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Research Article

Improved Channel Capacity in 5G Ultradense Network

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In general, it is necessary to evaluate the required bandwidth in each segment of the 5G ultradense network. After doing so, it is necessary to decide on the choice of OSI network and connection layer technologies. The most suitable models of network equipment are determined according to the technologies so selected. This question is not easy because performance depends directly on the performance of the hardware and also on the performance, software, and hardware configuration. These channel capabilities are the criteria for evaluating the performance of channels and equipment on 5G networks. In this paper, a model is proposed to increase the channel capacity of the 5G ultradense network. It is designed to increase the bandwidth usage of the channel and increase its functionality. Its main special feature is that its energy and power consumption is very low compared to other methods. This method is also ideal for sending more data with less power.

1. Introduction

Since the invention of the telegraphic theory in the 18th century, several methods for measuring the capacity of a channel have been developed. Performance criteria for pocket networks, on the other hand, are harder to calculate and are unlikely to produce accurate results [1]. It is caused by a wide range of situations (particularly those inherent in current multiservice networks), all of which are extremely difficult to predict in the first place. Using IP networks, a study can run multiple applications on the same network infrastructure, each with its own unique traffic model. This is possible because of the flexibility of IP networks. During a session, traffic in one direction may differ from traffic in the other, and this might be confusing. To make matters even more complicated, the pace of data between individual network nodes can fluctuate, making it more difficult to perform computations. If the study looks at what other companies have done with networks, the study will see that most of the time, performance is judged by these things [2–4].

Consider an email service. It uses protocols that run over TCP, which means that the data transfer rate is constantly adjusted and attempts to take over all available bandwidth [5]. So, let us start with the maximum value of the delay in sending a message—assuming that 1 second is enough for the user to be comfortable [6]. Next, the study needs to estimate the average size of the message sent. At the peak of the process, we will assume that there will be various links (invoices, reports, etc.) in the mail messages, so for our example, let us take the average message size of 500 kb [7]. Finally, the last parameter we have to choose is the maximum number of employees who can send messages at once. Suppose half the staff presses the "Send" button on the email client at the same time during an emergency [8–10].

The maximum performance required for email traffic is

$$\frac{500\,\text{kb} \times 150\,\text{hosts}}{1\,\text{s}} = 75,000\,\text{kb/s or } 600\,\text{Mbps}. \quad (1)$$

This allows the study to immediately identify that the mail server must be connected to the network via a 5G super dense channel as a result of the analysis. When this number is used as the network foundation, it can be used to figure out how much bandwidth is needed.

The UDP protocol is used to transmit both telephone traffic and video surveillance traffic, and the transfer rate is rather constant in both cases when using the protocol. With the exception of the fact that the streams on a phone are limited to bilateral communication and call time, the streams for video surveillance are sent in a single direction and are generally continuous in nature. According to an example of telephony traffic, the gateway must have the ability to handle a minimum number of 100 connections per second passing through it. Using the G.711 codec, single-stream speeds and service packets, including captions, for 5G super dense networks are approximately 100 kbps [11]. This suggests that the network hub bandwidth need during peak hours is 10 megabits per second.

It is possible to determine video surveillance traffic in a straightforward and accurate manner. For the sake of our application, a 4 Mbps stream is a realistic assumption [12–14]. It is necessary to calculate the required bandwidth by taking into account the combined speed of all video streams. Mbps stands for megabits per second multiplied by the number of cameras, which equals 80 Mbps. Thus, the total peak data rate for all three network services is 690 Mbps in aggregate. This amount of bandwidth will be provided by the network hub, which will be necessary. As the network expands in size, it is critical to consider the possibilities for scalability in order to ensure that the communication lines can manage the maximum amount of traffic. If studies are talking about the service requirements, Gigabit Ethernet will satisfy [15]. Additional nodes can be simply added to the network at the same time, if necessary.

