Research on Capacity Performance of TD-LTE System with Different Antenna Schemes

Jiangbo Dong, Yuan Fang, Nan Li, Wei Liu, Hao Sun, Yunbo Han, and YanLei Chen
China Mobile Design Institute, Beijing, China

Abstract—Network capacity performance, especially cell edge user average throughput is compared between 2-path antenna and 8-path antenna schemes in TD-LTE system. Simulation results show that the 8-antenna has about 30% gain. And when the real construction condition is unlimited, 8-antenna scheme is a better choice.

1. INTRODUCTION

There are several different transmission modes in TD-LTE system [1]. For transmission mode 7/8, 8-path smart antenna is necessary to implement beamforming, and for transmission mode 2/3, 2-path antenna can also work well. Considering the engineering factors, such as antenna size, antenna weight, the 8-path antenna is more difficult to build than 2-path antenna during the real network deployment; while the cell edge user data rate performance maybe better than the latter. Therefore, performance comparison between 2-path and 8-path antenna is an important problem and the comparison results will be an important technical basis for choosing the proper antenna scheme during the network deployment.

This paper addresses the planning of TD-LTE cellular radio networks for data services, enabling the evaluation of the network capacity performance, such as cell edge user data rate with different antenna scenarios. The modeling schemes of TD-LTE key techniques are proposed and developed to finish the research. Such schemes are also embedded in ANPOP® radio network planning tool.

The simulation results show that, when the ICIC (Inter Cell Interference Cancellation) function is off, cell edge user data rate with 8-path antenna is 32.4% higher than that with 2-path antenna; and this is also met with the field test results. When the ICIC function is on, the gain is down to 28.8%. It shows that ICIC can also enhance the ability of cell edge interference cancellation in the 2-path case. So we can draw an conclusion from the simulation results that 8-path antenna is a better choice for TD-LTE system, when the real construction condition is unlimited. This research is very important for construction of the large scale TD-LTE network.

The rest of the paper is organized as follows: In Section 2, the modeling schemes of TD-LTE key technique are introduced. Section 3 gives a brief presentation of the structure of the simulator. Evaluation assumption and simulation results are presented and analyzed in Section 4. Finally, some conclusions about choosing the proper antenna scheme are drawn in the Section 5.

2. SYSTEM MODEL

The starting point of the model is a given TD-LTE radio network deployment. The goal is to determine the cell edge user average throughput and cell average throughput with different antenna schemes. So first of all, a reasonable simulation model of TD-LTE should be proposed. AMC, OFDM, MIMO, Packet Scheduling, ICIC, Downlink Power Assignment and Uplink Power Control are the key techniques of TD-LTE system. In TD-LTE system, radio resource block, time slot, power and antenna are all radio resources which can be allocated according to the instantaneous channel conditions. A static simulation method is basically used as the TD-LTE system simulation algorithm.

Similar with HSDPA system [2], AMC is modeled through the process diagram which shows in the Figure 1. The SINR can be calculated or measured for any point in the network, and also at which the most efficient transport block can be achieved by lots of link level simulations; and then the transmission throughput can be calculated accordingly. So, the following mapping Table 1 can be pre-configured in the simulation tool to evaluate the AMC performance.

For packet scheduling, the multi-user gain of the network throughput can be achieved because the TD-LTE system can always schedule the special UE which has the proper channel quality condition to transmit. But for the static simulation, its time independent feature is incompatible with the time related character of packet scheduling. And dynamic simulation is time-assuming for
Table 1: Transport block mapping table.

<table>
<thead>
<tr>
<th>Transport Block Size for one RB at different MCS</th>
<th>Channel Model</th>
<th>SINR (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TBS1</td>
<td>PA, VA, etc</td>
<td>a</td>
</tr>
<tr>
<td>TBF...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

Figure 1: The working procedure of AMC.

Figure 2: Simulator diagram of TD-LTE.

the planning work of a real network which has thousands of E-NodeBs. Considering the complexity of the implementation, the method in paper [2] is used in this research.

Static ICIC is also studied in this paper, the user at the cell edge can only use part of the radio resources. In ideal cell structure, the interference among the neighbor cells can be reduced efficiently when the radio resources are divided into three groups. But in real environment, the number of the groups may be larger than three to cancel the inter-cell interference, and it should be investigated to find an optimal value. And how to determine that the user is cell edge should also be studied. In this research, the difference between the received power of the best server and that of the second best cell is used as the index to justify whether the user is at cell edge or not.

