Archives

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5.5 Network Problem Solutions

5.5.1 Coverage Problems

I. Solutuon Procedures

[Problem: the coverage is becoming smaller after the BTS is enabled]

After a BTS has run for a period of time (for example, half years), the coverage of the BTS may become smaller or even dead zone may appear due to various causes. In this case, the system performance will be affected. The shrink of the coverage is not only related to the technical indexes (such as the BTS sensitivity and power), but also related to the engineering quality, geographic factors, and the electromagnetic environment.

The factor concerning the BTS problems are as follows:

- Transmitter output power decrease
- Receive sensitivity decrease
- Antenna azimuth angle change
- Antenna tilt change
- Antenna gain change
- Feeder loss
- Coupler loss
- Working band change
- Propagation environment change
- Diversity effect change.

You can check the problem according to the following procedure:

1) Check the conditions around the BTS antenna

You are required to check if there are other antennas (such as micro antenna), decorations, billboard, trees, or glass walls standing around the BTS antenna. These barriers may exert a negative effect against the antenna reception and transmission, thus affecting the coverage of the BTS. In this case, you can tune the azimuth angel of the corresponding antenna or change the antenna height.

2) Check the change of the propagation environment

The change of the propagation environment of the electromagnetic wave will weaken the signals received by radio terminals. Especially for mountains, the propagation of the electromagnetic waves depends on the reflection of mountains. For example, the change in the vegetation of the mountain will reduce the coverage of the BTS. In addition, the climate and other natural factors also have some effect against the electromagnetic waves. The propagation loss varies with wood intensity, season, and so on. The maximum loss can reach 30 dB. If new buildings prevent the propagation of the electromagnetic waves and weakens the signals, the areas in the remote cannot be covered, so the subscribers cannot enjoy the service. Especially the high buildings near the BTS have a great effect against the propagation of electromagnetic waves.

3) Check if there is standing wave alarm and main diversity reception alarm at the operation and maintenance console

This problem can be checked according to the standing wave alarm messages and the diversity reception alarm messages. If the alarms of this kind occur, you should check the corresponding antennas and feeders.

4) Check if the standing wave ratio is smaller than 1.5%

The tolerance of the standing wave alarm threshold of the CDU or EDU is great. Therefore, after checking that the set-top power is normal, you can further check if the standing wave is smaller than 1.5%. If the standing wave ratio is abnormal, you need to check if the water has penetrated into the antenna or feeder connector, or if it is lightening protector problem.

5) Check if the tower amplifier work normally

Check if tower amplifier alarm is present at the operation and maintenance console. Generally, the problems are the low noise amplifier was damaged or the water has penetrated into the amplifier. The amplifier alarm always comes together with the damage of the low noise amplifier. If the water has penetrated into the tower amplifier, no alarm will be generated, but the RF loss is great. In this case, the receiver sensitivity will decrease dramatically.

6) Check the engineering parameters (including antenna tilt and azimuth angle)

The increase of the antenna tilt or the deviation of the azimuth angle will reduce the coverage of the BTS. Therefore, antennas must be firmly fixed so that they can stand strong wind and storms.

7) Check the set-top output power of the transceiver

First you should check if the lines are well connected, and then check if the set-top power is normal. If it not normal, you should replace the problem hardware.

8) Check if the receiver sensitivity is normal

Check if the coverage distance is shortened by the low receiver sensitivity. In addition, you can monitor the messages at the Abis interface and find out the relationship between level and bit error rate. After that, you can get the value of the level when the bit error rate is 2%. This means, however, only applies to the situation that when the receiver sensitivity drops dramatically.

9) Check if the parameters affecting the coverage are rationally set

10) Check if the high back noise in the coverage area is caused by interference and poor electromagnetic environment.

[Coverage problem caused by BTS expansion]

If the coverage of the BTS shrinks after expansion, in addition to making the previous checks, you are supposed to check the following items.

1) Check if the combiner keeps the same before and after expansion

The loss of different combiners varies greatly Therefore, the combiner configuration deserves special attention during BTS expansion. If different combiners are a must, you should fully communicate with customers.

2) Check if the antennas are rationally selected

Suitable antennas must be selected for project installation and network planning so that the best coverage can be achieved. It must be pointed out that you should use zero-point filling antenna or the electrical title antenna when the antenna height is great. In addition, omni antennas cannot be widely used for the large area coverage. In this case, the coverage problem can be solved by directional antennas.

3) Check if the installation of the newly-added antennas are qualified

You should first check if the design of the antenna height, azimuth angle, and antenna tilt is qualified. Generally, the important coverage areas cannot be bared by tower. Meanwhile, the important coverage areas cannot be perpendicular to the diversity direction of the antenna. In this case, the antenna diversity effect can be excavated to the maximum. To reduce the coverage shadow caused by the tower, you should pay attention to the distance between the antenna and the tower. Moreover, the pole of the omni antenna and the RF part of the antenna cannot be overlapped.

4) Check the position of the BCCH transmitter antenna

Since the tower effect is present, the BCCH transmitter antenna must be installed at a side of the important coverage area. In this case, the coverage shadow can be avoided. To prevent the assignment failure caused by the inconsistence of the BCCH coverage and TCH coverage, you can use the concentric channel allocation algorithm. In addition, the important coverage area cannot be perpendicular to the diversity direction of the antenna.

5) Check if the tilts and the azimuth angles of the directional dual transmitter antennas are consistent with each other

If the tilts and azimuth angles of the directional dual transmitter antennas are inconsistent, call drop, assignment failure, and handover failure will easily occur. In this case, the coverage area of the BTS will become small. In addition, since the tower effect is present, the BCCH transmitter antenna must be installed at a side of the important coverage area. In this case, the coverage shadow can be avoided. Moreover, the important coverage area cannot be perpendicular to the diversity direction of the antenna.

6) Check the set-top output power of various TRXs if the scheme for the maximum coverage is used.

When the maximum coverage is pursued, the TRXs are required to be combined in various ways. In this case, the coverage distance of the BCCH will be longer than that of the TCH. As a result, the TCH assignment failure will be caused, so the concentric technology is needed. The channel assignment failure caused by low transmit level in the inner circle and the channel congestion in the external circle can be avoided if the TA values of the inner circle and the external circle are correctly set and allocated to the inner circle and external circle according to the right priority.

[Coverage problems caused by BTS swap or construction]

1) Check if the azimuth angle and the antenna height are the same before and after the BTS swap

If all the antenna and feeder components are newly constructed, the old BTS can only be swapped after the new antenna is installed. Therefore, the azimuth angle and the antenna height may be different from that of the old antenna. In this case, the coverage area may decrease. As a result, you should check if the azimuth angle and the antenna height are the same before and after the bas station swap.

2) Check antenna tilt problems caused by network swap

Generally, the tilt must keep the same. If you need to control the coverage area due to new BTSs are added to urban areas, you can consider increasing the tilt.

3) Check if the set-top power of the swap BTS is the same as that of the old BTS.

4) Check if the receiver sensitivity of the BTS is normal.

5) Check if it is the interference or the poor electromagnetic environment that makes the back noise of the whole area too high.

6) Check if any standing wave alarm message or diversity reception alarm message is generated for antenna and feeder at the operation and maintenance console.

7) Check the parameters that will affect coverage are rationally set.

8) Check if the installation of the antennas is qualified after the BTS has been enabled or swapped.

9) Check if the right type of antenna is selected.

10) Check the position of the BCCH TRX transmitter of the omni dual transmitter antenna.
11) Check if the tilts and the azimuth angles of the two directional antennas keep the same after the directional dual transmitter antenna is used.
12) Check if the antennas and feeders of the cell are inversely connected.
13) Check if the tower amplifier works normally.
14) Check the set-top power for various TRXs when the configuration scheme for the maximum coverage is pursued.

II. Problems Affecting Coverage and Solutions

[Antenna water penetration]

It is quite accidental that the water penetrates into the antenna. Water penetration means that the water enters the RF internal channel. In this case, the voltage standing wave ratio of the antenna will increase; the antenna loss will increase, the coverage area will decrease; or event the power amplifier will be disabled.

[Antenna passive intermodulation]

The passive intermodulation of the antenna and various connectors will cause interference. The exclusive method can be used for the check. That is, you can connect the antenna feeders of the neighbor cells where there is no interference to the test cell. If any problem is found, you should change the antenna.

[Improper antenna selection]

Generally, if the antenna height exceeds 50m and if the first zero point under the main antenna beam is not filled, the "shadow under tower" may occur. That is, the area under the tower cannot be covered by signals. In this case, you should select the antenna with zero point filling function.

If three-sector directional antennas are used for vast coverage, the antennas must have a high gain and their half power angle must be greater than 90 degrees. If the half power angle is small, the gain of the two neighbor sectors will be low. In this case, the coverage radius is small.

If the antenna tilt is great, the all mechanical tilt antenna is not a suitable choice. In this case, you should select the fixed "electrical tilt + mechanical tilt" antenna or the "continuous adjustable electrical tilt (0 to 10 degrees) + mechanical tilt" antenna.

As the frequency reuse becomes more aggressive, the front-to-back ratio of the antenna may not meet the requirement of a single BTS or several BTSs. Therefore, you should select the antennas with greater front-to-back ratio.

[Tower effect against Omni antenna radiation]

The tower effect against omni antenna radiation deserves enough attention. It is hard to estimate the damage of the omni antenna directional diagram caused by the tower. The damage varies greatly with the distance between the tower and the antenna.

If the antenna is installed on the tower and metal tube, you should pay special attentions to the following items:

- The metal tube and the effect radiation part of the antenna cannot be overlapped.
- Take measures to avoid installing the whole antenna on the metal tube.
- If the antenna is installed on the tower, make sure that the distance between the antenna and the nearest end of the tower is greater than 6 wavelengths.
- The omni dual transmitter technology is not recommended.
- The antenna must be perpendicular to 1/8 of the half power beam width at least.

[Directional antenna installation problem]

Two problems may occur for directional antenna installation:

- The antenna is inversely or wrongly connected.
- The azimuth angles and the tilts of the transmitter antenna and the receiver antenna are inconsistent and or the error is great.

Engineering causes are the explanations of the two problems. Generally, the error scope of the azimuth angle cannot exceed 5 degrees, and that of the tilt cannot exceed 0.5 degrees. If the error is too great, the coverage of the transit antenna and that of the receiver antenna will be different. In this case, it is hard to make calls the coverage edges.

- Problems concerning the diversity distance between the transit antenna and the receiver antenna or the isolation between the antennas and tower.