Remember that VoIP traffic (IP telephony) is not only divided between phones, but it is also dispersed across the server computers. Different departments within an organization may also have variable levels of internet traffic: for example, the desktop department may use more phone calls, the project department may use more email, and the engineering department may use more traffic [16], among other things. In order to achieve this, some network components may consume more bandwidth than others. When calculating the IP telephony stream rate, the size of the codec that was used as well as the pocket title was taken into consideration. This is a very important factor to keep in mind.

The overall bandwidth of a stream is determined by the encryption method (codecs used), the amount of data carried in each packet, and the algorithms used at the connection layer [17]. This is the total amount of network bandwidth that must be taken into consideration when determining the required network bandwidth. The same cannot be said for all real-time streaming services, but it is particularly true in the case of IP telephony and other low-rate real-time streaming services [18]. In order to properly distinguish between the two VoIP streams, it is necessary to compare them side by side (see table). Each of these streams utilizes the same summary but has a different payload size (actual digital audio stream) and communicates over a different communication protocol [19] than the others.

If the selected network equipment is limited, in addition to the flexible configuration and scaling promised by the manufacturer, the study can take a lot of "risks." When selecting modules, the study should carefully read their description or consult the manufacturer. It is not enough to be guided only by the type of interfaces and their number—the study also needs to know the structure of the module [20]. While transporting traffic, it is not uncommon for some packets to be processed automatically, while others may send packets to the central processing unit for further processing (accordingly, for the same external modules, their price may vary several times). In the first case, the overall performance of the tool and, consequently, its maximum efficiency are higher than in the second, because the central processor converts part of its work to volume processors [21].

In addition, the main contribution of this modular equipment is that it often has a blocking configuration (when maximum performance is less than the total speed of all ports). This is due to the low bandwidth of the inner bus, through which the modules exchange traffic between themselves. For example, if a modular switch has a 20 Gbps internal bus, it can only use 20 ports when 48-gigabit Ethernet ports are fully loaded to its line card.

2. Literature Review

Bhushan et al. [1] discussed the signal information that is transmitted and transmitted in the form of a series of codes. From the source to the recipient, the message is sent through some material medium. When technical communication mechanisms are used in the transmission process, they are called communication channels (information channels). This includes telephone, radio, and TV. Human sensory organs play the role of biological information channels. They [2] accurately determine the bandwidth required for a designed network; it is essential to first know the requirements that those applications will use. Furthermore, for each application, it is necessary to analyze how the data transfer takes place at selected times, for which protocols are used.

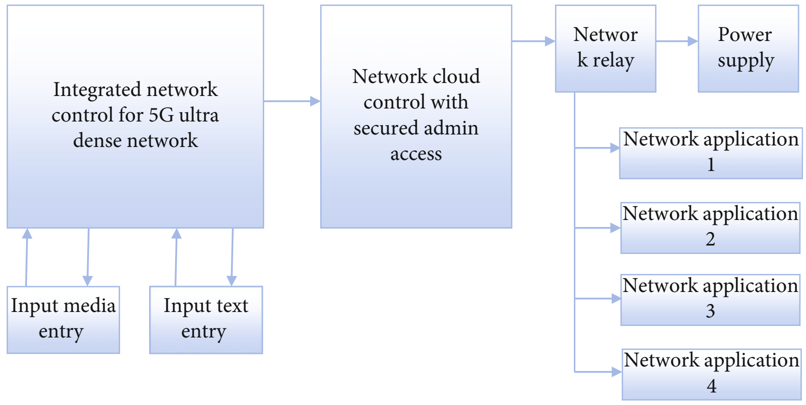

Figure 1: Proposed system design.

Jungnickel et al. [3] expressed that the code sent to the communication line must be redundant. Due to this, some part of the information can be lost during the transfer. However, you cannot magnify the layoff. This can lead to delays and higher communication costs. As they [4] discussed, the nonstandard equipment can distort the transmitted signal and lead to data loss. Such interruptions, first of all, arise for technical reasons: poor quality of communication lines and mutual insecurity of different information sent on the same channels. To protect against noise, different methods are used, for example, the use of different types of filters that separate the effective signal from the noise. Lu et al. [5] provide the definition of bandwidth which is generally used for a communication channel and determines the maximum amount of information that can be sent or received per unit time. Bandwidth is one of the most important factors in the user's view. Network, in range, is estimated by the amount of data that a unit time transfers from one device connected to another.