In 3GPP Release 8, there are seven kinds of transmission mode, but the transmission method of one dedicated user can only be chosen from diversity, multiplexing and beamforming at one time. And for the cell edge user, it only can be chosen from diversity and beamforming. Thus the performance comparison between 2-path and 8-path antenna is essentially the cell edge performance comparison between diversity and beamforming, and then diversity is used in the 2-path antenna scenario while beamforming is used in the 8-path antenna scenario.

From the description above, the TD-LTE is modeled in the static simulation successfully. The simulation procedure is introduced in the next section.

3. SIMULAITON DIAGRAM

All the algorithms above are implemented in the simulation tool ANPOP®. The basic blocks of the simulator are Geographical Information System (GIS), Coverage prediction, user generation and Monte Carlo simulation.

The simulation diagram is shown in Figure 2. In the UE generation block, the TD-LTE UE is distributed according to some real traffic distribution map. The best server is determined through RS received power level of the UEs’ position. For one SNAPSHOT, the UE is scheduled according to the selected scheduling method. And then, the number of allocated Radio Blocks and the selected MCS of the UE is determined iteratively according to the interference level of the network and the UE position. The transport block is chosen through the look-up table when the SINR is calculated, and then the throughput of the user can be decided. The cell edge throughput can be statistically achieved by a lot of snapshots.

Detailed simulation parameters are shown in the next section.
4. SIMULATION PARAMETERS AND RESULTS

Performance comparison between different antenna schemes is the major task of this paper. Considering the practical application scenarios, the 2-path and 8-path antennas are both dual-polarized, and the antenna gain and antenna pattern used in the simulation are the same with which used in the real networks. The performance comparison between 2-path and 8-path antenna schemes is respectively evaluated with and without the static ICIC function in the dense urban area, which has 340 base stations shown in Figure 3.

And the diversity is applied in 2-path case, while beamforming is applied in 8-path case. The antenna gain pattern for 2-path antenna is shown in Figure 4, and the broadcast beam and traffic beams of different angles for 8-path antenna are shown in Figure 5.

The other simulation parameters are shown in Table 2.

The simulation results are listed in Table 3.

The simulation results show that, when the ICIC function is off, cell edge user data rate with 8-path antenna is 32.4% higher than that with 2-path antenna. When the ICIC function is on, the gain is down to 28.8%. It shows that ICIC can also enhance the ability of cell edge interference cancellation in the 2-path case.

So we can draw an conclusion from the simulation results that 8-path antenna is a better choice for TD-LTE system, when the real construction condition is unlimited. This research is very important for construction of the large scale TD-LTE network.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subframe Configuration (UL:DL)</td>
<td>2:2</td>
</tr>
<tr>
<td>Special Subframe Configuration</td>
<td>10:2:2</td>
</tr>
<tr>
<td>ICIC threshold (dB)</td>
<td>6</td>
</tr>
<tr>
<td>Radio Resource Sub-Groups at cell edge</td>
<td>4</td>
</tr>
<tr>
<td>Scheduling Algorithm</td>
<td>Proportional Fair</td>
</tr>
<tr>
<td>Number of Scheduled User in a TTI</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 3: Simulation results.

<table>
<thead>
<tr>
<th>Cell edge user average throughput (kbps)</th>
<th>8-path</th>
<th>2-path</th>
<th>gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without ICIC</td>
<td>764.5</td>
<td>577.1</td>
<td>32.4%</td>
</tr>
<tr>
<td>With ICIC</td>
<td>820.3</td>
<td>636.8</td>
<td>28.8%</td>
</tr>
</tbody>
</table>

Figure 3: E-NodeB distribution.  
Figure 4: Antenna gain pattern for 2-path antenna.
5. CONCLUSIONS
The transmission method of the cell edge user is the mainly difference between 2-path and 8-path antenna scheme for TD-LTE system. So this research focused on the cell-edge user throughput with and without ICIC. Using the radio network plan tool ANPOP, the performance is evaluated. Simulation results show that the 8-path antenna has obvious throughput gain, and when the real construction condition is permitted, the 8-path antenna should be preferred to choose.

ACKNOWLEDGMENT
This work is supported by National Major Science & Technology Specific Projects-Next Generation Broadband Wireless & Mobile Communications (2012ZX03001028).

REFERENCES