The Optimization of TD-LTE Wireless Network Based on Lab Lech Simulation System

Jing-jie Shan\(^1\), Jian Jin\(^1\)\(^{a}\)

\(^1\) Electronic communication engineering college, Anhui Xinhua University, Hefei, Anhui, 230601, China

\(^{a}\) Corresponding author: kljjab@163.com

Abstract. The paper introduced the problems and solutions to optimize TD-LTE wireless network. The collected log file data was analyzed and processed based on Lab Lech simulation system, and it was applied to the actual system by adjusting the wireless parameters of the serving cells and the parameters of switching the cells, etc., thereby realizing the closed-loop network optimization of the TD-LTE system in real time.

1. Introduction

Compared with the 3G network, the TD-LTE system adopts a flat network structure and cancels the RNC nodes. Only eNodeB(Referred to as eNB) is included on the access network side, which reduces the network elements that the signaling process needs to pass through, and the network structure was shown in Figure 1\(^{[1]}\). The network architecture of the system is simple compared with the TD-SCDMA system of 3G, and it has the advantages of faster transmission rate, higher spectrum utilization efficiency and larger capacity. However, since the 4G network uses a large number of intra-frequency networking, the interference between the symbols is more when transmitting information, so effective network optimization will improve the communication quality of TD-LTE system\(^{[2]}\). Wireless network optimization is a new network technology that maximizes the use of existing network resources and solves some existing defects to achieve comprehensive signal coverage, high connection rate, audio effect fidelity and clear video images. It greatly satisfies people's demand for higher quality of the network.

![Figure 1. TD-LTE network structure diagram.](image_url)

2. The content of LTE wireless network optimization

The optimization of LTE wireless network mainly had the problems of narrow coverage, difficult access, poor anti-interference ability and frequent dropped calls, so how to solve the above problems will be the main optimization goals and difficulties of the technology. The problems can be solved one by one from the aspects of the rational planning of PCI, interferences checking, antenna adjustment...
and coverage optimization, neighboring area planning and optimization, and adjustment of system parameters after observing the phenomenon, analyzing the cause, summarizing and refining the laws of this kind of problems.

2.1 The rational planning of PCI
The PCI (physical cell ID) refers to the physical cell identifier of the TD-LTE cells, and it’s a wireless signal that the terminals distinguish between different cells by it. The LTE system provides 504 PCIs, values from 0 to 503, which are similar to the 128 scrambling codes in the TD-SCDMA system. However, compared with the allocation strategy of scrambling codes in SCDMA, the LTE PCI planning principles are much easier due to the sufficient ID code resources. Generally, the planning of physical cell ID meets the following three principles\(^3\): collision-free, confusion-free and inequality of PCI residue 3 in two adjacent cells.

2.2 Interferences checking
The TD-LTE interferences are divided into two types: intra-system interferences and inter-system interferences. Intra-system interferences are mainly caused by a large number of same frequency interferences, which are composed of intra-cell interferences and inter-cell interferences. For intra-cell interferences, OFDM technology can be directly used to solve the problem effectively\(^4\). OFDM is also called orthogonal frequency division multiplexing technology, whose main principle is to transfer multiple low-speed subcarriers instead of high-speed data streams, thus expanding the symbol period to a multiple to reduce the interferences between symbols. To achieve higher immunity to interferences, protection intervals that were greater than the signal delay expansion can be added between the symbols. By this way, the interferences can be substantially completely eliminated.

Inter-cell interferences can be solved by inter-cell interferences suppression technology, which includes interferences randomization, interferences cancellation and ICIC. ICIC (Inter Cell Interference Coordination) is a reasonable allocation of inter-cell resources to achieve the purpose of orthogonal frequency resources of adjacent cells, so as to coordinate inter-cell interferences, improve cell coverage and edge cell rate and enhance cell spectral efficiency\(^5,6\).

2.3 Antenna adjustment and coverage optimization
Coverage is the most important part of the optimization process. In the LTE network optimization process, there are mainly weak coverage, cross-area coverage, overlapping coverage and other issues. To solve the problem, the coverage of the network can be observed by DT (Drive Test) or CQT (Call Quality Test) in wireless network optimization, and the weak coverage areas and the cross-area coverage areas can be determined. For weak coverage, it is necessary to check whether there are buildings or trees blocking near the base stations. If there is no blocking and there is a base station near the problem areas, it is necessary to check whether there are equipment faults or alarms. When the above problems are eliminated, it is necessary to further check whether the setting of antenna azimuth angle and dip angle is reasonable\(^7,8\). If the signal of a certain cell was found far from the network by DT or CQT, which exceeds the coverage of other cells and occupies the dominant signals, then it can be judged that there is cross-area coverage phenomenon. To solve this problem, the base station should first be checked whether it is too high, if so, the transmission power should be reduced to reduce the impact on other cells or the site should be moved to solve the problem. Secondly, the antenna parameters setting should be checked if it is unreasonable, for example, if the following inclination angle is unreasonable, which can be controlled by increasing the inclination angle or replacing the electrically tuned antenna. After the adjustment, synchronous testing should be carried out to avoid the problems of weak coverage or coverage holes.

