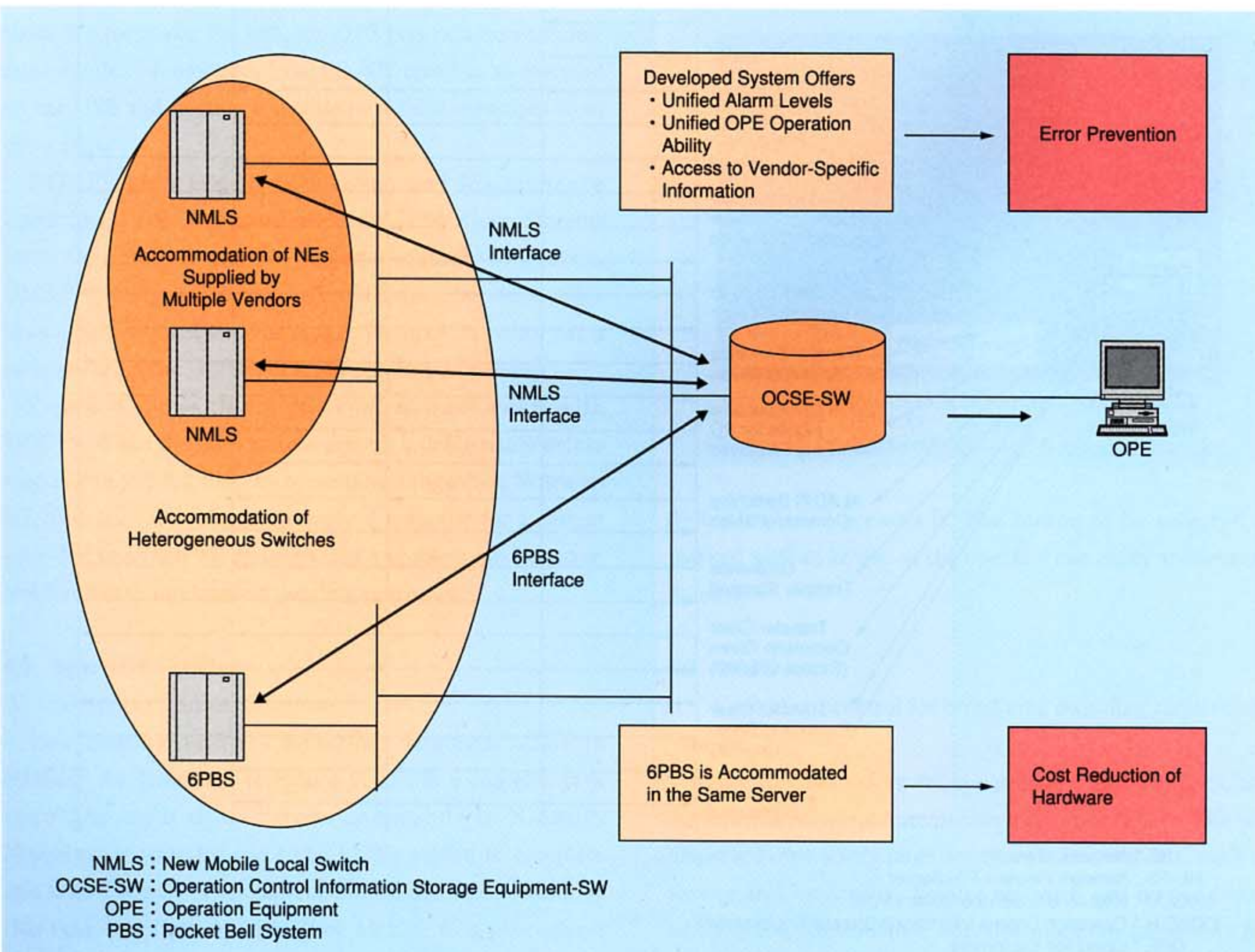


Figure 7 Accommodation of NMLS/6PBS

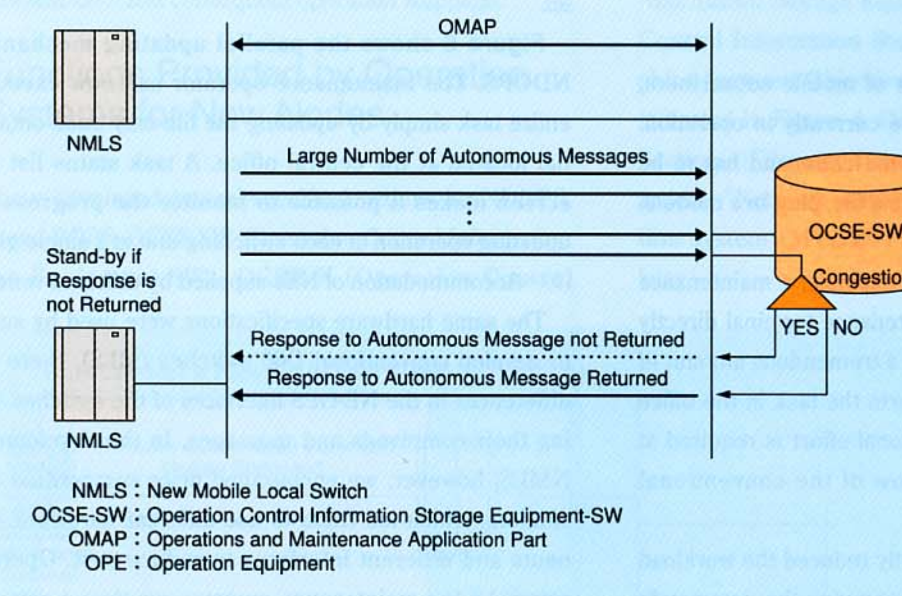


Figure 8 NE-Related OPS Congestion Control by OMAP

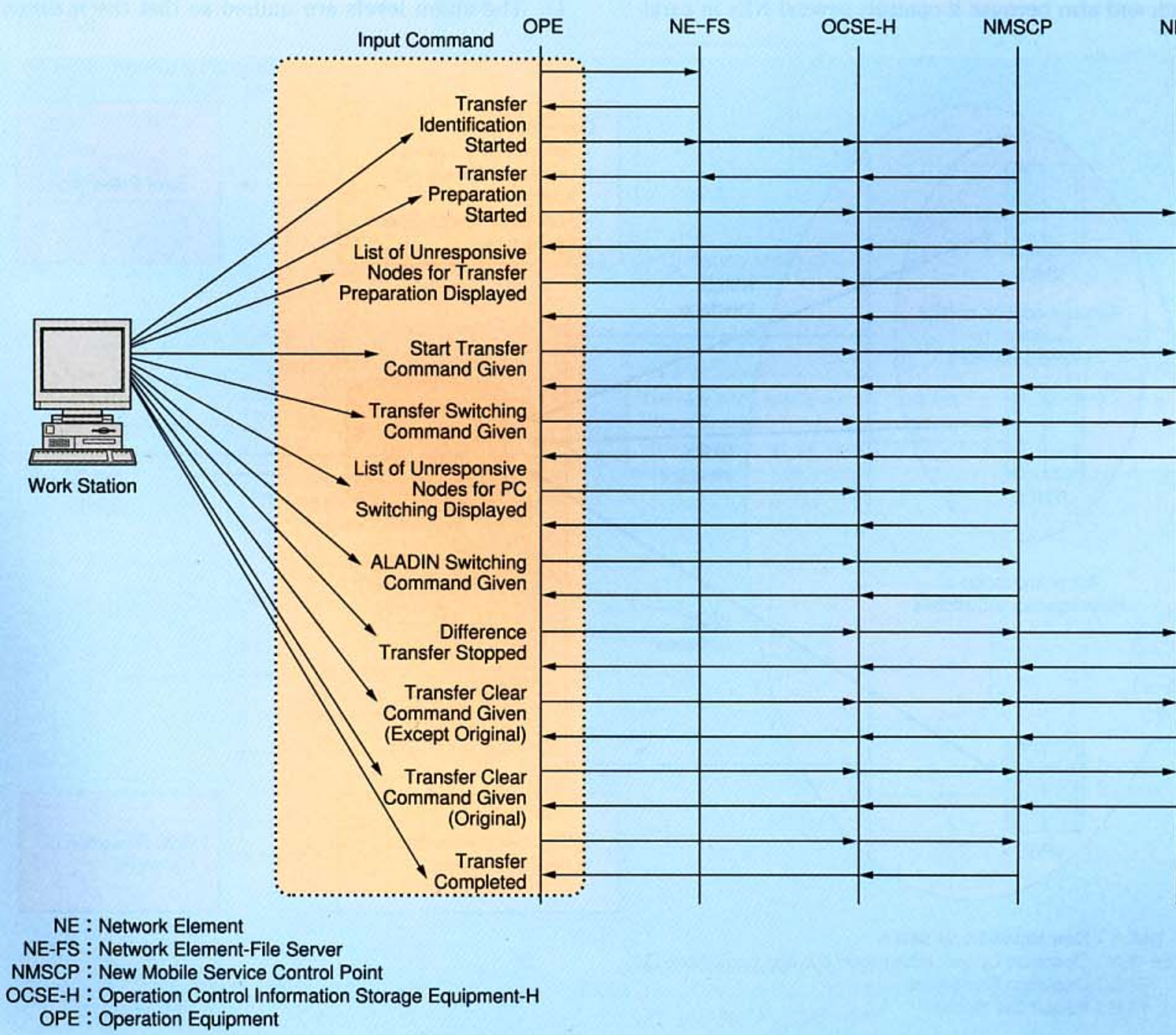


Figure 9 Operational Sequence of Subscriber Transfer

personnel can monitor the switching alarms without worrying about differences between suppliers.

② The maintenance terminal has unified operability so that maintenance personnel can control switches without worrying about differences between suppliers.

③ Vendor-specific information, which seems to be same for the maintenance operator is used to identify vendors and prevent operational errors.

(3) Mixed accommodation of NMLS/6PBS

In the past, a NE management OPS was developed for each type of switch. Each switch thus had its own OPS hardware, increasing the cost of the network. Because we