Operation Technologies

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Mobile communication networks are becoming increasingly large and complex, following the launch of IMT-2000 services. As a result, advancement and greater efficiency is required in Operation Support Systems (OSS).
This article reviews the advanced OSS for IMT-2000, with reference to network monitoring, network control, element monitoring and element management, for which special efforts have been made.

1. Introduction

Operation Support System (OSS) is indispensable for building, maintaining and operating mobile communication networks. In general, design & construction work and operation & maintenance work require prompt action based on strategic information management. In Personal Digital Cellular (PDC) networks, NTT DoCoMo has built an OSS that integrates various network equipment and raised the efficiency of operation & maintenance work through OSS [1].

In order to roll out the International Mobile Telecommunications-2000 (IMT-2000) services [2], NTT DoCoMo has developed an OSS enhanced by the wealth of technologies based on past operations and maintenance:

① Identifies the network status and reinforces network control focusing on improved service quality;
② Achieves data flow through construction, maintenance, quality control and planning tasks; and
③ Centralizes the maintenance and operation of the PDC network and the IMT-2000 network.

This article reviews the configuration of OSS for IMT-2000, and explains network monitoring and control, in addition to element monitoring and management.

2. OSS System Configuration

In general, the model of the Telecommunication Management

Network (TMN) specified by the International Telecommunication Union-Telecommunication standardization sector (ITU-T) [3] divides the management functions of communication networks into 4 layers of Operation System Functions (OSF): Element Management, Network Management, Service Management, and Business Management. The functions of the IMT-2000 OSS are categorized as follows in accordance with these layers. **Figure 1** shows the architecture of the IMT-2000 OSS.

(1) NE Management Layer

The Network Element (NE) management layer, which is for the operation and maintenance of each NE, consists of the following servers.

① Network Element Management System

Network element management systems are installed to monitor radio access equipment, switching equipment, transmission equipment and other network elements. Each network element management system manages the status of NE faults, performance, files and station data updating, etc.

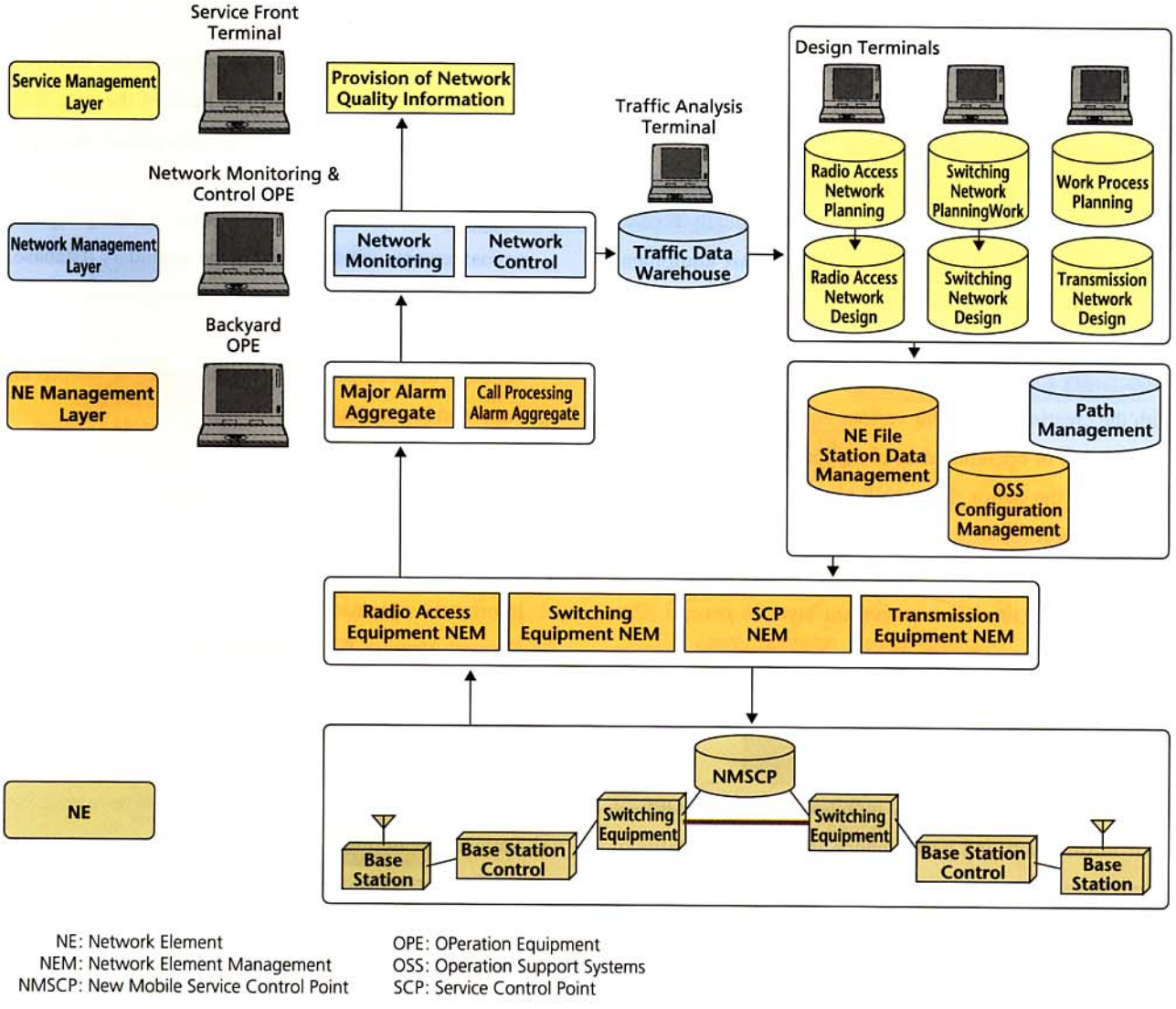
Also, the network element management system informs the major alarm aggregate server of most urgent alarms (major alarms).

