Special Article on Dual-band 800MHz/1.5GHz System

Node Equipment

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This article reviews the technologies enabled by node equipment to introduce the dual-band 800MHz/1.5GHz system in the Personal Digital Cellular telecommunication system (PDC).

1. Introduction

NTT DoCoMo launched its 800MHz band service based on PDC in 1993, followed by its 1.5GHz band service named "Cityphone service" in 1994, in response to new demand.

Although the coverage of the Cityphone service is limited to urban districts, namely, Tokyo, Nagoya and Osaka, it offers the same quality as the 800MHz band service at a more reasonable price. NTT DoCoMo had expected to disperse the users visiting the 800MHz band to disperse the load on network resources in the 800MHz band, by increasing the number of users of the Cityphone service, which is based on a different band (1.5GHz). Upon the launch of the Cityphone service, subscribers did increase steadily in number and the load on network resources was dispersed successfully.

However, the dramatic increase in the number of subscribers to the 800MHz band service outstripped the growth in the number of Cityphone service subscribers, NTT DoCoMo had to reconsider with the frequency saturation of the 800MHz band.

The dual-band 800MHz/1.5GHz system solves the frequency saturation of the 800MHz band by sharing the 1.5GHz band, which has more frequency capacity.

This article describes the technologies of node equipment for enabling the dual-band 800MHz/1.5GHz system in detail, considering the effective use of the existing PDC technologies and network resources. Firstly, Chapter 2 explains the PDC network configuration applied to the system. Chapter 3 reviews the improvements in the circuit-switched communication system, and Chapter 4 describes the functional enhancements in the packet-switched communication system in detail.

2. Node Equipment Functions

Broadly speaking, NTT DoCoMo made improvements and functional enhancements in the two systems as follows, to achieve the dual-band 800MHz/1.5GHz system.

(1) Improvements in the circuit-switched communication system.

(2) Functional enhancements in the packet-switched communication system.

Figure 1 shows the PDC node network configuration and the improved and enhanced function system. In the Figure, the New Mobile Service Control Point (NMSCP) is the node with the function to administer information the location of the mobile terminal, MS, the service contract information, etc. The New Mobile Local Switch (NMLS)/Mobile Local Switch (MLS) is a switch with circuit-switching functions, whereas the Packet Processing Module (PPM) is a switch with packet-switching functions.

For the dual-band 800MHz/1.5GHz system, NTT DoCoMo improved the billing system of NMSCP and NMLS/MLS with respect to (1) and added inter-band 800MHz/1.5GHz coordination functions to PPM with respect to (2). These improvements and functional enhancements will be described in the chapters below.

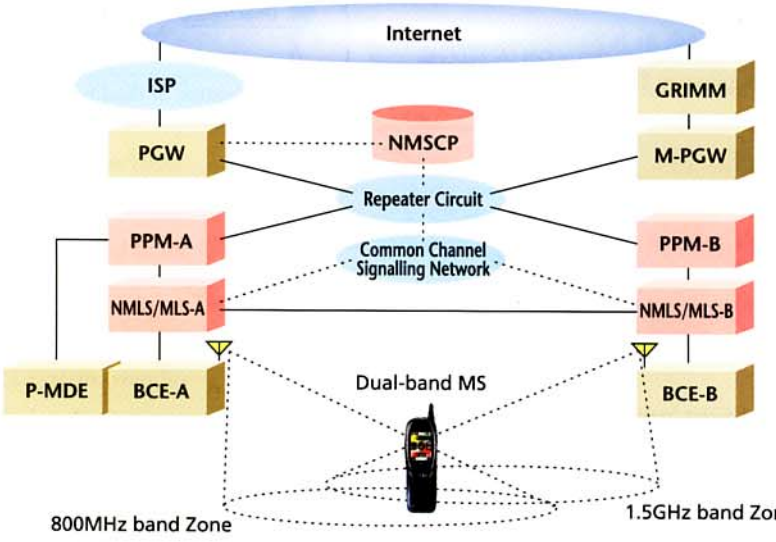
3. Improvements in Circuit-switched Communication system

(1) Improvements in NMLS/MLS

Currently, the service area of the existing 1.5GHz band system is limited to urban districts (i.e. Tokyo, Nagoya and Osaka) in which the 800MHz band suffers from frequency saturation.