They [6] expressed the transfer of information from computer to computer. This process is called synchronous communication in 5G ultradense network and allows you to store messages through an intermediate computer and transfer them to personal computers as requested by the user-asynchronous. They [7] discussed the transmission medium, and the twisted-pair cables are used to transmit digital data and are widely used in computer networks. It is also possible to use them for the transmission of analog signals. Twisting the wires reduces the influence of external interference on the effective signals and reduces the electromagnetic waves propagating outside. Shield increases cable cost, complicates installation, and requires high-quality landing. This work [8] discusses about the speed, and the information transfer depends on the speed of its creation (source performance), encryption, and decoding methods. The maximum data transfer rate on a given channel is called its bandwidth.

3. Proposed Model

The proposed 5G ultradense network capacity model (UDNCM) is shown in Figure 1. Consider the following scenario: a network with 300 active PCs and 300 IP telephones. In addition to email, IP telephones and video surveillance are also options. A total of twenty cameras are used for video monitoring, with video streams being supplied to the server from each one of these. All of the services will be able to use all of the bandwidth available on each server channel during the time between the network core switches and the point where the network meets them. It should be noted now that all calculations must be performed for the user's largest network activity time (in telegraphic theory—CNN, peak hours), as network performance is generally critical during such periods and the resulting usage failures associated with the lack of bandwidth are unacceptable.

3.1. Choosing Connection Layer. The protocols are usually not a problem (today, the question often arises as to how much bandwidth the Ethernet channel should have), but it is difficult for even an experienced engineer to choose the right equipment. The development of network technologies along with the growing needs of applications for network bandwidth is also forcing the equipment manufacturers to develop new software and hardware configurations. Often, from one manufacturer, there are identical equipment models at first glance but designed to solve different network problems. Take Ethernet switches, for example: with conventional switches used in companies, most manufacturers have switches for creating storage networks and organizing operator services. Models of the same price category differ in their configuration, being "sharp" for certain tasks.

There is integrated connection between the network devices getting the media and text entry of the devices. Then, this goes into the network admin approval. If the admin approved this for access, then the user goes to access the various parts inside the network. Then, the networks relay here to provide the important access to the network. The power supply module provides the required power to the network components. This will be helpful to run the network applications.

3.2. Choice of Hardware. In addition to the overall performance, the choice of hardware should be driven by

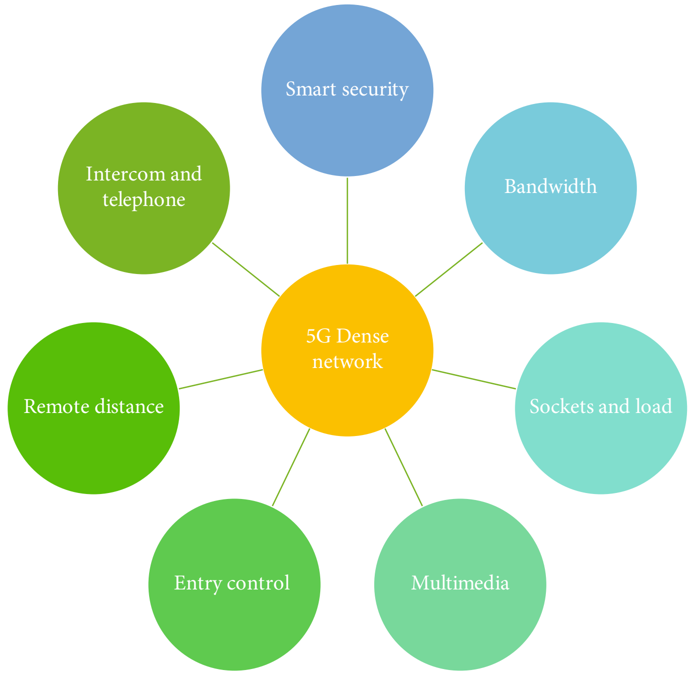

Figure 2: Implementation of 5G ultradense network.

