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Application and Challenge of Edge Computing Based on 5G Communication in Information and Communication Systems

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Abstract: With the rapid development of information technology, 5G communication technology has gradually entered real life, among which the application of edge computing is particularly significant in the information and communication system field. This paper focuses on using edge computing based on 5G communication in information and communication systems. First, the study analyzes the importance of combining edge computing technology with 5G communication technology, and its advantages, such as high efficiency and low latency in processing large amounts of data. The study then explores multiple application scenarios of edge computing in information and communication systems, such as integrated use in the Internet of Things, intelligent transportation, telemedicine and Industry 4.0. The research method is mainly based on theoretical analysis and experimental verification, combined with the characteristics of the 5G network to optimize the edge computing model and test the performance of edge computing in different scenarios through experimental simulation. The results show that edge computing significantly improves the data processing capacity and response speed of ICS in a 5G environment. However, there are also a series of challenges in practical application, including data security and privacy protection, the complexity of resource management and allocation, and the guarantee of quality of service (QoS). Through the case analysis and problem analysis, the paper puts forward the corresponding solution strategies, such as strengthening the data security protocol, introducing the intelligent resource scheduling system and establishing a multi-dimensional service quality monitoring mechanism. Finally, this study points out that the deep integration of edge computing and 5G communication will continue to promote the innovative development of information and communication systems, which has a far-reaching impact and important practical significance for promoting the transformation and upgrading in the field of information technology.

Keywords: 5G communication; Edge computing; Information communication system; Data security; Service quality

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1. Introduction

5G is the latest mobile network technology, and it is faster and stronger than previous technologies. 5G can make many things better connected together, such as mobile phones, computers and many smart devices in our daily use. With 5G, people can download things faster and watch videos without stopping. Edge computing is like a special helper for 5G, processing data faster and no longer waiting like computer games loading faster. By bringing data processing closer to users, 5G can do more. This can help in many ways, such as controlling devices online, doctors seeing doctors remotely online, self-driving cars and robots working in factories. But to do all this well, you need to protect people's data privacy, make sure the device works properly without mistakes, and keep the network in good condition. The research is to study the performance of combining 5G and edge computing in life, and to find ways to solve possible problems. In this way, the networks and devices can be understood and used better in the future. Overall, the combination of 5G and edge computing is a faster and better future for the network.

2. The fusion basis of 5G communication and edge computing

2.1. Characteristics and advantages of 5G communication technology

5G communication technology, with its high speed, low latency, large connection and high reliability, has become a key driving force in information and communication systems [1]. Its high-speed performance significantly improves the efficiency of data transmission and supports the smooth operation of high-bandwidth applications such as HD video and virtual reality. In terms of low latency, 5G can achieve millisecond latency to meet the needs of real-time applications, such as autonomous driving and telemedicine, enabling a rapid response to information [2]. The large connection feature allows more devices to access the network, providing a solid foundation for the development of the Internet of Things, and supporting the online and data interaction of massive devices. In terms of high reliability, 5G has strong system stability and security to ensure the stable operation of mission-critical communications, which is particularly important for industrial automation and critical infrastructure. The network slice function of 5G can provide customized and flexible network services according to the needs of different applications to optimize resource utilization and improve communication efficiency. These technological advantages make 5G an ideal partner for edge computing and play an indispensable role in promoting the innovative development of information and communication systems. Combined with edge computing, 5G not only improves the data processing capability but also further expands the application boundary of information and communication systems.

2.2. Principle and key technologies of edge computing

Edge computation, as a computational paradigm, achieves a low latency and efficient computing power by processing data at the edge of a network close to the data source. The basic principle is to sink data processing and storage from the central cloud to the edge of the network. This decentralized approach can reduce the data transmission distance and improve its real-time response capability [3].

In terms of critical technologies, edge devices need to have strong computing power and storage resources to support the processing of massive data. The adoption of the microservice architecture enables edge computing to flexibly deploy various applications to ensure the scalability and maintainability of the system. Distributed computing technology occupies an important position in edge computing and works together through task decomposition and coordination [4]. The wide application of virtualization technology enables

edge computing to provide an isolated operating environment with limited resources and improve resource utilization.

