Open-air Booster | LTE Access System OPS | Accommodating Legacy Systems

Technology Reports

Enhancement of Open-air Booster Monitoring Functions

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For improved reception in small-scale outdoor areas with weak electric fields, we are working on the introduction of an open-air booster. The monitoring and control of open-air boosters have hitherto been performed with simple dedicated monitor terminals. However, due to the rapidly growing number of installations, the importance of these boosters to NTT DOCOMO services has been increasing, and to allow them to be maintained and monitored to the same level as ordinary base stations, there is now a pressing need for these functions to be accommodated within the access system OPS. In this article, we present an overview of the route towards integrating these boosters into the access system OPS, the configuration of the maintenance network, and the additional functions.

1. Introduction

In the operation system for base stations in the LTE Access Operation System (LTE-AOPS), we have already integrated functions for the monitoring of open-air boosters that were built, maintained and operated by NTT DOCOMO. These open-air boosters were developed to offer better coverage in small-scale outdoor areas with a weak electric field, such as mountainous areas where it is difficult for radio waves from a base station to penetrate, and from 2008 we started introducing them as a low-cost alternative to optical feeder stations and 1 Carrier (CR) devices[*1] [1][2]. Since we initially planned to introduce just 150 open-air boosters, the maintenance and monitoring functions were performed by a monitoring system with simple functions that was supplied by an equipment vendor. Unlike an ordinary base station, an open-air booster does not need the installation of a transmission path and thus allows services to be started straight away. Due to this advantage, booster equipment was soon installed with the aim of achieving an early improvement of coverage in these areas. As a result, the initial estimate of the number of boosters installed was far exceeded, and it is expected that 7,000 will have been installed by the end of 2011. With the rapid increase in the number of boosters installed, their effects on — and importance to — our services have increased. As a result, it has become necessary to upgrade their simple maintenance functions so that they can be quickly adapted to facilitate maintenance and monitoring to the same standard as ordinary base stations. As the Operation System (OPS) for

*1 **1CR device**: A miniature BTS for a single carrier type.

diverse types of LTE/IMT equipment, NTT DOCOMO installed Linux®[*2] in small-scale IA servers[*3], and built Network-OPS (NW-OPS)[*4] using a Distributed Data Driven Architecture (D3A) [3]. Using these systems, we can perform maintenance and operability to the same standard as in ordinary base stations. By integrating NW-OPS into the open-air boosters, we aimed to reduce the cost of introducing and operating these boosters. Although NW-OPS is divided into different maintenance systems for radio equipment, transmission equipment and exchange equipment, the open-air boosters can be accommodated in LTE-Access OPS (AOPS), which is an LTE base station (eNB) maintenance and monitoring system for radio equipment. This makes it possible to achieve better development efficiency and reliability while reducing the maintenance workload.

In this article, we present an overview of the functions for configuring and adding maintenance networks through the integration of LTE-AOPS monitoring functions into open-air boosters.

2. Open-air Booster

2.1 Advantages of an Open-air Booster

An open-air booster is a device that has functions for receiving and amplifying radio signals from a base station with an antenna toward a base station, and outputting the resulting signals via an antenna toward a mobile station [1]. Open-air boosters are considered to be an effective means for (1) providing coverage in out-of-range areas and small-scale outdoor areas with weak electric fields (e.g., in mountainous regions or due to the effects of terrain shading), (2) maintaining area connectivity in tunnels and along roads and the like, and (3) dealing with blind spots in cities resulting from shading by buildings and the like. Since they do not need a transmission path, open-air boosters are also cheaper to install and operate than conventional stations, and allow services to be started up straight away.

2.2 Maintenance Network Configuration of Current Monitor Terminals

Figure 1 shows the maintenance network configuration of a current monitor terminal[*5] for an open-air booster. The open-air boosters use a FOMA module mounted in an accessory monitoring box to transmit changes of state to the current monitor terminal and to receive control signals from the current monitor terminal via an ISDN network. An open-air booster and a current monitor terminal are connected via xGSN[*6] and an ISDN network, so the monitoring and control functions of the open-air booster have incurred running costs due to the use of the ISDN line.

