2G, 3G Network Planning and Optimization...

Archives

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2.5 Traffic Analysis

2.5.1 Traffic Prediction and Cell Splitting

I. Traffic prediction

The network construction requires the consideration of economic feasibility and rationality. Therefore, a reasonable investment decision must be based on the prediction of the network capacity of the early and late stage.

When predicting network capacity, you must consider the following factors:
- Population distribution
- Family income
- Subscription ratio of fixed telephone
- Development of national economy
- City construction
- Consumption policy

After predicting the total network capacity, you must predict the density of subscriber distribution. Generally, base stations are constructed in urban areas, suburban areas, and transport arteries. Therefore, you can use the percentage of prediction method.

At the early stage of construction, the subscribers in cities account for a larger percentage of the total predicted subscribers. With the development of the network construction, the percentage of the subscribers in suburban areas and transport arteries grows. The traffic of each subscriber is 0.025 Erl in urban areas and 0.020 Erl in suburban areas.

The formula calculating traffic is:

$A = (n \times T) / 3600$

Here,
- “n” is the call times in busy hour
- “T” is the duration of each call, in the unit of second.

In this way, the number of voice channels needed for a base station can be obtained through predicting the traffic.

& Note:

When estimating the number of voice channels needed for a base station in the future, you must consider the effect caused by cell splitting.

In a GSM system, you can use Erl model to calculate the traffic density that the network can bear. The call loss can be 2% or 5% depending on actual conditions.

Because restrictions on cell coverage area and the width of the available frequencies are present, you must plan the cell capacity reasonably. If good voice quality is ensured, you must enhance the channel utilization ratio as much as possible.

In actual networking, if the network quality is ensured at a certain level, two capacity solutions are available, namely, a few stations with high-level configuration and multiple stations with low-level configuration. Both the advantages and disadvantages of the two solutions are apparent, so which one should be used depending on the actual conditions of an area.

For network construction, you can expand the capacity either through adding base stations or through expanding the base station capacity. The expansion strategies adopted must be in accordance with the traffic density in an area. For example, the strategies such as adding 1800 MHz base stations, expanding sector capacity, adding micro cells, or improving indoor coverage can be used to expand network capacity.

II. Cell splitting

Cell splitting is quite effective for the expansion of network capacity. An omni base station can split into multiple sectors, and a sector can split into multiple smaller cells. In other word, you must plan cell radius in accordance with the traffic density of an area.

Cell splitting means more base station and greater cost are needed. Therefore, when planning a network, you must consider the following factors:
- The rules and diagrams of frequency reuse are repeatable.
- The original base stations can still work.
- The transition cells must be reduced or avoided.
- The cell can split without effect.

Cell splitting is quite important in a network. The followings further describe the cell splitting based on 1-to-4 splitting.

Cell splitting is used to split a congested cell into multiple smaller cells. Through setting the new cells whose radiuses are smaller than the original cells and placing them among the original cells, you can increase the number of channels in a unit area, thus increasing channel reuse times. In this case, system capacity is expanded.

Through adjusting the project parameters relative to antenna feeders and reducing transmitter power, you can narrow the coverage area of a cell. Error! Reference source not found. shows that a cell splits into four smaller cells by half of its radius.

Smaller cells are added without changing the frequency reuse mode. They are split proportional to the shape of the original cell clusters.

In this case, the coverage of a service area depends on the smaller cells, which are 4 times outnumber of the original cells. To be more specifically, you can take a circle with the radius R as an example, the coverage area of the circle with the radius R is 4 times that of a circle with the radius R/2.

After cell splitting, the number of cell clusters in the coverage area increases. Thus the number of channels in this coverage area increases and the system capacity is expanded accordingly.

You can adjust the coverage area of the new cells through reducing the transmit power. For the transmit