The coverage of the antenna will be affected if the diversity distance between the transmitter antenna and the receiver antenna or the isolation between the antennas and the tower is not great enough. For GSM 900MHz system, the diversity distance between the transmitter antenna and the receiver antenna is required to be greater than 4m. For GSM 1800MHz system, it is required to be greater than 2m. The antenna mount must be at least 1.5m away from the tower. Meanwhile, the antenna mount must be installed within the 45-dregree protection areas of the lightening protector.

- There are shadows in coverage areas.

When installing a directional antenna, you should make sure that there is no shadow within the coverage area. Generally, if there are huge barrier, such as high buildings and mountains, around the BTS, shadows may appear. If you intend install the BTS on the roof of a high building, you should install it at the edges of the building so as to avoid the shadow. Since the environment around the roof is quite complex, the antenna height must be great enough. In this case, however, you should consider the ability of the antenna to stand the wind and storm.

[Omni antenna installation problem]

- The radiator of the omni antenna is barred by antenna pole.

The coverage will be affected if the radiator of the omni antenna is barred by antenna pole. Generally, there is a jacket installed at the bottom of the omni antenna and the jacket is used to connect the omni antenna and the antenna pole. From the perspective of installation, the top of the jacket must be at the same level with or higher than the top of the pole; otherwise the radiation will be affected.

- The problems concerning antenna diversity distance and isolation between antenna and tower.

If the antenna diversity distance or the isolation between antenna and tower is not great enough, the coverage will be poor. If the antenna diversity distance is too small, it will reduce diversity gain. In this case, the receiver sensitivity will reduce. Though the tower effect against the omni antenna radiation is unavoidable, you can increase the isolation between the antenna and the tower to reduce the effect.

It is suggested that the isolation between the omni antenna and the tower is greater than 2m, the horizontal diversity distance of the 900MHz omni antenna is greater than 4m, and the horizontal diversity distance of the 1800MHz antenna is greater than 2m.

- The omni antenna is not perpendicular to the horizontal plane.

If the omni antenna is not perpendicular to the horizontal plane, the antenna directional diagram will be distorted in the coverage area. In this case, the coverage of the antenna will be affected.

It is suggested that installation plane of the antenna mount be perpendicular to the horizontal plane. If the mount extends beyond the tower, make sure that the mount is still in the protection areas of the lightening protector. Generally, the areas 45-dregee under the lightening protector top are the protection areas.

[Connection problems of antenna and feeder, combiner and splitter, and CDU]

If various connectors of the antenna and feeder system are not connected according to requirement, the performance of the antenna and feeder system will be affected. In this case, the coverage area of the BTS will also be affected.

- Water penetration occurs at the various connectors of the antenna and feeder system.

If water has penetrated into the connector and feeder, the standing wave ratio will increase. In this case, the coverage area will be affected.

- Various connectors are not tightened.

If the connectors for set-top jumpers, for the cables from TRX boards to combiner and splitter, and for various RF cables are not tightened, both the reception performance and the transmit performance of the system will decrease. In this case, the coverage area and the conversation quality will be affected.

- The transmitter antenna and the receiver antenna are inversely connected due to inconsistent configuration of the set-top jumper and data.
- The connection between the jumper and feeder is not tight, which results in high loss and standing wave ratio. In this case, the coverage will be affected and interference will be caused.

[Tower amplifier problem]

- Water penetration will increase the loss, deteriorate the standing wave ratio, and decrease the receiver sensitivity.
- The damage of the LNA (it is in the tower amplifier) will decrease the gain or even decrease the gain to a negative value.
- The input end and the output end of the tower amplifier are inversely connected. In this case, the tower amplifier will be short-circuited. If the short circuit lasts for a long time, the front module will be damaged.

[BTS front module problem]

- Isolator problem
- Duplexer and other filter damage
- Standing wave ratio error alarm
- LNA (low noise amplifier) damage
- Low TRX or amplifier output power

[Parameter configuration problem]

The parameters affecting coverage are listed below:

- TRX power class
- Tower amplifier attenuation coefficient
- MS maximum transmit power control power
- MS minimum Rxlev
- RACH minimum access threshold

III. Coverage Cases

Case 1: Use down tilt omni antenna to improve coverage

[Problem description]

In a suburban area, the omni antenna with a gain of 11dBi is used for the BTS. This coverage distance can reach 9km in plain environment. However, the coverage in the area near the BTS is poor. The Rxlev in the small town 800-1400m away from the BTS is about -90dBm.

[Problem analysis and solution]

On-site survey shows that the antenna height is too great. The height of the tower on which the antenna is installed 50m. Moreover, the tower is established on a small mountain, so the town is 120m below the antenna. The first judgment is that the phenomenon of "shadow under tower" has been caused.

Further analysis of the collected data finds that omni antenna is used for the BTS. The antenna gain is 11dBi, and the vertical half power angel is 7 degrees. If the valid antenna height is 120m, the half power points of the antenna major lobe are scattered in the area about 2000m away from the BTS. Therefore, this town is not in the coverage area of the BTS.

Through checking the fluctuation of the Rxlev according to the drive test map, engineers found that this town locates within the radiation area of a zero power point of the BTS. However, the town is too far away from the mountains around, so it cannot get the signals reflected by the mountains. Therefore, the Rxlev in this town is quite slow.

After having replaced the antenna with an omni antenna with 5 degrees of the down tilt angle, engineers retested the Rxlev and found that it increased by 15-20 dB in the areas 3km within the BTS. In some areas, the Rxlev is increased by 30 dB. Therefore, the coverage has been improved remarkably.

Case 2: Improper installation of omni antenna has effect against the coverage

[Problem description]

A new BTS has been enabled for a local network. Users complain that the coverage area become smaller after that. For the low narrow areas 2km away from the BTS, the Rxlev is already lower than -90dBm.

[Problem analysis and solution]

Through surveying the environment around the BTS, engineers found that the major transmitter antenna and the diversity receiver antenna are installed in a plane parallel to the road. Apparently, this kind of installation does not meet the criteria.

The correct way is to install the major transmitter antenna and the diversity receiver antenna in a plane perpendicular to the road. In addition, the major transmitter antenna must be located at one side of the road.

Case 3: Improper configuration of data causes poor coverage

[Problem description]

During the optimization for a place, engineers found that the signals at a section of the road in the suburban area are quite poor. The measured Rxlev is -95dBm.

[Cause analysis]

This section locates in the suburban area and is about 3km away from the urban area. There is no abrupt change in terms of landform within this section. Theoretically, the Rxlev here should be about -80dBm, so the difference between the theoretical Rxlev and the measured Rxlev is great. According to the frequency sweep test, the strength of the Fa signal is about -95dBm, and the strength of the Fb signal is about -80dBm. For this section, it is covered by three cells of the BTS A and BTS B that are installed in the urban area (the BCCH frequencies are Fa and Fb). In addition, a cell of the BTS C installed at the remote suburban area also covers the section (the BCCH frequency is Fc).

Through checking data, engineers found that the Fb is not included in the neighbor channel numbers of the A-3 cell in the BA1. When the MS moves from the urban area to the suburban area, it will choose A-3 cell to camp on, because the Fb is not configured in the neighbor channel numbers. In this case, the MS cannot reselect the B-3 cell to camp on. In the cell neighbor relationship list, the A-3 cell and B-3 cell cannot work as the neighbor cell for each other, and the Fb is not configured in the neighbor channel numbers of the A-3 cell listed in BA2. Therefore, in conversation mode, the MS cannot keep the conversation in A-3 cell. When it arrives at this section, it cannot hand over to the B-3 cell. Therefore, the signals are poor, so is the voice quality.

[Solution]

Enable the A-3 cell and B-3 cell to work as neighbor cell for each other.

Case 4: Irrational BTS swap affects coverage

[Problem description]

In an urban area, a BTS must be swapped for the building on which the BTS was installed were to be moved. Considering that coverage for the scenic spot 2km away (the scenic spot locates behind a hill) is poor, so engineers intended to install the BTS on the top of the hill. On the top of the cell, the whole city and the scenic spot can be seen. However, after the BTS swap, users complaint that there were no signals in the indoor environment of the cells near the site where the old BTS was installed.

[Cause analysis]

The buildings of the resident area are densely distributed and the average height is 8m. Before the BTS swap, the cell used for this area is only 100m away, and the antenna height is 15m. Therefore, the indoor conversation quality can be guaranteed. After the BTS swap, however, the cell used this area is 1.8km away, and the antenna height is 30m. In this case, the signals are quite weak when arriving at the bottom of resident area, though the signals falling at the top of the building is good. To solve this problem, you can only increase the output power of the transmitter antenna or increase the antenna gain. However, the coverage is still not to users' satisfactory even increase the antenna height to 30m. Therefore, when swapping or constructing a BTS at the densely populated area, you should pay attention to the following items:

- It is suggested that the distance between the BTS and the resident area is equal to or smaller than 150m, otherwise the coverage for this area will become weak dramatically.
- The antenna of the swapped BTS cannot be too great. If the BTS is installed among resident buildings, the antenna height is suggested to be 7-10m. If the BTS is installed beyond the resident buildings and the buildings are high, you can increase the antenna height accordingly.
- You can solve the problems concerning cross area coverage can through controlling the power class of the BTS, tuning the azimuth angle of the antenna, or tuning the tilt angle of the antenna.

[Solution]

According to on-site survey, engineers found that the indoor signals of this area are too poor to hold the conversation. This area can be seen clearly from the tower on which the BTS is installed. The distance between the BTS and the area is only 1.8km, and between them are vast farmlands. To solve this problem, you can attempt to tune the azimuth angle and the tilt angle of the antenna. If the coverage is not yet improved, you can use the following methods:

- Replace the common antenna used for this cell (its gain is 15dBi) with the high-gain antenna used for the scenic spot (its gain is 18dBi)
- There are 4 TRXs in this cell, all in SCU mode, replace the SCU mode with the dual-CDU mode.

After the above methods are done, the antenna gain for this area can be increased by 6dB. After the antenna replacement, you need to tune the antenna tilt for the best coverage.

Through retesting the indoor signal level, engineers found that it increased by 6-12dB. And even the common MS can keep normal conversation.

5.5.2 Interference Problems

Interference is a key factor affecting network performance, including conversation quality, call drop, handover, congestion, and so on.

I. Interference Sources

In the mobile telecommunication system, when the BTS is receiving the signals from a remote MS, it will not only be interfered by other telecommunication equipments, but also it will be interfered by the other BTSs and MSs within the system.

Hereunder introduces the interference sources affecting the GSM system.

- Intra-network interference

If the frequencies are improperly planned, or the frequency reuse is too aggressive, intra-frequency interference or neighbor cell interference will be caused.

- Repeater interference

At the early stage of network construction, repeaters are widely used for extending the coverage distance of the network. However, if the repeaters are improperly planned, the network will be interfered.

If the repeaters are not installed according to requirement, that is, there is not enough isolation left between the donor antenna and the subscriber antenna, the BTS to which the repeaters attach will interfered.