anticipated that only a few PBSs would be installed, we decided to accommodate NMLS and 6PBS switches in the same hardware, thereby reducing the hardware cost of NDOPS. Figure 7 shows this accommodation.

(4) Traffic control function to guard against generation of numerous autonomous messages.

The NE management OPS monitors and controls NEs by exchanging commands and autonomous messages between them. If a particular NE fails, the OPS may receive a tremendous number of messages from the NE, creating an overload on the OPS and making it unable to receive messages from other NEs.

NDOPS uses OMAP (Operation and Maintenance Application Part), a standard protocol of OSI (Open Systems Interconnection) to prevent this type of traffic congestion. OMAP is designed so that failed NE does not send more than one autonomous message. Instead, it waits for a response from the OPS to its first autonomous message.

Figure 8 shows this traffic control mechanism with NDOPS. When the OPS are congested, it deliberately delays responding to NEs, thereby preventing congestion. When an NE from the OPS does not receive a response for a certain period of time, the NE assumes that a problem has occurred and forcibly terminates any pending processes.

6.2 HOPS

(1) Subscriber transfer function

This function transfers subscriber data from MSCP to NMSCP. As illustrated in Figure 9, this is a complex task requiring input of numerous commands to NMSCP. Maintenance operator has to be highly skilled to complete this task. To prevent operational errors, the screen used for this task was developed to look similar to a procedural instruction in Figure 10. To input a command, the operator simply selects an execution button such as "Start transfer