In the open-air booster monitoring system provided by the equipment vendor, 5,000 boosters can be accommodated by a single monitor terminal. The monitor terminal that performs the monitoring is determined by each monitored station. NTT DOCOMO currently performs maintenance and monitoring by dividing the equipment into two locations with four monitor terminals in eastern Japan and three in western Japan. Since the monitor terminal that performs the monitoring is determined by each monitored station, the system is subject to two constraints: (1) when the number of monitor terminals increases, it is necessary to ascertain which monitor terminal is accommodated within which open-air booster before maintenance can be performed, and (2) in a maintenance and monitoring method where monitor terminals for the whole country are consolidated in two locations in eastern and western Japan, it is not possible for maintenance and monitoring to be performed separately by each of Japan's nine regional companies. This is an issue because it can make it difficult to address fault handling promptly. By managing station information within the system, it becomes possible to receive alarm notifications from monitored stations, and to acquire and control the situation with regard to these stations. However, since it is not possible to produce different screen displays for different levels of alarm importance, critical faults can become buried under other less serious faults, which is disadvantageous

*2 **Linux®**: A registered trademark or trademark of Linus Torvalds in Japan and other countries.

*3 **IA server**: A server equipped with an Intel microprocessor. Its internal structure is very similar to that of an ordinary PC, and it is less expensive than servers based on other types of microprocessor.

*4 **NW-OPS**: A system for maintenance and monitoring of equipment within the NTT DOCOMO core network.

*5 **Monitor terminal**: A control terminal for the maintenance and monitoring of other equipment.

because it can lead to issues such as delays in the response to these faults. This system therefore needs to be improved.

2.3 Benefits of Integration into LTE-AOPS

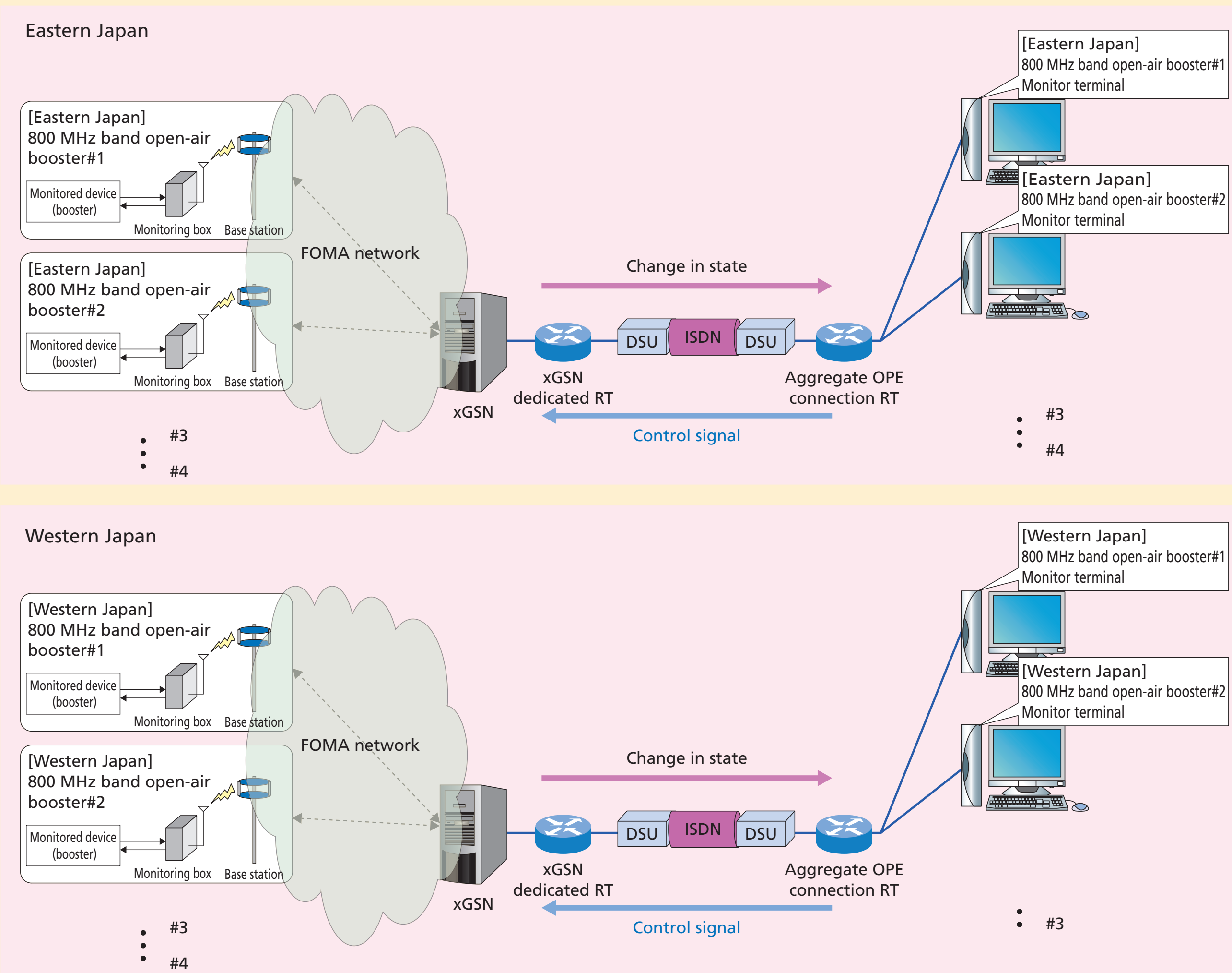
Integrating the open-air booster into LTE-AOPS has the following two merits:

