The Influence of 5g Technology on Communication Infrastructure and Solutions

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Abstract: with the popularization of 5g communication base station, 5g is more and more likely to interfere with communication infrastructure, and various factors have more and more obvious influence on multi-layer network capacity. In order to solve the problem of interference between 5g macro base station and small base station, the interaction between macro base station and micro base station of multi-layer network under 5g technology is modeled and simulated, and the optimization strategy of multi-layer multi cell network capacity is proposed. Before deploying a 5g network, engineers should plan 5g network scheme according to 5g network performance requirements, and evaluate 5g network performance after deployment, so as to give 5g network deployment scheme and guide the actual 5g network deployment. At this time, 5g network performance evaluation is often carried out by system simulation. In this paper, through the method of system simulation, we study the capacity factors of multi-layer heterogeneous cellular network from many aspects, including network structure, channel model, interference environment, etc., and give the corresponding simulation performance evaluation and analysis.

1. Introduction

The traditional wireless macro cellular network only contains a single type of macro cell, which is composed of macro evolved NodeB (Menb) and macro users. In this single network architecture, the factors that affect the network capacity are relatively simple, mainly including the macro base station antenna, the channel condition between the base station and the user, and the interference between the macro base stations. The influence of these factors on the performance of the single-layer macro cellular network is reflected in the system simulation parameter configuration used in the simulation evaluation. In the simulation, the 120 ° sector antenna model is commonly used in the Hongji station antenna model, and the empirical formula is used to model the wireless channel. The main parameters of the channel model in the simulation are the distance between the base station and the user. At the same time, the channel status between the Hongji station and the user and the interference between the Hongji stations are closely related to the small area layout and the user distribution points. Because the main application scenario of the multi-layer network is the urban environment, which is used to solve the traffic demand of the hot spot scenario, the urban scenario is used as the simulation environment in the performance simulation of the multi-layer network and the single-layer network. Table 1 summarizes the assumptions and system parameters of the macro cell layout and user distribution points of the urban scenario used in the simulation. The simulation adopts urban scene and static simulation method. The static simulation platform considers large-scale fading, mainly including path loss and shadow fading, excluding channel fast fading and base station dynamic scheduling. Compared with the macro base station single-layer network, the important factor of multi cell network capacity change is that the addition of low-power base station leads to the change of network structure, which leads to the change of network capacity. In order to simplify the analysis, the two-layer cellular network structure with Pico base station is considered first, and its network topology is shown in Figure 1. In a cell, in addition to the macro base station in the center of three hexagon sectors, there are also small Pico base stations represented by circles. In this study, Pico base station is arranged on the circular arc with three hexagon centers as the center, and the simulation parameters of small base station are given in Table 2.

Table 1 Urban Scene Simulation Parameter Settings

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Parameter	Simulation value
Community layout	Each cell has three rooms. Each sector has hexagonal cells
Station spacing (ISD)	500 m
Acer station number	Nineteen
Macro user number	20 households per sector
User distribution model	Uniform distribution
Minimum distance between macro user and macro base station	35 m
Carrier frequency	2 GHz
System bandwidth	10 MHz
Transmission power / antenna gain of Hongji station	46 dBm/14 dBi
Number of antennas in a station	2 Rx.2 Tx
Macro user transmit power / antenna gain	23 dBm/0 dBi
Number of macro user antennas	2 Rx.l Tx
Noise density	-174 dBm Hz
penetration loss	20 dB

Table 2 Simulation Parameters Of Small Base Station

parameter	Simulation value
Number of small base stations	Two sectors per cell
Location of small, medium and base stations	On an arc centered on the center of a hexagon
Minimum distance between user and small base station	3 m
System tape	10 MHz
Small base station transmit power / Antenna gain	26 dBm/0 dBi
Number of small base station antennas	2 Rx.2 Tx
Noise density	-174 dBm Hz
User transmit power / Antenna gain	23 dBm/0 dBi
Number of user antennas	2 Rx.l Tx
Penetration loss	20 dB
Antenna molding	Omnidirectional antenna

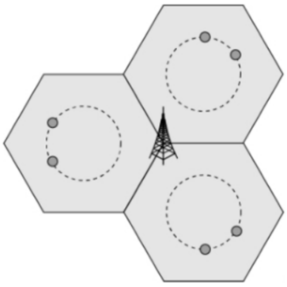

Fig.1 Pico Base Station Distribution

1.1 Frequency Resource Allocation

Different from the same frequency between the single-layer macro cellular network base stations, the multi-layer network needs to consider the problem of spectrum division between the macro and micro base stations. Different spectrum division schemes will cause different interference between the macro base stations and the small base stations. There are two typical schemes in the division of frequency resources between macro base station and small base station: full multiplexing and orthogonal allocation. These two schemes are introduced respectively below.