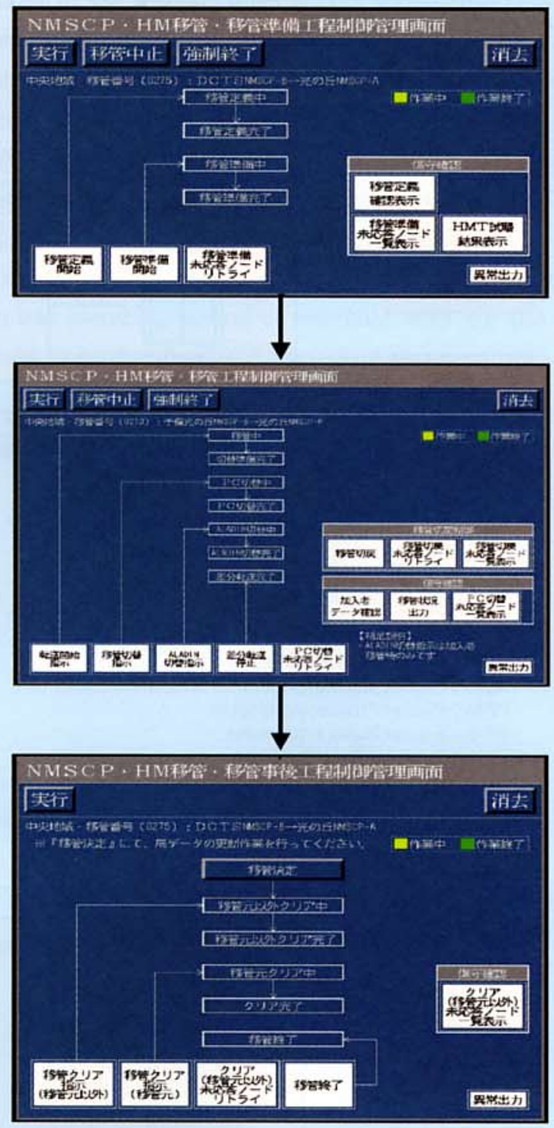


Figure 10 Operational Screen of Subscriber Transfer

definition" and presses it. The button to be selected is marked with an arrow, so the operator can easily see what to do next.

6.3 POPS

(1) Centralized control for broad area including radio equipment

Many NEs, including radio equipment and switches, are deployed in mobile communication network. These NEs are dispersed over a very large area for various reasons, such as service area expansion, disaster recovery, and limited installation space. Maintenance operator monitors these NEs for problems around the clock. For example, the NEs for PDC mobile packet communication systems are monitored and

