Utilization Efficiency of 5G Spectrum Based on Homomorphic Encryption and Encryption Circuit and Its Application in Teaching Practice

Zheng Zhang*

Jiangxi Vocational and Technical College of Communication, Nanchang, China

123212069@qq.com

*corresponding author

Keywords: Homomorphic Encryption; 5G Spectrum; Encryption Circuit; Principal Component Analysis

Abstract: Along with social progress and technological development, 5G technology has gradually matured and become the focus of research. 5G technology is related to all aspects of the future society, and each country has carried out fierce competition for the leading right of 5G technology. However, with the continuous progress of 5G technology, there are also many problems, among which the shortage of spectrum resources is of great concern. 5G spectrum is an important prerequisite to ensure the smooth development of 5G technology and system. Therefore, it is necessary to study the utilization efficiency of 5G spectrum, so as to improve the utilization efficiency of 5G spectrum and ensure the smooth operation of 5G system. Based on homomorphic encryption and encryption circuit, and with the help of principal component analysis, this paper tries to establish an evaluation method and system for the utilization efficiency of 5G spectrum, and carries out relevant detection on this system. At the same time, the application of 5G network technology in teaching practice is studied. On the one hand, it is beneficial to improve the efficiency of spectrum utilization, and on the other hand, it provides a certain theoretical basis for future research on relevant aspects.

1. Introduction

The network communication spectrum is an invisible but critical strategic communication resource, and it is the channel for the smooth communication of various wireless network devices [1]. In recent years, with the rapid development of wireless network technology and the increasing demand of mobile network for data traffic, the worldwide demand for network communication spectrum has increased dramatically. In particular, the number of mobile users rises in a straight line, which greatly increases the amount of relevant data of network communication [2-3]. In this case, the problem of insufficient spectrum resources of network communication appears, and there is a serious contradiction between spectrum resources and spectrum user demand. Therefore, it is urgent to solve the problem of insufficient network communication spectrum resources [4]. However, at the current level of technology, the supply of spectrum resources is limited, so efforts must be made to improve the efficiency of spectrum use. 5G network system is the object of national key development in recent years, related to the quality of the future development of society. At present, 5G network technology has been applied in a few industries. As education is the foundation of national development, large-scale use of 5G network for teaching in the future is an inevitable development trend, and 5G network will definitely have a profound impact on teaching practice [5-6]. The current rapid development of 5G puts forward new requirements on the use efficiency of spectrum. In order to ensure the rapid improvement of 5G users and the normal use of 5G users, it is particularly important to study the use efficiency of 5G spectrum [7-8].

The international telecommunication union (itu) has made relatively clear provisions on spectrum management. The preface of the relevant document "radio rules" clearly requires that the reasonable allocation and use of limited spectrum resources must be guaranteed, and the use efficiency of visible spectrum occupies an extremely important position in spectrum management

[9]. To the use of spectrum efficiency correctly evaluated, to further improve spectrum efficiency, in 2016 the national related department issued a "national radio office about evaluation norm of the utilization of radio spectrum commissioning work notice, embodies the country to the attention of the frequency spectrum resource utilization, represents the scientific evaluation of the efficiency of spectrum use has become a regular work [10]. From this we can see that the domestic and foreign countries attach great importance to the work of improving the efficiency of spectrum utilization, and try to enhance the evaluation level of the efficiency of spectrum utilization. However, the current research on the utilization efficiency of 5G spectrum in China is not mature, and the research based on homomorphic encryption and encryption circuit is even less. Meanwhile, only a small part of research is combined with teaching practice [11-12]. Therefore, there are some theoretical gaps in this aspect.

In order to fill this theoretical gap, based on homomorphic encryption and encryption circuit, this paper studies the utilization efficiency of 5G spectrum. With the help of principal component analysis, it tries to establish an evaluation method and system for the utilization efficiency of 5G spectrum, and carries out relevant detection on this system [13-14]. At the same time, the application of 5G network technology in teaching practice is studied. On the one hand, it is conducive to improving the use efficiency of the spectrum, and on the other hand, it provides a certain theoretical basis for future research on relevant aspects [15].