(1) Complete reuse

In the scheme of frequency fully multiplexing, all macro base stations and small base stations use the same frequency carrier, which can also be called the same channel resource allocation. The reuse of frequency resources makes the small base station use the same bandwidth resources as the macro base station while providing services to its users. Because the cellular network is composed of many layers of macro cell and small cell, the scheme of full frequency reuse will cause mutual interference between the two layers of base stations.

(2) Orthogonal distribution

In the frequency orthogonal allocation scheme, the frequency band resources used by the macro base station and the small base station are orthogonal and do not overlap each other. This scheme can also be called the adjacent channel resource allocation scheme. All small base station users use the frequency resources assigned to the small base station.

1.2 Interference Calculation

The key problem of multi-layer cellular network is interference, so calculating interference is the key to analyze the performance of multi-layer network. First, the interference of orthogonal distribution is considered. In the orthogonal allocation of resources, macro base station users and small base station users use non overlapping frequency resources. In this way, users of the Acer station will not receive interference from the small base station, and users of the small base station will not receive interference from the Acer station. However, the spectrum efficiency of orthogonal distribution is not high. Secondly, in the case of complete frequency multiplexing, the same frequency resource is used by the macro base station and the small base station. The users of macro base station receive the interference from other macro base stations and all small base stations, while the users of small base stations receive the interference from other small base stations and all macro base stations, which greatly improves the efficiency of spectrum utilization, but at the same time, the interference to each user is also greatly improved. Combining the two main factors of spectrum utilization efficiency and interference, we can design a partial frequency multiplexing scheme to further improve the spectrum efficiency of edge users while ensuring the average spectrum efficiency.

1.3 Simulation Results of Multi-Layer Network Capacity

This paper studies the user capacity of cellular system in multi-layer and multi cell scenarios, and simulates 19 traditional cellular networks at system level. The simulation adds a layer of small base station in the macro cellular topology environment, and the location deployment of the base station is shown in Figure 3. Two small base stations are deployed in each sector. Based on the idea of symmetry, they are located on the circular arc with the sector center as the center. The radius of the circle is R / 3, and the included angle formed after connecting with the center of the circle is 60 °. See Figure 2. The simulation uses the fully reused frequency resource utilization mode to count the SINR and throughput characteristics of all users.

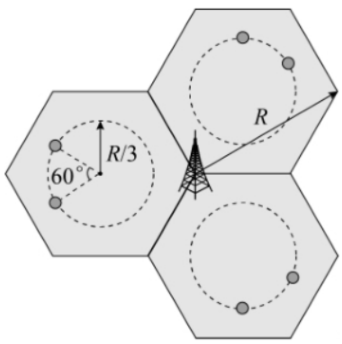

Fig.2 Two Layer Network Topology 1

Among them, the average spectral efficiency of all users is 0.313 bit / (s · Hz), and that of edge users is 0.042 bit / (s · Hz). That is to say, the average spectral efficiency of the system is 6.26bit / (s · Hz · cell), and the spectral efficiency of edge users is 0.042bit / (s · Hz · cell · user). It can be seen from the figure that after adding a small base station, although the SINR value of the user has slightly decreased, the throughput value has greatly improved. Because the number of interference sources of all users increases greatly in the case of full frequency multiplexing after adding a small base station, the SINR value of users may be reduced. However, due to frequency reuse, the frequency resources allocated to each user are greatly improved compared with the traditional mode, so the throughput of users will be significantly improved. Adjust the location of the small base station, and investigate the performance of SINR and throughput of users under different topologies. The topological structure is shown in Figure 3, which increases the radius of the circle and keeps the angle unchanged. This topology increases the distance between the small base stations and the macro base stations, so as to reduce the interference between them. At the same time, the interference between the small base stations in a sector is reduced, while the interference between the small base stations in the sector is likely to increase.