1) Reducing the Maintenance Workload

Since an open-air booster is serviced by radio waves from its parent base station, its current status can only be checked if the current status of the parent station is also checked. To improve the maintenance efficiency and thereby reduce the maintenance workload, we therefore made the screen operations for status checking and fault resolution methods identical to the screen operations for the parent base station.

2) Ensuring Development Efficiency and Reliability

Information about an open-air booster's parent base station is managed in the shared parts of LTE-AOPS/IMT-AOPS, so it is possible to



DSU : Digital Service Unit
OPE : OPErationsystem (Monitor terminal)
RT : Router

Figure 1 Maintenance network configuration of a current open-air booster monitor terminal

*6 **xGSN**: A packet communication processing device in the FOMA network. It has both the Serving General packet radio service Support Node (SGSN) function and the Gateway General packet radio service Support Node (GGSN) function specified by 3GPP.

re-use programs when implementing data processing functions for information in the attribution of information between the parent station and open-air booster. In the parts that maintain the current status of the open-air booster, it is also possible to re-use programs in the processing part that stores the current status of the LTE-AOPS base station.

By re-using the existing LTE-AOPS processing units for storing the current status and processing data, we can ensure that software is developed more efficiently and reliably than would be possible if developing a new system from scratch.

3. Maintenance Network and Server Configuration

3.1 Post-integration Configuration of Maintenance Network

Figure 2 shows the configuration of the maintenance network after integrating the open-air boosters.

We had to ensure that no changes were made to the IP addresses of monitor terminals registered in the open-air boosters when studying the maintenance network configuration after integrating the open-air boosters. This is because it would have entailed making on-site modifications to the IP addresses of several thousand open-air boosters in order to update their integration with LTE-AOPS. To resolve this, we configured the networks in the eastern and western regions between the open-air booster and LTE-AOPS as logically separate entities.

By using our corporate network (IP-RT network[*7]) instead of ISDN lines, we were able to reduce the system's running costs and increase the security level. Also, to make more efficient use of the network bandwidth in the IP-RT network, we produced a new access point in xGSN at the office where LTE-AOPS is installed, and by modifying the Access Point Name (APN)[*8] information we connected the open-air booster to this xGSN.