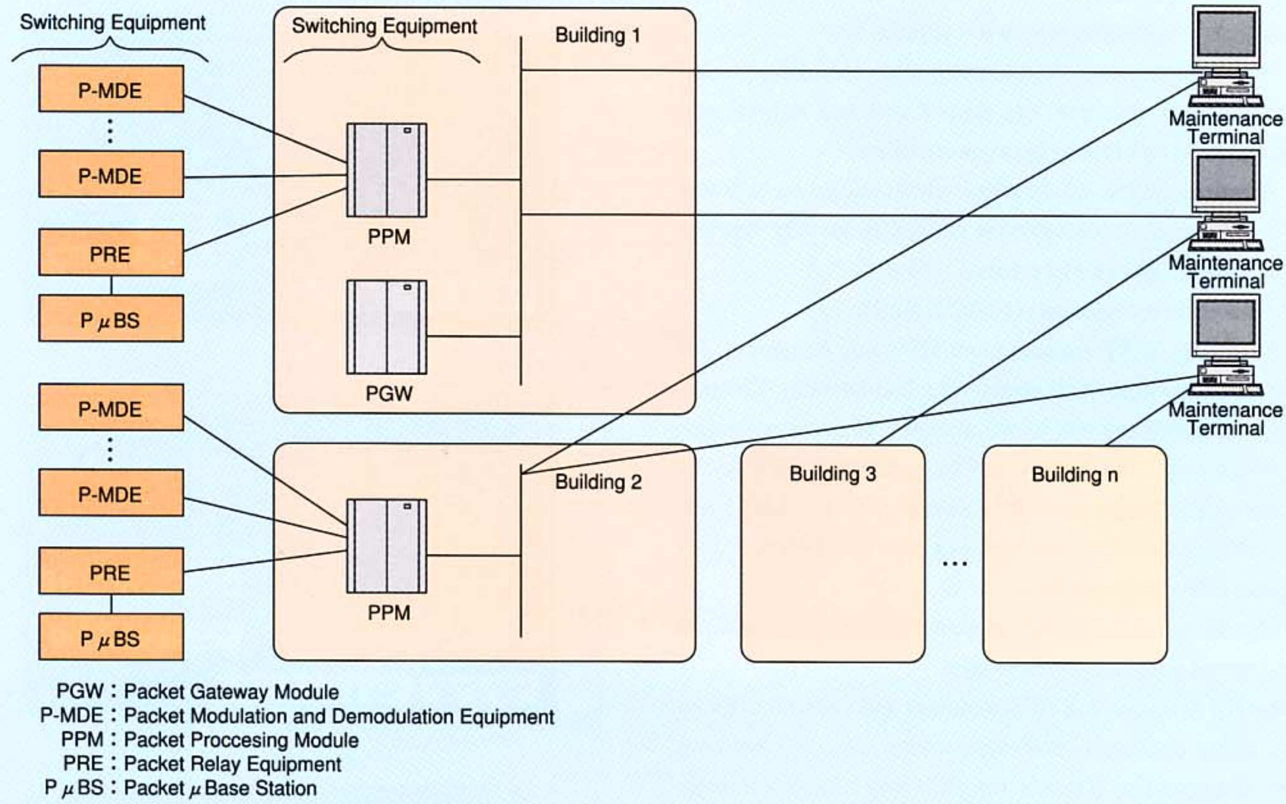


Figure 11 Conventional PDC-P Monitoring

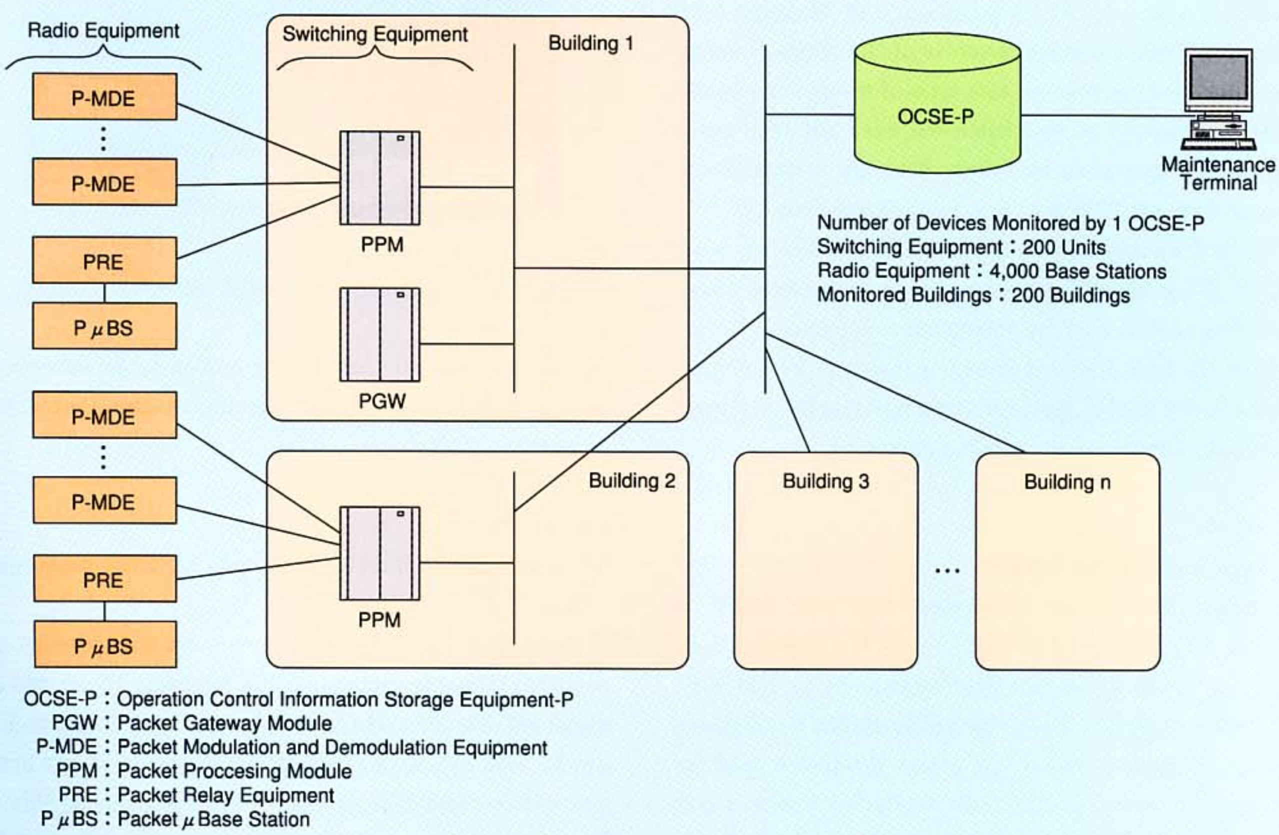