For the repeaters enabling broadband non-linear amplifier, the intermodulation indexes are far greater than that required in the protocols. In this case, the greater the power is, the greater the intermodulation will be. Therefore, the BTS near the repeaters will be interfered.

- Interference from other big-power telecommunication equipments

These equipments include radar, analog BTS, and other telecommunication equipments using the same band.

- Hardware problems

TRX problem: If the performance of the TRX decreases, the system may be interfered.

CDU problem or splitter problem: Active amplifier is used in the CDU splitter and splitter module. When any problem occurs, the system may also be interfered.

Stray and intermodulation: If the out-band stray of the power amplifier or the TRX of the BTS go beyond requirement, or the isolation of the transmission and the reception of the CDU duplexer is too small, the connection channel will be interfered. Meanwhile, the passive equipments, such as the feeder and the antenna, will generate intermodulation.

II. Interference Positioning and Elimination

[Positioning and elimination procedure]

1) Find out the interference cell according to KPI

If the call drop rate, handover success rate, traffic volume, congestion rate, and interference band of a cell deteriorate to a bad level abruptly, it means that interference may exist in the cell.

In this case, you can also check the historical record of operations made in this cell. For example, check if the hardware and software of the BTS has been added or increased and if the data of the BTS has been modified. Generally, the appearance of interference is related to these operations.

If these parameters are not adjusted, the interference may be from the hardware itself out outside factors. In this case, you are suggested to check if it is hardware problem. If it is not, you should check outside factors.

2) Check OMC alarm

Sometimes high call drop rate, low handover success rate, and high congestion rate may be related to equipment problems. In this case, you can check OMC alarm records. These records are related to the deterioration of these indexes.

3) Check frequency planning

If the interference is doubt in a cell, you can check the frequency planning for the cell and the neighbor cells of the cell. For this check, you are required to make clear the distribution of the antennas, find out the azimuth angle of each cell, draw the topology, and mark the BCCH/TCH channel numbers. Meanwhile, you are also required to compare the planned channel numbers with the configured channel numbers in the BSC.

According to the accurate frequency planning topology, you can make sure if the intra-frequency interference or neighbor frequency interference is present in the network.

4) Check cell parameter configuration

The cell parameters, such as CRO, threshold, handover duration, neighbor cell relationship, and so on, may have interference against the system.

If the CRO is set to a great value, the MS may be guided to an idle cell whose level is lower than its surrounding cells. Once the conversation is started but the C/I cannot meet the threshold requirement (12dB), interference will be caused.

If neighbor cells are missing, the MS cannot hand over to a cell with better signal level and quality. In this case, the interference will also be generated. If the handover threshold and the P/N are too great, the handovers between cells are unavailable. If the P/N is too small, however, it will result in frequent handover. In this case, both the call drop rate and the system load will be increased.

5) Drive test

Drive test is an effective method to position the interference. There are two drive test methods: idle mode test and dedicated mode test.

For idle mode test, the test equipment can test the signal level of both the signal level and the neighbor cells. In addition, the test equipment can also perform the frequency sweep test for the designate channel numbers or bands. In this case, the interference caused by cross-cell coverage signals can be discovered.

For dedicated mode test, the test equipments can test the signal level of the service cell and neighbor cells, the Rxqual, the TA, and so on. If the Rxlev is equal to or greater then -80dBm and the Rxqual is equal to or greater than 6 in an area, it can be confirmed that the interference exists in the area. Some test equipment can display the FER (frame error rate). Generally, if the FER is greater or equal to 25%, the conversation will not be continuous. That is, the interference exists.

6) Interference elimination

You can eliminate the interference according to the above checked results, and then evaluate the elimination through KPI and drive test.

[Hardware problem positioning and elimination]

When the interference is doubted in a cell, you should first check if the BTS where the cell locates works normally. In the remote end, you should check if there is antenna alarm, TRX alarm, or BTS clock alarm generated. In the near end, you should check if there is antenna problem, water penetration, feeder (jumper) damage, CPU problem, TRX problem, wrong jumper connection or clock problem occurred.

- Antenna performance decline

Antenna a passive component and its damage probability is small. However, if the antenna is damaged or its performance declines, the voice quality will become poor.

- Antenna connector problem

GSM RF signals are micro wave signals. If the connections between TRX, CDU, feeder, and antenna have any problem, both the standing wave ratio and the intermodulation will increase. In this case, the interference will be resulted.

- Inverse antenna connection

The inverse antenna connection is a commonly seen problem. If the antenna is inversely connected, the channel numbers used by the cell and the planned channel numbers are completely inconsistent. In this case, intra-frequency interference, inter-frequency interference, and handover difficulty will be resulted. Especially for the networks that have inadequate frequency resource, the inverse antenna connection has great effect against network quality.

- Jumper problem

Many jumpers locate between antennas, so they are often wrongly connected. In this case, high call drop rate will be resulted.

- TRX problem

If TRX problems occur, the interference will increase, the coverage distance area will decrease, and the access is difficult.

- Clock failure

If the clock deviation is too great, it is hard for the MS to lock the frequencies of the BTS, so the handover failure always occurs, or the MS cannot camp on any cell of the BTS. In addition, if the clock deviation is too great, the BTS cannot understand the signals of the BTS, which will result in bit errors. However, the clock failure will not really introduce interference, but it is the transmission errors that make the voice quality decrease.

- Conclusion

Any problem concerning the TRX, CDU, feeder, antenna, jumper, and connector may cause interference or call drop. Therefore, if interference appears, you should check the hardware of the BTS. In addition, BTS clock failure will also cause interference and call drop.

It is easy to solve the hardware problems through changing the boards or adjusting traffic data. If there is spectrum analyzer available, you can position the problem more efficiently. Especially when the interference appears without any modification of network data, you should focus on checking the hardware.

[Intra-Network Interference]

The intra-network interference is mainly from intra-frequency interference and neighbor cell interference. When C/I is smaller than 12dB or the C/A is smaller than -6dB, the interference is unavoidable. However, the aggressive frequency reuse technology will increase of the occurrence probability of interference.

- Same-frequency and neighbor frequency interference

In GSM system, the frequency reuse is unavoidable. When the frequency reuse distance of two cells using the same frequency is smaller than cell radius, same-frequency interference will be easily caused. Past experiences show that the frequency reuse must be avoided in many cases.

The interference against the uplink channel numbers can be judged by the interference band data in the traffic statistics.

For the interference against the downlink channel numbers, the existing drive test equipments can be indirectly used to measure if the same-frequency interference is present. First you should lock the test MS in the service cell and enable make the MS work in conversation mode during drive test. If you find that the Rxlev in an area is high but the Rxqual is low, it is likely that the same-frequency is present in this area.

- Interference caused by cross coverage

In a properly designed network, each cell covers the areas around the BTS only and the MS camps on or holds conversation in the nearest cell. Cross coverage means that the coverage of a cell is too large and the cell can cover the areas under the control of other BTSs. If cross coverage occurs, irrational traffic absorption, interference, call drop, congestion, and handover failure may arise.

- Interference caused by aggressive frequency reuse

Capacity and quality always contradicts to each other. In urban areas, the aggressive frequency reuse technology must be used for the number of subscribers in urban areas are great. In this case, the network quality will surely decrease. In the areas where BTSs are irrationally distributed, the aggressive frequency reuse technology may cause the collision of same frequency and neighbor frequencies.

- Interference caused by repeater

It is convenient to use repeater for special coverage. However, if a repeater is not qualified or it is not properly installed, it will cause interference.

- Interference caused by outside environment

Outside environment, such as TV station, big-power radio station, micro wave, radar, high voltage wire, analog BTS, and so on, will cause interference.

III. Interference Cases

Case 1: Interference cause by antenna performance decline

[Problem description]

There are 5 BTSs in a county. The configuration type is S4/4/4 or S6/6/6. The interference band 5 reaches 15 according to the TCH performance measurement of the most cells. There is no alarm found at the OMC.

[Problem positioning and solution]

1) Through monitoring and registering the interference band traffic statistics for the problem cells all day, engineers found that the interference band 5 mostly appeared at day time, and it seldom appeared at early morning.
2) Through sending the idle BURSTS of all the BTSs, engineers found that the interference bands of these cells appeared in the early morning. If the sending of these idle BURSTS stopped, these interference bands disappeared. Therefore, it can be proved that the interference came from the network. It is not related to other telecommunication equipments.
3) The frequencies and other data were not adjusted before the interference appeared, so the interference is not related to the frequency planning.
4) Through surveying the RXM test interface of the CDU using the spectrum analyzer during the traffic peak at day time, engineers found that the broadband interference was strong and the back noise was rising.
5) There was no interference in one cell, but the interference in another two cells was strong. Through replacing the antenna feeder of the cell with no interference with the antenna feeders of the cells with interference and sending idle BURSTS, engineers found that the interference went with the antenna feeder. Therefore, it can be decided that the problem occurred at the antenna and feeder system.
6) Through changing the antenna, engineers found that the interference went with the antenna. Therefore, the problem is likely present at the antenna.
7) Through replacing the antenna with dual polarization antenna, engineers found that the strong interference disappeared immediately. Through replacing the old antenna of another BTS with a new one, engineers found that the interference also disappeared.

Case 2: Call drop caused by intra-network interference

[Problem description]

Customers in a place complaint that call drop happen frequently.

[Problem analysis and solution]

1) Through a careful test, engineers found that there were 12 channel numbers gathering at the call drop spot and Rxlev reached -73dBm. When the MS seized channel number 11, the interference from channel number 112 caused the call drop.
2) Through testing the CGI of channel number 12 using test MS, engineers found that this channel number was one of the BCCH number of D3.
3) Through surveying BTS D, engineers found that the antenna of D3 is installed at the top of a building. In addition, a house made of glass was found 8m away and 4m under the antenna. Engineers tested that the signal strength near the antenna was about -45dBm, and the signal strength at near the glass was -30dBm, which was beyond the expectation of engineers. In fact, the cause was that the signals reflected by the glass were reflected to the call drop spot.

4) It is suggested to change the antenna installation place and channel number. You should interchange the channel number 111 and channel number 114 of BTS A and increase the down tilt angle of A3 cell. In addition, to avoid the interference caused by channel number 111 after the interchange, you should adjust the direction of channel number 113 of C1 cell.
5) Test shows that everything is normal after the adjustment. The channel number 113 of BTS C has no effect against channel number 114. And the call drop disappears.