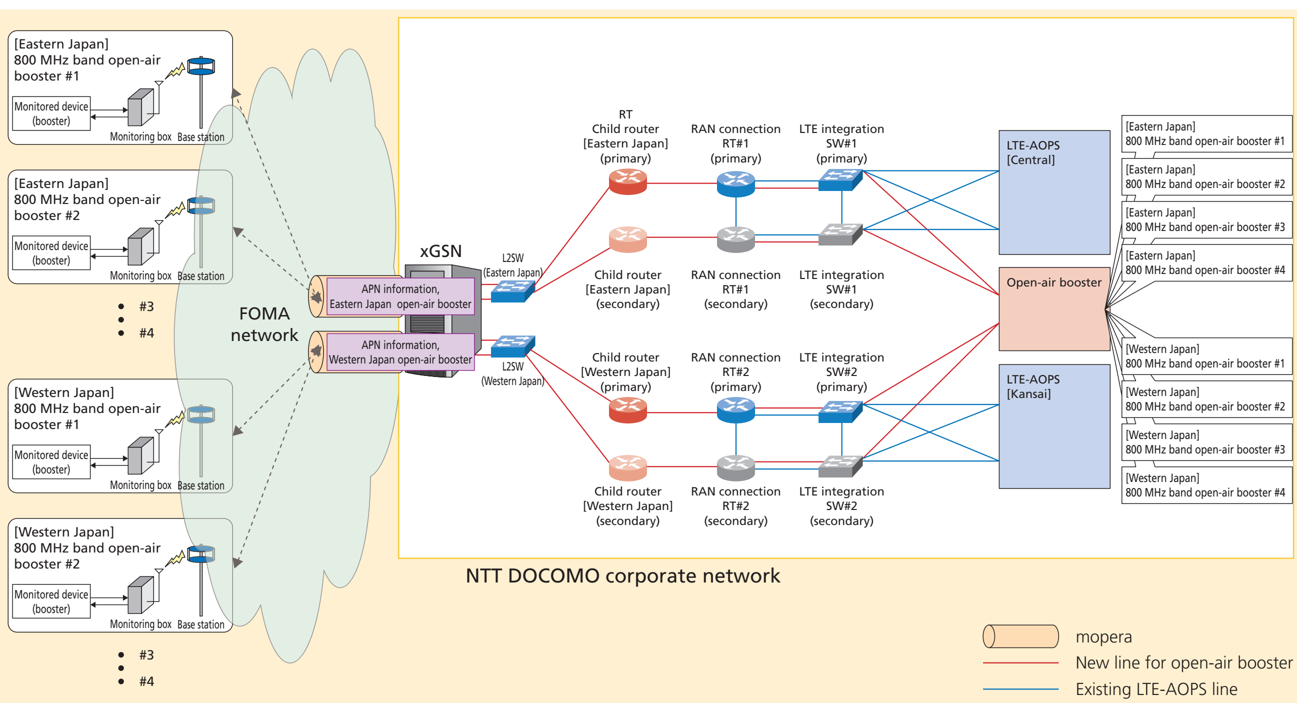


Figure 2 Post-integration configuration of maintenance network

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*7 **IP-RT network**: An economical broadband network combining IP routers and optical transmission paths in which reliability is ensured by the inclusion of redundancy. It went into operation on March 4th 2004 with the aim of handling data calls, which are expected to grow rapidly in volume.

*8 **APN**: An address name that is set as the destination of a connection when performing data communication over a network connection.

3.2 Post-integration Server Configuration

Figure 3 shows the server configuration in LTE-AOPS after integrating the open-air boosters.

In LTE-AOPS, the servers are partitioned into regional units in order to improve the load distribution and maintainability in each region.

However, when integrating open-air boosters into a server as monitored Network Elements (NEs), we aimed to achieve cost reductions by reducing the number of servers. Therefore instead of a conventional regional partition method where multiple servers are required, we studied a nationwide method where the number of servers can be reduced to one. In the course of our study, the IP addresses allocated to installed open-air boosters were allocated according to different rules in the eastern and western regions, so instead of a fully nationwide system we opted for a system where integration was performed in two regions (eastern and western).