2. Method

2.1 Overview of Homomorphic Encryption and Encryption Circuits

Homomorphic encryption has undergone a long development period, among which Rivest et al. first proposed homomorphic encryption algorithm. They first proposed that this function could project a set of operations on plaintext to other ciphertext, so that the encrypted data could be directly operated on. Homomorphic encryption has a set of fixed algorithm, which can guarantee semantic security, belongs to public key encryption algorithm, and can guarantee the security environment of data and operation. Homomorphic encryption algorithm also has other properties: for the specified two ciphertext E(A) and E(B), one of the ciphertext E(A·B) can be found so that E(A) · E(B) = E(A·B), · represents the meaning of multiplication or addition. However, because the algorithm can be used in the case of undecrypted plaintext, it has some limitations. Therefore, many researchers have improved the homomorphic encryption algorithm and obtained the now widely used full homomorphic encryption.

The encryption circuit has something in common with homomorphic encryption, that is, the operation of plaintext can also be carried out without decryption of both parties. The encryption circuit is mainly composed of two parts, namely garble value and garble table. The encryption circuit refers to the random function f, whose calculation form is Boolean circuit C. Meanwhile, it encrypts each input and output circuit by means of symmetric encryption. However, compared with homomorphic secrets, the encrypted plaintext cannot be directly calculated in the encryption circuit, and the garble table mentioned above must be used for calculation.

2.2 Principal Component Analysis

Principal component analysis is to reduce the index dimensions in the evaluation system, for example, there are X indicators. With the help of principal component operation method, only the main index dimensions are selected and the indexes with poor correlation are deleted. Suppose there are m network communication operators on the basis of n indicators, which form the initial data matrix m×n. The establishment of indicators of 5G spectrum utilization efficiency with the help of principal component analysis can include the most important indicators in the evaluation system and improve the accuracy and scientificity of the evaluation effect of 5G spectrum utilization efficiency. Firstly, the sample data is processed to a certain extent, and the correlation matrix is calculated with the help of the data matrix after dimensionless. The specific calculation formula is as follows:

$$
\begin{aligned}
&X_1 = a_{11}F_1 + a_{12}F_2 + ... + a_{1m}F_m \\
&X_2 = a_{21}F_1 + a_{22}F_2 + ... + a_{2m}F_m \\
&... \\
&X_p = a_{p1}F_1 + a_{p2}F_2 + ... + a_{pm}F_m
\end{aligned} \tag{1}
$$

The second is to calculate the eigenvalues of the correlation matrix. As shown in formula (1), the correlation eigenvalues of the matrix are added up one after another. Only when the sum of the final eigenvalues reaches 85% can the calculation be completed. Otherwise, I'm going to keep doing it. Suppose N samples are obtained through data collection, and there are p indicators reflecting the characteristics of each sample, then the collected data can be represented by matrix A, where A can be expressed as:

$$
A = \frac{a_y - \frac{1}{p}\sum_{i=1}^{n} a_y}{\sqrt{\frac{1}{p}\sum_{i=1}^{n}(a_y - \frac{1}{p}\sum_{i=1}^{n} a_y)^2}} \tag{2}
$$

The score of principal factors can be calculated through A, and sorted and analyzed according to the score. The main index factors in the evaluation system are ranked in the front.

3. Evaluation Method and Index Selection of 5G Spectrum Utilization Efficiency

Since there are different scenarios for the use of 5G spectrum, and there is a big difference between the use scenarios of low frequency and high frequency spectrum, the evaluation method for the use efficiency of 5G spectrum must cover different application scenarios. In this paper, in reference to the related information, the network communication of the number of users, 5 g spectrum coverage and frequency spectrum in different time and place, and other important factors to join the 5 g spectrum efficiency evaluation system, multi-angle comprehensive factor of consideration can make 5 g spectrum efficiency assessment is scientific.

