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# Research on energy efficiency optimization technology in cellular network

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**Abstract.** This paper analyzes the energy consumption of base stations involved in cellular networks, including main equipment, power supply equipment, environmental equipment and other auxiliary equipment, etc. On this basis, this paper discusses energy efficiency optimization techniques at several levels, such as base station deployment, components, and repair cotton. Under the current limited channel resources, it is inevitable to consider the balance between data services and voice services, and then to analyze the relevant indicators of network performance as a basis for the specific time.

**Keywords:** cellular optical lo, energy efficiency optimization, channel resources, base station, energy efficiency metric.

## 1. Introduction

With the continuous development of network technology, the previous network configuration technology can hardly cope with the increasing traffic demands of people today. Based on this demand, a new generation of heterogeneous cellular network technology combining traditional low-power nodes and macro base stations has emerged, allowing the capacity of the network system to be significantly increased and users to obtain higher communication quality [1]. This network not only enables flexible network construction and does not require much cost to maintain, but it also greatly improves spectrum utilization and significantly reduces the overall cost, and all end-users can be adequately covered.

## 2. The main energy consumption of base station of cellular network

The main base station modules involved in heterogeneous cellular networks are: power supply equipment, environmental equipment, main equipment, and other auxiliary equipment.

(1) Power supply equipment: the proportion of total network energy consumption is about 5%-10%. Most of the base station supplies are switching power supplies. Power supplies and related power equipment are cascaded with each other, and in terms of energy consumption, there is still a cascade effect with each other, which directly affects the energy-saving situation at base stations.

(2) The main equipment: the proportion of the total energy consumption of the network is about 50%-80%. The main equipment is specifically the main body of the base station, which is composed of transmitting and receiving antennas, base station transceiver stations and feeder systems. The

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specific function is to receive, process, and send signals. In the whole base station for communication, this part of the equipment consumes the most energy [2].

(3) environmental equipment: the proportion of the total energy consumption of the network is about 10%-20%. Its equipment composition is mainly humidifiers and air conditioning, the main function is to adjust the temperature and humidity in the room. In the entire base station in the communication, in order to effectively regulate the temperature of the room, one must often open the air conditioning system, so this aspect of energy consumption is also very critical, although it is only slightly lower than the main equipment generated by the energy consumption.

(4) Other auxiliary equipment: the proportion of the total energy consumption of the network is about 5%-15%. These modules basically belong to some modules outside the core functions, specifically, there is related equipment to guarantee the operation and provide light.

## 3. Energy efficiency metrics for heterogeneous cellular networks

At this stage, society strongly advocates energy savings and emission reduction, China is a big energy consuming country in the world, and $CO_2$ emissions are promised to peak in 2030. In the current society, base stations are essential equipment for people's communication, and their energy consumption is rising every year, mainly because of people's rising demand for mobile Internet use, which also brings higher power consumption of base stations. But only focusing on the reduction of energy consumption of base stations and ignoring the quality of service [3] is an act that is not worth the loss, so we must consider the reasonable reduction of energy consumption of base stations on the basis of not affecting the quality of communication service. The concept of network energy efficiency was born, and the following is a brief introduction of its evaluation criteria.

Network energy efficiency is specifically a metric that evaluates network performance by comparing network throughput and total energy consumption (involving infrastructure and communication equipment). The European Telecommunications Standards Institute (ETSI) and the Alliance for Telecommunications Industry Solutions (ATIS) have done a lot of exploring in this area and have proposed a number of measures related to network performance. The European Telecommunications Standards Institute (ETSI) and the Alliance for Telecommunications Industry Solutions (ATIS) have made a lot of explorations and proposed a lot of contents related to network energy efficiency, which have largely promoted the progress and improvement of communication network energy efficiency. Energy efficiency is classified based on the module type, which mainly includes device level, node level, and network level [4].

## 4. Energy saving technology of base station in heterogeneous cellular network

To achieve energy savings and consumption reduction in mobile communication base stations, the main programs include the following, which are described in detail below.

Base station deployment: With the further development of 5G network technology, the heterogeneous cellular network system also has more new situations in terms of deployment, as the density of macro base stations further increases, and with it comes certain costs. In the current stage of rising traffic, in order to make the QoS continuously improve, only the deployment of macro base stations will solve the problem, which will not only interfere with the signal, but also cause more capital expenditure and costs, and increase the network's power consumption, resulting in unnecessary energy waste. Therefore, in order to optimize the network construction, the network operation should be combined with the actual situation and small base stations should be chosen for deployment [5].

New energy: Resources such as solar and wind can be used in the network. New energy sources have significant advantages over non-renewable traditional resources such as carbon. In addition, wind energy and cold air can also be used in the process of cooling various equipment, such as base stations, to reduce energy [6].

Base station components: From the perspective of base station equipment, energy saving in base stations can be considered at both the hardware and software levels. First, in terms of hardware, various devices in the base station should be improved to make better use of energy, such as using

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various energy-efficient power amplifiers; in terms of software, algorithms can be used to improve the performance of the devices. For example, wireless power amplifiers can be based on digital pre-distortion technology (DPD), so that the device presents better linearity and significantly improves efficiency [7].

## 5. The core content of network optimization

In general, network optimization engineering is based on effective analysis of the collected relevant data, finding and correcting various problems hidden in the network, and adjusting the system in time to improve the overall network quality. The current network optimization involves three main aspects: switching network optimization, wireless network optimization and transmission network optimization [8].