Case 3: Interference caused by repeater

[Problem description]

Users in an area complaint that the MS cannot seize a channel to hold conversation, or the noise is great after channel seizure and the channel and the MS signal is strong. Two BTSs are installed in this area. The antenna azimuth angle of cell1 rightly directs to the north. Before user complaint, the BTS in this area ran normally and the network indexes met the requirement. After the problem arisen, the traffic volume of the two BTSs dropped sharply from the perspective of traffic statistics indexes. In addition, the traffic volume of cell1 and cell3 also dropped sharply. Though the signals for the conversation were strong, the voice quality was quite poor. According to traffic statistics, the interference bands of the four cells were of level 3, level 4, and level 5, and 95% of the channels were interfered. In addition, other channels were interfered to some extent. However, no alarm messages were generated at the OMC.

[Problem analysis and solution]

1) According to user feedbacks, the possible reasons include transmission problem, antenna feeder problem, hardware problem, intra-network interference, and outside interference.
2) The uplink interference signals in the northwest direction might strong. Therefore, cell1, cell2, and cell3 of the two BTSs were interfered, in which cell1 and the cell3 were seriously interfered.
3) Through on-site dialing test, engineers found that it was hard to make calls in the areas covered by cell1 and cell3. Even if a call was put through, the voice quality was quite poor. In addition, the voice was discontinuous and the interference was strong. Through using MS to call a fixed phone, engineers found it was hard to hear the voice clearly. On the contrary, they could hear the voice from the fixed phone clearly. This has proved the above analysis. That is, the interference might be from the outside, or the standing wave problem was occurring at the antenna (from this perspective, it can be judged that the interference existed on the uplink only).
4) Through using antenna feeder analyzer to perform on-site test, engineers found no problem was existing at any BTS. A new repeater was found in this area, and it was located two kilometers away from the BTS in the northwest direction. Moreover, the interference appeared just when the repeater was enabled. On-site test found that the BTS became normal state once the repeater shut down, and the interference bands also became normal, so did the call. If the repeater was enabled, however, it was hard to make calls and the interference was strong. At last, the agreement to shut down the repeater was reached. After that, the conversation became normal.

Case 4: Microwave interference

[Problem description]

During network maintenance, through analyzing BSC traffic statistics, engineers found that the call drop rate of the cell2 and cell3 of a S2/2/2 BTS arisen abruptly, and the value even reached 20% at some time.

[Problem analysis and solution]

1) Through checking BSC traffic statistics, engineers found that the number of idle TCHs was increasing at the interference bands 3-5 around 8:30. Around 10:00, the idle TCHs were found at the interference band 4 and interference band 5. Around 22:00, the idle TCHs were found at the interference band 1. Therefore, it could be judged that the interference existed.
2) Because the BTS ran normally, the problems cannot be related to frequency planning.
3) According to the TRX management messages, engineers found that the interference existed at the four boards of the cell2 and cell3 of the BTS. Because the probability for the four boards to be damaged simultaneously is quite small, the TRX problem can be excluded. However, one board was changed in case of abnormal conditions, but the interference was not eliminated.
4) Through checking all the BSC traffic statistics data, engineers found that cells of the BTSs near the BTS and the cells of the cell2 and cell3 of the BTS were interfered to some extent. In addition, engineers also found that the SDCCHs (16 SDCCHs in total) of the seriously-affected cells were seized at sometimes. However, the number of subscribers determined that the probability for all the SDCCHs to be seized simultaneously is quite small. Therefore, it could be judged that the uplink was interfered by outside factors. However, the interference might be related to direction only.
5) To further position the problem, engineers interchanged the jumpers of cell1 and cell3 at the set top. In this case, the interference was found at cell1, but the interference was disappearing from cell3. Therefore, the interference was not related to channel number.
6) Because the interference was not related to channel number, it might be the big-power signals that caused the interference.
7) Through using the spectrum analyzer to perform the measurement at the output interface of the BTS splitter, engineers found that the big-power signals existed at the 904MHz channel number (it has an interval of 5M between the used channel number. For the BTS where the interference was strong, the signal level can reach as high as about -25dBm. For other BTSs, the signal level was about -50dBm. Therefore, it could be judged that it was this signal that affected the BTS.

8) Through using the spectrum analyzer to scan the areas near the BTS, engineers found that there was a microwave antenna outputting big-power at the channel number 904.
9) The interference disappeared after the microwave equipment was shut down.

5.5.3 Call Drop Problems

For the GSM network, call drop is users' major worry and the call drop rate is an important index evaluating network quality.

I. Call Drop Resasons and Solutions

i) Call drop due to coverage reasons

[Reason analysis]

- Discontinuous coverage (dead zone)

For a single BTS, the quality of the signals at the edge of the station is quite poor, so the MS cannot hand over to another cell. In this case, the call drop occurs.

If the landform of the coverage areas is complex or fluctuates greatly, or the radio transmission environment is complex, the signals will be barred. In this case, the coverage is discontinuous and call drop will occur.

- Poor indoor coverage

If the buildings in an area are densely populated, the signal attenuation is great. And if the walls of the buildings are thick, the penetration loss is great and the indoor signal level is low. In this case, the call drop may easily occur.

- Isolated island effect

As shown in Figure 8-13, the service cell forms an isolated island due to various reasons (for example, the power is too great). In this case, the MS still seizes the signals of the service cell A after moving to cell C, but the cell A does not define the neighbor cell C. At this time, if the MS still performs the handover according to the neighbor cell B provided by neighbor cell A, it cannot find a suitable cell. In this case, the call drop will occur.

- Small coverage

If the coverage is too small, the hardware equipment of a cell may fail. For example, the antenna is barred or the TRX failure occurs (the power amplifier part).

[Judgment methods]

First you should find out the areas where the coverage is inadequate according to user complaints, and then you should perform the drive test in a larger scope to check if the signal level and the handover are normal and if the call drop exists. In addition, you can employ the traffic statistics recorded at the OMC to check the BSC overall call drop rate and find out the cell with great call drop rate. Furthermore, you can still make the analysis and judgment by referring to other traffic statistics items. Hereunder lists some ones:

- Power control performance measurement (to check if the mean uplink and downlink signal strength is too low)
- Rxlev performance measurement (to check if the ratio of the low Rxlev is too great)
- Cell performance measurement/inter-cell handover performance measurement (to check if the level class and the mean Rxlev are too low)
- Call drop performance measurement (to check if the signal level is too low during call drop and if the TA value is normal before call drop)
- Defined neighbor cell performance measurement (to position the cell with low mean signal level)
- Undefined neighbor cell performance measurement (to check if the undefined neighbor cells with high signal level exist)
- Power control performance measurement (to measure the greatest TA value between the MS and BTS)

[Solutions]

1) Check the areas where the coverage is inadequate

You can find out the area where the coverage is inadequate through drive test. For an isolated BTS or the BTSs installed in mountain areas that cannot form seamless coverage, you can add BTSs to these areas for seamless coverage. Or you can improve the coverage through other means. For example, you can enhance the maximum transmit power of the BTS, change the antenna azimuth angle, change the antenna tilt, change the antenna height, and so on. In addition, you should also analyze if the call drop is caused by landforms. Generally, call drop can easily occur at tunnels, big shopping market, underground railway entrance, underground parking lot, and low-lying places. In this case, you can use the micro cell to solve the coverage problem.

2) Ensure indoor call quality

To ensure indoor call quality, you should make sure that the outdoor signals are strong enough. To strength the outdoor signals, you can increase the maximum BTS transmit power, change the antenna azimuth angle, change the antenna tilt angle, and change the antenna height, and so on. If the indoor call quality is still not improved remarkably, you can consider adding BTSs. For improving the indoor coverage of office buildings and hotels, you can consider using the indoor antenna distribution system.

3) For the cells having no neighbor cells, you can configure the neighbor cells for the cell so as to reduce the call drop rate. To eliminate the isolation island effect, you can reduce the tilt angle of the BTS.
4) Eliminate hardware problems

You can check if there are hardware problems and if the coverage area is too small through drive test. If the call drop rate of a cell arises dramatically but all other indexes are normal, you should check if the neighbor cells of this cell work normally. (Generally, the downlink problems may occur. For example, TRX problem, diversity unit problem, and antenna problem are commonly seen. If the uplink fails, the outgoing handover failure rate of the old cell will be high.)

ii) Call drop due to handover reasons

[Reason analysis]

- Irrational parameter configuration

If the signal level at the cross-area of two cells is quite low, the level of the handover candidate cell is too low, and if the handover threshold is too low, some MSs will hand over to the neighbor cell when the signal level of the neighbor cell is higher than that of the service cell. If the signal level of the neighbor cell deteriorates dramatically just after the handover, the call drop will occur if no suitable cell is available for the handover.

- Incomplete neighbor cell definition

If the neighbor cell definition is incomplete, the MS will hold the conversation in the existing cells until it moves beyond the edges of the cell but cannot hand over to a stronger cell. In this case, the call drop will occur.

- Neighbor cells with same BCCH and same BSIC exist.
- Traffic congestion

If the traffic is unbalance, no TCH will be available in the target cell. In this case, the handover failure will occur.

- BTS clock lost synchronization

If the BTS lost synchronization, the frequency offset will go beyond the requirement. In this case, the call drop will occur if handover fails.

- T3103 expiry

The T3103 will be started when the network sends a handover command. Upon the reception of the message to complete the handover or the message to remove the command, the T3103 will stop. T3103 is used to hold the channel long enough for the MS to return to the old channel. If the T3103 is set to a too small value, the MS cannot necessarily return to the old channel. In this case, call drop may occur during handover.

[Judgment methods]

You can judge if the cells with low handover success rate, frequent re-establishment failures, and high call drop rate through analyzing traffic statistics indexes. After the judgment, you can find out what causes the handover. For example, the uplink and downlink Rxlev can cause the handover; the uplink and downlink Rxqual can cause the handover; power budget can cause handover; call direct retry can cause handover; and also handover can be initiated by traffic reasons.

To check if the BTS clock runs normally, you can check if the any alarm is generated for the BTS clock. If necessary, you must correct the BTS clock to eliminate clock problem. You can check if there is handover problem through drive test. If there is a problem cell, you should perform drive near the cell for several times. Hereunder lists the indexes concerning call drop:

- Inter-cell handover performance measurement (frequent handover failures, frequent re-establishment failures)
- Inter-cell handover performance measurement (frequent handovers, high re-establishment rate)
- Undefined neighbor cell performance measurement (the undefined neighbor cell level and the number of measurement report go beyond the standard)
- Outgoing cell handover performance measurement (find out the reasons for low outgoing cell handover from the handover target cell)
- Low incoming cell handover success rate; the cell handover parameters are improperly set; the target cell is congested.
- TCH performance measurement (the handover times are not proportional to the TCH call seizure successes; the handover happens too frequent)

[Solution]

1) Check the parameters affecting the handover. For example, you can check the hierarchical and level setting, each handover threshold, each handover hysteresis, handover time, handover duration, the minimum access level of the handover candidate cell, and so on.
2) If the call drop is caused by unbalance traffic volume or if the call drop occurs due to no handover channel is available at the target BTS, you can solve the problem by adjusting the traffic volume. For example, you can adjust the project parameters, such as antenna tilt and antenna azimuth angle, to control the coverage scope of a cell. To balance the traffic volume, you can use CRO to guide the MS to camp on other idle cells, or you can set the hierarchical and level priority to guide the MS to hand over to the idle cell. In addition, you can solve the problem by expanding the TRX directly.
3) Calibrate the problem BTS clock to enable the synchronization of the clock.

iii) Call drop due to interference reasons

[Reason analysis]

If the MS receives strong same-frequency interference signals or strong neighbor frequency interference signals in the service cell, the bit error rate will deteriorate. In this case, the MS cannot demodulate the BSIC code of the neighbor cells accurately, or it cannot receive the measurement report from the MS correctly. As a result, the conversation will be interfered, the call quality will become poor, and call drop will occur.