supported technologies. Depending on the type of equipment, specific functions and types of transport can be processed at the hardware level without the use of CPU and memory resources. In this case, the traffic of other applications is processed at the software level, which greatly reduces the overall performance and, consequently, the maximum performance. For example, multilayer switches, due to their sophisticated hardware configuration, are capable of transmitting IP packets without performance degradation when all ports are fully loaded. Also, if we want to use more complex encapsulation (GRE, MPLS), such switches (at least the cheaper models) do not apply to us because their configuration does not support the relevant protocols, and at best, such connection occurs. The central processor has low performance cost. So, to solve such problems, for example, depends on software rather than routers and hardware implementation based on high-performance core processor. In this case, we get a large number of support protocols and technologies that are not supported by switches of the same price category, at maximum performance cost.

3.3. Maximum Performance. One is expressed in pockets per second, and the other in bits per second. This is because most of the performance of network equipment is usually spent on processing pocket headers. Roughly speaking, the equipment must accept the packet, find the appropriate transition path, create a new header, and (if necessary) send it. Obviously, in this case, it is not the amount of data sent per unit time, but the number of packets. Comparing two streams at the same rate but with different pocket sizes requires a higher performance for a stream with a smaller pocket size. This fact must be taken into account if the network is to be used, for example, a large number of IP telephony streams—where the maximum performance in bits per second is much lower than that reported. It is clear that with mixed transport and taking into account additional services (NAT, VPN), it is very difficult to calculate the load of equipment resources, as is the case in most cases. Often, equipment manufacturers or their partners carry out load testing of different models under different conditions and publish the results on the Internet in the form of comparison tables. Dealing with these results greatly simplifies the task of selecting the appropriate model.

$$A = \sum_{h=1}^{t} \sum_{b=1}^{v} c_j^{(a)} - k_h^2, \tag{2}$$

where in the above equation (2), A is the utility point of the network, t the quantity of the cluster, v network quantity, $c_h^{(t)}$ the j^{th} case of h^{th} network cluster, and k_h the centric of h^{th} network cluster.

When designing 5G ultradense networks, bandwidth is an important parameter that affects the structure of the network as a whole. The list of network services is shown in Figure 2. For a more accurate assessment of performance, the study can follow these guidelines:

(i) Read the application study plan to use on the network, the technologies they use, and the amount of traffic they transfer. Use the advice of developers and the experience of colleagues to take into account all the nuances of these applications when building networks

(ii) Learn more about the network protocols and technologies used by these applications