power of the new cells whose radiuses are half of that of the original cell, you can check the power "Pr" received at the new cell edge and at the original cell edge, and make them equal. However, you must ensure that the frequency reuse scheme of the new micro cells is the same as that of the original cell.
As for Figure 5-1,
- Pr [at the edge of the original cell] = Pt1R-n, and,
- Pr [at the edge of the new cell] = Pt2 (R/2)-n
Here,
Pt1 and Pt2 are the transmit power of the base stations of the original cell and the new cell, and n is path fading exponent. If make n = 4, make the received power at the edge of the new and original cell equal, the following equation can be obtained:
Pt2 = Pt1/16
That is to say, if the micro cells are used to cover the original coverage area and the requirement of S/I is met, the transmit power must be reduced by 12 dB.
Not all cells need splitting. In fact, it is quite demanding for carriers to find out a perfect cell splitting scheme. Therefore, many cells of different scales exist in a network simultaneously. As a result, the minimum distance among intra-frequency cells must be maintained, which further complicate frequency allocation.
In addition, you must pay attention to the handover because success handover ensure the all subscribers to enjoy good quality of service regardless of moving speed.
When two layers of cells are present within an area but their coverage scale is different, according to the formula Pt2 = Pt1/16, neither all new cells can simply apply the original transmit power, nor all original cells can simply apply the new transmit power.
If all cells apply great transmit power, the channels used by smaller cells cannot be separated from the intra-frequency cells. If all cells apply lower transmit power, however, some big cells will be exclusive from the service areas.
For the previous reason, the channels in the original cells can be divided into two groups. One group meets the reuse requirement of the smaller cells, and the other group meets the reuse requirement of the bigger cells. The bigger cells are applied to the communication of fast-moving subscribers, which requires a fewer handover times.
The power of the two channel groups decides the progress of cell splitting. At the early stage of cell splitting, the channels in the low-power group are fewer. As the requirement grows, more channels are needed in low-power group. The cell splitting does not stop until all channels within this area are applied in the low-power group. In this case, all cells in this area have split into multiple smaller cells, and the radius of each cell is quite small.
& Note:
Commonly, you can restrict cell coverage area through adjusting the project parameters of the base station.

2.5.2 Voice Channel Allocation

I. Voice channel decision
The base station capacity refers to the number of channels that must be configured for a base station or a cell. The calculation of the base station capacity is divided into the calculation of the number of radio voice channels and the calculation of the number of radio control channels.
According to the information of base stations and cells and the density distribution of subscribers, you can calculate the total number of the subscribers. Then according to the radio channel call loss ratio and traffic, you can obtain the number of voice channels that must be configured by checking Erl B table.
Generally, you can decide the number of voice channels as follows:
1) According to the bandwidth and the reuse mode allowed by current GSM networks within the areas to be planned, you can obtain the maximum number of carriers that can be configured for a base station.
2) Each carrier has 8 channels. You can obtain the maximum number of voice channel numbers that can be configured for a base station by detracting the control channels from the 8 channels.
3) According to the number of voice channels and call loss ratio (generally 2% dense traffic areas and 5% for other areas), you can obtain the maximum traffic (Erl number) that the base station can bear through checking Erl B table.
4) Through dividing the Erl number by the average busy-hour traffic of subscribers, you can obtain the maximum number of subscribers that the base station can accommodate.
5) According to the data of subscriber density, you can obtain the coverage area of the base station.
6) After the areas are specified based on the subscriber density, according to the area of an area and the actual coverage area of the base station, you can calculate the number of needed base stations.
7) For important areas, you must consider back up stations and the cooperation between carriers. For example, an important county needs at least two base stations and three important carriers.
8) For the areas where burst traffic is possible, such as the play ground and seasonal tourism spots, you must prepare the equipments (such as carriers and micro cells) and frequency resources for future use.
9) The dynamic factors, such as roaming ratio, subscriber mobility, service development, industry competition, charging rate change, one-way charge, and economic growth, must be considered.
10) To configure a base station, you must consider the transmission at the Abis interface so that the capacity can be met while saving transmission. For example, the application and concatenation of the Abis interface 15:1 and 12:1 should be considered.
11) For indoor coverage and capacity, you can use micro cells and distributed antenna systems. For the coverage in countryside areas and highroads, you can use economical micro base stations. For the transmission in countryside areas and highroads, you can use HDSL because it is cost effective.
12) Prepare the some carriers, micro cells, and micro base stations for new coverage areas and future optimization.
13) In some special areas, you can use the base stations consisting of omni and directional cells, but you must consider the isolation between omni antennas and directional antennas. For traffic control, you can use the algorithm in terms of network layers.
14) For some highroads which require a little traffic by large coverage, you can use the two networking modes. They are:
- (A micro base station with single carrier) + (0.5 + 0.5 cell with two set of directional antennas)
- A micro base station with single carrier + 8-shaped antenna
II. Relationship between carrier number and bearable traffic
Erl traffic model can calculate the traffic that a network can bear. The call loss ratio can be 2% or 5% according to actual conditions. Table 5-7 describes the relationship between the number of carriers and