In terms of ensuring data security and privacy, the combination of encryption technology and access control mechanism provides an important guarantee for edge computing. Through data localization processing, edge computing effectively reduces network bandwidth consumption by reducing the risk of data privacy issues [5]. The application of edge computing in the 5G era provides a new technical path and development direction.

2.3. Significance of edge computing and 5G communication

The combination of edge computing with 5G communication has important implications. With its high bandwidth, low latency and large-scale connectivity characteristics, 5G communication technology provides an ideal basic network environment for edge computing. Edge computing reduces the data processing power to the edge of the network, reducing the burden of the central server and improving the data processing efficiency. In the 5G environment, edge computing can respond to user needs more quickly, achieve more efficient data flow and lower latency, and is critical to real-time application scenarios such as intelligent transportation and telemedicine [6]. Edge computing also provides a new guarantee for the privacy protection and security of the data in the network, and promotes the overall performance improvement and innovative development of the information and communication system.

3. Diversified applications of edge computing in information and communication systems

3.1. Edge computing applications in the Internet of Things environment

In the Internet of Things (IoT) environment, the application of edge computing is particularly critical. IoT devices are usually widely distributed, large in large numbers, and produce a huge amount of data. Traditional cloud computing architectures may face problems such as bandwidth pressure and high latency in data processing [7]. By calculating at the edge nodes close to the data source, it can not only effectively reduce the burden of the central server, but also greatly reduce the delay of data transmission and improve the real-time data processing capacity.

In smart cities, edge computing is widely used in areas such as traffic management, environmental monitoring and energy distribution. Edge nodes can process the data collected by intersection cameras, sensors and other devices in real-time, and make timely traffic signal optimization and abnormal situation warnings to reduce traffic congestion and improve traffic efficiency. In environmental monitoring, edge computing can quickly analyze the data of air quality sensors, supporting timely pollution source tracking and response strategy development.

Smart home systems also benefit from the edge computing application [8]. Through edge nodes, all kinds of intelligent devices can realize rapid interconnection and collaboration within the LAN, and improve the device response speed and user experience [9]. This architecture also ensures the continuous operation of the basic services when a network failure occurs.

At the beam level, using 5G mm-wave spectrum technology, through beamforming and smart antenna and other means, to achieve more accurate signal transmission and reception, and improve the signal coverage and transmission distance. At the same time, the high bandwidth characteristic of 5G mm-wave spectrum provides strong support for large-scale data transmission. In addition, the low delay characteristics required

by the 5G communication system are also fully guaranteed, and the end-to-end efficient data transmission is realized by optimizing the hardware and protocol. The deployment of independent 5G private networks provides customized network solutions for specific industries and application scenarios, ensuring the security and reliability of data transmission. These edge computing measures based on 5G communication have jointly promoted the upgrading and development of information and communication systems and injected new vitality into smart manufacturing and smart cities.

3.2. Implementation case of edge calculation in the intelligent transportation system

In the intelligent transportation system, the implementation of edge computing greatly improves the efficiency and safety of traffic management. By moving data processing to the edge of the network and analyzing road information in real-time, it can effectively reduce traffic congestion and reduce accidents. With the help of edge computing, the data exchange between vehicles and infrastructure is more rapid, supporting the rapid adjustment and optimization of traffic signals. Edge computing also provides a more stable platform for driverless technology, which reduces the driving risk through the rapid response-ability to the surrounding environment of the vehicle [10]. In intelligent parking management, edge devices realize the rapid recognition and dispatch of parking spaces through real-time data processing, and improve the parking experience of car owners [11]. For public transport systems, edge computing helps monitor vehicle location and passenger traffic in real time, and optimizes wiring and service quality. Although the application of edge computing in intelligent transportation has shown significant results, it still faces challenges such as equipment deployment and maintenance costs, network coverage and so on [12]. Expanding the application scope and function of edge computing will bring a wider range of innovation opportunities for intelligent transportation, and with the continuous progress of technology, its application potential in the transportation system will continue to expand.