3. Simulation and performance analysis
The aim of TD-LTE network optimization is to establish a network system with wide coverage, high transmission efficiency, stable connection, strong anti-interference ability and corresponding
performance requirements for a certain period of time in the future under the premise of meeting the network service requirements and controlling a certain operation and maintenance cost. In this chapter, the network optimization simulation software Lab Lech system was used to analyze the performance indexes combined with practical cases. By analyzing the problems found in the existing network, the cause of the problems, proposed solutions and implemented optimization strategies were found out. Then the previous environment (Ensure no other factors interfere) was simulated again, and it was compared with previous performance data.

The LTE network optimization overall simulation diagram was shown in Figure 2. The planning route was from the starting point S to the terminal point E, the direction was from west to east. There were three base stations nearby, namely A, B and C. Each base station was further divided into three sectors, named Cell1, Cell2 and Cell3. The whole road can be divided into three zones: R1, R2 and R3, that R1 was mainly covered by base station A, R3 was mainly covered by base station B and R2 was covered by both base station A and base station B.

![LTE network optimization overall simulation diagram](image)

Figure 2. LTE network optimization overall simulation diagram.

It was found that there was weak coverage near the R2 section while a car was driving on the planned route. Then the road test simulation test software was started, the log file was opened and the road test track was imported. The exported table of coverage for RSRP (Reference Signal Receiving Power) and SINR (Signal to Interference plus Noise Ratio) was shown in Table 1. The problem area was covered by base station A (PCI was 101) and base station B (PCI was 203). The coverage signal at R2 and R3 intersections had been gradually weakened and the value of RSRP was also getting smaller and smaller. There were also some interferences near R2 and the value of SINR was gradually reduced, the minimum value can reach -5dB, and there was a certain quality difference.

| Cell Name | PCI   | RSRP  | RSRQ | SINR |
|-----------|-------|-------|------|------|
| A_Cell2   | 101   | -108  | -11  | -5   |
| B_Cell3   | 203   | -95   | -11  | 16   |
| C_Cell1   | 305   | -103  | -15  | -7   |
| B_Cell2   | 202   | -113  | -15  | -6   |
| B_Cell1   | 201   | -114  | -15  | -3   |
| C_Cell3   | 303   | -116  | -15  | -5   |
| A_Cell1   | 102   | -117  | -15  | -5   |

The corresponding parameter statistics can be monitored in the road test software. By taking the two parameters of RSRP and SINR as an example, the section of the problem areas was analyzed, and the parameter statistics scales of RSRP and SINR were shown in Table 2 and Table 3. As shown in the tables, the ratio of RSRP from -110dBm to -90dBm was 36.58%, it showed the existence of weak coverage phenomenon. And the ratio of SINR from -5dB to 3dB was 14.4%, it showed that signal interference in this section was also an important problem to be solved.

The use of sections to divide the text of the paper is optional and left as a decision for the author. Where the author wishes to divide the paper into sections the formatting shown in Table 2 should be used.

| Parameter segmentati | Number of Distribution | Cumulative |
|----------------------|------------------------|------------|

Table 2. Parameter statistics scale of RSRP before optimization.
After inspection, the PCI of the current serving cell (B_Cell2) was 101, and the PCI of the neighbor cell (C_Cell1) was 305. For the two, the remainder of 3 was 2, which generates mode 3 interference. If the signal amplitude of the two was close, because of the superposition of reference signal position, it will cause large intra-system interferences and result in lower SINR value of the terminal measurement reference signal. Therefore, to reduce the intra-system interferences and improve the reliability of information transmission, the PCI of both should be modified, the PCI value of B_Cell2 was changed to 100, and the PCI value of C_Cell1 was changed to 300. It can be seen from the trajectory coverage map of RSRP and SINR, that the starting position of the route was covered by the base station A_Cell1, and the direction of A_Cell1 toward the reverse side of the driving section, which resulted in unsatisfactory values of both RSRP and SINR. This indicated that there was a problem with the antenna parameter setting of A_Cell2, so the azimuth of Cell 2 should be increased to cover the starting position of the road section. On the other hand, the indicators at the intersection of the two base stations were also not up to standard, and the dip angle of A_Cell2 was 3° after inspection. If the angle was too small, it will cause interferences with the neighboring area. Serious cross-over coverage may occur and the capacity of the system may be reduced. Therefore, the dip angle should be adjusted from 3° to 8°.

After adjusting the antenna engineering parameters, the road test simulation test software was run again, which showed that the coverage and interference problems had been solved in most of the road sections. However, there were still some road sections with weak coverage at the intersection of the two base stations (ie, the R2 road section). According to the past experiences, it was possible that switching was not timely. The switching in the system was reported based on the measurement events, and the report was based on the “optimal cell” measurement events (Event A3). There were many parameters related to the A3 events and the important observation point was the TimeToTrigger
parameter, which was the time delay of the same frequency switching measurement events. If the value of it was too large, it may increase the difficulty of switching and result in untimely switching, thus affecting users’ perception. After checking, the value was found to be 3 seconds, and it was modified to 1 second by repeated experiments to realize timely switching between the two base stations. At this point, all parameters had been adjusted and the modified parameters table was shown in Table 4.