② Major Alarm Aggregate Server

The major alarm aggregate server gathers and manages major alarms of all NEs via the network element management systems. Major alarms from the server are notified to the backyard OPeration Equipment (OPE) that constitutes the control desk. This arrangement enables the operator to identify the activation status of all NE major alarms at one backyard OPE.

③ Call Processing Alarm Server

The call processing alarm server gathers and stores call release factors due to semi-normal processing from radio



NE: Network Element
NEM: Network Element Management
NMSCP: New Mobile Service Control Point
OPE: OPeration Equipment
OSS: Operation Support Systems
SCP: Service Control Point

Figure 1 OSS Architecture

access equipment and switching equipment. When semi-normal processing frequently occurs, the call processing alarm server informs the backyard OPE, the network monitoring OPE and the service front terminal as an alarm.

Moreover, in response to customer's complaints about call abnormalities, the operator can check the status of the abnormalities with reference to the database of the call processing alarm server using the subscriber number as the key.

④ NE File Management System

This manages the version of systems files of each NE and station data, and executes the remote updating of files in coordination with the network element management system. In order to make the data flow through with the use of station data, station data is updated in the order of [design system → NE file management system → network element management system → NE], and the operation data of various equipment (OSS server/OPE) is created and updated in the order of [NE file management system → configuration management system → network element management system/OPE].

⑤ Configuration Management System

This system appropriates NE files and station data from the station data management server, automatically creates the data required for the operation of various equipment (OSS server operation data and OPE screen display data), and downloads the data to the equipment. This makes it unnecessary for the operator to make new entries associated with the creation of data for various equipment, and enables the updating of operation data of equipment in sync with the updating of the station data of NE itself.

⑥ Backyard OPE

This is a control desk for carrying out maintenance tasks associated with the NE management layer in general. One OPE monitors and controls various NEs based on common operation.

(2) Network Management Layer

① Network Monitoring System

This informs the network monitor and control OPE of fault information and performance information (status of resource usage) of radio access equipment and switching equipment required for network control, in addition to the circuit connection status, call loss status and other traffic data, in coordination with the network element management system and the network control system.

This enables the operator to simultaneously identify the service quality status in the entire network, from the access network up to the switching network, and the status of network components, that is, the network status.

② Network Control System

The network control system gathers fault information and performance information on switching systems, detects congestion and executes network control by ordering restriction control to switching systems and base station controllers as required.

This enables prompt and accurate network control aimed at assuring service quality and maximizing the use of networks.

③ Traffic Data Warehouse

The traffic data warehouse gathers traffic information in radio access equipment and switching equipment on a regular basis, via the network element management system and the network control system. The primary database, in which the data is stored, is designed for non-standard forms i.e. the user can freely create the forms. Parts of the data stored in the primary database are automatically edited and processed at nighttime to suit standard forms required for periodic management, such as weekly reports, monthly reports and annual reports, and are stored in the secondary database.

The quality control operator applies general-purpose On-Line Analytical Processing (OLAP) to the network data stored in these databases to promptly analyze various data.

④ Path Management Server

The path management server receives the circuit order information of the transmission design system, automatically opens the circuit and manages the transmission path configuration information. It also detects faults in the path and informs the operator of such faults.

⑤ Network Monitor & Control OPE

This is a control desk for accessing the network monitoring system and the network control system, for the purpose of monitoring and controlling the network.

(3) Service Management Layer

① Service Monitoring System

The service monitoring system provides network information that are useful for identifying the service quality and sending it to the service front, including the call loss status identified by the network monitoring system in the network management layer and call processing alarms. This enables

the service front to identify the network quality status at real-time and deal with customers accordingly.

② Planning System

The planning system receives traffic information from the traffic data warehouse, assesses the traffic records, forecasts the traffic and develops element plans.

③ Design System

According to the planning information from the planning system, the design system is in charge of the logical network design such as the allocation of NEs, path design, capacity design and other physical designs. It also creates station data based on the design information.

As described above, the IMT-2000 OSS is adapted to large-scale operations by integrating various services and systems. The following sections will explain network monitoring, network control, network element management and network element management, which have been especially enhanced in the IMT-2000 OSS.

3. Network Monitoring

The existing network monitoring system monitors the relay-switching network by calculating the call volume and the connection rate between switching systems through common channel signal monitoring. In other words, it is a monitoring system specializing in switching networks.

NTT DoCoMo has developed a network monitoring system with the following two objectives in mind, in order to identify the network status and execute network control focusing on the improvement of service quality, which is one of our basic OSS concepts [4].

- Monitor the traffic status of the entire network, from the access network to the switching network.
- Monitor the connection status between switching stations, and monitor call losses. Execute monitoring in a manner that complies with the customers' perception.

