Management System for Mobile Networks

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Fujitsu is working on the development of an integrated system to be used in the future for managing various communication networks. This paper introduces a system for managing one such communication network: a mobile network. It describes the current status of this development and how it could proceed in the future, based on the features of managing mobile networks. First, this paper gives a general introduction of systems for managing mobile networks, and then describes the features of managing networks and the problems involved. It goes on to explain the main points of various measures that can be used to solve these problems. Next, this paper explains the architectural concepts behind system and software configurations used to achieve these measures. It gives an overview of self-organizing network (SON) that is a characteristic of network management systems and that allows Fujitsu to differentiate itself from its competitors. The last part explains the concept of a system to integrate communication management systems that have been individually developed.

1. Introduction

For Fujitsu, the development of a management system for a mobile network is a trigger to work on integrating the communication management systems currently developed for individual projects.

Based on the features of the management system intended for a mobile network, this paper describes the way to build a system and activities for future functional enhancement and orientation.

2. Network management system

This section presents a general outline of a network management system.

A network management system functions as a human interface with a network for an operator who maintains and operates the network. It is indispensable for network quality maintenance activities such as visualizing the status of a network, including the constituent communication devices, from various perspectives. It lets the network operator know whether the entire network is operating normally or whether there are any faults.

Figure 1 is a conceptual diagram of a network management system that takes a mobile network as an example.

A mobile network is composed of a base station network, which comprises mobile network base station equipment units (hereafter "base stations") that directly communicate with user terminals (mobile terminals). It also contains a core network consisting of switching devices used in configuring communication paths between network devices, and a transmission network mainly including transmission equipment units that connect those network devices. A management system for operating and maintaining these networks is composed of element management systems (EMSes) that directly manage the respective network devices

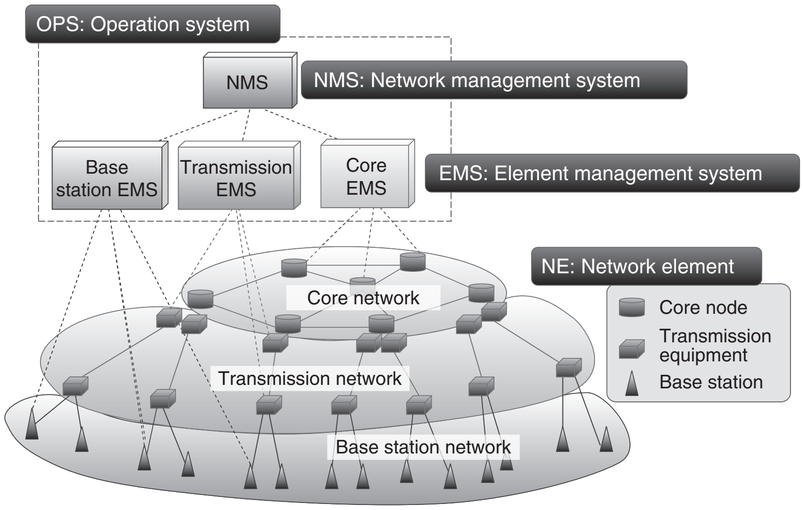

Figure 1
Mobile network management.

and a network management system (NMS) that manages them in an integrated manner. The management system consisting of the EMSes and NMS is sometimes referred to as an operation system (OPS).

The four main functions of an OPS are:

- Fault management
- Configuration management
- Performance management
- Security management

These functions will be described later.

3. Features of base station EMS

This section focuses on EMS, which manages a base station network device, and presents its features.

3.1 Features of base station network and challenges

1) Movement of user terminals and guarantee of communication quality

To manage a transmission network or core network, the EMS can be directly connected with the constituent network devices to monitor and control the devices and thus grasp and maintain the quality of the network. In a base station network, however, a user terminal, which is a device that constitutes the network, is connected via a wireless link and the terminal itself moves around in the network. For this reason, an unspecified large number of user terminals may be connected with base stations. In a base station network, in which such an unspecified large number of user terminals make random access, constantly managing the communication status of each user terminal as a network device is cumbersome. Further, the base station EMS is not equipped with a function to identify user terminals for constant status management.