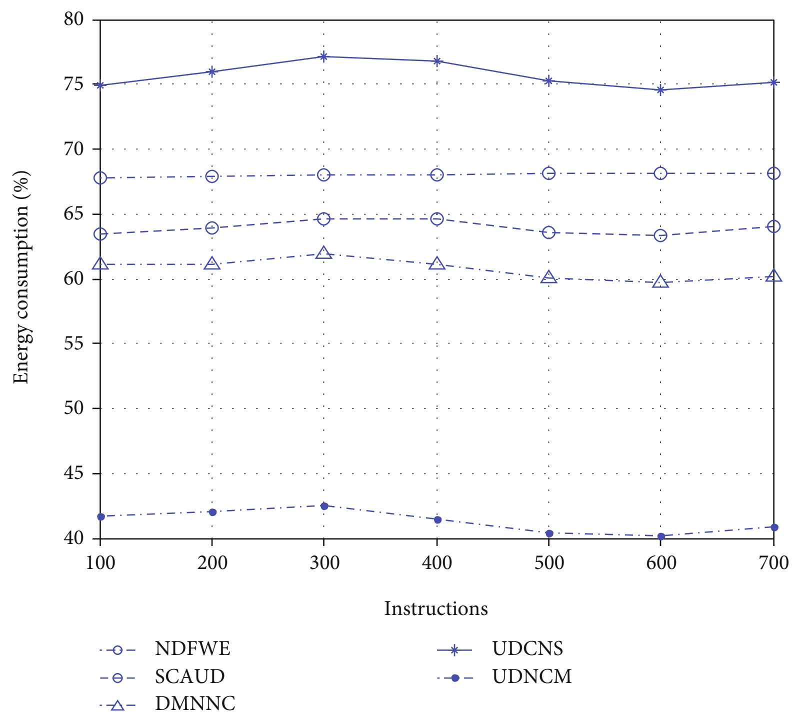

Figure 3: Comparison of energy consumption (%).

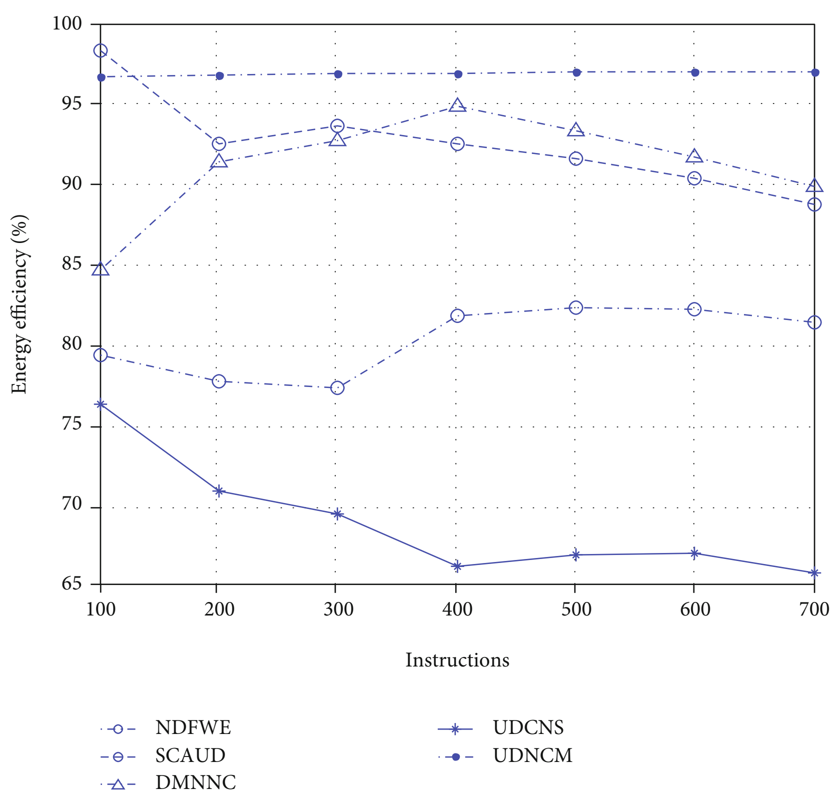

Figure 4: Comparison of energy efficiency (%).

(iii) Read the documentation carefully when selecting equipment. To get some stock of ready-made solutions, check out product lines from different manufacturers

As a result, with the right choice of technologies and equipment, the study can be confident that the network will fully meet the needs of all applications and will be flexible and scalable for a long time.