The pricing of the 1.5GHz band system is lower because it is less convenient for users than the 800MHz band system which covers the entire nation.

On the other hand, the dual-band 800MHz/1.5GHz method covers the service areas of both 800MHz band and 1.5GHz band systems, as convenient as the 800MHz band system. This enabled NTT DoCoMo to apply the same billing system and the pricing plans to the dual-band 800MHz/1.5GHz system as the 800MHz band system, regardless of whether the call zone is in the 800MHz band or the 1.5GHz band. It has also made it possible to offer all optional services under the same conditions as the digital 800MHz band system for the dual-band 800MHz/1.5GHz system. According to the dual-band 800MHz/1.5GHz system, NMLS/MLS is equipped with a function to calculate fees upon call release to enable the immediate fee notification function in PDC. NTT DoCoMo has newly established the "dual-band 800MHz/1.5GHz service call dis-



BCE: Base station Control Equipment
GRIMM: Gateway service Representative Internet Market Mobile access exchange
ISP: Internet Service Provider
M-PGW: Mobile message-Packet GateWay module
MLS: Mobile Local Switch
NMLS: New Mobile Local Switch
NMSCP: New Mobile Service Control Point
P-MDE: Packet-Modulation Demodulation Equipment
PGW: Packet GateWay module
PPM: Packet Processing Module

Figure 1 Network Configuration

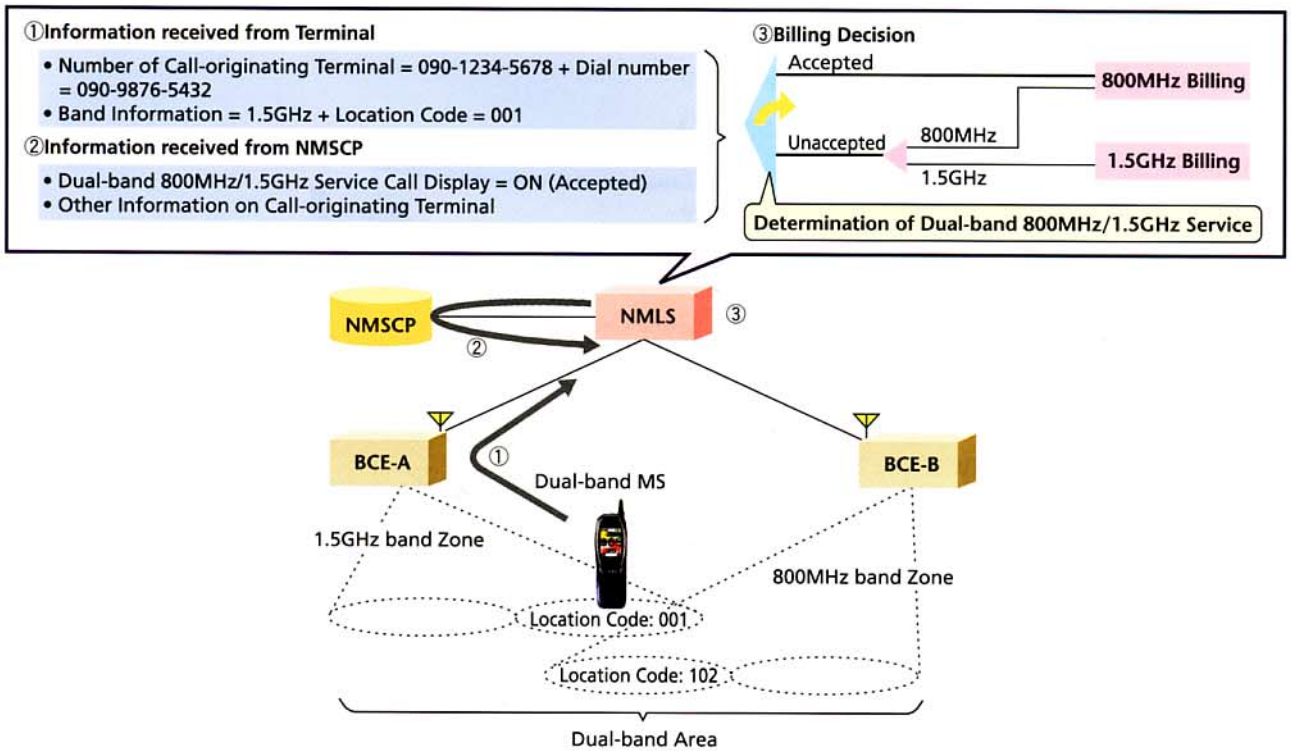
play," as information for identifying users of the dual-band 800MHz/1.5GHz system.