However, it is important for mobile network end users to be able to communicate anytime and anywhere. One challenge to overcome in this respect is to let a network operator see all possible locations of moving end users as a service area whenever possible and guarantee a certain level of communication quality in the entire service area.

2) Handling numerous base stations

Operators deploy tens of thousands of base stations in order to build and cover a large service area with a high-quality network (number of 3G base stations in Japan as of the end of February 2011: 243 214).[1] The capital expenditure (CAPEX) for introducing the base stations and operational expenditure (OPEX) for maintaining and operating the numerous base stations are huge amounts. In particular, ensuring the quality for the service area described in 1) above requires fine-tuned parameter settings for individual base stations. Parameter settings for each and every base station are naturally expected to require an enormous number of person-hours and how to address this issue is a challenge.

3.2 Requirements of base station EMS

As a solution to the challenges mentioned in the previous subsection, the following functions are required of the base station EMS.

3.2.1 Understanding of network conditions

1) Cell statistics collection

Rather than identifying user terminals to monitor the respective communication status, statistics can be collected for each cell (sector), which is the smallest unit for a base station to communicate with user terminals. Accordingly, among the required functions is statistics management, in which an understanding of communication statuses between user terminals and base stations is obtained as statistics. Examples of statistical data to be collected include:

- Number of successful and failed incoming and outgoing calls
- Number of dropped calls
- Number of successful and failed handovers
- Traffic volume (throughput)

The pieces of data to be collected in an LTE system are formulated by the 3rd Generation Partnership Project (3GPP)[2) as specific requirements for standardization.

In this way, collecting statistics by the base station EMS is an important function for gaining an understanding of network conditions.

2) Wireless trace

In addition to collecting cell edge statistics, a function to collect the quality data for wireless sections is also required. Examples of the items of data to be collected include:

- Wireless transmission power
- Wireless reception power
- Wireless intereference signal level

Implementing this function in the base station allows more detailed quality data to be acquired for the specific wireless sections by using limited test terminals.

3.2.2 Network optimization

1) Base station parameter setting

After checking the communication quality status of the service area based on the data collected by the functions described in the subsection "Understanding of network conditions" above, base station parameters must be changed as appropriate so as to optimize the quality of the area. The base station EMS is required to have a function to set parameters of the base station equipment to be managed. The base station EMS needs a capability to not simply set the parameters but to maintain the consistency between base stations by synchronized setting as in handover parameters. To achieve this capability, functions such as collective setting based on scheduling are also required.

2) Base station control

The EMS needs to have control functions such as call barring control to address congestion and block control for base station maintenance. However, the large number of base stations deployed in a network makes it inefficient to control them individually. For that reason, as with parameter setting, the base station control needs a simplification function to reduce the burden of the process by such means as collective control and autonomous control.

3) Base station plug and play

Functions for saving network operator labor are also important for simplifying the initial setting of base stations when they are started. These functions may include ones such as a plug and play function that allows base stations to be automatically detected so that data can be registered with the EMS and software updates and parameter settings can be performed for base stations.

4) Provision of SON functions

In recent years, there has been demand for self-organizing network (SON)[3] functions, which is intended for autonomously optimizing the network with minimum network operator intervention. For the EMS, it is important to adopt an architecture that allows these functions to be easily implemented.

3.2.3 Functions of Fujitsu's mobile network EMS for global markets

Based on the requirements described above, Fujitsu's EMS is equipped with the following functions for global markets.

- Cell statistics collection function
- Wireless trace function
- Parameter scheduling collective setting function
- Base station scheduling collective control function
- Base station plug and play function

It also adopts a flexible architecture in view of providing SON functions.

4. NM architecture and its features

A mobile NMS is required to have flexible scalability in accordance with the scale of a network. The present system is capable of managing in an integrated manner the entire network including the transmission and core networks as well as the base station network on one platform. Hence, it can help reduce carrier CAPEX and OPEX in addition to standardizing operations.

The network management system covers functions referred to as "FCPS," which stands for fault, configuration, performance and security management, specified by Open Systems Interconnection (OSI).

1) Fault management

Fault management provides a fault monitoring function for a mobile network. It monitors the alive status of network devices and traps from the devices and notifies the user of information on any faults.