the traffic that a network can bear according to Erl B table.
According to Erl B table, the larger the number of carriers and the call loss ratio are, the greater the traffic that each TCH bear, and the greater the TCH utilization ratio is (the channel utilization ratio is an important indicator of the quality of network planning and design). If the number of subscribers of a base station is small, you can consider delaying the construction.
Because restrictions on the coverage area of a cell and the bandwidth of the available frequencies, you must plan a reasonable capacity for the cell. If good voice quality is ensured, you must take measures to enhance the channel utilization ratio as much as possible.
For the construction of the dual-band network, you can use the frequencies with wider bands to enhance channel utilization ratio, which is helpful for traffic sharing.
In actual applications, when the traffic on each TCH accounts for 80-90% of total given by Erl B table (the call loss ratio is 2%), the congestion ratio in this cell rise greatly. Therefore, we generally calculate the traffic that a network can bear by taking the 85% of the traffic given by Erl B table as a reference.
III. Example
The capacity of a local network needs to be expanded. According to the service development, population growth and mobile popularity, the subscribers in this area are expected to reach 100,000 in 2 years.
If only the followings are considered:
- Roaming factor (according to the development trend of traffic statistics) = 10%.
- Mobile factor (the subscriber moves slightly within the local network instead of roaming) = 10%.
- Dynamic factor (with burst traffic considered) = 15%.
The network capacity = 100000 * (1 + 10% + 10% + 15%) = 135,000.
However, because the congestion is present, we generally calculate the traffic that a network can bear by taking the 85% of the traffic given by Erl B table as a reference. As a result, the network capacity must be designed as follows:
The network capacity = 135, 000/85% = 158,800, about 160,000.

2.5.3 Control Channel Allocation

I. SDCCH allocation
Stand-alone dedicated channel (SDCCH) is an important channel in a GSM network. Mobile station activities, such as location update, attach and detach, call setup and short message, are performed on SDCCH. The SDCCH is used to transmit signaling and data.
It is difficult to induce a traffic model for the SDCCH; especially it even becomes impossible after the large-scale application of layering networks and short messages. Moreover, the equipments of some carriers support SDCCH dynamic allocation function. As a result, the traffic model for SDCCH must be adjusted according to actual conditions.
The advantages of the SDCCH dynamic function are as follows:
- Adjusting SDCCH capacity dynamically
- Reducing SDCCH congestion ratio
- Reducing the effect of initial SDCCH configuration against system performance
- Making SDCCH and TCH configuration more adaptive to the characteristics of cell traffic
- Optimizing the performance of the systems under the same carrier configuration.
In conclusion, the SDCCH dynamic allocation function is divided into two types, namely,
- Dynamic allocation from SDCCH to TCH
- Dynamic recovery from SDCCH to TCH
II. CCCH allocation
Common control channels (CCCH) contain access grant channel (AGCH), paging channel (PCH) and random access channel (RACH). The function of a CCCH is sending access grant message (immediate assignment message) and paging message.
All traffic channels in each cell share the CCCH. The CCC can share a physical channel (a timeslot) with SDCCH, or it can solely occupy a physical channel. The parameters relative to the CCCH include CCCH Configure, BS AG BLKS PES, and BS PA MFRMS.
Here,
- CCCH Configure designates the type of CCCH configuration, namely, whether the CCCH shares one physical channel with the SDCCH. If there are 1 or 2 TRX in a cell, it is recommended that the CCCH occupies a physical channel and share it with the SDCCH. If there are 3 or 4 TRXs, it is recommended that the CCCH solely occupies a physical channel. If there are more than 4 TRX, it is recommended to calculate the capacity of the paging channels in the CCCH according to actual conditions first, and then you can perform the configuration.
- BS AG BLKS PES indicates that the number of CCCH message blocks reserved to the AGCH. After CCCH configuration is done, this parameter, in fact, decides allocates the ratio of AGCH and PCH in CCCH. Some carriers can set sending priority for the “access grant message and “paging message”. When the former message set to be prior to the later one, the BS AG BLKS PES can be set to 0.
- BS PA MFRMS indicates the number of multi-frames that can be taken as a cycle of paging sub-channels. In fact, this parameter decides the number of paging sub-channels that a cell can be divided into.
& Note:
In CCCH configuration, the location area planning, paging modes and system flow control must be considered.

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