Upon the call origination, NMLS/MLS acquires the "dual-band 800MHz/1.5GHz service call display" from NMSCP to identify the dual-band 800MHz/1.5GHz system users. Based on this arrangement, it is distinguished from the present service providers by the terminal information such as the terminal number and the dial number of the dual-band MS originating a call in the 1.5GHz band, and 800MHz band/1.5GHz band area information, also with information on the dual-band 800MHz/1.5GHz service call display=ON [accepted] received from NMSCP. This helps to accomplish the same billing system as the 800MHz band system, regardless of whether the call zone is in the 800MHz band or the 1.5GHz band (**Figure 2**). Also, the administration of the "dual-band 800MHz/1.5GHz service call display" at the network has made it possible to provide services in a flexible manner without affecting the present services.

(2) Improvements in NMSCP

In the present PDC, NMSCP has the role of administering the customers' service usage information (subscriber data) and transmitting the call charge to the accounts center. As the NMSCP must determine the use of the dual-band MS by the customer at the accounts center, it notifies that the customer is using the dual-band MS, in combination with the information on his/her charges.

In the present PDC, the MS of the 800MHz band system performed location registration based on the 800MHz band system, while the MS of the 1.5GHz band system did the same based on the 1.5GHz band system. Location registration in the dual-band 800MHz/1.5GHz service is different from the present system which may perform location registration based on either the 800MHz band system or the 1.5GHz band system. In radio zones, MSs are administered on individually according to the bands' respective identifiers, administering from where the subscribers registered their respective band locations. However, NMSCP does not administer subscribers with respect to the band system but the area from which they registered their respective locations. The code indicating the area is commonly set for both the 800MHz band system and the 1.5GHz band system, and the same settings are applied to enable the dual-band 800MHz/1.5GHz service as well, making the service feasible without making the network complex.



BCE: Base station Control Equipment
NMLS: New Mobile Local Switch
NMSCP: New Mobile Service Control Point

Figure 2 Improvements in Billing Process

4. Functional Enhancements in the Packet-switched Communication Method

In the PDC mobile packet communication system, NTT DoCoMo has rendered the DoPa service (launched in March 1997) and the i-mode service (launched in February 1999), both only served in 800MHz band zones.

In order to realize the dual-band 800MHz/1.5GHz system, NTT DoCoMo adopted a system to add a stand by function in the 1.5GHz band zone rather than newly developing a packet communication function in the 1.5GHz band. The advantage of this arrangement is that the traffic of MSs standing by in the 800MHz band can be reduced by using the present standby function in the 1.5GHz band without newly installing Packet-Modulation Demodulation Equipment (P-MDE) for the 1.5GHz band. Based on the dual-band 800MHz/1.5GHz system, when operating packet call origination or a packet alert when the MS is standing by in the 1.5GHz band zone, the MS starts packet communication in the 800MHz band zone after shifting to the 800MHz band zone (**Figure 3**). As the dual-band MSs go into standby state in either the 800MHz band zone or the 1.5GHz band zone, the location registration process and paging associated with packet alert is dispersed between the two bands, which reduces the traffic in the Signaling Control CHannel (SCCH) and the Paging CHannel (PCH) in the 800MHz band zone.