[Judgment methods]

The interference may be from the network itself or the outside network, or it may exist in the uplink signals or downlink signals. The following methods can be used to position the interference.

- Find out the cells might be interfered through checking traffic statistics.
- Perform the call drive test for the areas that might be interfered and check the uplink and downlink interference according to user complaint. You can find out if there is a place where the signal is strong but the call quality is poor through drive test tools. In addition, you can use a test MS to perform dialing test to check if a channel number is interfered.
- Check the frequency planning to see if same-frequency interference and neighbor frequency interference occur in the area where the frequency is improperly planned.
- Adjust the channel numbers that might be interfered to see if the interference can be avoided or reduced.
- Exclude the interference caused by equipment.
- If the previous methods fail to eliminate the interference, you can use the spectrum analyzer to scan the frequencies to find out the interfered channel number and the interference source.

Hereunder lists several traffic statistics indexes used for interference analysis:

- Interference band

  You can check the uplink interference through analyzing the interference band in the traffic statistics. If an idle channel appears at the interference bands 3-5, the interference is present. If it is intra-network interference, it will increase as the traffic volume grows. Generally, if it is outside interference, it is not related to traffic volume. It must be pointed out that the interference bands are reported to the BSC by the BTS TRX channel (when in idle mode) through RF resource indication messages. If the current channel is busy and cannot report RF resource indication message, you must consider the traffic volume for the measuring the interference bands.

- Rxlev performance measurement

  The Rxlev performance measurement provides the matrix relationship between the signal level and quality. If the signal level is high but the quality is poor, it means that the interference (same-frequency interference, intra-frequency interference, and outside interference) is present at the channel numbers of the TRX board.

- Poor quality handover ratio

  The cell performance measurement, inter-cell handover performance measurement, or the outgoing cell handover performance measurement records the outgoing handover attempt times. If the frequent handover is caused by poor signal quality, it means that the interference is present.

- Rxqual performance measurement

  It is related to the mean Rxlev and Rxqual during call drop.

- Call drop performance measurement

  It records the mean Rxlev and Rxqual during call drop.

- Frequent handover failures and frequent re-establishment failures

  It means that the interference may be present in the target cell.

[Solutions]

1) Check the interfered road and the distribution of signal quality through dive test. As far as the actual conditions are concerned, you can adjust the BTS transmit power and antenna tilt of the related cells or adjust the channel number planning to avoid the interference.
2) Use DTX technology, frequency hopping technology, power control, and diversity technology

   These technologies can be used to reduce the system noise and enhance anti-interference capacity of the system. DTX is divided into uplink DTX and downlink DTX. In this case, the transmit time can be reduced and the interference level of the system can also be reduced. However, you should adjust the DTX according to the actual radio environment and the neighbor cell relationship. When signals received by the MS are poor, the use of the DTX will result in call drop. If the downlink DTX is enabled, the BTS will increase its transmit power after the call is established. During the conversation, however, the BTS will reduce its transmit power. In this case, the interference against other BTSs will be reduced. If the interference is present near the BTS, the downlink DTX will deteriorate the conversation quality. When the BTS reduces its transmit power, the conversation quality will decrease or the call drop may even occur in the areas where the Rxlev is low but the interference signal is strong.

3) Solve the equipment problems, such as the self-excitation of TRX boards and the antenna demodulation interference.
4) Exclude the outside interference.

iv) Call drop due to antenna feeder reasons

[Reason analysis]

- Engineering problem may be one of the reasons. For example, if the transmit antennas between two cells are inversely connected, the level of the uplink signal will be far poorer than that of the downlink signal. In this case, the call drop, one-way audio, and call difficulty will be found in the areas far away from the base station.
- If polarization antennas are used, a cell had two sets of antennas. If the tilt angles of the two antennas are inconsistent with each other, the call drop will occur.

  If a directional cell has a master antenna and a diversity antenna, the BCCH and the SDCCH of the cell may be transmitted through the two antennas respectively. If the tilt angles of the two antennas are different, the coverage scope of the two antennas will be different. In this case, the MS can receive BCCH signals but cannot seize the SDCCH when starting a call. Thus the call drop is resulted.

- If the azimuth angles of the two antennas are inconsistent with each other, call drop may also occur. That is, the MS can receive the SDCCH signals, but it may be assigned with the TCH. In this case, the call drop will occur.
- The problems concerning antenna feeder will also cause call drop. For example, if the antenna is damaged, or water penetrates into the antenna, or connector problem is present, the transmitter power and the receiver sensitivity will decrease. In this case, the call drop will occur. To confirm the problem, you can check the standing wave ratio.

[Problem positioning and solution]

1) Check if any alarm concerning the combiner, CDU, tower amplifier, and standing wave is generated and check if the BTS boards are normal in the OMC.
2) Analyze if the path balance is realized according to traffic statistics.
3) Further analyze if the path balance is realized through monitoring the messages sent across the Abis interface.
4) Perform drive test and dialing test. During drive test, you can check if the BCCH numbers of the service cell are consistent with the planned ones, namely, if the transmit antenna of the antenna is correctly installed.
5) Check and test the on-site BTSs. Here the installation of the azimuth angle and the tilt angle of the antenna must be checked. In addition, you should also check if the feeder and jumper are correctly connected, if there is connector problem, and if the feeder is damaged. Furthermore, you must still check if the standing wave is normal.
6) Judge if it is BTS hardware that causes path unbalance and call drop. To solve hardware problem, you can either change the components that may have problems or disable other TRXs in the cell. To find out the problem TRX, you can position the problem through dialing test. Once a problem hardware component is found, you must replace it with a sound one. If no sound one is available, you must shut down the problem hardware component to prevent it from affecting network quality.

Hereunder lists several traffic statistics items for path balance analysis:

- Path balance measurement (to analyze if the path balance is realized)
- Call drop performance measurement (to analyze the uplink and downlink level and quality during call drop)
- Power control performance measurement (to analyze mean Rxlev on the uplink and downlink)

v) Call drop due to transmission reasons

If the transmission quality across the Abis interface and A-interface may be not good and stable, call drop may occur. The following methods can be used to solve the problem:

1) Check the transmission alarm and board alarm and analyze if there is transmission intermittent and board failure.
2) Check the transmission channel, test the bit error rate, check 2M connectors, and check if the equipment grounding is rational to ensure stable transmission quality and reduce call drop rate.
3) Check the traffic statistics to see if the frequent call drop is caused by transmission problems. Especially you should check TCH performance measurement, because it can indicate if the A-interface failures during TCH seizure is normal, if the TCH utilization is normal, and if the ground link call drop times are great.

vi) Call drop due to parameter reasons

Here you should focus on checking if the parameters related to call drop are irrationally set. If the following parameters are not irrationally set, the call drop may be resulted.

- Radio link failure counter

  This parameter acts on the downlink. When the MS fails to decode the SACCH, it will use this parameter to decide when to disconnect the call. If this parameter is set to a too small value, the radio link failures will easily occur and cause call drop. For dead zones or the areas where the call drop frequently happens, you are recommended to set this parameter to a greater value.

  When changing the radio link failure counter, you should change the corresponding T3109. The T3109 must be set to a value great enough for the MS to detect a radio link failure. For example, if the value of the radio link failure counter is 16 (about 8 seconds), the value of T3109 must be greater than 8 seconds (you can set T3109 to 9 seconds or 10 seconds).

- SACCH multiframe number

  This parameter acts on the uplink. The BTS uses this parameter to notify the radio link connection failure message to BSS. The BSS side judges the radio link failure according to the bit error rate on the uplink SACCH. If this parameter is set to a too small value, the radio link failure will happen frequently and the call drop rate will be resulted.

- Access control parameters

  The access control parameters include the Minimum RACH Rxlev, RACH busy threshold, and so on. If the access control parameters are irrationally set, the call drop will be easily resulted.

- T3101, T3107

  T3101 is started when the BSC sends a CHANNEL ACTIVATE message to the BTS. It stops when an ESTABLISH INDICATION message is received. This timer monitors the immediate assignment procedure. If T3101 expires, the allocated channels will be removed.

  T3107 is started when the BSC sends an ASSIGNMENT COMMAND message to the BTS. Once the BSC receives the ASSIGNMENT COMPLETE message from the BTS, this timer will reset. T3107 is used to hold the channels long enough so that the MS can return to the old channel. Or it can also be used by the MS to release a channel.

If the two timers are set to a too small value, the system will not have enough time to send the ASSIGNMENT COMPLETE message to the BSC. In this case, the call drop will occur if the timer expires.

- T200; N200

T200 is an important timer used for the LAPDm (Link Access Procedure on the Dm channel). It prevents the deadlock from occurring when the data is transferred across the data link layer. In GSM system, the messages transferred across radio interfaces can be divided into two types: the messages needing opposite acknowledgement and the messages not needing opposite acknowledgement.

For the messages needing opposite acknowledgement, a T200 must be started once the message is sent. If the opposite acknowledgement is not received after a period of time, the message should be retransmitted. In this case, the timer must be restarted. If the retransmission times exceed the maximum allowed times, the message will no longer be retransmitted and the link will be released. That is, this call drops. N200 is the maximum retransmission times allowed. T200 and N200 have different types depending on channel types (TCH full rate, TCH half rate, and SDCCH) and service types (signaling and messages). The given channel type and service type matches a pair of T200 and N200.

The call drop rate can be reduced if the message is retransmitted as early as possible before the opposite acknowledgement is received. That is, the value of T200 must be set as small as possible and the value of N200 must be set as great as possible. However, the T200 cannot be set to a too small value and the N200 cannot be set to a too large value. If the opposite party has acknowledged that the link had been removed, the retransmission will make nonsense.

Therefore, to reduce the call drop rate, you can adjust the T200 and N200 according to actual radio conditions.

