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2.8 Location Area Design

2.8.1 Definition of Location Area

In GSM protocols, a mobile communication network is divided into multiple service areas according to the codes of location areas. Thus the network pages a mobile subscriber through paging its location area.

Location area is the basic unit of paging areas in a GSM system. That is, the paging message of a subscriber is sent in all cells of a location area. A location area contains one or more BSCs, but it belongs to one MSC only.

Figure 5-13 shows the division of service areas.

Figure 5-1 Division of service areas

2.8.2 Division of location areas

The coverage area of each GSM PLMN is divided into multiple location areas, in which an MS is positioned. The size of a location area, namely, the area covered by a location area code (LAC), plays a key role in a GSM system. Therefore, this section mainly introduces the principle for planning location areas.

I. Dividing the location area according to the distribution and behaviour of mobile subscribers

The distribution of location areas in cities and suburbs is different. Generally, suburban areas or counties occupy independent location areas. In cities, the distribution of location areas is similar to a concentric circle. (The areas in the internal circle can be divided into several location areas due to the requirements on capacity. The concentric circle can be divided into several fragments.)

In addition, if two or more location areas are present simultaneously in a big city of great traffic, the landforms, such as mountains and rivers within this city can be used as edges of the location areas. In this case, the overlapped depth between the cells of the two location areas can be reduced. If no such landforms available within this city, the areas (such as streets and shopping centers) with great traffic cannot be used as edges of the location areas.

Generally, the edge of a location area is oblique instead of parallel or perpendicular to streets. In the intersected areas of urban areas and suburban areas, to avoid frequent location update, you must design the edges of location areas near the outer base stations instead of the base stations just installed at the intersections.

II. Calculating coverage area and capacity of a location area

If the coverage area of a location area is too small, the mobile station will perform frequent location update. In this case, the signaling flow in the system will increase. If the coverage of a location area is too larger, however, the network will send a paging message in multiple cells until the mobile station is paged. In this case, the PCH will be overloaded and the signaling flow at the Abis interface will increase.

The calculation of location areas varies with the paging strategies designed by different carriers. During early network construction stage, the traffic is not great, so a location area can accommodate more TRXs. However, it is still necessary for you to monitor the PCH load and traffic growth. When the traffic grows great, you can enhance the PCH capacity by adding a BCCH to the system, but the number of voice channels can be added is reduced by one accordingly.

Generally, the capacity of a location area is calculated as follows:

The number of paging blocks sent in each second × the number of paging messages sent in each paging block = the maximum paging times in each second. As a result, the number of paging times in each hour, the traffic allowed in each location area, and the number of carriers supported in each location area can be deducted.

The followings introduce the items present in the previous paragraph respectively.

(1) The number of paging blocks sent in each second

1 frame = 4.61ms, 1 multiframe = 51 frames = 0.2354s; suppose the number of access grant blocks is AGB, the number of blocks, the number of paging blocks sent in each second is calculated by the following formulas:

For non-combined BCCH, the number of paging blocks sent in each second = (9 – AGB)/0.2345 (paging block/second).

For combined BCCH, the number of paging blocks sent in each second = (3 – AGB)/0.2345 (paging block/second).

For non-combined BCCH, the AGB is 2 according to Huawei BSC. Therefore, the number of paging blocks sent in each second is 29.7 (paging block/second); when AGB is 0, it is 38.2 (paging block/second).

For combined-BCCH, the AGB is 1, so the number of paging blocks sent in each second is 8.5 (paging blocks/second); when the AGB is 0, it is 12.7 (paging block/second).

According to the previous analysis, the larger the number of AGB, the smaller the number of the paging blocks sent in each second and the smaller the paging capacity is. Moreover, the paging capacity of the combined BCCH is far less than that of the non-combined BCCH.

& Note:

Generally, a combined-BCCH cell and a non-combined-BCCH cell are not configured simultaneously within a LAC, and the number of AGB must be consistent with a location area; otherwise the paging capacity of the location area will decrease (now the paging capacity of the cell with the least paging capacity is the paging capacity of the location area).

However, if the capacity of a location area is small and the LAC resource is scarce, you can configure the combined-BCCH cell and non-combined-BCCH cell within a LAC to enlarge the number of traffic channels for O1 and S111 base stations.

(2) The number of paging messages sent in each paging block (X)

According to section 9.1.22 of GSM0408 protocols, each paging block has 23 bytes, and can send 2 IMSI pages, or 2 TMSI and 1 IMSI pages, or 4 TMSI pages.