In the network configuration shown in Figure 1, the 800MHz band zone and the 1.5GHz band zone are not accommodated in the same PPM, NMLS/MLS or Base station Control Equipment (BCE). However, it is feasible to have a configuration in which both 800MHz band and 1.5GHz band zones are accommodated in the same PPM, NMLS/MLS and BCE.

In packet communications based on the dual-band 800MHz/1.5GHz system, standby state function in the 1.5GHz band zone is an additional function to packet communication and standby states in the 800MHz band zone, meaning that an independent packet communication is impossible in the 1.5GHz band zone. Inter-band coordination functions are therefore required, such as the function to give information on the 1.5GHz band zone to dual-band MSs engaged in packet communication in the 800MHz band zone, and conversely, the function to give information on the 800MHz band zone to dual-band MSs standing by in the 1.5GHz band zone.

The five functions realized by the packet-switched communication system in relation to this are:

- Function to provide information on packet restrictions to the 1.5GHz band zone;
- Function to monitor failures in PPM accommodating the 800MHz band zone;
- Packet-alert function for the 1.5GHz band zone;
- Function to provide information on control channel in the 1.5GHz band zone; and
- Function to shift to voice communication in the 1.5GHz band zone during packet communication.

The details of the functions are as follows.

(1) Function to provide information on packet restrictions to the 1.5GHz band zone

Dual-band MSs standing by in the 1.5GHz band zone are given information on packet restrictions in the 800MHz band zone in order to determine as to whether or not the packet communication is possible in the 800MHz band zone. For example, if information on packet restriction in the 800MHz band zone has been changed to 25% restriction, the 1.5GHz band zone corresponding to the 800MHz band zone will be given the same information referring to the 25% restriction (**Figure 4**).

With this function, the packet restriction information is always consistent in the 800MHz band zone and the 1.5GHz

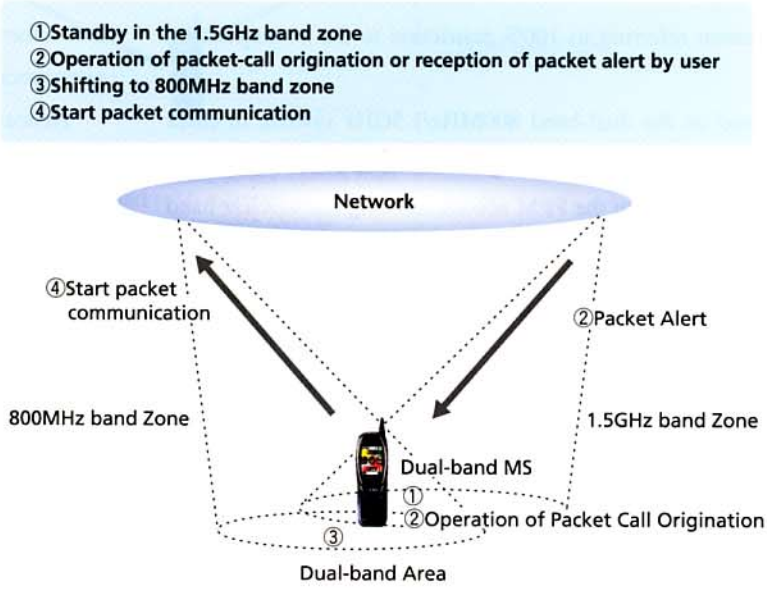
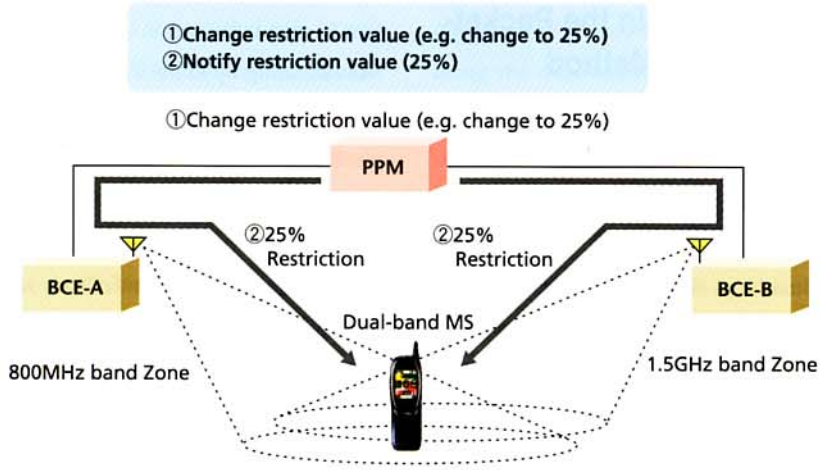