2) Configuration management

Configuration management includes configuration information management and setting change of network devices. It provides functions such as wireless resource management, station data management and software upgrade. It also offers plug and play, which detects whenever any device is added to the network and automatically downloads the latest firmware.

3) Performance management

To maintain the network availability, this function monitors the traffic and wireless resource status of network devices and notifies the user of information on a fault if any threshold is exceeded.

4) Security management

Security management controls access to resources managed by the network management system (by user management, access log, etc.).

Such an NMS is based on two concepts: component-orientedness and network virtualization. **Figure 2** shows the configuration of the present system.

1) Component-orientedness

The present system is applied by using distribution technology based on the asynchronous messaging technology of JavaEE used in enterprise systems and comprised of loosely coupled functional components with high independence. The present system has two message models defined including one-way and two-way models. It allows parallel processing of large-volume transactions (load balancing) and scale-out configuration and the system can be flexibly extended according to the requirements.

To reduce the weight of each functional component, various resources (such as DB connections, threads, transactions and messages) used by the functional components are realized by a plug-in structure that makes

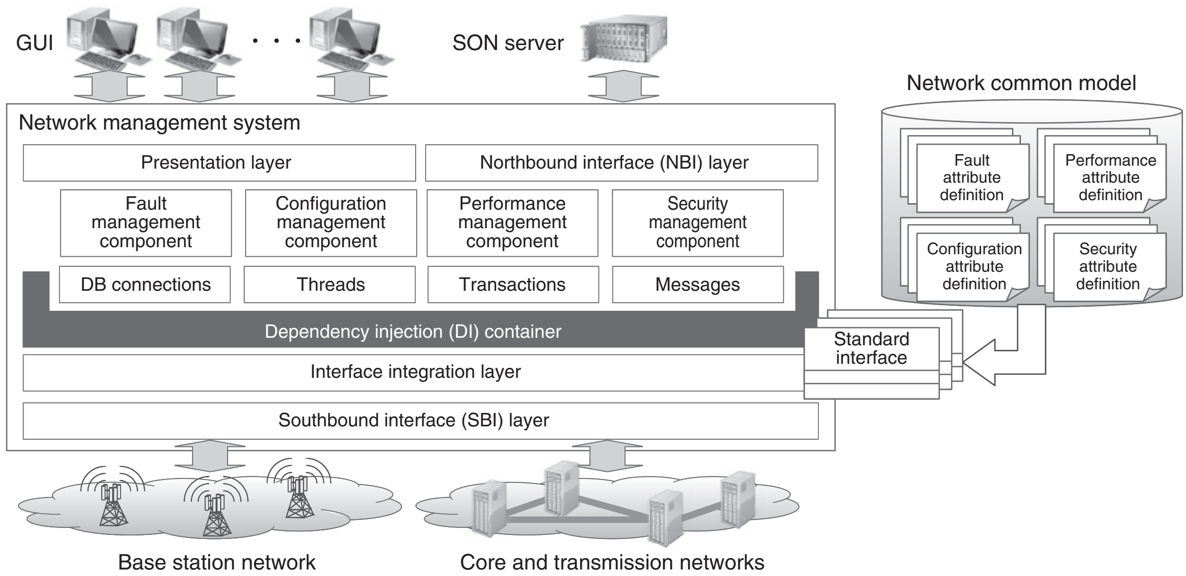

Figure 2
Structure of mobile network management system.

use of Dependency Injection (DI) Container. By rewriting the configuration file, this allows resources to be changed so that they can be used simply (Figure 2).

2) Network virtualization

To have integrated management of a network on one platform, various network devices with different communication protocols and data structures must be centrally managed. For that purpose, a network common model, which has been built by abstracting the data structures of network devices from the perspective of the network management system, is newly defined.

The network common model derives from the abstraction of the attributes and operations provided by network devices based on the standard management model specified by the recommendations of the 3GPP, etc.

On the model of the network common model, by creating a standard interface class handled by functional components, the functional components can have structures independent of the data structures of network devices. This makes functional components more reusable and makes it possible to use them in common with other network devices on the integrated network (Figure 2).