About specific evaluation indexes, to comprehensively consider all aspects of economy, technology, ecology factors considered, by the use of 5 g spectrum efficiency of technology demand is higher, so this paper chose the technical part of the index system, based on principal component analysis (pca), finally determine the main indicators include the following aspects, respectively is: first, the frequency domain dimension index. This index considers two options of frequency band occupancy and frequency domain density. The second is the time domain dimension index. This index takes into account the time-domain density of users and another evaluation option of population penetration rate, where population penetration rate refers to the degree of population coverage by mobile communication service. Third, spatial dimension index. The most important index option in the spatial dimension index is the coverage option, which is related to the actual coverage of 5G spectrum. Fourth, business level indicators; This index is mainly to test the actual operating effect of 5G spectrum, which is an important index to measure the efficiency of spectrum use. Fifth, spectrum demand level indicators. With the rapid progress of 5G technology, the contradiction between supply and demand of spectrum resources becomes more and more prominent. Therefore, the actual demand of spectrum can be incorporated into the index system to better measure the actual use efficiency of spectrum.

4. Discuss

4.1Strategies to Improve the Utilization Efficiency of 5G Spectrum

Based on homomorphic encryption and encryption circuit, relevant calculation is carried out on relevant evaluation indexes of 5G spectrum utilization efficiency with the help of principal component analysis method. We can draw the conclusion that: currently, the utilization efficiency of

5G spectrum in China is relatively low, which is far from ideal. The low efficiency of 5G spectrum has hindered the development and application promotion of 5G technology. The specific data are shown in table 1 and figure 1. The data in the figure is the result of the author's operation and arrangement.

Table 1. 5G spectrum utilization efficiency index data

Indicators	Effect Value	Percent of Pass
Frequency Domain Dimensions	72.17%	61.54%
Temporal Dimension	68.59%	52.17%
Spatial Dimensions	71.44%	63.42%
Business Level	72.54%	62.14%
Spectrum Demand	51.47%	49.58%
Actual Service Efficiency	63.37%	
Ideal Service Efficiency	91.57%	
*Data came from the in-depth analysis of financial data in the experiment		