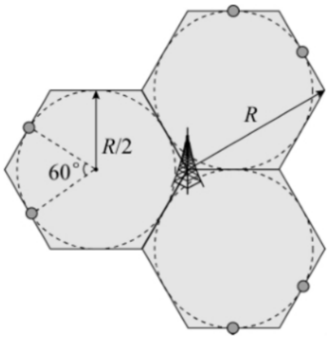

Fig.3 Two Layer Network Topology 2

Among them, the average spectral efficiency of all users is 0.317 bit / (s · Hz), and that of edge users is 0.044 bit / (s · Hz). That is to say, the average spectral efficiency of the system is 6.34bit / (s · Hz · cell), and the spectral efficiency of edge users is 0.044bit / (s · Hz · cell · user). Compared with topology 1, the SINR of users in topology 2 is generally higher, because the interference of small base station users by macro base station is significantly reduced, while the interference of macro base station users by small base station is almost the same. Therefore, the overall CDF curve of throughput in topology 2 shifts to the right, and the average spectral efficiency and edge spectral efficiency are slightly higher than those in topology 1. Table 3 lists the average throughput and edge user throughput values of the above three topologies. Figure 4 shows the results of comparing the throughput values of two multi-layer topologies with the average and edge user throughput of traditional cellular networks.

Table 3 Comparison of Average Spectral Efficiency and Edge Spectral Efficiency

	Traditional	Topology 1	Topology 2
Average throughput/[(bit •(S • Hz • cell)-1]	3.26	6.26	6.34
Edge user throughput/[bit • (s • Hz • cell • user)-1]	0.039	0.042	0.044

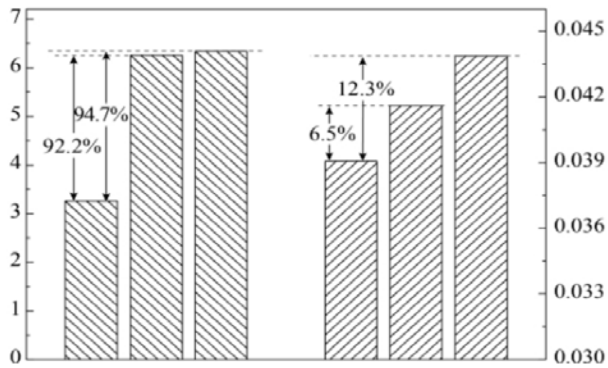

Fig.4 Comparison of Average Spectral Efficiency and Edge Spectral Efficiency

Through the comparison of the three network structures in Figure 7, we find that under the multi-layer multi cell network, the average spectrum efficiency of users under the network topology 1 and topology 2 is greatly improved compared with the traditional macro cellular network structure, because the two-layer network increases the frequency resources that users can allocate, and users are interfered by the adjacent base stations because they are closer to the service base station, But it will not lead to a significant decline in SINR. The throughput of edge users in multi-layer and multi cell network is not significantly improved compared with that in traditional cellular network topology.

This is because after joining the small base station, those users who are near the small base station but not connected to the small base station will be greatly interfered by the nearby base station, which accounts for a large proportion of the 5% of the poor throughput. If we want to improve the capacity of multi-layer and multi cell, we need to further study the methods to improve the edge spectrum efficiency on the basis of improving the average spectrum efficiency.

2. Capacity Optimization of Multi-Layer and Multi Cell Network

2.1 Partial Frequency Multiplexing

As mentioned in the previous section, the allocation of fully multiplexing frequency in multi-layer network can greatly improve the average spectrum efficiency of users, but it is not helpful to improve the spectrum efficiency of edge users. In this section, we will study the technology of partial frequency multiplexing to optimize the capacity of multi-layer network and further improve the spectral efficiency of edge users. According to the partial frequency multiplexing method, the whole bandwidth of the system can be divided into four areas, one area is occupied by the central users of the macro base station, and the remaining three areas are shared by the small base station users and the edge users of the macro base station.