(1) Configuration of Network Monitoring Functions

Figure 2 shows an example of the configuration of network

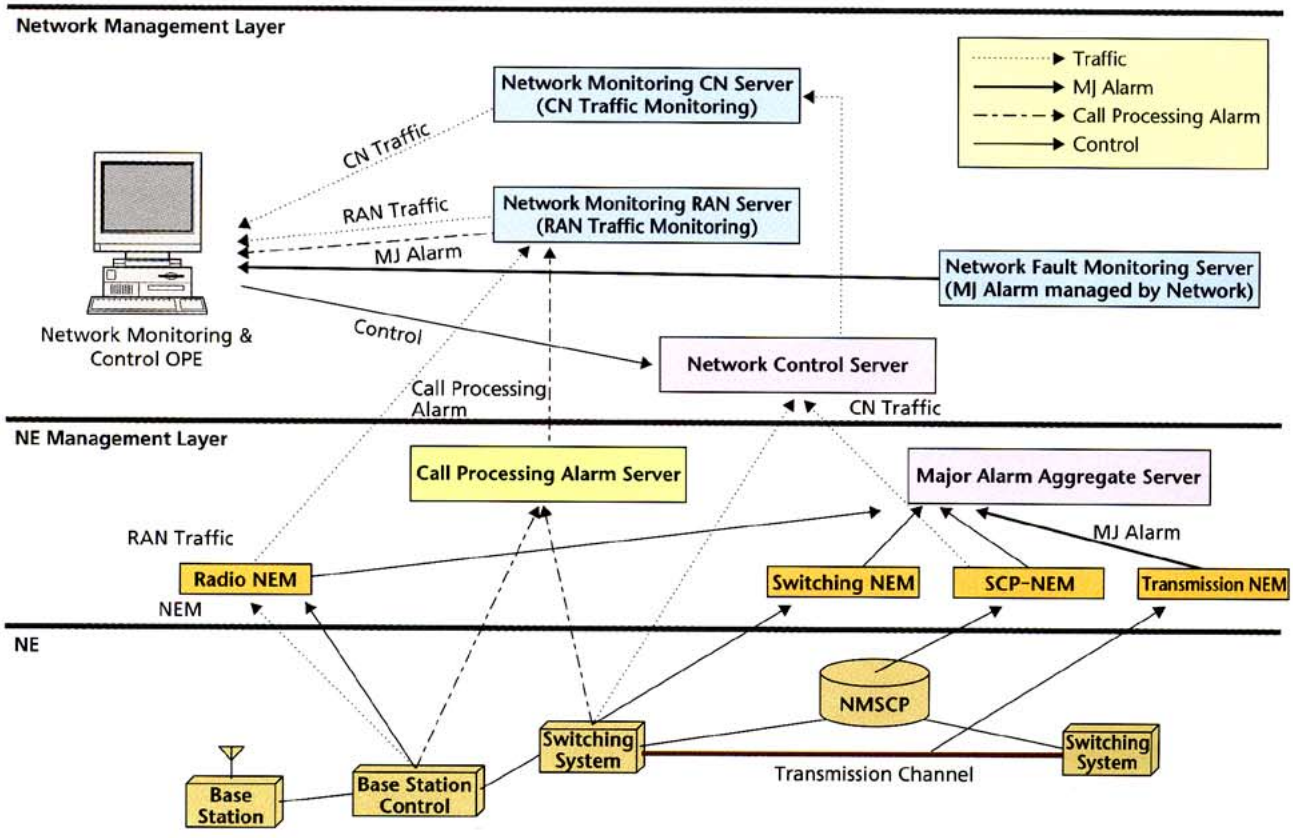


Figure 2 Configuration of Network Monitoring Functions

monitoring functions.

The network monitoring system monitors the traffic status and the equipment status of the network as a whole, from the access network to the switching network, based on coordination between the network monitoring Core Network (CN) server, the network monitoring Radio Access Network (RAN) server and the network monitoring fault server, as shown in Figure 2.

(2) Characteristics of Network Monitoring

There are following three characteristics of network monitoring.

① Total monitoring from the access network to the switching network: The operator monitors the service quality status of the nationwide network, from RAN through CN. The operator can also check the level of impact on services in the event of access network failure, by displaying the affected area in the map.

② CN monitors the call loss status from the call-originating switching system to the call-terminating switching system, end-to-end. This makes it possible to monitor the connection quality and determine, for example, where it is difficult to establish calls.

③ NE performance information and fault information are displayed to identify the causes of network failure according to RAN strata and CN strata. Network control is possible with reference to such detailed information.

As the status of NE faults, network congestion and restriction can always be identified, services can constantly be provided in a stable manner. **Figure 3** shows an example of the screen.

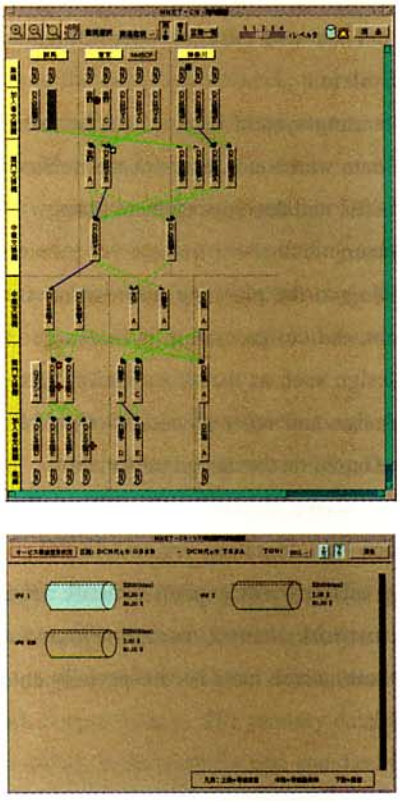


Figure 3 Network Monitoring GUI (Example: Display of CN Strata and VP Band)

4. Network Control

Normally, elements of the communication network are designed in accordance with traffic volume. If a large volume of traffic in excess of the element capacity flows in, the network would suffer from congestion and stop functioning.

