Archives

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2.9 Dual-Band Network Design

2.9.1 Necessity for Constructing Dual-Band Network

The earlier GSM mobile communication network is constructed on the 900 MHz band. With rapid growth of subscribers, the network capacity also grows rapidly. Therefore, the lack of frequency resources and radio channels is a major concern for mobile telecommunications.

Many methods can be used to expand the capacity of a GSM system, including:

Adding macro cell base stations to the system

Reducing distance between base stations

Adopting aggressive frequency reuse technologies (such as MRP and 1×3)

Adding micro cells to the system

Applying half rate to the system

However, all these methods cannot thoroughly solve the problems concerning network capacity. As a result, the GSM 1800MHz network is introduced (uplink: 1805–1880 MHz; downlink: 1710–1785 MHz). And the network integrating GSM 900MHz and GSM 1800MHz can meet the growth of network capacity.

The application of GSM 1800MHz can bring the following advantages:

It does not occupy the bands of GSM 900MHz and has a communication bandwidth of 75M. Therefore, it breaks the bottleneck of GSM 900MHz in terms of frequency resources.

The system networking, project implementation, network planning, and network maintenance of a GSM 1800MHz network are almost the same with that of a GSM 900MHz network.

The GSM 1800MHz and GSM 900 MHz can share a base station, so a GSM 1800MHz network can be finished in a short time, which is quite helpful for network expansion.

Dual-band mobile phones now accounts for a major part of the total, so a GSM 1800MHz network can provide services to the dual-band subscribers. In this case, the capacity pressure on GSM 900MHz can be greatly eased.

2.9.2 GSM 1800MHz Coverage Solutions

I. Propagaiton features of GSM 1800MHz

The propagation features of the electromagnetic waves of 900 MHz and 1800 MHz are different in the following aspects:

The propagation loss in free space

The propagation loss of the 1800 MHz signals is 6 dB greater than that of the 900 MHz signals in free space.

Penetration loss

The penetration loss of the 900 MHz signals is greater than that of the 1800 MHz signals, but their difference is slight.

Diffraction loss

The longer the waves, the smaller the diffraction loss is. The diffraction ability of the 1800 MHz signals is poorer than that of the 900 MHz signals.

II. Dual-Band Networking Mode

There are three dual-band networking modes, namely, independent MSC networking, co-MSC/independent BSC networking, and co-BSC networking, among which the former two are called independent networking, and the later is called hybrid networking.

III. Coverage requirements on GSM 1800 MHz

Outdoor coverage

The outdoor coverage can be easily realized when the distance between base stations are not large. In necessary cases, you can add a GSM 1800MHz base station at the address of the original GSM base station. And in some places, you should consider add a new base station.

Indoor coverage

To ensure that the indoor coverage of GSM 1800MHz is good, you must control the distance between the base stations installed in urban areas within 1000 meters. In China, however, the buildings in most cities are constructed by concretes and metals, so the penetration loss is great. As result, the distance between base stations in urban areas of China ranges from 500 to 800 meters.

IV. Coverage mode of GSM 1800MHz

(1) Scattered coverage in hotspot areas

At the early network construction stage, the GSM 1800MHz base stations are scattered in hotspot areas. When the capacity configured for a GSM 1800 MHz base station is small, you must solve the problems, such as SDCCH congestion, TCH congestion, and frequent update between GSM 1800MHz and GSM 900MHz. The cost in early construction stage is small.

Scattered coverage of GSM 1800MHz in hotspot areas

The coverage of the dual-band network of this mode is based on the original GSM 900MHz network. The GSM 1800MHz base station is constructed in some hotspot areas, so the seamless coverage of GSM 1800MHz is not available in this case.

If a dual-band mobile phone starts conversation in an area covered by GSM 1800MHz, after leaving this coverage area, it hands over to the GSM 900MHz cell where it originally was. And the handover of this type is called the inter-band handover caused by coverage.

If a dual-band mobile phone starts the conversation in an area covered by GSM 900MHz, but because the traffic in this area is great, the mobile phone will hand over to an area covered by GSM 1800MHz. And the handover of this type is called the inter-band handover caused by capacity.

The scattered coverage in hotspot areas only relieves capacity problems in a short term. Moreover, frequent inter-band frequency handover increase the signaling load, which results in the loss of system capacity.

(2) Seamless coverage in hotspot areas

If the coverage of this mode is available; the GSM 1800 MHz network can share greater traffic for GSM 900MHz network and expand the system capacity. In addition, it is cost-effective.
(3) Perfect seamless coverage
If a GSM 1800MHz network adopts the coverage of this type, the advantages are as follows:
The seamless coverage area within a city can be realized.
The GSM 1800MHz network can share the traffic load for GSM 900MHz network as much as possible.
The system capacity can be greatly expanded.
The ratio of the handover between layers is small.
The quality of the network is quite satisfying.
The frequencies can be planned by patch.
The carriers can be expanded step by step.
However, there are still disadvantages. They are as follows:
The number of base stations is large.
The work load of network planning and optimization is huge.
The investment is large.
The base station addresses cannot be decided once.