II. Call Drop Cases

Case 1: Call drop caused by frequency hopping collision

[Problem analysis]

A BTS uses 1 x 3 RF frequency hopping. After capacity expansion, the TCH allocation failure rate is still high due to radio link problems. In addition, the TCH call drop rate and incoming handover failure rate are high. The SDCCH call drop rate is normal.

[Problem positioning and solution]

Because high call drop rate and high incoming handover failure rate come together with the TCH allocation rate, it can be judged that the problem may arise during TCH assignment or the channel numbers or timeslots seized by the call are interfered or unstable. Because the SDCCH call drop rate is normal, it can be judged that the probability for the BCCH carriers and BCCH numbers to the interfered are small, but the non-BCCH carriers and non-BCCH numbers may be greatly interfered.

Through checking the hardware, antenna feeder, and transmission, engineers found no problem. According to drive test, engineers found that the signal level was high but the quality was poor. Through on-site dialing test, engineers found that the conversation quality was poor. Through checking engineering parameters, engineers found that the MAIO of the new carrier was the same as that of the old carrier. Therefore, it can be judged that the call drop was caused by the frequency hopping collision. After modifying the MAIO, engineers found that call drop rate became normal.

Case 2: Call drop caused by isolated island effect

[Problem description]

Users complained that call drop always occurred above the fifth floor of a building.

[Problem analysis]

1) Through on-site test, engineers found that call drop and noise existed here. As far as the test MS was concerned, it was always in the service area of the other BTS (hereunder called BTS B) other than the local BTS (hereunder called BTS C) before the call drop.
2) It is estimated that the service cell belongs to BTS B, which is 3-4 kilometers away from the building. Therefore, it can be judged that the signals from the BTS B are reflected signals. As a result, an area similar to an isolated island is formed.
3) Through checking data configuration, engineers found that only the cell 2 of BTS A has the neighbor cell relationship with BTS B. Therefore, when the MS is using the signals in cell 2 of the BTS B, if the signals in cell 3 of BTS A were strong, and if the cell 2 of BTS B has no neighbor cell relationship with the cell 3 of the BTS A, the handover cannot be performed.

The signals from the cell 2 of BTS B are reflected many times. Therefore, when signals (from BTS B) received by the MS became poor dramatically, emergent handover may be initiated. In this case, however, either the cell 2 or cell 3 of the BTS A is not an ideal candidate cell for the cell 2 of BTS B. As a result, the MS may hand over to other BTS (hereunder called BTS C), but the MS cannot receive the signals from BTS C. Therefore, call drop occurs.

[Solution]

You are recommended to change the data in the BA1 (BCCH) list, BA2 (SACCH) list, and neighbor cell relationship list. For example, you can configure the cell 3 of BTS A as the neighbor cell of cell 2 of BTS B. To eliminate the isolated island effect, you should also further optimize the engineering parameters. After that, the call drop problem can be solved.

Case 3: Reduce call drop rate through optimizing handover parameters

[Problem description]

The drive test in an area found that the call drop rate at a cave near the BTS high because the handover cannot be performed in due time.

[Problem analysis and solution]

The cave is near the BTS. The signal level of the target cell is about -80dBm in the cave, but the signal level of the old cell drops below -100dBm. The downlink power of the two cells outside the cave is good, so the handover cannot be initiated. However, the signal level deteriorates dramatically in the cave, so the call drop occurs before the measurement time is arriving.

To reduce the call drop rate, you can optimize and adjust the handover parameters:

1) If no ping-pong handover is present and the conversation is continuous, you can make the PBGT handover happen as easily as possible.
2) Set the threshold to trigger the emergent handover rationally so that the emergent handover can be triggered before call drop.

For the parameter modification, see

Handover parameter optimization

Parameter Name	Before Modification	After Modification
PBGT handover measurement time	5	3
PBGT handover duration	4	2
PBGT handover threshold	72	68
Uplink quality threshold for emergent handover	70	60
Minimum downlink power for handover candidate cell	10	15

Case 4: Call drop caused by clock problem

[Problem description]

The cell A of an 1800MHz network has been cutover. After the establishment of a cell at site B, the calls made in the cell handing over to the GSM900 MHz cell that shares the same BTS site drops in the GSM900 MHz cell. And the call drop rate is great.

[Problem analysis and solution]

Engineers find that the clock of the GSM900 MHz BTS and that of the GSM1800 MHz BTS are asynchronous. When the calls established on the GSM1800 MHz cell intend to hand over to the GSM900 MHz cell, the drive test data shows that the FER arises dramatically first, and then gradually disappears to none. If the handover is from a GSM900 MHz cell to a GSM1800 MHz cell, this phenomenon is also present. Through monitoring signaling, engineers find that the conversation held several seconds before the call drop is just process for call re-establishment. However, the test MS shows that the call has been handed over to the GSM900 MHz cell. Therefore, it can be judged that the clocks are seriously asynchronous. To solve this problem, the carrier concerned and the GSM900 equipment provider cooperate with each other on clock calibration. After that, the abnormal call drop disappears. Therefore, for dual-band handover, the clock of the GSM900 MHz BTS and that of the GSM1800 MHz BTS must be synchronous.

5.5.4 Handover Problems

The MS is always moving during conversation. To ensure channel quality, the MS must measure the quality of the channels of the surrounding channels without stop, and then send the measurement report to the BSC through the service cell. The BSC will perform radio link control according to the signal level and quality contained in the measurement report. If the MS moves to another cell, the new cell will replace the old cell to ensure the continuity of the service. The handover enables each cell to form a seamless network.

I. Handover Problem Positioning Steps

1) Find out if the problem occurs at an individual cell or all cells and find out the characteristics of the problem cells. For example, if the cells are the neighbors cell of a cell, or if they are co-BSC cells, or if they are co-MSC cells.

If the handover between two cells fails, you should focus on checking if the data of the two cells is correctly configured. In addition, you should also check the hardware of the two cells.

If the problem is found in all the neighbor cells of a cell, you should focus on checking of the data of this cell is correctly configured. In addition, you should also check the hardware of the cell.

If the problem is found in all the cells under the same BSC, you should focus on checking the data configuration between the BSC and MSC.

If the problem is found in all the cells under the same MSC, the cooperation between the local exchange and the opposite exchange may fail. For example, the signaling is incompatible and the timer setting is irrational.

2) Check if the data has been modified before handover problems occur.

If the problem is found in an individual cell, you should focus on checking if the data configuration for this cell has been modified.

If the problem is found in all the cells under the same BSC, you should focus on checking the data configuration for the local BSC and the opposite MSC has been modified.

If the problem is found in the cells under the same MSC, you should check if the data configuration for the opposite MSC has been modified.

3) Check if it is the hardware failure that causes the handover problem.

4) Register the related traffic statistics items, such as the handover performance measurement and TCH performance measurement.

- Check if the TCH seizure of the problem cell is normal. For example, if the call drop rate is high.
- Check if the outgoing handover success rate is normal.
- Find out the causes for the handover failure.
- Check if the radio handover success rate is normal.

5) Perform drive test for the problem cell and analyze the drive test signaling.

- Check if the uplink and downlink of the problem cells are balanced, because unbalanced path may cause handover problem (BTS problem may cause the unbalance).
- Check if the measurement report for the problem cell contains correct neighbor cell list.
- Check if a call can hand over from a problem cell to a neighbor cell correctly and check if it can hand over from a neighbor cell to the problem cell.
- Analyze if the signaling procedure for the handover is normal.

II. Handover Problem Analysis Methods

i) Handover cannot be initiated

If the MS is in a cell where the signal is poor, it cannot hand over to another cell. In this case, you should consider of the handover conditions are met and if there is an outgoing cell available.

Hereunder details the possible reasons:

- The handover threshold is set to a low value

For edge handover, the handover triggering condition is that the Rxlev must be smaller than the handover threshold. If the edge handover threshold is set to a too small value, the signal level of the neighbor cells will be far higher than that of the service cell. In this case, the handover cannot be initiated. As a result, the conversation quality will be affected, or even the call drop will be resulted. The setting of the handover threshold depends on the coverage scope of the cell. You can change the size of the service area of the cell through changing the handover threshold.

- Neighbor cell relationship is not set

Though the signal level in the neighbor cells of the service cell is high, the MS will not report the neighbor cells if the neighbor cell relationship is not set. In this case, the MS cannot hand over to a neighbor cell. Through performing cell reselection or dialing test, you can check the neighbor cell list reported by the MS. If the MS has moved to the major lobe of a cell but this cell is not found in the neighbor cell list, you should check if the correct neighbor cell relationship has been correctly set. During the drive test, you can use another MS to scan the BCCH numbers to check if the strong BCCH numbers are in the service cell or in the neighbor cell list.

- Handover hysteresis is irrationally set

If the difference between the signal level of the handover candidate cell and that of the service cell is greater than handover hysteresis, the cell can work as a target cell. If the hysteresis is set to a too great value, the handover is hard to be initiated.

- The best measurement time "N" and "P" are irrationally set

During normal handover, the MS uses N-P rules to list the handover candidate cells in a certain order. If a candidate cell is the best cell within P seconds out of N seconds, it will be treated as the best cell.

When there are two cells become the best cell alternately, the MS may find it hard to select a best cell through N-P rule, which makes the handover difficult. In this case, you can adjust the values of N and P and reduce the measurement time to make the handover decision more sensitive to level change.

If the landform and the ground objects of the service cell are quite complicated, the signals received by the moving MS will fluctuate greatly. In this case, the handover candidate cell cannot meet N-P rule, which will make the handover difficult.

ii) Handover problem caused by hardware failure

If the data configuration for the problem cell and the neighbor cells has not been modified recently but the handover problems occur abruptly, you should first consider if the problems are caused by BTS hardware equipment.

If the cells sharing the same base station with the cell have similar problem, you should consider if the problem is caused by the common hardware of the cells.

If the problem is found in only one cell under the base station, you should consider if it is the hardware of this cell that causes the problem. For example, if some of the carriers are damaged. To test the problems of this kind, you can disable some of the carriers. If the handover success rate returns to normal state after a carrier is disabled, you can check if the problem is present at this carrier or if the CDU and antenna feeder part related to this carrier fails. If signals of a cell on the uplink and downlink are seriously unbalanced, frequent handover will be caused and the handover success rate will decrease.

To check if the signaling flow of the cell is normal and if the uplink Rxqual and downlink Rxqual are good, you can monitor the messages sent across the Abis interface. If the Rxqual is poor, it means that the hardware equipment of the fails or serious interference is present in the cell. In this case, the signaling exchange is unavailable and the handover problem will occur.

iii) Handover problem caused by irrational data configuration

- For stand-alone networking mode, if the outgoing MSC or incoming MSC handover is abnormal, you should check if the signaling cooperation of the two MSCs is correct. In addition, you should also check if the data configuration for the opposite MSC and the local MSC has been modified recently.