Figure 3 Starting Packet Communication in 1.5GHz band Zone



BCE: Base station Control Equipment
PPM: Packet Processing Module

Figure 4 Function to Provide Information on Packet Restrictions

band zone that corresponds to the 800MHz band zone. It enables the dual-band MS standing by in the 1.5GHz band zone to receive packet restriction information on the 800MHz band zone and determine whether or not the packet communication is possible in the 800MHz band zone without shifting to the 800MHz band zone.

(2) Function to monitor failures in PPM accommodating the 800MHz band zone

In the event of any failures in PPM, it becomes impossible to engage in packet communication in the zone covered by the PPM. Therefore, NMLS/MLS is already equipped with the function to monitor the operating status of PPM, and when any failures are detected in the PPM, it gives packet restriction information referring to 100% restriction to the corresponding zone.

Based on the dual-band 800MHz/1.5GHz system, in cases where the PPM accommodating the 800MHz band zone (PPM-A) is different from the PPM accommodating the 1.5GHz band zone (PPM-B), in the event of the failure of PPM-A, neither packet communication can be performed in the 800MHz band zone covered by PPM-A, nor, at the same time, packet communication can be started in the corresponding 1.5GHz band. Hence, in the event of the failure of PPM-A, packet restriction information referring to 100% restriction must be given not only to the 800MHz band zone but also to the corresponding 1.5GHz band zone.

In order to accomplish this, NTT DoCoMo created a function for PPM-B to monitor PPM-A, and added a mode in which the corresponding 1.5GHz band zone will be informed of the 100% restriction if the failure of PPM-A is detected (**Figure 5**). With this function, a dual-band MS standing by in the 1.5GHz band zone can acquire information on the 100% restriction without shifting to the 800MHz band zone.

(3) Packet-alert function for the 1.5GHz band zone

When a packet alert is announced to a dual-band MS standing by in the 1.5GHz band zone, the dual-band MS shifts to the 800MHz band zone and starts packet communication in the 800MHz band zone. At this time, the PPM-A accommodating the 800MHz band zone must acquire information on call termination in advance, in order to execute the packet communication commencement process in response to packet call termination rather than the normal packet communication commencement process.

Hence, upon the announcement of packet alert at PPM-B accommodating the 1.5GHz band zone, PPM-B gives information on the call termination to the PPM-A accommodating the corresponding 800MHz band zone before announcing the packet alert (**Figure 6**). This function enables the announcement of packet alerts across bands.

(4) Function to provide information on control channel in the 1.5GHz band zone

This is a function to give control channel information relating to the 1.5GHz band zone during packet communication for the purpose of accelerate the shifting from the 800MHz band zone to the 1.5GHz band zone.