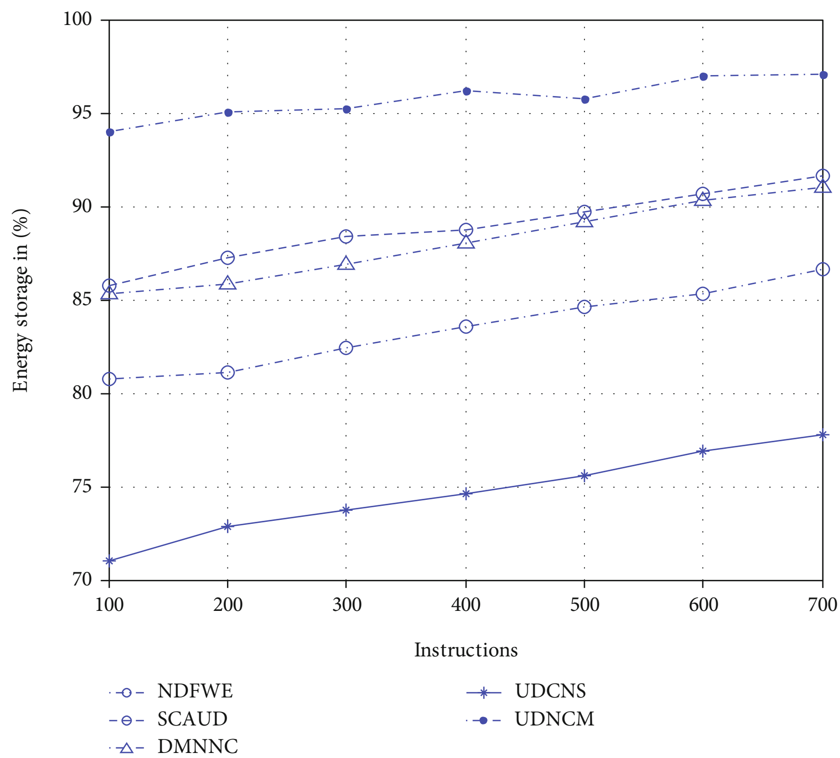

Figure 5: Comparison of energy storage (%).

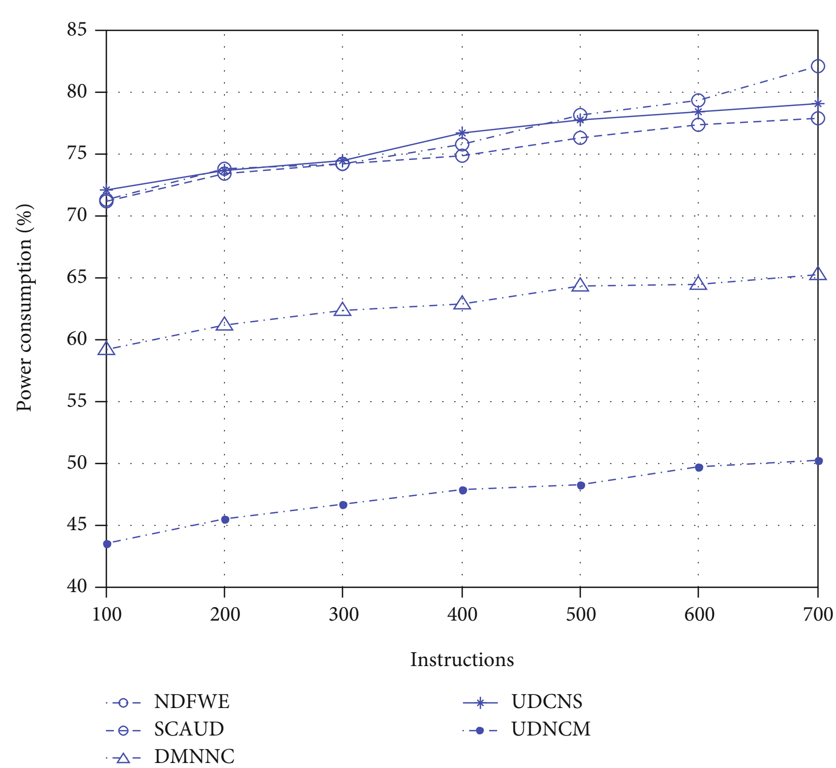

Figure 6: Comparison of power consumption (%).