As a result, the number of servers was cut by 14 from 18 to four. Also, nine servers were eliminated by piggybacking the Element (EL) of LTE-AOPS in the Configuration Management System (CMS), which is a func-

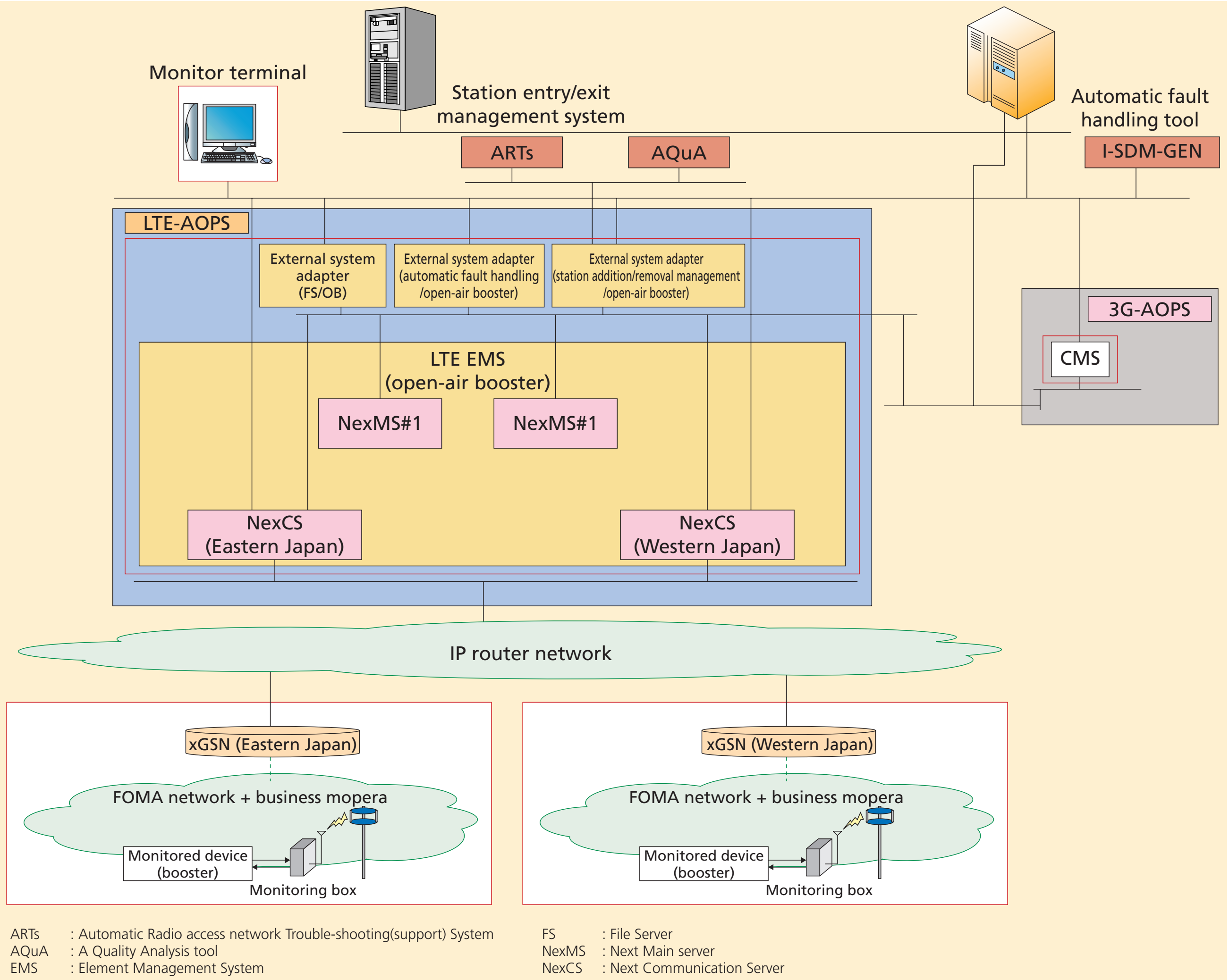

Figure 3 Post-integration server configuration in LTE-AOPS

tional part that manages the configuration information of the 3G base station (Base Transport Station (BTS)) accommodated in 3G-AOPS.