- For co-MSC networking mode, if the handover is performed within the BSCs of different providers and the inter-BSC handover is abnormal, you should first check if the signaling cooperation between the BSCs is normal, and then check if the data configuration for the BSCs has been modified.
- If the abnormal handover is found at a cell only, you need to analyze the abnormal handover according to actual conditions.

If the incoming handover of a cell is abnormal, you need first check if the incoming handovers to this cell is abnormal. Generally, when the handover is abnormal, the handover success rate is low, or even the handover does not occur.

If all the incoming handovers to this cell is abnormal, you should check if the data configuration for this cell is correct. Here the data configuration includes both the data configured for this cell and the data configured for other cells but is related to this cell. For example, the CGI of this cell may be correctly configured, but it may be wrongly configured in other cells.

If there is only one incoming handover to a cell is abnormal but other incoming handovers to this cell are normal, in addition to checking if the data configuration for this cell is correct, you should also check if the data configuration for the neighbor cells is correct. Furthermore, you should also check if the hardware equipment of the cell is normal.

The methods to analyze the abnormal outgoing handovers are similar to the methods to analyze the abnormal incoming handovers.

- Check the timers (such as T3105, Ny1, T3103, and T3142) related to the handover.

T3105 indicates the interval for continuous PHYSICAL INFORMATION to be sent to the MS. The network will start T3105 for the sending of the PHYSICAL INFORMATION. If the timer fails before receiving any correct frame from the MS, the network will resend the PHYSICAL INFORMATION and restart the timer. A piece of PHYSICAL INFORMATION can be sent Ny1 times to the maximum. Here the product of Ny1 and T3105 must be greater than the sum of T3124 and delta ("delta" indicates the interval between the expiry of T3124 and the reception of the Handover Failure message of the old BSC), otherwise the MS cannot perform successful handover.

T3124 is a timer waiting for the PHYSICAL INFORMATION from the network side during asynchronous handover. When sending the HANDOVER ACCESS message on the DCCH for the first time, the MS will start T3124. Upon receiving a piece of PHYSICAL INFORMATION, the MS will stop T3124. If the channel type allocated in the HANDOVER COMMAND message is SDCCH (+SACCH), the T3124 is set to 675ms. For other cases, the T3124 is set to 320ms.

III. Handover Cases

Case 1: No handover candidate cell is available due to CGI error

[Problem description]

The handover in an area is abnormal. When the MS moves from cell A to cell B, the signals in cell B are stronger than that of cell A, but the handover does not happen. After the MS moves from cell B to cell C, the MS hands over from cell A to cell C.

[Cause analysis]

If a cell can work as a service cell and can hand over to other cells, but the incoming handover is unavailable, you can check if the CGI, BSIC, BCCH number of the cell are correct.

[Problem solution]

1) Use the test MS to lock the BCCH numbers of cell B. The call is normal. The MS can hand over to any other cell by force.
2) Make a call after locking the BCCH umber of any neighbor cell of cell B, and then force the MS to hand over to cell B, but the handover does not happen, because no handover command is seen in the drive test software.
3) The handover procedure requires the MS detecting the neighbor cell signals and reporting the detected signals to BSC with a measurement report. Upon receiving the measurement report, the BSC must make the handover decision. If the handover conditions are met, the BSC should activate the TCH of the service cell, and then send a handover command to the MS.
4) If the signals of cell B are far stronger than that of cell A and the handover conditions are met (the PBGT handover threshold is 70), but no handover command is sent, it means that errors occur during the activation of the target cell TCH.
5) If the cell B works as the target cell but the TCH cannot be activated, the data may be incorrectly configured for the cell. In this case, the BSC that contains the cell cannot find the target cell, so the TCH cannot be activated and no handover command can be found in the service cell.
6) The CGI error is found in cell B through data checking. The handover is normal after the CGI is changed to correct value.

Case 2: Unbalanced path causes low handover success rate

[Problem description]

The incoming BSC handover success rate is quite low for the two cells under a BTS, ranging from 10% to 30%.

[Cause analysis]

Generally, if the data problems, such as CGI error or intra-frequency interference, exists and if there is dead zones in heavy-traffic areas, or if it is hard for the MS to access the cell due to poor uplink signals, the incoming BSC handover success rate is low.

[Solution]

1) The cell data is found normal.
2) Through checking traffic statistics items, engineers found that all incoming cell handover success rates were low.
3) Through drive test, engineers found that frequent handover attempts were made in the area 2km away from the BTS, but the handover always failed. Even if a successful handover was made, call drop occurred immediately. During the handover, engineers found that the downlink level was about -85dBm. Engineers made 10 dialing tests with frequency locked, all the originating calls failed. For the answering calls, they can be connected but cannot be called out.
4) It is estimated that the CDU uplink channel loss is great, or the jumpers are incorrectly connected at the BTS top. In this case, the uplink signals will be poor, which causes the problem.
5) After changing the CDU, engineers found that the incoming handover success rate increased to 95%.

Case 3: Improper antenna planning causes low handover success rate

[Problem analysis]

The handover success rate among the three cells under a BTS is quite low according to traffic statistics. For the handover from cell1 to cell3 and the handover from cell2 to cell3, the success rate is lower than 30%.

[Cause analysis]

Generally, low handover success rate is caused by board failure, handover data error, or improper antenna planning.

[Solution]

1) The BTS hardware is normal and no alarm concerning handover parameters is generated, so the hardware problem and parameter setting problem can be excluded.
2) The BTS locates at the eastern side of a south-north road and is 700m away from the road. The azimuth angles of the three cells are 0°, 80°and 160°. They three cells direct to the two directions and the open resident areas lying under a hill in the east respectively. Among the three cells, the down tilts of two cells are 7°. To make the coverage as specified as possible, engineers concentrated the antenna azimuth angles of the three cells in design. In this case, however, the cells of the BTS are seriously overlapped in the east. For the areas just in the west, the coverage is provided by the side lobes and back lobes of the three cells. Therefore, when the MS is moving on this road, first it is covered by cell1. When it moves to the west, the signals of the three cells are poor and fluctuating greatly. In addition, since the handover measurement time and the handover duration is set to a small value, the handover is rather sensitive, and that's why the frequent handover failure occurs.
3) After setting the azimuth angles of the three cells to 60°, 180°, and 350°, engineers found that the handover success rate of among the three cells increased to 95%.

Case 4: Problems concerning the cooperation of different carriers' equipment cause low outgoing BSC handover success rate

[Problem description]

There is a dual-band network in which the GSM900 MHz network and the GSM1800 MHz network are stand-alone. After the two networks completed cell reselection and handover parameter setting, engineers found that the dual-band handover success rate was low; especially the success rate of the handover from the GSM1800 MHz network to the GSM900 MHz network was low, ranging from 60% to 80%. However, the success rate of the handover from the GSM900 MHz network to the GSM1800 MHz network was higher than 92%.

[Cause analysis]

For a dual-band network, if the problems concerning the cooperation of different carriers' equipment are found, you must know the data configuration of the equipment. For example, if the equipment supports Phase 2+ and EFR.

[Solution]

1) Through using signaling analyzer to analyze the message flowing across the A-interface and E-interface, engineers found that the MSC of the GSM1800 MHz network would send back a Handover Reject message to the BSC of the GSM1800 MHz network when the BSC sent a Handover Required message to the MSC.
2) The MSC of the GSM1800 MHz network sent a Prepare Handover message to the MSC of the GSM900 MHz network. Upon receiving the message, the MSC of the GSM900 MHz network sent back an Abort message.
3) Because the success rate of the handover from GSM900 MHz network to the GSM1800 MHz network was high, engineers found that the voice version carried in the Prepare Handover message (from the GSM900 MSC to GSM1800 MSC) is half rate version 1, but the voice versions carried in the Prepare Handover message (from GSM1800 MSC to GSM900 MSC) are full rate version 1, full rate version 2, and half rate version 1, which belong to PHASE 2+. However, MSC of provider A does not support the PHASE 2+, so the handover failure is caused.
4) Through modifying the MSC data of the circuit MSC data at the A-interface and selecting the full rate version 1 only, engineers found that the voice versions carried in the Prepare Handover message (from GSM1800 MSC to GSM900 MSC) are full rate 1 and 2. After that, the dual-band handover success rate was greatly increased.

5.5.5 Congestion Problems

This section introduces the methods to handle SDCCH congestion and TCH congestion, in which TCH congestion indicates SDCCH seizure all busy. The TCH congestion has two cases. One is TCH seizure all busy. For this case, the real channels cannot be allocated to the MS, so the MS will fail to request the channels. The other one is that the TCH assignment fails after an assignment is sent due to various reasons.

I. Congestion Problem Solutions

- Congestion caused by heavy traffic

You can check if the SDCCH traffic and TCH traffic are normal through viewing traffic statistics. If the congestion is caused by heavy traffic, the most efficient method to solve the problem is to expand the capacity of the network. In addition, you can adopt traffic sharing technologies to ease the congestion. For example, you can modify the CRO, enable direct retry or load handover function.

- SDCCH congestion caused by burst traffic

If the SDCCH congestion rate is high and the traffic is heavy but the TCH traffic is normal, the SDCCH congestion may be caused by burst traffic. The SDCCH congestion always occurs at BTSs along railways and tunnel exits, because the BTSs are installed in remote places and the capacity of a BTS is small. As a result, when the train moves fast along the railways or stops at a railway station, most of MSs failing to capture a network will perform location update, which will result in SDCCH congestion. In addition, when short messages are sent at a concentrated time, the SDCCH congestion will also occur easily. SDCCH congestion cannot be completely avoided, but some measures can be taken to ease the congestion. For example, you can add the number of SDCCHs, or enable the dynamic conversion between SDCCH and TCH.

- Congestion caused by TRX problems

When a carrier configured in a multi-TRX cell cannot provide services, the channel congestion will also occur. To solve the problem, you should replace the problem TRX with a sound one. If the TRX problem cannot be positioned, you should check if the antenna feeder connection is correct and if the antenna standing wave is normal. If yes, recheck the TRX where the problem may be generated.

- Congestion caused by interference

The interference present across the radio interfaces will also cause congestion. In this case, you should solve the interference problem first.

- Channel assignment failure caused by inconsistent coverage

If the concentric technology is not used, the transmit power of the TRXs within the same cell will be inconsistent, which will result in inconsistent coverage. In this case, the channel assignment failure will easily occur. To position this problem, you can check if the connection between the splitter and connector and if the connection between CDU and SCU are correct.

When a cell uses multiple transmitter antennas, inconsistent coverage will be inconsistent, which will result in channel assignment failure. To solve this problem, you should make the coverage of each transmitter antenna as consistent as possible through engineering adjustment.