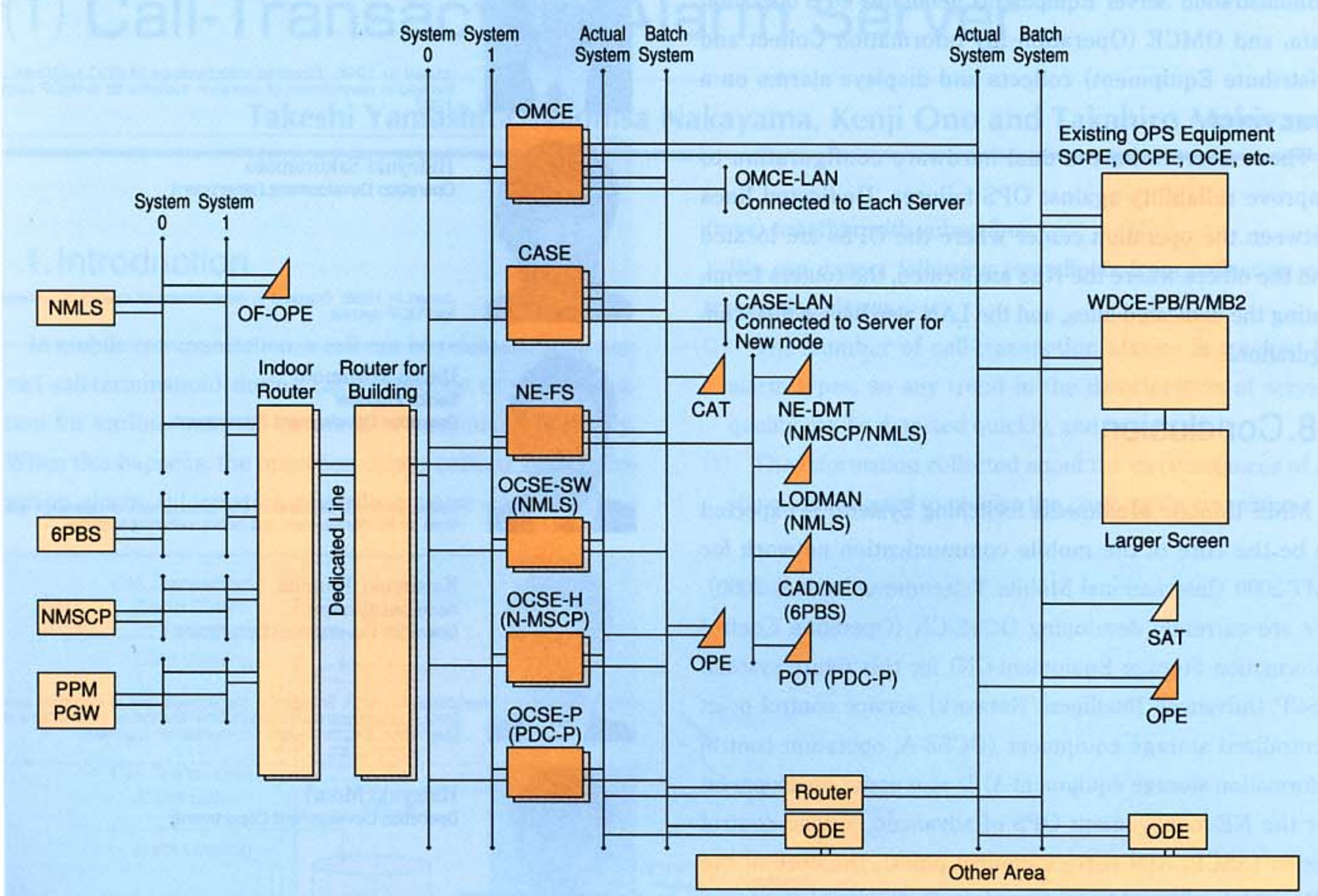
Figure 12 PDC-P Wide Area Monitoring

controlled.

