Archives

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3.7 Multiple Reuse Pattern Technology

3.7.1 Basic Principle

According to multiple reuse pattern (MRP), the carriers are divided into several groups. The carries in each group work as an independent layer, and each layer uses a different frequency reuse pattern. During frequency planning, you can configure the carriers layer by layer, with reuse aggressiveness increases layer by layer.

MRP has no special requirement on hardware. It is developed from the concept of carrier layering. That is, the available channel numbers are divided into multiple groups, and each group works as a carrier layer. According to the rules of the aggressive frequency reuse pattern, the channel numbers allocated for each layer are listed in Table:

Channel number allocation for each layer

Layer	Channel number
BCCH	n1
TCH1	n2
TCH2	n3
…	…
TCHm-1	nm
Note: *n1 ≥ n2 ≥ n3 ≥ n4 ≥…≥nm.*	

For MRP, first you must divide an available band into several sub-bands. Generally, the sub-bands work as the bands for BCCH. The reasons are listed below:

- BSIC decoding will not be affected by traffic. TCH numbers cannot affect separated BCCH numbers, which is helpful for the MS to decode the BSIC.
- The planning for adjacent cell list can be simplified. The separated BCCH numbers contributes the simplification of adjacent cell list, so the MS can capture the useful BCCH quickly.
- Maximum gain can be obtained from power control and DTX. Downlink power control and DTX can be applied to TCH carriers only, so the separated BCCH numbers can maximize the function of downlink power control and DTX.
- The re-planning for TCH numbers will not affect BCCH. When a TRX is added to the system, if not considering the isolation of combiner and adjacent frequency interference, you do not have to change the BCCH numbers.

After that, you must divide the remaining channel numbers into multiple TCH bands. For MRP, different frequency reuse patterns must be used for different TCH bands.

According to the carrier allocation in the network, you can decide the average frequency reuse degree. According to the maximum number of carriers configured in each cell and the number of cells configured in the network, you can adjust the average frequency reuse degree to a proper value. In this way, you can effectively control network quality.

The increase of the carries has little effect on the frequency allocation plan. The increased channel numbers affect other cells that have more carriers than the service cell has. For example, if a cell has four carriers, the cells that have been configured with more than four cells will be affected.

MRP technology enables carriers to be configured flexibly. According to MRP, the frequencies of a cell can never be completely identical with that of the adjacent cells. Therefore, the MRP improves both the intra-frequency interference protection ratio and frequency hopping effect.

According to the requirements defined in GSM protocols, all the downlink timeslots of the BCCH carriers must transit with full power and the interference features of the BCCH are different from that of the TCH. Therefore, to ensure network quality and security, you are recommended to use 4 x 3 frequency reuse pattern for BCCH. In this case, the channel numbers used for BCCH are equal to or more than 12. In actual conditions, they are from 12 to 15.

If the available bandwidth is 7.2MHz, the available channel numbers are from 60 to 95, 36 in total, and they can be divided into 4 groups

To ensure network security, you must finish BCCH number allocation first. To be specific, plan the 12 channel numbers according to 4 x 3 frequency reuse pattern and allocate 1 BCCH number to each of the 12 cells. After that, you should allocate 1 carrier at the TCH3 layer to each cell, and then you should allocate the TCH2 and TCH1 numbers to the cells.

In this case, you can configure four channel numbers for each cell of a base station (S4/4/4). The remaining 3 channel numbers can be configured for micro cells or mini-micro cells.

3.7.2 MRP Sequence Grouping

Because BCCH numbers and TCH numbers are selected in different ways, the MRP can be divided into two types. They are MRP sequence grouping and MRP space grouping, the first of which is introduced hereunder.

If the available bandwidth is 10MHz, the channel numbers are from 46 to 94. In this case, you can plan the frequencies at the BCCH and TCH carrier layers according to the sequence of the channel numbers. If using the sequence planning, you should add 1 to 2 extra channel numbers to the BCCH numbers. For the MRP sequence grouping, see:

MRP sequence grouping

Carrier type	ARFCN of the available channel number	Available channel numbers
BCCH	83–94	12
TCH1	74–82	9
TCH2	66–73	8
TCH3	58–65	8
TCH4	52–57	6
TCH5	46–51	6
Note: *ARFCN stands for absolute radio frequency channel number.*		

According to this table, the channel numbers can be divided into 6 groups. For BCCH, 12 channel numbers can be reused at the carrier layer. Traffic channels can be divided into 5 groups, from TCH1 to TCH5. For TCH1, 9 channel numbers can be reused; for TCH2 and TCH3, 8 channel numbers can be reused; and for TCH4 and TCH5, 6 channel numbers can be reused.