In addition, if the transmitter antenna and the receiver antenna of a cell is not in the same plane or the antenna tilt angles are inconsistent, the channel assignment failure will also be caused. In this case, you can calibrate the antennas to solve the problem.

- Congestion caused improper data configuration

If the congestion is caused by improper location area planning, you can reduce the SDCCH congestion rate by planning the location area properly.

If the congestion is caused by the problems concerning SDCCH dynamic allocation, you can reduce the SDCCH congestion rate by enabling the SDCCH dynamic allocation function.

For dual-band network, you can properly set the parameters (such as CRO, CBA, and cell reselection hysteresis) to reduce the SDCCH congestion rate.

If the timers, such as T3101, T3103, T3107, T3122, T3212, and T3111, are not properly set, SDCCH congestion will also be caused.

Hereunder are the solutions to the previous problems.

You can ease the congestion caused by SDCCH dual allocation through reducing the T3101 to a smaller value. If the T3101 is set to a large value, the radio resources will be seized for a long period of time. To fully use the radio resources, therefore, you can reduce the T3101 value.

You can save the TCH resources through reducing the T3103 and T3107 to a rational value. Generally, T3103 and T3107 are set to about 5 seconds.

The T3122 must be stopped once the MS receives an IMMEDIATE ASSIGN REJECT message. Only after the T3122 expires, the MS can send a new channel request message. If the MS sends channel request messages frequently, the RACH load and CCCH load will increase. To solve this problem, you can increase the T3122 to a larger value.

T3212 stands for the time limit value for periodical location update. You can ease the SDCCH load by increasing the T3212 to a larger value.

T3111 is related to release latency. It is used for the deactivation of the latency channels after the major signaling link breaks. T3111 can be initiated during either TCH release or SDCCH release. The value of T3111 must be consistent with that of the T3110 at the MS side. Generally, it should be 2 seconds. If the T3111 is set to a large value, great SDCCH congestion rate may be caused.

II. Congestion Cases

Case 1: SDCCH congestion caused by wrong LAC configuration

[Description]

A BTS is configured as S1/1/1. It is found that the SDCCH congestion rate for 2 cells reaches as high as 8%.

[Problem analysis and solution]

1) Through checking the measurement indexes for TCH and SDCCH, engineers found that the TCH traffic was not heavy. The traffic volume for each cell during busy hours is lower than 2.2Erl. However, the requests for SDCCH seizure are great, reaching 3032 times during busy hours. The SDCCH traffic reaches 1.86Erl, and the congestion rate reaches 8%.
2) The main reasons for SDCCH seizure include the messages sent before call setup, the messages sent during handover, the location update messages sent under the idle mode, and other short messages.
3) The TCH traffic is normal, the requests for TCH seizure (including handover) are normal (318 times), and the handover requests are also normal (146 times). Therefore, the SDCCH congestion may be caused by a large number of location update messages or short messages.
4) The LAC of the BTS is 0500, and the LACs of other cells of the surrounding cells are 0520. After changing the LAC of the BTS to 0520, engineers found that the requests for SDCCH seizure during busy hours were 298, the SDCCH traffic was 0.27Erl, and the congestion rate reduced to 0.

Case 2: SDCCH congestion caused by burst location updates

[Problem description]

The radio connected ratio of a local network is lower than average level. According to traffic statistics analysis, it is found that the SDCCH congestion happened at several BTSs.

[Problem analysis and solution]

1) Through analyzing traffic statistics, engineers found that the SDCCHs of the congested cells were seized for 300 to 400 times during busy hours. Here the BTS was configured as S1/1/1 and each cell was configured with 8 SDCCHs. Therefore, the SDCCHs can be seized by 400 times, but the SDCCHs were congested for tens of times during busy hours.
2) As far as the registered traffic statistics items were concerned, most of the SDCCH seizures were caused by location update. Taking the BTS location into consideration, engineers found that most of the BTSs were installed at the intersections of two railways. Therefore, it might be the burst location update that caused SDCCH congestion.
3) To verify if it was the burst location update that caused the congestion, engineers registered the traffic statistics items in 5 minutes and found that most of the location update happened within the five seconds. Through querying the train time table, engineers found that there were 4 to 5 trains passing by within the five seconds. When the trains passed the intersections, a large number of location updates were generated in a short time. In this case, the congestion was caused.

Therefore, if the BTSs are installed at the railway intersections, you are suggested to enable the SDCCH dynamic allocation function and configure a suitable margin for the SDCCH.

Case 3: Great TCH congestion rate caused by the inconsistent tilt angles of two antennas under the same cell

[Problem description]

It is found that the TCH congestion rate of a cell is great (greater than 5%) according to traffic statistics.

[Problem analysis and solution]

1) Through checking BSC traffic statistics, engineers found that it was the TCH seizure failure that directly caused the great TCH congestion rate.
2) Generally, TCH seizure failure is caused by TCH assignment failure. Through monitoring Abis interface, engineers found that most of the TCH assignment failure occurred at the No.4 TRX and No.5 TRX, and the probability for the assignment failure rate for the No.4 TRX was near that for the No.5 TRX.
3) Through checking the antenna feeder part, engineers found that the tile angle corresponding to the transmitter antennas of the two TRXs were too great (it is 10 degrees than that of the antenna for BCCH, because the antenna nuts were found loosen. Therefore, if the MS is far away from the BTS, it can receive the BCCH signals but cannot receive the TCH signals. If the TCH is assigned to the MS when the MS starts a call, the TCH seizure failure will occur.
4) To solve the problem, you can enable the tilt angel of the TCH antenna and that of the BCCH antenna to be consistent with each other. In this case, the TCH congestion rate can be reduced to 2% or lower.

Case 4: High TCH congestion rate caused by downlink interference

[Problem description]

A cell of BTS is responsible for covering a large area of sea surface along the coast. According to the registered traffic statistics items, engineers found that when the traffic volume was lower than 1Erl, the TCH congestion of the cell reached 10% at some time. However, no alarm was generated. All the interference bands fell within the interference band1 and the hardware and RF connections were normal.

[Problem analysis and solution]

Because all the interference bands fell within the interference band1, the uplink interference is impossible. Considering that the coverage distance reaches 60 to 70 kilometers and multiple normal cells are present along the coast, the probability for the channel numbers of the downlink areas and the cell to be interfered is high. Through modifying the channel numbers of the cell, engineers found that the TCH congestion rate was improved. Through further optimizing the channel numbers, engineers found that the TCH congestion rate was lower than 1%. Therefore, it can be judged that the 10% of congestion rate is caused by the downlink interference of some areas.

5.5.6 Other Problems

I. Subscriber Is Not in Service Area

When a subscriber is not in service area, the MS works as the called party when the signals received by the MS are good and the calling party hears a voice saying that the subscriber is not in the service area. If the coverage, operation, and data configuration of a network are good, the occurrence probability for the problem must be lower than 1%, otherwise it is other causes that result in the problem.

Generally, if a subscriber is not in the service area, the following causes may be present:

- Coverage problem

If the subscriber complaint happens at cell edges, the problem may be related to coverage. In this case, the probability for the calling party failure is equal to the probability for the "subscriber is not in service area".

- Parameter setting

If the subscriber is not in service area, the parameters concerning the paging, access, and immediate assignment may be not properly set. In this case, you can check if the messages concerning RACH overload, PCH overload, and SDCCH overload are generated through querying traffic statistics and alarms. If yes, the subscriber may not in the service area.

- System capacity limit or overload

If system capacity limit or overload occur (for example, HDB overload, CPU overload, or capacity overload during busy hours), the system may fail to read the subscriber information, or subscribers cannot access the radio network. In this case, the subscriber may not in the service area. To solve this problem, you can take measures to expand the system capacity.

- Transmission problem

If the links between systems (such as the LAPD link of the Abis interface and the links of the each network entity) and the links within a system (such as the link among the modules of BCS/MSC) are not stable, the messages sent through these links may be missing. In this case, subscribers may not in the service area. To position the problem, you can check the alarms.

- Equipment causes

If the designs concerning MSC and BSC are incomplete, the probability of "subscriber is not in service area" will increase.

- MS causes

If the RF parts or the software parts of the MS have problems, for example, the reception capability of the MS is poor; the frequency deviation goes beyond the requirements defined in the protocols; and the dual-band performance of the MS is poor, this problem may also occur.

II. Signal Fluctuation

Signal fluctuation indicates that change of the MS signal strength. The following factors may cause signal fluctuation.

- Radio wave propagation

The strength of the signals received by the MS is the amplitude of the sum of the vectors of various propagation paths. Because the propagation environment is ever-changing, the attenuation of radio channels is ever-changing. Therefore, even if the MS does not move, the strength of the received signals will change.

- Cell reselection and handover

When the MS moves from the old cell to the new cell through handover or cell reselection, the signals of the MS will fluctuate because the signal strength of the old cell and that of the new cell are inconsistent.

- Antenna shake

When the antenna shakes, the antenna gain will change, so the signals will also fluctuate.

- Location update or channel assignment occurs at non-BCCH TRX

If the SDCCH is assigned to a non-BCCH TRX during location update and power control is available on SDCCH, the signal strength may fluctuate.

III. Voice Discontinuity

Voice discontinuity stands for pauses or words loss occurs in conversation. If the voice continuity is remarkable, the conversation quality will be affected.

The following factors may cause voice discontinuity

- Frequent handovers

Only hard handover is available in GSM system. Therefore, when the MS hands over from the source channel to the target channel, the downlink frames may loss at the Abis interface. As a result, the voice continuity is unavoidable during handover. Generally, frequent handovers may occur at cell edges or during cross coverage. In this case, the voice discontinuity will become a headache of subscribers. To avoid the frequent handovers, you can adjust the antenna tilt and height and configure the data, such as uplink and downlink quality threshold and restriction properly.

- Radio link interference

Radio link interference will increase the bit error rate, which will cause voice discontinuity. In addition, the signals always fluctuate greatly at cell edges, so the conversation quality at the cell edges is bad.

- Poor network coverage

If the network coverage is poor, the Rxlev and Rxqual will become poor, thus the conversation quality will be affected.

- BTS transmission problem

BTS transmission problems will affect conversation quality. For connectors, you should check of the connection among the connector is good. For optical transmission, you should check if the optical headers are clean and if the transmission errors are great. For micro wave transmission, it may be affected by weather. If there is large amount of dust in the equipment, the conversation quality may also be affected. If both micro wave transmission and optical transmission are used, you should pay attention to the cooperation of the transmission impedance at the equipment interfaces.

- TRX board failure

Hardware problem will result in poor conversation quality. In this case, you should replace the problem hardware with the sound one.

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