A PDC-P network consists of radio equipment (P-MDE), packet micro base stations (P μ BS, packet μ base stations), and packet gateway processing equipment (PGW, packet gateway modules). At DoCoMo's central office, there are 4,000 base stations and 200 switching units.

In the past, only a limited number of NEs could control centralized maintenance terminals, so many maintenance terminals had to be installed, with a maintenance operator assigned to each one. This conventional monitoring and control method is illustrated in Figure 11.

Once POPS was implemented, it became possible for an operator to use a single maintenance terminal to centrally monitor and control NEs dispersed over a broad area, so the monitoring and controlling related workload was significantly reduced. The monitoring and controlling operation with POPS is illustrated in Figure 12. Because a monitoring screen is defined for each level of the hierarchy (building, unit, device, etc.), operator can immediately identify which NE in which office has failed. Reset control of radio equipment and switching control of switching units are also centralized to further facilitate immediate recovery from NE-



CAD/NEO : Computer Aided Design / New Office Data Generator
CASE : Configuration Administration Server Equipment
CAT : Configuration Administration Terminal
DMT : Discrete Multitone Modulation
LODMAN : Logical Office Data Making Assist Network System
NE : Network Equipment
NE-DMT : Network Element-Data Making Tool
NE-FS : Network Element File Management Server
NMLS : New Mobile Local Switch
NMSCP : New Mobile Service Control Point
OCE : Operation Control Equipment
OCPE : Operation Control and Processing Equipment for Exchange
OCSE-H : Operation Control Information Storage Equipment-H
OCSE-P : Operation Control Information Storage Equipment-P
OCSE-SW : Operation Control Information Storage Equipment-SW
ODE : Operation Information Distribute Equipment
OMCE : Operation MJ Information Collect and Distribute Equipment
OPE : Operation Equipment
OPS : Operation System
PBS : Pocket Bell System
PDC-P : PDC Mobile Packet Communication System
PGW : Packet Gateway Module
POT : Packet Office Data Terminal
PPM : Packet Proccesing Module
SAT : System Data Administration Terminal
SCPE : Supervisory Control Processing Equipment
WDCE-PB/R/MB2 : Wall Display Control Equipment-PB/R/MB2

Figure 13 Redundant Configuration of NDOPS/HOPS/POPS related failures.

7. System Configuration of NDOPS, HOPS and POPS

A system was configured as shown in Figure 13 to implement the failure measures discussed in section 5. The NE-management OPS server contains monitor and control servers for the NEs : OCSE-SW for NMLS/6PBS, OCSE-H for NMSCP, and OCSE-P for PPM/PGW. The NE-FS server manages NE-related files (system file, plug-in file, base station data, and so on), the CASE (Configuration Administration Server Equipment) generates OPS operation data, and OMCE (Operation MJ Information Collect and Distribute Equipment) collects and displays alarms on a large screen.

These servers have a dual hardware configuration to improve reliability against OPS failures. Dedicated lines between the operation center where the OPSs are located and the offices where the NEs are located, the routers terminating the dedicated lines, and the LAN also have a dual configuration.

8. Conclusion

MMS (Mobile Multimedia Switching System) is expected to be the core of the mobile communication network for IMT-2000 (International Mobile Telecommunications-2000). We are currently developing OCSE-CN (Operation Control Information Storage Equipment-CN) for this future system. ASCP (Advanced Intelligent Network) service control point centralized storage equipment (OCSE-A, operation control information storage equipment-A) is also under development for the NE-management OPS of advanced service control nodes (ASCP, AIN service control point), the core of the AIN, which will enable easy service offering in the next-generation system. Reducing maintenance workload, preventing operational errors, reducing the cost of NE-management OPS hardware, and improving the reliability of the NE-management OPS will continue to be our objectives in these new development tasks.