Therefore, when the bandwidth is 10MHz, the base station type can be configured as S6/6/6. If the traditional 4/12 frequency reuse pattern is used, the maximum base station type can be configured as S4/4/4 only.

For MRP sequence grouping, intra-frequency and neighbor frequency interference may exist within the frequency layer, and the interference between frequency layers exist at the critical points of the frequencies.

3.7.3 MRP Space Grouping

For MRP space grouping, neighbor frequency interference does not exist within the frequency layer, but exist between frequency layers. When the traffic is not busy, this frequency reuse pattern can reduce network interference.

If the available bandwidth is 10MHz, the available channel numbers are from 46 to 94. In this case, the frequencies can be allocated according to

Carrier type	ARFCN of the available channel number	Available channel numbers
BCCH	46, 48, 50, 52, 54, 56, 58, 60, 62, 64, 66, 68	12
TCH1	70, 72, 74, 76, 78, 80, 82, 84, 86	9
TCH2	88, 90, 92, 94, 47, 49, 51, 53	8
TCH3	55, 57, 59, 61, 63, 65, 67, 69	8
TCH4	71, 73, 75, 77, 79, 81	6
TCH5	83, 85, 87, 89, 91, 93	6
Note: *ARFCN stands for absolute radio frequency channel number.*		

At the very beginning, not each cell needs the TRX of the last layer, so the TRX of the last layer can reuse the frequencies more aggressively. In addition, though interference increases after the MRP is enabled, the TRXs in the cells also increase. In this case, more the channel numbers will participate in frequency, which enhances frequency hopping gain.

If both the channel numbers with a little interference and the channel numbers with great interference exist simultaneously within a cell, the frequency hopping technology will average the interference through mixing these channel numbers. In this case, the system can still decode the signals normally.

When allocating the frequencies according to MRP, you must notice that the minimum frequency reuse degree at the TCH layer must be equal to or greater than 6. In actual conditions, however, the minimum average frequency reuse degree at the TCH layer ranges from 7 to 8. Therefore, when the frequency resource is adequate, you can reserve some channel numbers to for future use during frequency planning.

Fixed MRP means that the channel numbers allocated to each TCH are fixed. They are independent of each other, as shown in Figure 6-14. For MRP, you should plan the channel numbers layer by layer so that the TCH numbers can be easily adjusted. In this case, if

interference is present at a TCH layer, you need to adjust the channel numbers allocated to that layer only.

3.7.4 Characteristics of MRP Technology

MRP technology can enables you to plan the frequencies flexibly according to traffic distribution. Compared with 3 x 3 frequency reuse pattern, MRP contributes to greater network capacity. Compared with 2 x 3 and 1 x 3 frequency reuse pattern, MRP has little effect against network quality. In addition, MRP technology is compatible with the technologies, such as frequency hopping, power control, DTX. Moreover, it has no special requirement on hardware and software.

Generally, the advantages of the MRP are listed below:

- The network capacity is great and frequency utilization rate is high.
- The channel configuration is flexible. The frequency reuse pattern is selected according to network capacity and traffic distribution. In the areas where the traffic is high, you can add carriers to these areas.
- No two cells have the same channel numbers, so no intra-frequency cell exists in the system if the MRP is used.
- Baseband hopping and RF hopping can be used.
- The base station type can be configures flexibly, which is good for network quality.
- The channels to be allocated are weighted, which enhances the network quality.

3.7.5 Comparison between MRP and 1 X 3 Frequency Reuse Pattern

In fact, 1 x 3 frequency reuse pattern is a special kind of MRP. The configuration for the equivalent MRP is 12/3/3/3/3/3. The following is a comparison between MRP and 1 x 3 frequency reuse pattern.

- The network capacity under 1 x 3 frequency reuse pattern is greater than that under MRP.
- For 1 x 3 frequency reuse pattern, you need to plan a group of frequencies for TCH only. If you have to add new carriers to the system without adding new base stations, you do not have to re-plan the frequencies. Therefore, the frequency planning is simpler under 1 x 3 frequency reuse pattern than that under MRP.
- If the network is irregular in landforms and traffic distribution, you should better not use 1 x 3 frequency reuse pattern. In most cases, a base station is interfered by many base stations nearby. If the 1 x 3 frequency reuse pattern is used, you will find it hard to position the interference source. Therefore, when adding new base stations to the network, you cannot eliminate the interference by adjusting some channel numbers only. If using MRP, however, you can easily solve this problem.