Several patterns of congestion are as follows:

- Congestion caused by disasters, etc.
- Congestion due to many calls terminating at a particular phone number (fixed/mobile)
- Congestion due to traffic generated by events such as congratulation calls
- Spot congestion at concerts and cherry-blossom viewing parties
- Congestion caused by i-mode mail and large-volume packet-switched communications
- Congestion caused by broadband communications such as audiovisual communications

There are two ways to carry out traffic control to deal with congestion: internal control, which is done by the node itself; and external control, which is done by the traffic monitor & control system. The former is a self-defense mechanism against sudden increases in traffic, whereas the latter is a control method that takes the entire network into account with the aim to maximize the use of communication network resources.

In traffic control, it is important to identify the signs of congestion before the traffic flows into the network and take adequate measures to minimize the impact of the abnormal traffic on the network. Also, less network resources must be used on processing calls and signals annulled by traffic control, and execute congestion detection and restriction control as close as possible to the source, in order to use network resources in an efficient manner. **Figure 4** shows a concept of traffic monitor and control system.

5. Network Element Monitoring

Network elements are based on a multivendor configuration. The network element Monitoring system is vital to maintain

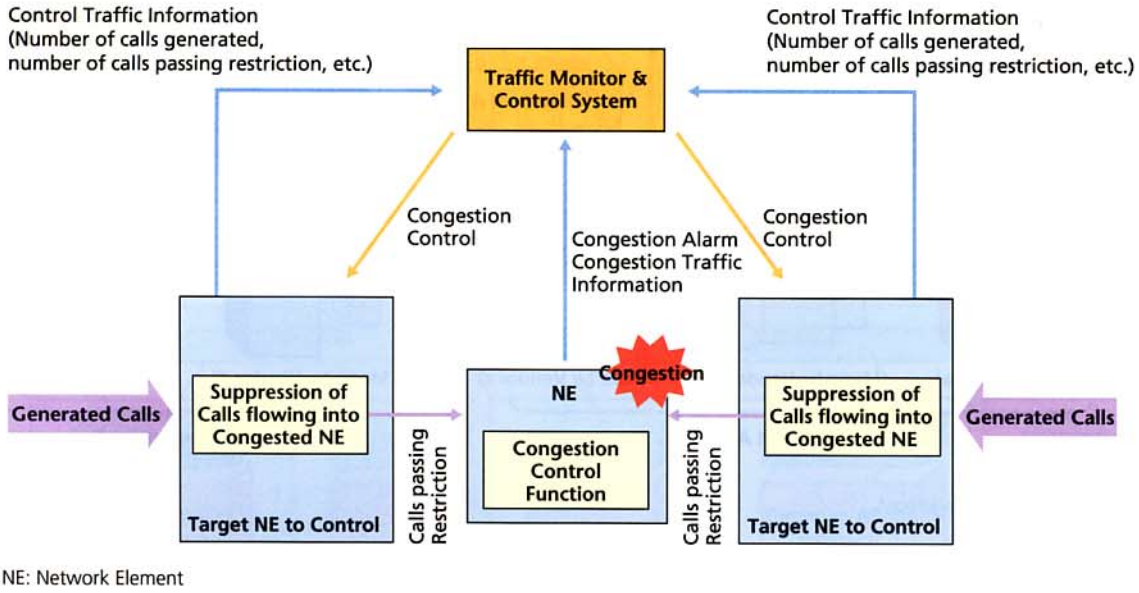


Figure 4 Concept of Traffic Monitor and Control System

efficiently and operate huge numbers of various network elements.

(1) Network Elements in a Multivendor Environment

For example, an access network consists of the Base Transceiver Station (BTS), the Radio Network Controller (RNC) and the Multimedia signal Processing Equipment (MPE). Each equipment is supplied by multiple vendors. As illustrated in **Figure 5**, the design philosophy varies between every vendors even if the equipment is the same, resulting in a totally different equipment configuration. Thus, in general, an OSS unique to each network element has to be installed, which may add up to a dozen types or more, as shown in **Figure 6**.

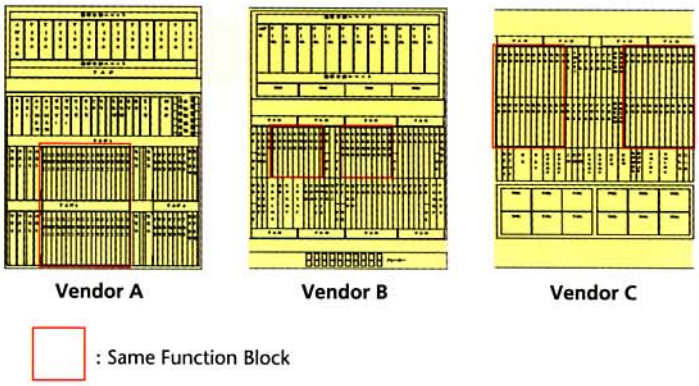


Figure 5 Different Configuration of Same Equipment by Vendors

In IMT-2000, there is only one OSS due to maintenance requirements, as shown in **Figure 7**. The same concept has been applied to node systems, transmission systems and other network elements.

(2) Monitoring Functions of Network Elements

There are two functions required in network element operations.