Perfect coverage of GSM 1800MHz in hotspot areas

If a GSM 1800MHz network adopts this coverage mode, it can be easily expanded to meet future coverage.
Compared with the scattered coverage in hotspot areas, the perfect seamless coverage is characterized by great intensity and large area. Therefore, the ratio of inter-band handover under this coverage mode is far smaller than that under scattered coverage mode. As a result, the signaling load is reduced greatly. Therefore, this coverage mode is an ideal coverage solution. If a GSM 1800MHz network adopts this coverage mode, it does not necessarily attach to the GSM 900MHz network, instead, it can form an independent network.

2.9.3 Location Area Division for Dual-Band Network

The location area division for dual-band network is suggested as follows:
If 1800 MHz cells and 900 MHz cells are under the control of two MSCs respectively, their location areas are different. Therefore, you must set related parameters to maintain the mobile stations stay in the 1800 MHz cells where the traffic is absorbed. In this case, the times for the mobile station to handover between the two bands and reselect cells will decrease. Meanwhile, when designing signaling channels, you must fully consider the load resulted from location update.
If 1800 MHz cells and 900 MHz cells share a MSC, at the early network construction stage, they are suggested to use the same location area without affecting the network capacity. If the restriction on paging capacity is present, two location areas must be divided for them either in terms of band or geographic location, as shown in Figure 5-17 and Figure 5-18.

Location area division based on geographic location

If the location area is divided in terms of band, because frequent location updates are resulted from inter-band handover and cell reselection, you must set related parameters to maintain the mobile stations stay in the 1800 MHz cells where the traffic is absorbed. In this case, the times for the mobile station to handover between the two bands and reselect cells will decrease. Meanwhile, when designing signaling channels, you must fully consider the load resulted from location update.
If the location is divided in terms of geographic location, the frequent location updates resulted from inter-band handover and cell reselection can be avoided. However, you need to modify the related data of the original 900 MHz network. In addition, at the edges of the location areas, because the location updates caused by intra-band and inter-band handover and cell reselection is present simultaneously, the signaling flow is huge at these edges. As a result, you must carefully design the edges of the location areas.

2.9.4 Traffic Guidance and Control Strategies of Dual-Band Network

I. Traffic guide of Dual-Band Network
At early construction stage of a dual-band network, traffic control concerns how to use the new GSM 1800MHz network to share the traffic flow for the GSM 900MHz network. According to the original intension of the GSM 1800MHz network, the traffic can be guided according to the following principles:
1) At the early construction stage of a dual-band network, the GSM 1800MHz network is mainly applied to absorb the traffic of the dual-band subscribers so that the load of the GSM 900MHz network can be eased.
2) When the number of dual-band subscriber grows large, each band must share the traffic so that the inter-band handover times can be reduced.

Process of traffic guide and control strategies.

The various traffic control strategies can be realized through adjusting parameter settings as follows:
1) In idle mode, when the mobile station is selecting cells after it is switched on and reselecting cells when it is in standby state, you can set higher priorities for the 1800 MHz cells by designing the system parameters, including CBQ, CBA, CRO, TO, and PT. In this case, subscribers are more likely to stay in the 1800 MHz cells. As a result, their calls are established on the 1800 MHz cells.
2) If traffic congestion is present in the service cell when a mobile station is setting up a call, the system applies directed retry function to assign the mobile station to a TCH in the neighbor cells of the service cell and adjust the traffic allocation.
3) In conversation state, the traffic must be guided to the 1800 MHz cells in lower layers and levels according to the hierarchy cell structure. In addition, you can use Huawei dual-band handover algorithms so that the traffic load can be allocated more properly.
II. Hierarchical Cell Structure
According to the hierarchy cell structure of the dual-band network, a GSM system covering an area can be divided into four layers, as listed in Table 5-25.
To enable the network to develop smoothly and flexibly, you can divide each of the four layers into multiple levels, and then you can set multiple priority classes (for example, 16 classes) for the levels in each layer. This method is not only helpful for adjusting the traffic load in part of the areas. Therefore, the hierarchical cell structure enhances the cooperation of the current network equipments and meets the devolvement of the future network.
In terms of traffic priority, the cells in lower layers and levels has higher priorities, namely, the cells in lower layers has the priority to absorb the traffic.

2.9.5 Dual-Band Networking Engineering Implementation

During network construction and optimization, a dual-band network is debugged and commissioned step by step, which facilitates debugging the new GSM 1800 MHz networks and the original GSM 900MHz networks that has been expanded respectively. After each signal network is perfectly adjusted, you must debug each base station in the dual-band network. And you cannot stop the debugging until the whole dual-band network is finished.