In future NMSes, we intend to flexibly enhance the functions as required to include the realization of SON functions that help reduce OPEX and connection with SON servers of other companies, in addition to the management functions described above.

5. Extension of SON functions

SON provides functions discussed by the next generation mobile networks (NGMN) and 3GPP, which are new and advanced communication network management functions for the current purpose of reducing communication network operator OPEX and CAPEX.

It is obvious that the mobile communication environment will see explosive growth in communication traffic and an increase in the number of base stations in the future. Under such circumstances, constructing a mobile network that can be used anytime with a sense of security and satisfaction is a challenge. From the viewpoint of communication operators, suppressing the increase in operational and equipment costs for realizing them is another challenge.

In the management system currently being developed, we plan to incorporate some ways to address the challenges above. Specifically, SON function software equipped with the know-how and knowledge on the operation and maintenance for each phase (planning, construction and operation) of the communication lifecycle will be run on the management system. This will allow a highly reliable and efficient mobile communication network to be offered.

The configurations for the implementation of SON include the following three types.

1) Distributed SON (D-SON)

As shown in **Figure 3**, relevant base stations and cells are managed between base stations and SON functions are executed based on the decisions of the base stations.

2) Centralized SON (C-SON)

As shown in Figure 3, the statuses of base stations and cells are managed by the higher-level management layer and control of the individual base stations is executed based on the decisions and instructions by the higher-level management layer.

3) Hybrid SON (H-SON)

This configuration integrates D-SON and C-SON.

In the management system described in this paper, we plan to execute these SON functions for our network elements (NEs) by using H-SON.

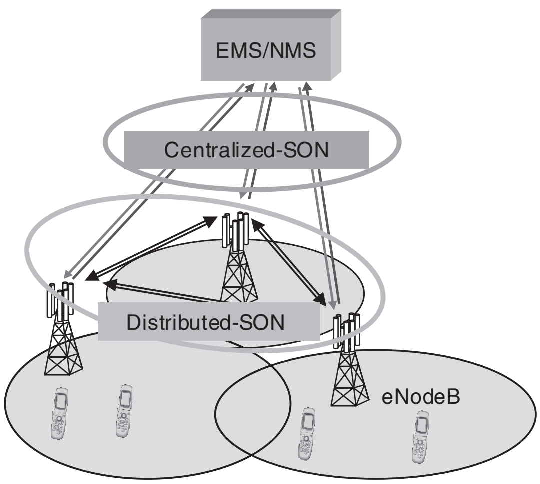

Figure 3
SON structure.

6. Future development

Mobile network systems managed by customers are composed of a wide variety of NEs including entrance communication equipment (wireless/optical) such as 3G base stations, LTE base stations and mobile back haul (MBH) and core network equipment and the diversification of equipment to be managed is expected to continue. Accordingly, partially optimizing the individual pieces of equipment is not enough for operation and maintenance by using EMSes. It is necessary to construct an OPS that manages an entire network system from the service perspective.

It is important to optimize the network system as a whole so as to allow the burden on operators to be reduced and further decrease OPEX. Specifically, for example, if cell addition is judged necessary when a traffic increase is detected in a certain area, not only cell addition control for base stations but also bandwidth increase control of entrance communication equipment (wireless/optical) for the relevant base stations and parameter setting control for the core network should be comprehensively realized.

To achieve this integrated control, management that covers the entire network constituents must be made possible and, in the future, providing support for other companies' products as well as Fujitsu's will be necessary.

Furthermore, provision of an OPS for customers will make it easier to propose highly compatible NEs for operation and maintenance and allow the realization of Fujitsu's original differentiating functions combining the OPS and NEs. Accordingly, we intend to continue with the coordinated development with NEs to achieve human-centric operation and maintenance and bring it to market.

7. Conclusion

This paper has presented a mobile network management system.

At present, the scope of management only includes mobile devices and their base station networks (macro, femto, pico, etc.). We are committed to making continued efforts to develop the management system and make it capable of integrating various communication networks. In addition, we intend to further improve not only the basic performance including reliability, along with the increase and complication of items to be managed, but also technical and system construction capabilities. In this way, we will allow timely introduction of SON functions as differentiating technology, and thereby contribute to the expansion of the management system market while meeting operators' needs.

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