4. Overview of Additional Functions

4.1 Real-time Monitoring and Control Functions

The current monitor terminals have suffered from two main issues: (1) it is not possible to tell which open-air boosters are integrated into which monitor terminals, so it is not instantly known which has failed, and (2) it is impossible to identify the parent station of an open-air booster or the control operations that have been previously performed on the open-air booster, making it impossible to implement prompt fault correction measures. Therefore in LTE-AOPS, we implemented the following functions to provide real-time monitoring capabilities.

1) Monitoring and Control Functions for Regional Units

When the open-air boosters are integrated into LTE-AOPS, regional units perform the monitoring of and collation of data from these boosters. In this way, we set up the system so that any monitor terminal accessible to LTE-AOPS can perform real-time monitoring of open-air boosters.

We made it possible for any monitor terminal with suitable authorization to monitor open-air boosters anywhere in the country in regional units, and we made it possible to check the fault status of open-air boosters in real time.

2) Equipment Monitoring History Function

Conventionally, the previous control operations of an open-air booster are checked by manual log analysis. However, by re-using the functions in LTE-AOPS we recorded the control operations and changes in state in a database, making it possible to search the booster's equipment monitoring and control history. In this way, the operator can check the past fault occurrence status and thereby prioritize the remedial measures for ongoing issues.

4.2 Integration with Other Systems

Since current monitor terminals do not have any functions for cooperating with tools and systems that cooperate via NW-OPS, all the maintenance and monitoring work and station entry/exit management have had to be performed manually by an operator.

When open-air boosters are integrated into LTE-AOPS, they can cooperate with the various tools and systems of NW-OPS. This enabled us to cooperate with and automate the operation of automatic fault handling tools and station entry/exit management systems.

1) Automation of Monitoring and Control Operations by Cooperating with Automatic Fault Handling Tools

By cooperating with automatic fault handling tools, we can obtain the following benefits compared with a conventional monitor terminal.

(1) Immediate fault handling for alert occurrence NE

By creating a fault handling scenario for each alert occurrence in the automatic fault handling tool, we made it possible to handle faults promptly in response to alerts reported by LTE-AOPS. In this way, even when alarms have been raised from multiple open-air boosters, the automatic fault handling tool can still implement primary fault handling measures. At night, alarms that can be recovered by primary fault handling measures can be recovered immediately, even if the operator is away.

(2) Reducing the workload of monitoring operations

With the immediate processing of (1), maintenance personnel can expect a reduction in their workload because they only have to deal with faults that cannot be corrected by primary fault handling measures by the automatic fault handling tool.

2) Automating the Admission of Workers to Station Facilities by Coordinating with a Station Entry/exit Management System

In the current monitor terminal, the normality checks performed when a worker leaves a station had to be performed manually by an operator, which took time. In LTE-AOPS, by cooperating with the station entry/exit management system, it became possible to automatically judge whether or not a worker can leave a station by checking for any remaining alerts and releasing the maintenance mode at the time when the worker leaves the station. In this way, a worker that has entered a station for recovery work can check the maintenance mode release status while on site, thereby reducing maintenance tasks such as checking for remaining alerts after recovery operations have been performed by the operator, and confirming that the maintenance mode has been released.

4.3 CM Data Creation Function

In the current open-air booster monitoring functions, the compilation and registration of data necessary for monitoring the open-air booster is all performed by an operator. In this case, the operator can only compile and record data for one booster at a time, resulting in poor work efficiency.

There are also more data items to input due to the cooperation with automatic fault handling tools. This increases the likelihood of typing errors.