① Execute real-time monitoring and control in response to reports from NE, and identify the operation status of NE. At the same time, identify the impact on the network and services.

② Gather various traffic information on NE, and provide the information to additional element installation planning tasks.

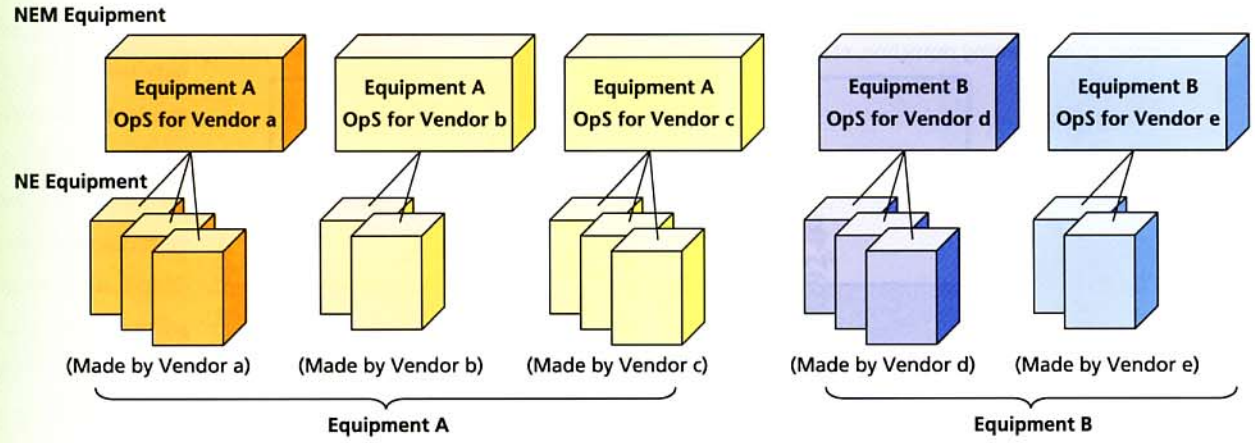
These operation functions must be fulfilled by various NEs in a multivendor environment. However, if the monitoring conditions and the information gathered depend on each NE, it would be difficult to monitor the entire network, analyze the information and promptly deal with faults in a uniform manner. As a result, it would increase the number of OSS units and maintenance tasks.

(3) How to fulfill Network Monitoring Functions

For the operation of access network elements in a multivendor environment, NTT DoCoMo developed an operation system with the following factors in mind, including NE, so that the maintenance staff would hardly recognize the differences in vendors and equipment .

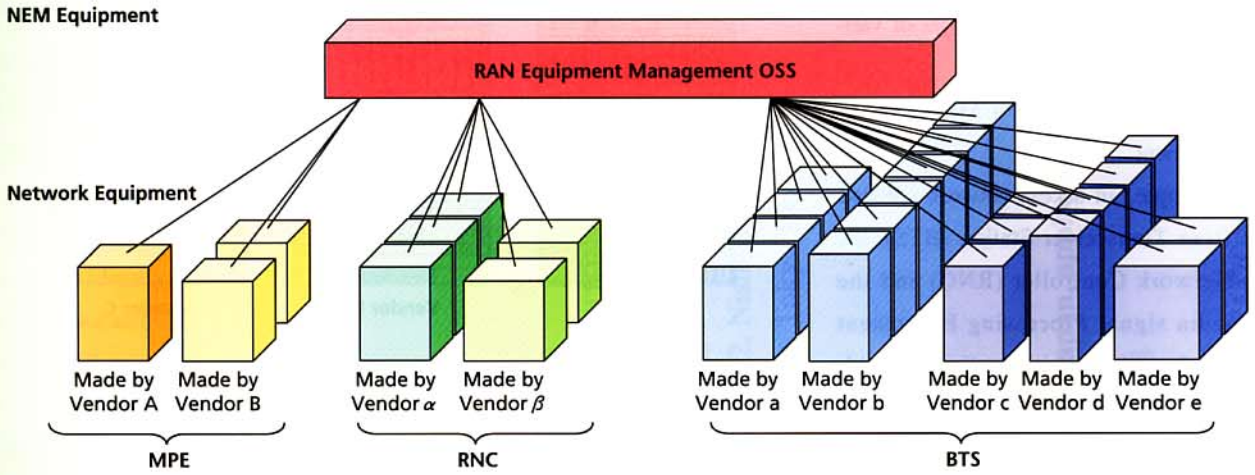
① Uniform NE Monitoring Conditions

As the hardware of NE is totally different between vendors, the NE side is equipped with a vendor-common



NE: Network Element
NEM: Network Element Management
OpS: Operation System

Figure 6 Legacy System divided by Equipment and Vendor



BTS: Base Transceiver Station
NE: Network Element
NEM: Network Element Management
MPE: Mobile multimedia Proccessing Equipment
OSS: Operation Support Systems
RNC: Radio Network Controller

Figure 7 Equipment/Vendor-integrated OSS

APplication (AP) that specifies the Application Program Interface (API) for each function required as a vendor-common Operation And Maintenance (OAM) function. The exchange of information for operations is based on a common interface (**Figure 8**).

Under this arrangement, maintenance staff does not have to worry about the vendors apart from the cards at the very bottom. Also, when determining the impact of element faults on services offered to customers, the maintenance staff can monitor and control equipment supplied by different vendors under the same conditions.

② Standardized Format of Gathered Information

The functions to gather information including traffic data were standardized so that the maintenance staff would not have to worry about the differences in vendors.