When a dual-band MS stands by in the 1.5GHz band zone

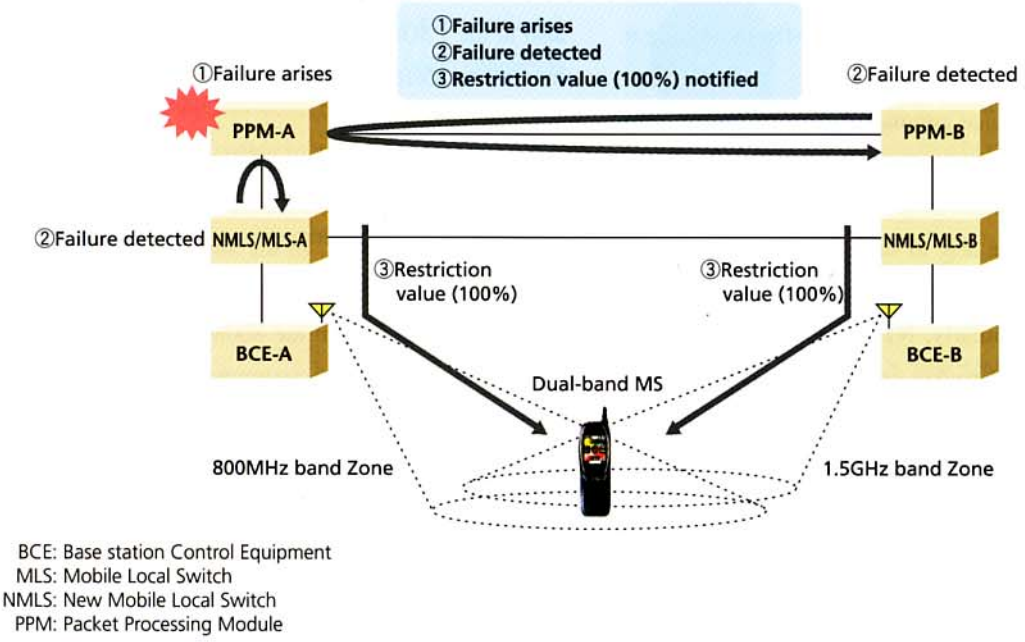


Figure 5 Failure Monitoring

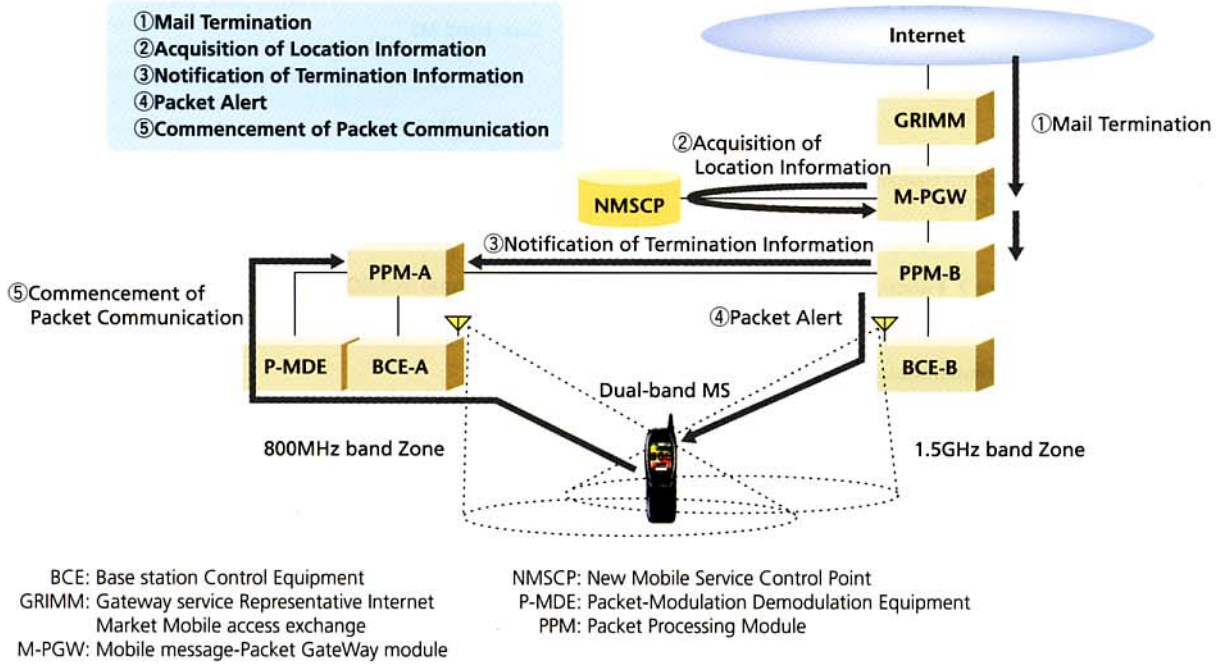


Figure 6 Packet Call Termination in 1.5GHz band Zone

after the completion of packet communication, or when it engages in voice communication in the 1.5GHz band based on voice-communication shifting process during packet communication, it uses the control channel signals that it has received. The MS keeps the channel information, so that it can shift promptly from band to band using this information when it is necessary to shift to the 1.5GHz band zone, upon the completion of packet communication or upon the shifting to voice communication during packet communication.

The control channel information is administered at BCE-A, and PPM is constantly given the latest information. PPM keeps the control channel information of the 1.5GHz band zone it has received from BCE, and upon the transmission of Mobile Management (MM) in Layer 3 to the dual-band MS, it transfers

the kept information on Radio frequency Transmission management (RT) and transmits RT to the dual-band MSs by making it share-ride with MM (**Figure 7**).

(5) Function to shift to voice communication in the 1.5GHz band zone during packet communication

When limited to the 800MHz band zone, MSs engaged in packet communication were able to sustain the packet communication status and shift to voice communication in the event of voice call termination. Similarly, NTT DoCoMo has enabled dual-band MSs engaged in packet communication to shift to voice communication not only in the 800MHz band zone but also in the 1.5GHz band zone. **Figure 8** shows the voice communication shifting sequence to the 1.5GHz band zone during packet communication.

In the event of voice call termination at MS engaged in packet communication, MLS-A communicates the voice call termination to PPM-A. In the subsequent stage, whereas the BCE-A had performed voice channel assignment to shift to voice communication in the 800MHz band zone, BCE-B executes the voice channel assignment process to shift to voice