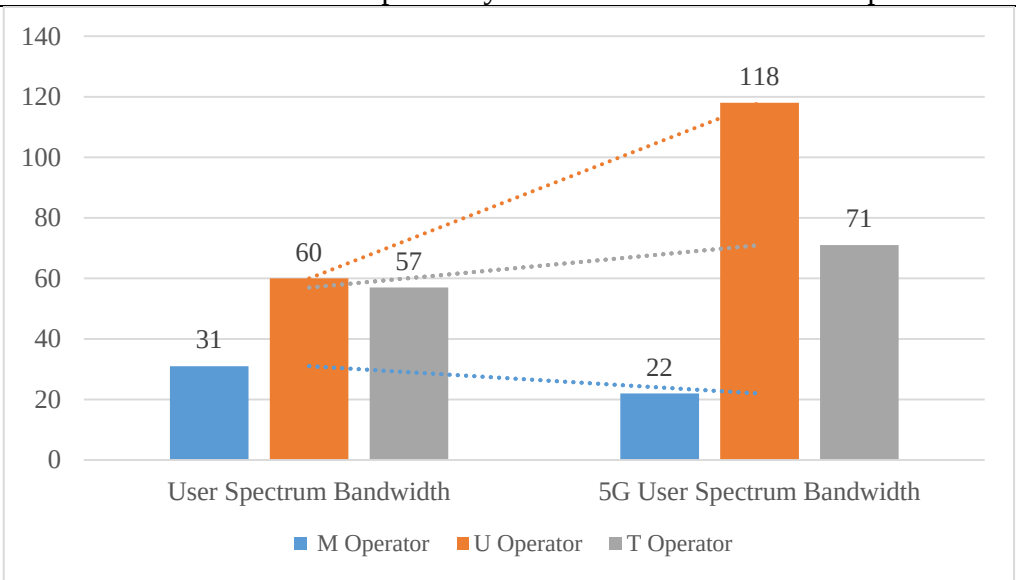

Figure 1. Analysis results of spectrum bandwidth of operators

According to table 1, we can see that the actual use effect of 5G spectrum is far from the ideal use effect, which is about 30% lower than the ideal use effect. According to figure 1, we can find that there is a big difference in spectrum bandwidth between operators in China, which will also have a huge impact on the utilization efficiency of 5G spectrum. Therefore, in order to ensure the normal development of 5G network technology, efforts must be made to improve the utilization efficiency of 5G spectrum. The improvement of 5G spectrum efficiency can be mainly carried out from the following aspects: first, reasonable allocation of 5G spectrum resources can be carried out. Only by ensuring reasonable allocation of resources can the use effect be maximized; Second, enhance the overall improvement of 5G technology. Technology is a guarantee for improving the use efficiency. Only by vigorously improving the operation technology of 5G can there be no waste of spectrum resources in the utilization process of 5G spectrum and the use efficiency of spectrum can be improved. Third, to increase the cooperation between China's major operators. The data in figure 1 shows that there is a great difference in spectrum bandwidth between operators in China, which will certainly have a great impact on the rational allocation of spectrum resources and not conducive to the improvement of spectrum utilization effect. Therefore, China's major communication operators must strengthen mutual cooperation, realize the complementary advantages of 5G spectrum resources development, try to narrow the spectrum bandwidth gap between major operators, promote the rational allocation of spectrum resources, and jointly strive to improve the use efficiency of 5G spectrum.

4.2. 5G Spectrum in Teaching Practice

The improvement of the utilization efficiency of 5G spectrum can, to a large extent, guarantee and promote the in-depth application of 5G network technology in all walks of life, especially in the application of education and teaching practice. 5G communication network technology has the technical characteristics of "ultra-high speed and ultra-low delay", which can provide important technical support for the good development of teaching in the future. First of all, 5G technology promotes the diversified development of future teaching mode, promotes the better development of future distance teaching and intelligent classroom, and realizes the sharing of high-quality teaching resources, which to some extent makes up for the uneven distribution of teaching resources. Furthermore, digital media plays a positive role in teaching practice, which enriches teaching methods and improves teaching efficiency greatly. Secondly, 5G technology and AR technology can be better combined to help students establish a real classroom situation. On the one hand, it is beneficial for students to understand the teaching content. On the other hand, it promotes the construction of experiential classroom through the creation of real situation, which greatly improves students' learning enthusiasm and teachers' teaching enthusiasm. Finally, the improvement of 5G technology and its application in teaching practice can provide more information resources for actual teaching, enrich the teaching content and greatly change the situation that books were the only teaching resource. However, in the application of 5G network communication technology in teaching practice, attention should be paid to avoid the adverse effects of science and technology, such as not allowing the information network to cover up the leading role of teachers. Only when the relationship between 5G technology and teaching practice is properly handled and the two are coordinated, can 5G network communication play its best role in teaching practice fundamentally.

5. Conclusion

Spectrum use efficiency is related to the future development of 5G and has a profound impact on the use effect of 5G in all walks of life. The improvement of spectrum utilization efficiency is conducive to solving the prominent contradiction between spectrum resources and spectrum demand in the era of 5G and alleviating the problem of insufficient spectrum resources. At the same time, the improvement of the utilization efficiency of 5G spectrum is conducive to promoting the in-depth application of 5G network technology in teaching practice, which is conducive to the development of China's education. The relevant research conducted in this paper is not only conducive to the improvement and application of 5G spectrum efficiency, but also provides a certain theoretical basis for future research on relevant aspects.

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