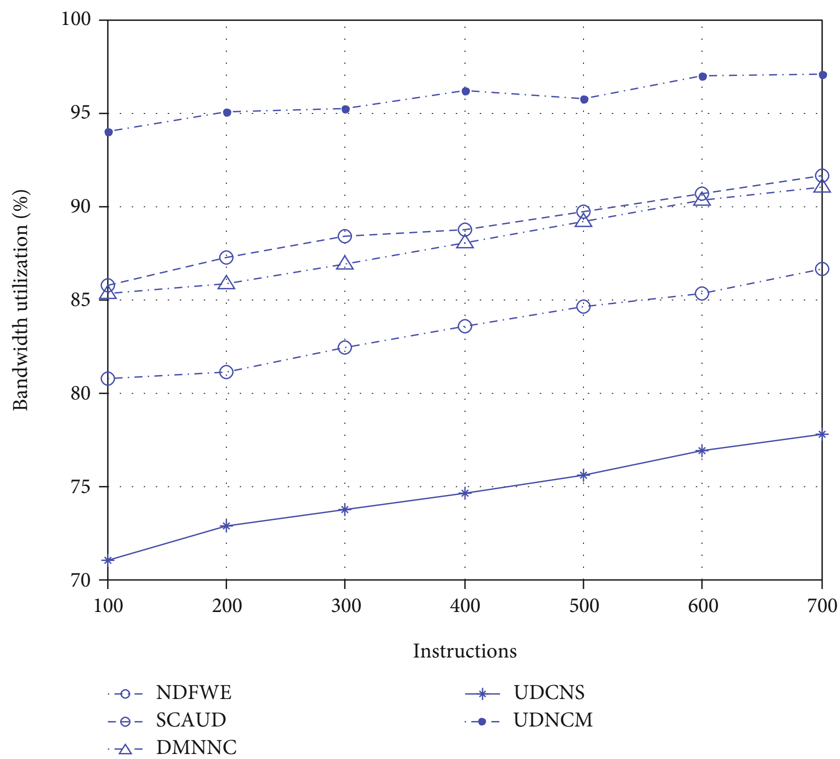

Figure 7: Comparison of bandwidth utilization (%).

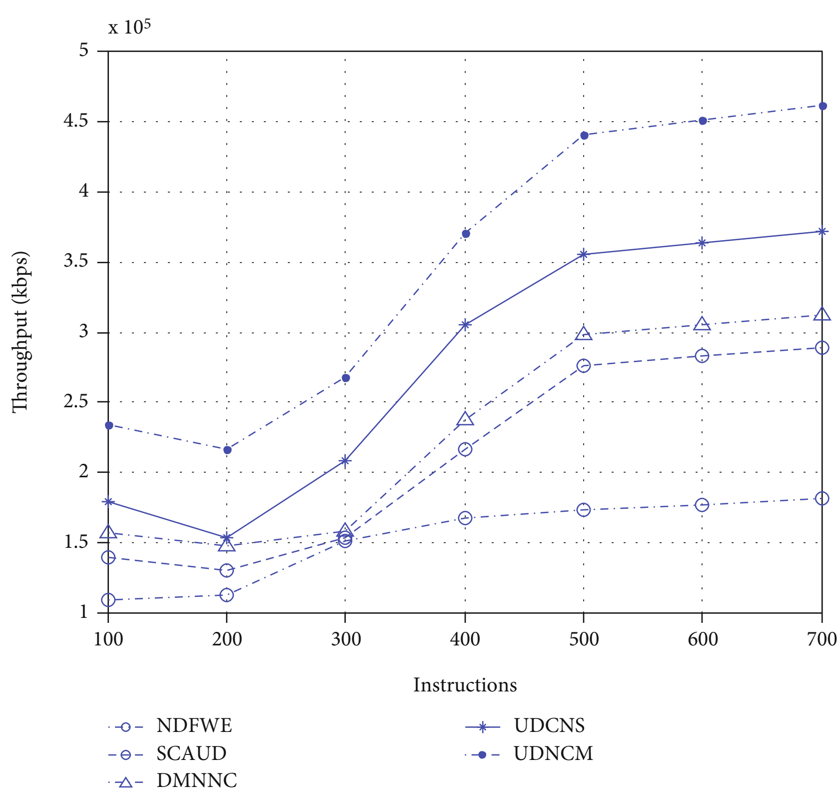

Figure 8: Comparison of throughput (%).