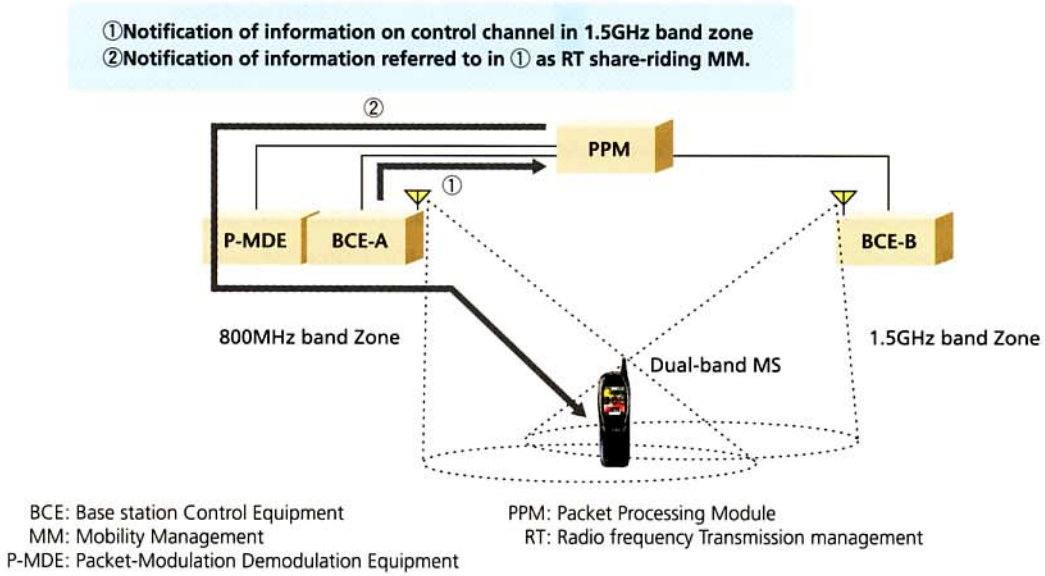


Figure 7 Function to provide Information on Control Channel in 1.5GHz band Zone

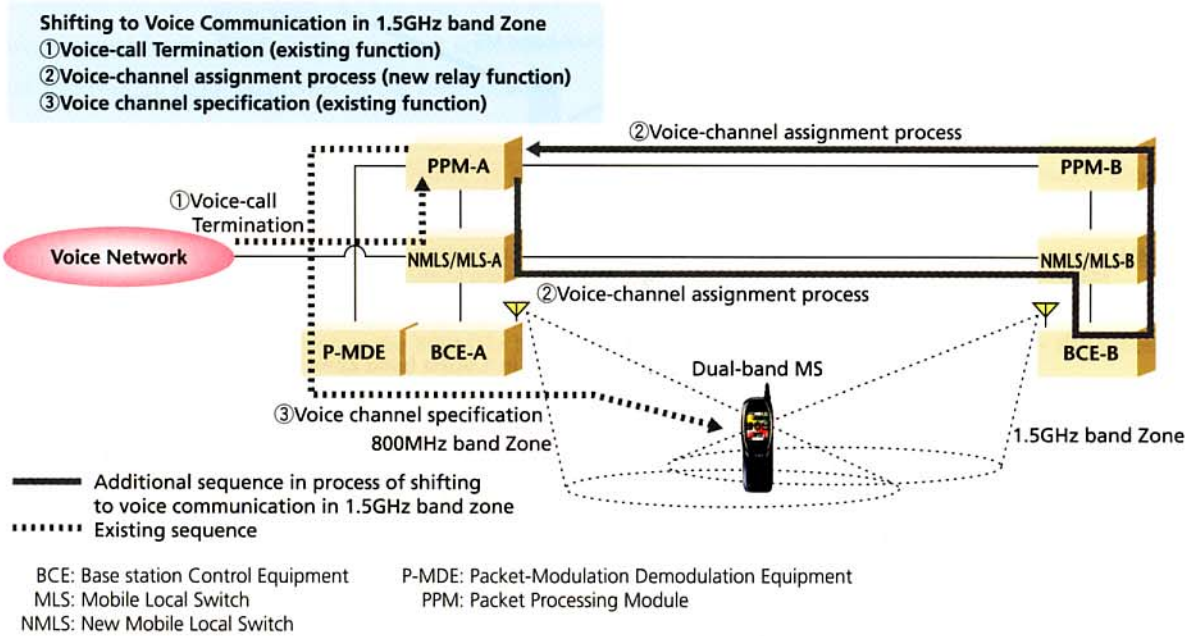


Figure 8 Shifting to Voice Communication during Packet Communication

communication in the 1.5GHz band zone, for which the signal relay process between PPM-A and BCE-B has been realized. After the voice channel assignment process, the voice channel is specified for the MS and the MS shifts to voice communication accordingly. This makes it possible to assign the voice channel in an alternative band —i.e. the 1.5GHz band zone— to dual-band MSs engaged in packet communication in the 800MHz band zone.

5. Conclusion

This article described the technologies of node equipment in detail for enabling the dual-band 800MHz/1.5GHz system.

We will continue our studies to improve the functions of node equipment in consideration of users' requests.

GLOSSARY

BCE: Base station Control Equipment
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ISP: Internet Service Provider
M-PGW: Mobile message-Packet GateWay module
MLS: Mobile Local Switch
MM: Mobility Management
NMLS: New Mobile Local Switch
NMSCP: New Mobile Service Control Point
P-MDE: Packet-Modulation Demodulation Equipment
PCH: Paging CHannel
PDC: Personal Digital Cellular telecommunication system
PGW: Packet GateWay module
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RT: Radio frequency Transmission management
SCCH: Signaling Control CHannel