Table 4. Schematic diagram of modified parameters.

| Parameter           | Pre-adjusted value | Adjusted value |
|---------------------|--------------------|----------------|
| A_Cell1-PCI         | 101                | 100            |
| C_Cell1-PCI         | 305                | 300            |
| A_Cell1-Azimuth     | 120                | 130            |
| A_Cell1-Angle       | 8                  |                |
| TimeToTrigger       | 3s                 | 1s             |

The modified parameters were applied to the Labech software for simulation and the retest was completed in the road test system. The statistical histograms of the RSRP and SINR parameters were shown in Figure 3 respectively. Table 5 showed the trajectory coverage table of RSRP and SINR of R2 road sections after optimization. The parameter scaling tables of RSRP and SINR of R2 road sections after optimization were shown in Table 6 and Table 7 respectively. The horizontal axis in Figure 3 represented the RSRP parameter range, and the vertical axis represented the parameter statistical ratio. The figure showed that the RSRP parameter contained a total of six intervals, and the interval parameter ranges were (-140dBm, -110 dBm), (-110 dBm, -100 dBm), (-100 dBm, -90 dBm), (-90 dBm, -85 dBm), (-85 dBm, -75 dBm) and (-75 dBm, +∞). The horizontal axis in Figure 3 represented the SINR parameter range consists of six intervals, and the range parameters were (0, 3 dB], (3 dB, 6 dB], (6 dB, 10 dB], (10 dB, 15 dB], (15 dB, 20 dB] and (20 dB, 25 dB]. It can be seen from the charts that the overall planning section had no coverage and interference problems, and all indicators met the requirements. Table 6 showed that there was no sampling point in the range of -∞<RSRP<-90dBm, that means there was no weak coverage in this area and the histogram showed a straight upward trend. Table 7 showed that the average value of SINR was 26.24dB, and the ratio of 10dB<SINR<50dB was occupied 92.94%, that means after modifying parameters, the mode 3 interference, the cross-over coverage and the untimely switching were solved and the reliability of the system transmission information was improved.

![Figure 3. Statistical histograms of RSRP and SINR parameter after optimization.](image)

Table 5. Trajectory coverage table of RSRP and SINR after optimization.

| Cell Name | PCI | RSRP | RSRQ | SINR |
|-----------|-----|------|------|------|
| B_Cell3   | 203 | -72  | -5   | 29   |
| A_Cell1   | 100 | -94  | -11  | 16   |
| C_Cell1   | 300 | -103 | -14  | -1   |
| B_Cell2   | 202 | -109 | -15  | -5   |
Table 6. Parameter statistics scale of RSRP after optimization.

| Parameter segmentation | Number of sampling points | Distribution percentage (%) | Cumulative percentage (%) |
|-------------------------|---------------------------|-----------------------------|--------------------------|
| -∞ < x < -140           | 0                         | 0                           | 0                        |
| -140 < x < -110         | 0                         | 0                           | 0                        |
| -110 < x < -100         | 0                         | 0                           | 0                        |
| -100 < x < -90          | 0                         | 0                           | 0                        |
| -90 < x < -85           | 8                         | 2.35                        | 2.35                     |
| -85 < x < -75           | 158                       | 46.47                       | 48.82                    |
| -75 < x < +∞            | 174                       | 51.18                       | 100                      |

Table 7. Parameter statistics scale of SINR after optimization.

| Parameter segmentation | Number of sampling points | Distribution percentage (%) | Cumulative percentage (%) |
|-------------------------|---------------------------|-----------------------------|--------------------------|
| 0 < x <= 3              | 0                         | 0                           | 0                        |
| 3 < x <= 6              | 0                         | 0                           | 0                        |
| 6 < x <= 10             | 24                        | 7.06                        | 7.06                     |
| 10 < x <= 15            | 12                        | 3.53                        | 10.59                    |
| 15 < x <= 20            | 20                        | 5.08                        | 16.47                    |
| 20 < x <= 25            | 284                       | 83.53                       | 100                      |
| 25 < x <= +∞            | 0                         | 0                           | 100                      |

4. Summary

4G technology, as a pure IP network, is of great practical significance to optimize the network of TD-LTE to better serve the public. The paper mainly analyzed the problems that frequently encountered in the network and gave solutions. The solutions of modifying the corresponding parameters were put forward and implemented in the actual network by using the simulation platform and combining with the examples of optimization problems of Central China Normal University. It was retested in the road test simulation test software, and the simulation results verify that the scheme was reasonable and effective. It also reduced the time and money of the actual road test, thereby reducing the cost of operators and users.

However, no matter how advanced technology is, it is impossible to always meet the growing needs of the audiences. Therefore, we must pay more attention to observing existing problems and bottlenecks in existing network technologies in real life, and constantly enrich ourselves, learn new technologies and continuously improve and upgrade optimization technologies to meet the high demands for continuous growth of network quality in the future.
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