In this frequency multiplexing mode, the frequency utilization diagram of multi-layer multi cell network topology is shown in Fig.5, in which a circle centered on a small base station approximately represents its coverage.

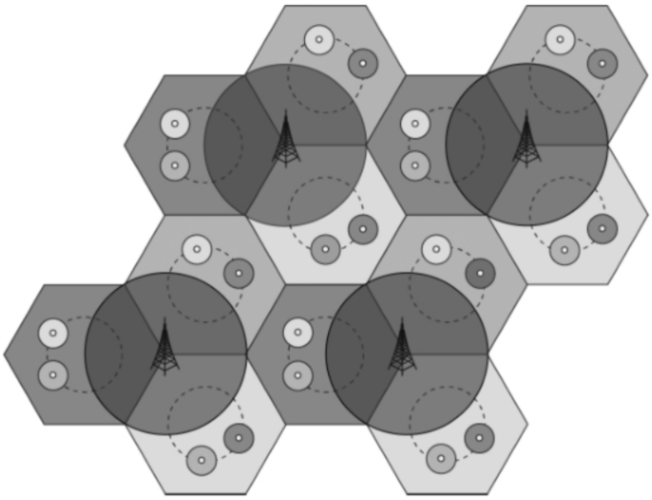

Fig.5 Frequency Utilization Diagram of Multi-Layer and Multi Cell Network Topology

In this partial frequency multiplexing scheme, there are also a variety of frequency allocation schemes. Since the three sectors are equal in geographical position, the frequency bandwidth allocated by users at the edge of the three sectors is equal. Fig. 10 takes the ratio of frequency bandwidth allocated to the central user of the macro cell as a variable to investigate the throughput of the edge user of the cell.

2.2 Cooperative Multipoint Transmission

Coordinated Multi point (cAMP) transmission technology is a dynamic collaboration among multiple transmission points which are geographically independent and distributed. It is an important tool to improve the coverage of high data rate, improve the cell edge throughput and / or increase the system throughput. Among them, multiple transmission points can be ENB with complete resource management module, baseband processing module and RF unit It can also be multiple radio frequency units and antennas (such as distributed antennas) with different geographical locations, or relay nodes. In this book, cooperative transmission between. ENB is the main research direction.

There are two main transmission schemes for camp transmission.

(1) Coordinated scheduling / coordinated beamforming (CS / CB)

In CS / CB, the data information of each user is known only in the service cell and also sent by the service cell. However, the scheduling and beamforming of users are determined by the coordination of each cell in the cooperative concentration, so the interference between cells in the cooperative concentration can be effectively coordinated and avoided.

(2) Joint processing (JP)

In JP, data is shared by all cells in the cooperative set of the camp. At the same time, multiple cells in the cooperative set send data to a user in correlation or non correlation, so as to improve the received signal and quality of the user and eliminate the interference from other users. In the cooperative multi-point transmission, multiple collaboration points serve for one UE, so which collaboration points serve for this UE is a problem worth studying. This kind of problem is called cooperative set selection problem. At present, it is mainly divided into three ways: static cooperation selection, dynamic cooperation selection and semi dynamic cooperation selection.

① Static collaboration selection

A fixed number of cooperative cells are selected as a cooperative set, which will not change in a long period of time. The static collaboration set is generally determined by the network and notified to UE through high-level signaling. This method does not need to measure the channel information frequently, so the signaling interaction is less; but the disadvantage is that when the UE to be served is far away from the cell in the static collaboration cluster or the cell with strong interference to the UE is not in the collaboration concentration, the performance gain of the cooperation transmission can be very small, even lead to the performance degradation.

② Dynamic collaboration selection

The main service cell selects the cooperation cell dynamically according to the channel state and other conditions, so the cooperation is dynamic. If the global scheduling is adopted, the performance can reach the optimal theoretically, but it needs a large amount of information and a high computational complexity. If distributed scheduling is adopted, it will bring the conflict and waste of cooperation resources, and reduce the resource utilization of the system.

③ Semi dynamic cooperative selection

A cooperation set is defined in advance, in which the main service cell dynamically selects the cooperation cell. This approach can be seen as a compromise between the first two.

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