③ Standardized Signal Interface between NE and OSS

The signal interface was standardized for all NE and vendor types. All NEs can be accommodated in one NE monitoring OSS.

As a result, the maintenance staff can normally engage in operations without having to worry about the differences in equipment due to vendors. Not only does it help prevent operation mistakes and reduce maintenance tasks, it also cuts the costs for developing OSS equipment as the OSS equipment is now common to all vendors.

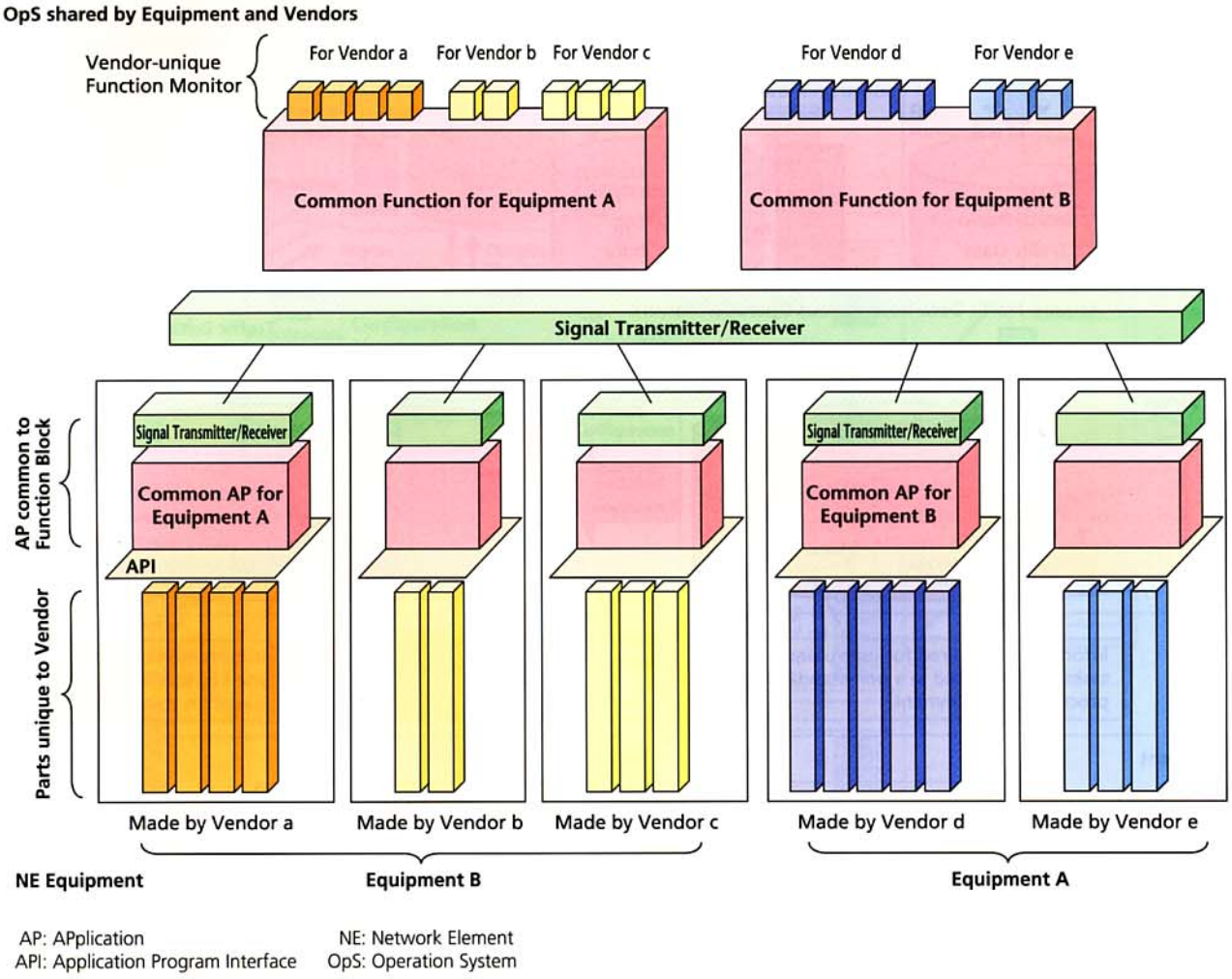


Figure 8 Element Operation absorbing Differences among Vendors

6. Network Element Management

It is important to offer new services and better quality by installing various network equipment in an accurate and speedy manner in response to customer's demand in advance of competitors. These equipments include many base stations, various switching systems, Service Control Points (SCP) and common channel signaling equipment that are installed nationwide, as well as transmission equipment that interconnect switching stations, and entrance equipment that connect switching stations with base stations.

The following three functions are required for the management of equipments in such large-scale networks.

① Function to efficiently gather and analyze large volumes of network quality data (network quality control function);

② Function to install additional elements data file for existing equipments and new elements data file for new services equipment in an efficient and speedy manner (remote file updating function); and

③ Function to efficiently create and edit elements data for equipments designing (equipments design function).

By coordinating these three functions, network quality control and remote file updating were achieved.

(1) Network Quality Control

A data warehouse is provided for network quality control, which stores various traffic data and improves the efficiency of traffic data analysis. **Figure 9** shows an example of the configuration of a traffic data warehouse.