The construction of a whole dual-band network can be divided into three stages, namely, deployment preparation, signal 1800 MHz network debugging, and 900/1800 MHz dual-band network debugging.

I. Deployment perparation

The coordination of dual-band technologies and network planning must be finished in this stage. The coordination of dual-band network technologies is a prerequisite for the cooperation of different carriers' networks. Network planning is the first step in network construction and involves many tasks, including base station address survey, channel number planning, electromagnetic background test, coverage test, and so on.

The followings must be emphasized in dual-band cooperation:

The customers, the third party (the designing institute or the original equipment supplier), and the new equipment supplier must be cooperate with each other well.

If one party meets a tough problem during the debugging of the dual-band network, the engineers from a third party must be present in site and help position the problem.

The 900 MHz BSC and 1800 MHz BSC must synchronize their clocks with the same source clock. Meanwhile, the clock of each base station in the existing GSM 900 MHz network can lock the clock of the BSC, and the clock of the BSC can lock the clock of the MSC.

When modifying the parameters related to dual-band handover (such as modifying the parameters at the BSC side or MSC side), you must notify that to other two parties.

If the some problems concerning the cooperation of dual-band network arise, a meeting must be organized, in which each party discuss with each other on how to solve the problems.

Both the designing institute or the original equipment supplier and the new equipment supplier must provide the project implementation plan, cutover plan, and precise cell information.

II. Signal 1800 MHz network debugging

At this stage, you need not modify any data of the original GSM 900 MHz network, but it is still the GSM 900MHz network provides services to subscribers. The GSM 1800MHz network does not absorb traffic.

When debugging the GSM 1800MHz network, you must adjust the following parameter so that the existing subscribers can be least affected.

In the system message data list, set the parameter "CBA" to "NO" to prevent general subscribers from selecting and reselecting the 1800 MHz network. Theoretically, general subscribers can hand over to the 1800 MHz network, but in fact, the handover relationship is not configured with the dual-band network, so the general subscribers cannot enter the 1800 MHz network.

After that, you use the testing mobile phone which can access the network by force to perform dialing test in each cell. If all goes normal, you can test coverage, handover, power control, interference, downlink and uplink balance, power adjustment, the coverage of the GSM 900MHz network, and the coverage of the GSM 1800MHz network.

Through these tests, you can not only discover the problems present in the networks, but also adjust the channel number, power, tilt angle, and parameter setting and optimize the parameter configuration for the GSM 1800MHz cell. In this case, the coverage and operation of the single GSM 1800MHz network can be ensured.

III. 900/1800 MHz dual-band network debugging

After finishing the single GSM 1800MHz network debugging, you must change back the parameter "CBA" to "YES" and configure the data for dual-band handover. The tests involved into the dual-band network debugging include:

Cell reselection and location update

Traffic load control

Continuous conversation mode

Automatic dialing and scan

Dual-band network handover

Calls and handovers initiated on major streets

Calls and handovers initiated on edge areas

Dialing tests in poor coverage areas and indoor environment

Dialing tests in outdoor and indoor environments in key areas

The data includes neighbor cell relationship, layer and level setting, handover type, and handover threshold. In this case, when a mobile phone is in idle mode, it can reselect an 1800MHz cell, the GSM 1800MHz network can absorb the traffic of dual-band subscribers, and the subscribers can perform handover between 1800MHz cells and 900MHz cells.

At the beginning, you can control the GSM 1800MHz network to absorb only a small part of the traffic of subscribers through adjusting the setting of CRO and handover threshold. When good cell reselection and dual-band handover are ensured, you can take measures to enable the GSM 1800MHz network to absorb more traffic, with the prerequisites that no congestion is present among cells and the network quality is ensured.

At this stage, the following parameters must be configured:

The parameters related to cell selection and reselection, including CBA, CBQ, ACCMIN, CRH, and CRO.

The parameters related to neighbor cell relationship, layer and level setting, and handover.

The configuration of the previous parameters must be based on the prerequisite that the cooperation of the GSM 1800MHz cells and GSM 900MHz cells is normal.

After the GSM 900MHz and 1800MHz dual-band network is enabled, you must do the followings:

1) Find out the problems present in the network through multiple means, such as drive test.

2) Adjust and optimize the network according to the problems so that the dual-band network can run stably.

3) Check if the dual-band network runs stably, analyze all the traffic statistic data, and check the network operation indexes.

4) Make sure the problems and take effective measures according to the analysis of the drive test and traffic statistics.

5) Adjust the related parameters and retest the network till the network indexes meet the design requirements.

Thus, a dual-band network is constructed and optimized according to the three stages as introduced in this section.

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