Transmission network optimization and switching network optimization are basically similar to fixed communication networks at the content level, because fixed communication networks have been developed for a long time and various optimization methods have been systematized. However, only mobile communication networks are involved in wireless network optimization, and they have just been developed and need to be further improved and enriched with relevant experience. Therefore, the mobile communication network optimization we generally mention is mostly related to wireless network optimization. Its specific content mainly includes: network planning, troubleshooting, engineering supervision, data statistical analysis, network testing, etc. In the process of optimizing the current mobile network communication, the most critical thing is to grasp the call balance, data statistics, and coverage optimization [9].

### *5.1. Statistical data analysis*

Statistical data analysis, which is based on the observation and analysis of various indicators in the GSM network, enables a full understanding of the specific operation of the network, the analysis of the existence of faults, and the overall network performance.

### *5.2. Call balancing*

Call balancing, which is based on adjusting the specific call load of cells in close proximity to each other and in different frequency bands (900MHz and 1800MHz bands) in the same coverage area of the network, to achieve maximum equalization in the region and reduce the occurrence of network congestion problems.

### *5.3. Coverage optimization*

Coverage optimization is an important prerequisite for all optimization measures. If effective network coverage is not guaranteed, network optimization cannot guarantee quality. To achieve effective network coverage in each area through different types of devices and to clear the blind areas of the network is the key to ensuring the improvement of other network indicators [10].

## 6. Relevant indicators that have an impact on channel resources

Under the condition of insufficient channel resources, the balance between data and voice services should be considered first, so that users' call demands can be guaranteed as a priority, and data services can be satisfied to the maximum extent. The first thing we need to understand is the relevant indicators that users can directly experience in the process of using wireless network [11].

### *6.1. TCH voice congestion rate*

TCH voice congestion is when a user's voice call (making a phone call) is on a channel that is not available because the network is too busy. Congestion of this channel will directly affect user experience and performance of the wireless base station. When voice congestion occurs, the real user experience is often that the phone is on standby, or makes three rhythmic rings during a call. If these situations arise, it will cause great disturbance to the user and create a bad impression of the wireless network. The probability of TCH voice congestion in real world situations is a key indicator of its ability to satisfy the user's calling needs.

### *6.2. TCH half-rate voice ratio*

TCH Half Rate (HR) is a common way to carry GSM network voice services, specifically corresponding to Full Rate (FR). The half rate can effectively reduce the actual transmission rate of voice services, so that it is reduced from the full rate of 13kbit/s to 6.5kbit/s, and the code rate is reduced in the process, while the spectrum utilization can be improved, based on the theoretical level, which can effectively improve the wireless network capacity and double the effect. However, if the C/I (signal-to-noise ratio) environment is not good during the use of the half-rate method, it will affect the voice quality of integrated calls and even cause more dropped calls. Therefore, half-rate is not a long-term solution when it is used mainly when the channel is tight in order to alleviate the wireless network congestion problem caused by sudden high traffic. The half-rate ratio is the proportion of half-rate in all traffic [12].

### *6.3. TBF establishment success rate*

TBF (Temporary Block Flow) is mainly used in GPRS to transmit point-to-point related data. During the actual transmission, the TBF can be allocated to one or more PDCH channels, and the data service is transmitted through the PDCH channel. The TBF is critical to the overall GPRS service, as it must first be established in order to transmit data via the GPRS function. The success rate of TBF establishment is the core index to measure the capacity of the PDCH channel, which reflects the degree of difficulty for users to apply for the PDCH channel. Only when the provided PDCH channels are sufficient is the possibility of TBF establishment greater.

### *6.4. PDCH multiplexing degree*

Because the military data service is based on packet mode transmission, it differs from the voice mode, where all users use one TCH channel independently, in that PDCH channels allow different users to use them together at the same time, and each user can choose a different PDCH channel. The reuse degree specifically represents the depth of the actual interleaved TBF of the cell, that is, the average number of users that can be carried by independent PDCH channels at the same time. For example, if the PDCH is 0.25, it means that 4 PDCH channels are used by the same users; if it is 4, it means that one PDCH channel is used by 4 users at the same time. The higher the reuse degree, the stronger the PDCH channel strain.

### *6.5. IP throughput rate*

The IP throughput rate mainly reflects the packet forwarding capacity per unit time in the network. Simply understood, it is the amount of data forwarding that can be accomplished per unit of time when fully loaded. In terms of the specific allocation of PDCH channels, the higher the PDCH reuse, the more users agree to occupy the PDCH channel at the same time, and the lower the throughput rate of the wireless network IP, regardless of other factors. Since many cell phones currently include EDGE (Enhanced Data Rate for GSM Evolution) functionality, with IP rates up to 384kbps, we can effectively evaluate the quality of the network in terms of data services based on the IP throughput rate. The higher the throughput rate, the better the service delivery capability and the smoother the user experience.

## 7. Conclusion

This paper studies the new-generation heterogeneous cellular network technology combining traditional low-power nodes and macro stations, and draws the following conclusions:

On the basis of not affecting the quality of network communication, we can optimize the energy efficiency of cellular networks in many ways, such as by optimizing the network, deploying small

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base stations, using algorithms to improve device performance, and paying attention to related indicators.

The future research direction of cellular networks will be devoted to the performance optimization of the whole system and the minimization of energy efficiency loss.

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