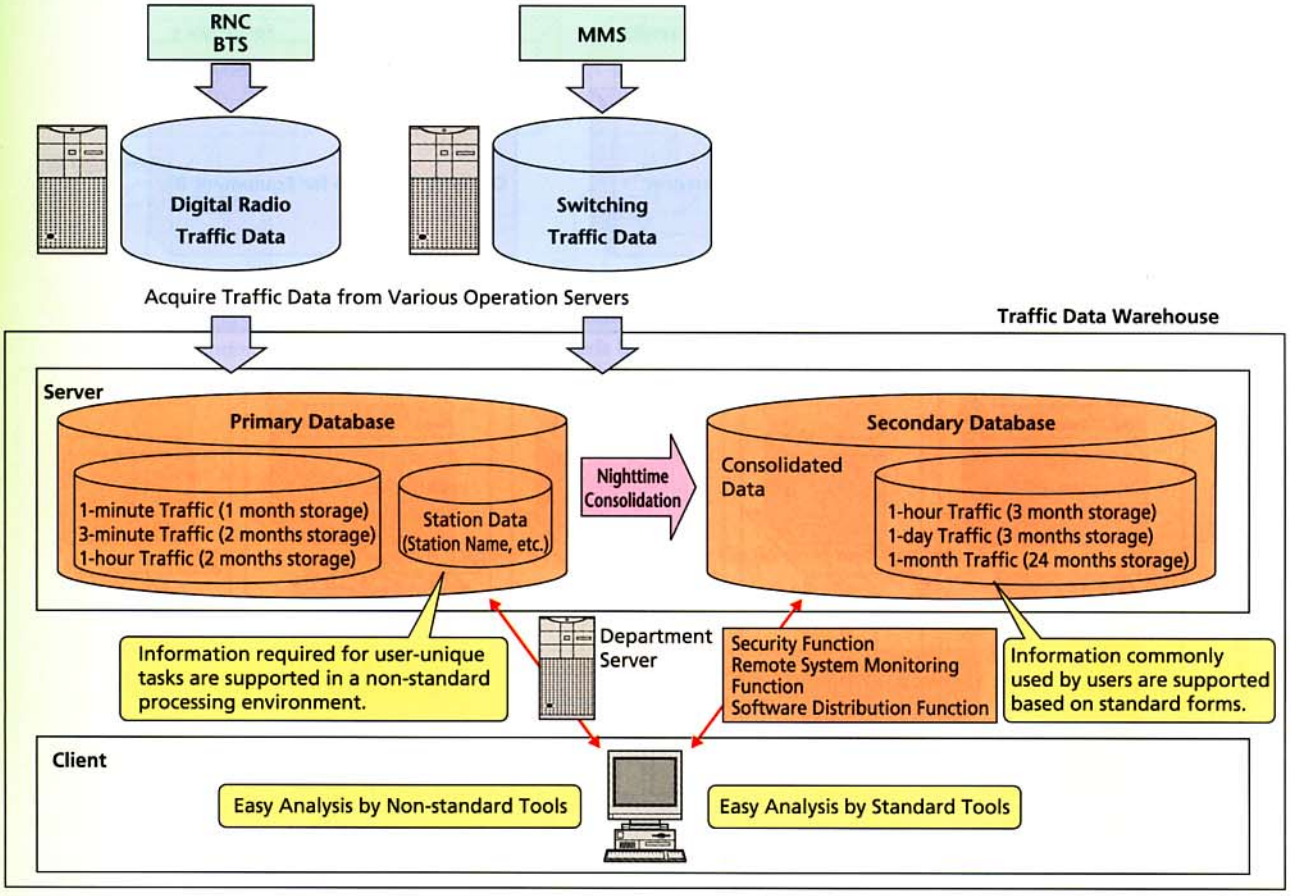
The traffic data warehouse offers the following functions.

① Automatic Traffic Data Gathering

Traffic data is gathered on a regular basis (30 minutes – 1 hour) from the server of various network element management systems that have an interface with NEs. The data is then stored in the primary database.

② Traffic Data Consolidation Function

At nighttime, calculations are collectively performed



BTS: Base Transceiver Station
MMS: Mobile Multimedia switching System
RNC: Radio Network Controller

Figure 9 Configuration of Traffic Data Warehouse

with respect to various traffic data stored in the primary database and items for various forms are created. Data consolidated in this process is stored in the secondary database.

③ Search/Form Output Function by Data Search Tool

There are two types of forms supported: standard and non-standard. As the analysis of standard forms is based on a fixed pattern, the information in standard forms can be shared by multiple users. Non-standard forms are arranged by the user at discretion for specific tasks, which can be analyzed in detail.

(2) Remote File Updating

The remote file updating system is provided to accelerate the process of updating NE files (station data, system files, etc.) upon the installation of additional NEs, and to improve the efficiency of updating operation data of OSS.

OSS accelerates the download process by adding the following functions in the NE file management system. **Figure 10** illustrates the flow of NE files and operation data between systems.

The NE file management system offers the following functions.