3.3. Edge computing integration in the telemedicine and Industry 40 scenarios

The integration of edge computing in telemedicine is mainly reflected in improving the efficiency of data processing and reducing latency, supporting real-time monitoring and diagnosis, and improving the quality of medical services. In the Industry 4.0 scenario, edge computing enables the optimization of intelligent manufacturing and equipment maintenance through the rapid processing and analysis of production data. Combined with the high bandwidth and low latency characteristics of a 5G network, edge computing effectively improves the response speed of the automation system, and improves the flexibility and efficiency of production. This integrated application not only drives innovative development in the medical and industrial sectors but also significantly improves service quality and resource utilization.

4. Challenges and solution strategies faced by them

4.1. Challenges of data security and privacy protection

The application of 5G communication-based edge computing in information and communication systems is faced with significant data security and privacy protection challenges [13]. As the number of edge computing nodes increases, more user data is processed and stored on edge devices close to the data source. Due to the widely distributed edge devices, they are easy to become targets of cyber attacks, increasing the risk of data leakage and tampering. Data types in different application scenarios are diverse and sensitive, including

personal health information, traffic flow data and industrial operation parameters, which put forward higher requirements for data privacy protection.

In response to these challenges, it is urgent to strengthen the security protection measures of edge devices and implement strict data encryption protocols to ensure the integrity and confidentiality of data during transmission and storage [14]. Privacy protection mechanisms deployed at the edge, such as differential privacy and homomorphism encryption, can also effectively reduce data exposure risk. The formulation and implementation of privacy protection laws and regulations and industry standards applicable to the marginal environment will help to provide both technical and legal protection, and further reduce the data security risks. On the edge nodes, the comprehensive adoption of multi-level security strategies can also effectively resist potential attacks and improve the anti-risk ability of the entire information and communication system.

4.2. Complexity of resource management and allocation

In 5G communication computing applications based on edges, the complexity of resource management and allocation is an important challenge [15]. Under different application scenarios, the resource demand is changeable, especially in large-scale distributed systems such as the Internet of Things and intelligent transportation, and efficient resource scheduling is very important. Traditional resource management makes it difficult to cope with the highly dynamic and heterogeneous network environment, which makes the problem of insufficient resource utilization or even overload more prominent.

To meet these challenges, an intelligent resource scheduling system can be introduced, dynamically allocated and optimized to use machine learning algorithm and improve the adaptability of the system. A unified resource management platform can also be developed so that each edge node can cooperate and share resources from a global perspective, which can effectively reduce resource waste. A multi-level resource allocation strategy should also be established, considering not only computing and storage resources but also network bandwidth and energy consumption, to ensure the balanced use of various resources.

The application scenarios of edge computing in a 5G environment are complex and diverse. By optimizing resource management and allocation strategies, the overall performance and service quality of the system can be significantly improved, laying a solid foundation for the future development of information and communication system.

4.3. Strategies to guarantee the quality of service (QoS)

Ensuring service quality (QoS) is one of the key challenges for the successful application of edge computing in the 5G environment. Efficient QoS management requires comprehensively considering multidimensional factors such as network bandwidth, latency, and data throughput. The solution strategy should include the introduction of an intelligent traffic control mechanism to dynamically adjust the network resource allocation and improve the system response speed. Implement advanced transmission protocol optimization to ensure the stability and reliability of data transmission. A machine learning-based prediction model is helpful to predict the changing trend of network load and adjust the resource allocation in advance. A multi-level QoS monitoring and evaluation system can track service quality in real-time and find potential problems in time. Through these strategies, the QoS level can be effectively improved in the complex and changeable network environment to meet the needs of edge computing in diversified information and communication systems.

5. Conclusion

This article is about how 5G communication and edge computing used together can make our information systems work better. Like in a computer game, edge computing helps the game load faster, and reduces the waiting time, while 5G makes the network faster and things in the game can appear quickly without stalling. The article also discussed that while this method is great, there are still some problems to be solved, such as making sure that our information is not leaked, and ensuring that services like games and other services run smoothly. The article offers some good ideas to help solve these problems. Finally, the article believes that in the future, if 5G can better combined with edge computing, it can be applied widely in various fields, such as autonomous driving and smart homes, but at the same time, it is also important to pay attention to safety issues to make all services run better and more safely.

Disclosure statement

No conflict of interest.

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