According to the paging strategies of Huawei MSC, if the IMSI paging mechanism is adopted, the number of paging messages sent in each paging blocks is 2 (paging times/paging block); if the TMSI paging mechanism is adopted, it is 4 (paging times/paging block)

(3) The maximum paging times in each second (P)

The maximum paging times in each second is calculated by the following two formulas:

For non-combined BCCH, P = (9 – AGB)/0.2345 (paging block/second) × (paging times/paging block).

For combined BCCH, P = (3 – AGB)/0.2345 (paging block/second) × (paging times/paging block).

For combined BCCH, P = (3 - AGB)/0.2345 (paging block/second) × (paging times/paging blocks).
If the IMSI paging mechanism is adopted, for non-combined BCCH, when AGB = 2, P = 59.47 (paging times/second); when AGB = 0, P = 76.47 (paging times/second). For combined-BCCH, when AGB = 1, P = 16.99 (paging times/second); when AGB = 0, P = 25.49 (paging times/second).
If the TMSI paging mechanism is adopted, for combined BCCH, when AGB = 2, P = 118.95 (paging times/second); when AGB = 0, P = 152.93 (paging times/second). For combined BCCH, when AGB = 1, P = 33.98 (paging times/second); when AGB = 0, P = 50.98 (paging times/second).
According to the previous analysis, the paging capacity under IMSI paging mechanism is half of that under TMSI paging mechanism.
(4) The traffic allowed in each location area (T)
When designing the capacity for a location area, you must be attention that the paging capacity of a location area cannot break its limit. For network expansion, you can collect the times of the busy-hour paging orders delivered by BSC from OMC, and then convert the times into the number of paging orders sent in each second.
If no traffic measurement data is available, such as in the case of new network construction, you can calculate the traffic allowed in each location area by assuming a traffic model.
For example, if the average conversation duration is 60s and the ratio of the times for the mobile station to be successfully paged to the times of total pages is 30%, the 60s of conversation duration matches 1/60 calls (in the unit of second. Erl), and 30% of calls is generated by the called parties. Therefore, the successful calls of the 30% mobile stations are 0.05 times (that is, 1/60*30% = 0.005), in the unit of second. Erl.
If the 75% of the mobile stations respond to the first page and 25% respond to the second page, the mobile stations responding to the third page can be neglected. (It is just an assumption, which may be different from actual conditions.). Therefore, 1.25 pages are needed if a mobile station is successfully called each time (25% of the pages must be resent). In this case, the following equation is present:
Y = 0.005*(1+25%) = 0.00625 paging times/(second. Erl)
Suppose the congestion on paging channels will occur when the paging capacity is 50% greater than maximum theoretical paging capacity, the original paging messages are still present even the paging queue is full in the BTS. In this case, the paging capacity in one second is P*50%.
Therefore, the traffic allowed in each location area can be calculated according to the formula T = P*50%/Y.
(5) The number of carriers supported by each location area (NTRX)
Each TRX had 7.2 TCHs in average, so the maximum traffic of each TRX in each hour is 7.2.
Therefore, the number of carriers supported in each location area can be calculated according to NTRX = T/7.2 and the specific values are listed in

All the previous assumptions do not include the effect of the point-to-point short messages against on paging capacity. If the conversation times of a subscriber are equal to the number of the short messages to be sent, and if the sent ratio and received ratio are consistent with each other, the paging times/second. Erl will double in busy hour and the capacity of the location area will reduce by half. Therefore, some common short messages must be sent on CBCH.

2.8.3 Others

This section introduces some other information about location area design.
The capacity of a location area is closely related to paging mechanism, and is directly related to the combinations of AGB and BCCH. When the combinations of AGB and BCCH are inconsistent with each other in a location area, the capacity of the location area is determined by the cell with the smallest capacity. Therefore, the combinations of AGB and BCCH must be designed to be consistent in location area planning.
If the number of point-to-point messages grows large immediately, the number of paging messages will increase, but the number of supported subscribers will decrease. In this case, you must control and protect the flows in the system.
Because the traffic density varies with location areas, it is recommended that the combined-BCCH cells, non-combined-BCCH cells, and multi-BCCH cells form a location area respectively. When a cell with BCCH/SDCCH combination, the location area can be as large as possible when the paging capacity of the BTS does not reach the limit. However, because all paging messages will be broadcasted in all cells within a location area, the cell with BCCH/SDCCH combination is the bottleneck of the location area.
The LAC is a kind of number resource. Therefore, you must cooperate with carries to plan location areas.