① NE File Online Registration and Version Management Function

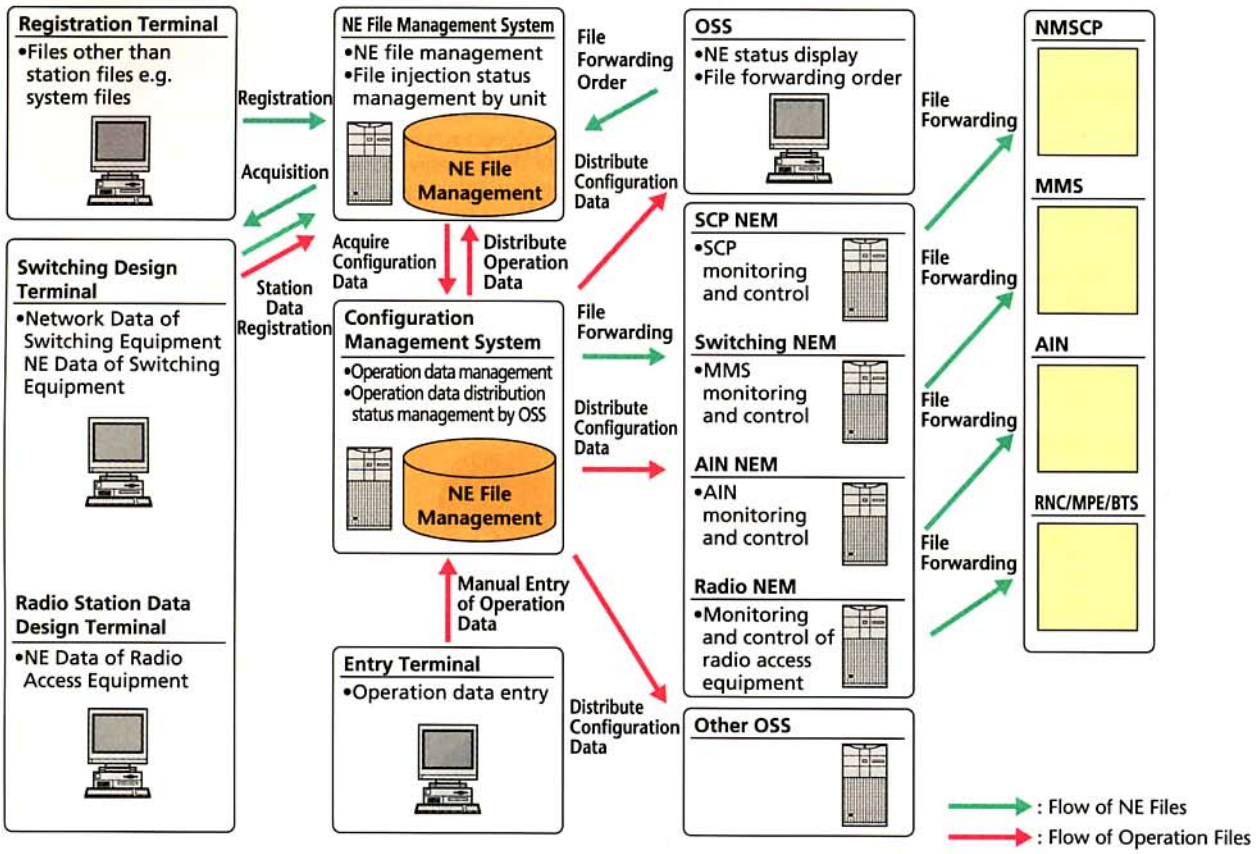
NE files can be registered online, in coordination with the backyard OPE and the design system. Also, the required version number can be managed with respect to each NE file, to manage the file status according to each version.

This makes it possible to distinguish the version in use at each NE unit, which helps prevent the selection of the wrong file and reduces the required disk space.

② NE File Forwarding Function

Files are forwarded to NE online in coordination with the OSS for the New Mobile Service Control Point (NMSCP), the switching equipment and the radio access equipment. The status of forwarding/updating results are also managed.

This function, which eliminates the need to go to the site



AIN: Advanced Intelligent Network
BTS: Base Transceiver Station
MMS: Mobile Multimedia switching System
MPE: Mobile multimedia Proccessing Equipment
NE: Network Element
NEM: Network Element Management
NMSCP: New Mobile Service Control Point
OSS: Operation Support Systems
RNC: Radio Network Controller
SCP: Service Control Point

Figure 10 Flow of NE Files and Operation Data

where the NE is installed, enables NE file updating by remote control.

The OSS configuration management system offers the following functions to raise the efficiency of updating operation data required by OSS.

(3) Operation Data Management Function

Data required for OSS operation data is automatically acquired from the station data, in coordination with the station design system and the NE file management system. Only the data that are missing from the station data are entered by the operation data entry tool. The combination of these data are managed as operation data and their consistency is checked within the system to assure the data. This arrangement has made it possible to reduce the injection of operation data and promptly reflect operation data in each OSS.

7. Conclusion

This article reviewed the monitoring and control of networks based on the IMT-2000 OSS, and the monitoring and management of elements.

OSS is expected to make significant contributions to construction, maintenance and operations in line with the expansion of the IMT-2000 service area and the increase in users.

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GLOSSARY

AIN: Advanced Intelligent Network
AP: APplication
API: Application Program Interface
BTS: Base Transceiver Station
CN: Core Network
IMT-2000: International Mobile Telecommunications-2000
ITU-T: International Telecommunication Union-Telecommunication standardization sector
MJ: MaJor
MMS: Mobile Multimedia switching System
MPE: Mobile multimedia Proccessing Equipment
NE: Network Element
NEM: Network Element Management
NMSCP: New Mobile Service Control Point
OAM: Operation And Maintenance
OLAP: On-Line Analytical Processing
OPE: OPeration Equipment
OpS: Operation System
OSF: Operation System Function
OSS: Operation Support Systems
PDC: Personal Digital Cellular
RAN: Radio Access Network
RNC: Radio Network Controller
SCP: Service Control Point
TMN: Telecommunication Management Network