4. Results and Discussion

The proposed 5G ultradense network capacity model (UDNCM) was compared with the existing network densification for wireless evolution into 5G (NDFWE), system capacity analysis for ultradense (SCAUD), distributed monitoring of normalized network capacity (DMNNC), and 5G ultradense cellular networking system (UDCNS).

4.1. Energy Consumption. As a general rule, the amount of energy used has an impact on the amount of energy used. Multiplying the amount of power used in a certain time period by the total amount of power used is how the study figure out how much power the study uses. Figure 3 shows the estimation of the energy consumption between existing NDFWE, SCAUD, DMNNC, UDCNS, and UDNCM.

4.2. Energy Efficiency. The energy efficiency ratio is a measure of how efficiently a machine uses the energy it receives in comparison to the energy it produces as output. Due to the increase in efficiency, all of the available energy was utilized to its full capacity. Figure 4 shows the estimation of the energy efficiency between existing NDFWE, SCAUD, DMNNC, UDCNS, and UDNCM.

4.3. Energy Storage. The following formula is used to store the energy stored capacitor used in all the modules' commonly proposed methods in which the energy is stored. Figure 5 shows the estimation of the energy storage between existing NDFWE, SCAUD, DMNNC, UDCNS, and UDNCM.

4.4. Power Consumption. The power requirements of each gadget must be met in full. Ensuring that such a payment is received requires setting a fair price for the electricity generated. If this is not done, the test accuracy will be jeopardized. Figure 6 shows the estimation of the power consumption between existing NDFWE, SCAUD, DMNNC, UDCNS, and UDNCM.

4.5. Utilization of Bandwidth. At a given time, the highest quantity of data transferred over a user is referred to as the bandwidth. The percentage of consumed bandwidth off the total available bandwidth is called the bandwidth utilization. Figure 7 shows the estimation of the bandwidth utilization between existing NDFWE, SCAUD, DMNNC, UDCNS, and UDNCM.

4.6. Network Throughput. The network throughput is the amount of the data rates that are distributed to all users in a network. It refers the data flow rate of a communication channel. In wireless environment, throughput is an essential measurement while the data are moving without any traffic simultaneously.

$$\text{Throughput}\left(\frac{\text{bits}}{\text{sec}}\right) = \sum \frac{(\text{number of successful packets}) * (\text{average packet size})}{\text{total time sent in delivering that amount of data}}. \quad (3)$$

Figure 8 shows the estimation of the bandwidth utilization between existing NDFWE, SCAUD, DMNNC, UDCNS, and UDNCM.

The proposed method achieves 96% of bandwidth utilization, 50% of power consumption, 97% of energy storage, 96% of energy efficiency, and 41% of energy consumption.

5. Conclusion

The wide range of devices and bandwidths commonly used in a 5G network will increase its reliability by operating at a range of speeds and precision. In addition, the services of users on such dense networks are designed to be different. This will increase the time of use. For this reason, the number of users using it will be greatly reduced. The way to fix this is to convert it to the existing bandwidth of the band so that its speed is higher and the difficulties in use are minimized. The proposed 5G ultradense network capacity model (UDNCM) was compared with the existing network densification for wireless evolution into 5G (NDFWE), system capacity analysis for ultradense (SCAUD), distributed monitoring of normalized network capacity (DMNNC), and 5G ultradense cellular networking systems (UDCNS). So, the proposed model performs well and good in 5G ultradense networks and the improved channel capacity. Based on the results, the proposed model was getting higher energy efficiency and high bandwidth utilization. This shows that the proposed model effectively allows the various device functions inside the network. The proposed model uses very low energy and power consumption. This shows that the proposed method shares the energy and power as per the device requirements. The further enhancements of the proposed model are to enhance the entire channel capacity of the distributed network section. Now, the device and cluster capacity was getting more attention than this was enhanced. If the clusters are enhanced, then the node values are also increased. Then, the network capacity also increased. So the future focus will be the entire network capacity increment.

Data Availability

The data used to support the findings of this study are included within the article. Further data or information is available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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