To address this situation, we reduced the amount of input work required of operators in order to reduce the rate of typing errors by providing data input tools and a function for using an operating system for 3G base stations (3G-AOPS) and LTE-AOPS to automatically acquire some of the data.

1) CM Data Creation Function

In LTE-AOPS, we developed our own tool (open-air booster station information editing tool) for the preparation of Configuration Management (CM) data[*9] for open-air boosters. This tool is based on Excel, which makes it easy to compile data for multiple boosters. Also, in LTE-AOPS, the eNB CM data is produced in a form where constituent data suppled from the IMT-2000-SystemDataMemory-GENerator (I-SDM-GEN)[*10] is converted into CM data, but I-SDM-GEN has no function for producing CM data for an open-air booster. We therefore used our own CM data production tool to enable the production of CM data for open-air boosters.

2) Parent Station Data Completion Function

The parent station completion function discussed below made it possible to identify a parent station's data in an open-air booster at a monitor terminal.

The parent station data set in the CM data of an open-air booster was automatically made accessible from the CM data of 3G-AOPS and LTE-AOPS.

By supplying this CM data to the automatic fault handling tool, we made it possible to automate the monitoring and control operations by cooperating with the automatic fault handling tool.

By implementing the parent station data completion function, we achieved greater operational efficiency because the operator only has to enter information that can identify the booster's parent station.

An overview of the parent station data completion function is shown in **Figure 4**.

(1) Download data for editing

The open-air booster's CM data (for editing) is downloaded by the CMS, and the CM data is edited by the open-air booster station information editing tool.

(2) Import edited data

The CM data (for importing) edited at step(1) is imported into the CMS.

(3) Completion of parent station data

When importing the edited data at step(2) , the CMS automatically completes the parent station data needed for the automatic fault handling tool with CM data by using CM data from 3G-AOPS and LTE-AOPS from the parent station information input by the operator.

(4) CM data delivery request

The operator instructs the delivery of CM data from the operation terminal (OPE screen).

(5) CM data delivery

Having received a CM data delivery request, the CMS delivers the CM data of the open-air boost-

*9 **CM data**: Data such as the NE configuration and NW configuration that is needed to run OPS.

*10 **I-SDM-GEN**: An IMT-2000 station data generation tool. Circulates station data and configuration data that form the basis of CM data for an access system NW-OPS.

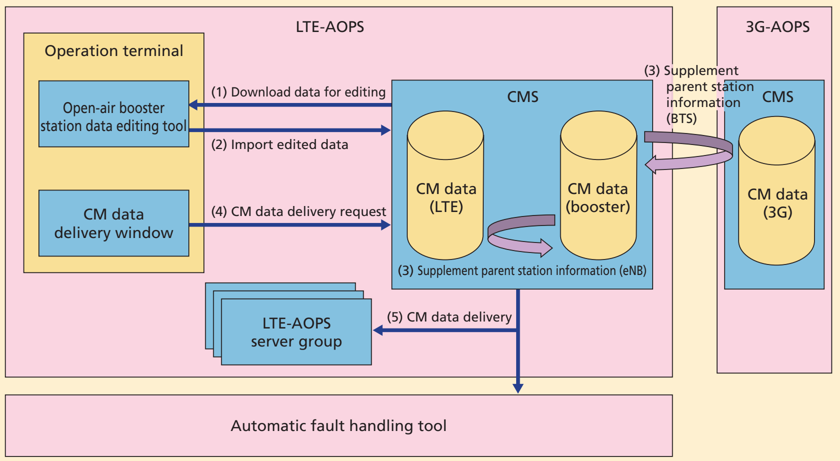

Figure 4 Overview of parent station data completion function

er to the LTE-AOPS server group and to the automatic fault handling tool.

5. Conclusion

In this article, we have described the background to the integration of open-air booster maintenance and control functions in LTE-AOPS, and we have described the maintenance network configuration and additional functions used for this purpose. For existing NW equipment apart from open-air boosters, ongoing issues include improving the maintenance functions by integrating them into OPS, and reducing the costs of introduction and operation. In the future we plan to conduct further research and development along these lines.

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