Research on Optimization of Efficient Computing Unloading Algorithm in Moving Edge Computing

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Abstract: With the continuous growth of mobile communication technology, mobile terminal services have brought great convenience to people's lives. Moreover, new demands emerge one after another, which brings many new challenges to mobile computing technology. The traditional central cloud is usually far away from users, so the transmission delay of tasks is long. Mobile Edge Computing (MEC) offloading is the key technology of MEC, whose main function is to migrate the intensive computing tasks of mobile devices to the edge server for execution, so as to achieve low-energy and low-latency services. However, the transmission delay and energy consumption generated during the offloading of computing tasks reduce the quality of users' experience. In this article, a joint optimization strategy of computing unloading and resource allocation based on game theory is proposed to solve the problem of high latency caused by mobile terminals with insufficient computing power in MEC network when dealing with low latency and high reliability applications.

1. Introduction

Due to the growth of Internet, a variety of new data services have greatly enriched users' daily mobile application experience, such as face recognition, interactive games and virtual reality technology [1]. In order to achieve this goal, mobile terminals need to migrate computing-intensive tasks to the cloud server through wireless access. Although this method can reduce the load of the mobile terminal, it also has obvious defects, that is, the long distance between the mobile terminal and the cloud server and a large number of terminal service requests will increase the network delay, thus reducing the service experience of the end users [2]. In the process of computing and unloading, the high energy consumption and high delay caused by transmitting data greatly reduce the user's experience quality [3]. Therefore, MEC technology came into being. The gap between the limited computing power of mobile devices and the need to execute complex applications is gradually widening, especially when computing-intensive mobile applications are executed on mobile devices, the computing performance is poor [4]. These problems have greatly affected the operating efficiency and user experience of mobile applications, and limited the further growth of mobile application platforms [5]. Hu et al. used markov decision processes to perform random computing task scheduling, and obtained the best unloading decision through one-dimensional search algorithm [6-7]. Dong et al. studied the cooperation between cloud and edge cloud [8]. Lin et al. expressed the computing task as a constrained markov decision processes, which is an offline strategy pre-calculated based on the prior knowledge of application characteristics and statistical behavior of radio environment [9]. Pan et al. considered a multi-user edge computing offload system based on time division multiple access [10]. Aiming at the problem of high latency caused by mobile terminals with insufficient computing power in MEC network when dealing with low latency and high reliability applications, this article proposes a joint optimization strategy of computing unloading and resource allocation based on game theory.

2. Methodology

With the rapid growth of Internet of Everything technology, the infrastructure of communication network is gradually transitioning to 5G. 5G is also called the fifth generation mobile

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communication technology, and its appearance redefines the production and operation mode of all walks of life. MEC research mainly focuses on reducing users' time delay and energy consumption, and seldom fully studies the economic factors. However, the main body providing MEC services and the terminals needing MEC services belong to different market main bodies, so it is necessary to design a charging mechanism to enable the owners of mobile edge servers to serve other users for a long time. Moreover, in order to further improve the overall efficiency of the system, users are allowed to assist in calculation. In MEC system, mobile devices require high delay, and minimizing the response delay of computing tasks is an important goal to be considered in research. Moreover, different mobile devices need to compete for computing resources and wireless resources in MEC system. MEC enhances the computing power of mobile devices by transferring computing tasks from mobile devices to edge servers, which breaks the limitations of mobile devices in computing power, battery capacity and storage availability.

In MEC, the computing resources and wireless network resources of mobile edge cloud are also limited, so it is necessary to allocate resources reasonably to minimize the processing delay of computing tasks. The mobile edge layer is composed of edge servers near users. Compared with the resources of user equipment terminals, the resources of edge servers are more abundant. Through the computing unloading technology, information can be exchanged in real time to meet the service requirements of different types of applications. The cloud layer is composed of cloud servers. Although the edge servers have high service capabilities, the cloud servers can still serve as the strongest data processing center, which is suitable for non-delay sensitive tasks with complex data processing. Compared with the remote cloud server, the computing resources of MEC server are limited, and it is always difficult for a single MEC server to meet different task unloading requirements. With the increase of task scale, the load of edge server also increases.

The location of MEC server is flexible. In this article, MEC computing server is deployed on the microcellular base station to realize specific computing functions, and local devices interact with the server in a wireless way. If it is assumed that the uplink and downlink transmission rates of task T_{ui} accessing to the site are fixed at r_i, and when the number of tasks S_i transmitted to the internal server of MEC server is D_{ui}, the transmission delay can be expressed as:

$$T_{ui} = D_{ui} / r_i \tag{1}$$

If the task S_i is executed at the mobile terminal, the total system delay from sending the uninstall request to the completion of the task execution can be expressed as:

$$TC_i = T_{ti} + tb_i + \min(P_{ci,j} + t_i) \tag{2}$$

T_{ti} represents the transmission delay, tb_i represents the delay waiting caused by insufficient bandwidth, $P_{ci,j}$ represents the delay caused by queuing at MEC, and t_i represents the delay caused by MEC server when executing tasks. If task S_i executes related commands on MEC server, its execution delay can be expressed as:

$$TC_{i,j} = T_{ti} + tb_i + P_{ci,j} + t_i \tag{3}$$

A comprehensive decision-maker is set up at the mobile edge cloud to decide the wireless resource allocation strategy of the system, the number of lease instances of the central cloud and the task scheduling of the mobile device unloading task, with the goal of minimizing the response delay and energy consumption cost of the mobile edge. In order to reduce the load of the edge server, the existing schemes mainly refuse, postpone or wait in line for the user's uninstall request. However, the above scheme will lead to service interruption, which will lead to the extension of task waiting and execution time, and the user experience will be greatly reduced. In this article, the central cloud, the working conditions of mobile edge cloud service nodes, wireless access points and mobile devices, as well as the decision strategy of comprehensive decision makers in the central cloud-assisted computing unloading and resource allocation problems are abstracted. MEC can use the real-time network data interaction between the edge terminal and the mobile device terminal to track the information of the user equipment. When there is an edge in the network structure of the system, according to the relevant information of the edge, the specific position of each access device can be inferred, thus generating a set of service-oriented use cases.

3. Result analysis and discussion

MEC emphasizes providing services near mobile terminal users or data sources. Its core lies in sinking the service, using wireless access network to quickly deploy services for users at the edge close to mobile devices, so as to realize the flexible use of resources, prevent congestion in the core network, and better meet the low-delay needs of users. In an abstract MEC system assisted by central cloud, many delay-sensitive and computationally intensive applications are running on each mobile device. Figure 1 shows the comparison of simulation running time of different MEC unloading algorithms.

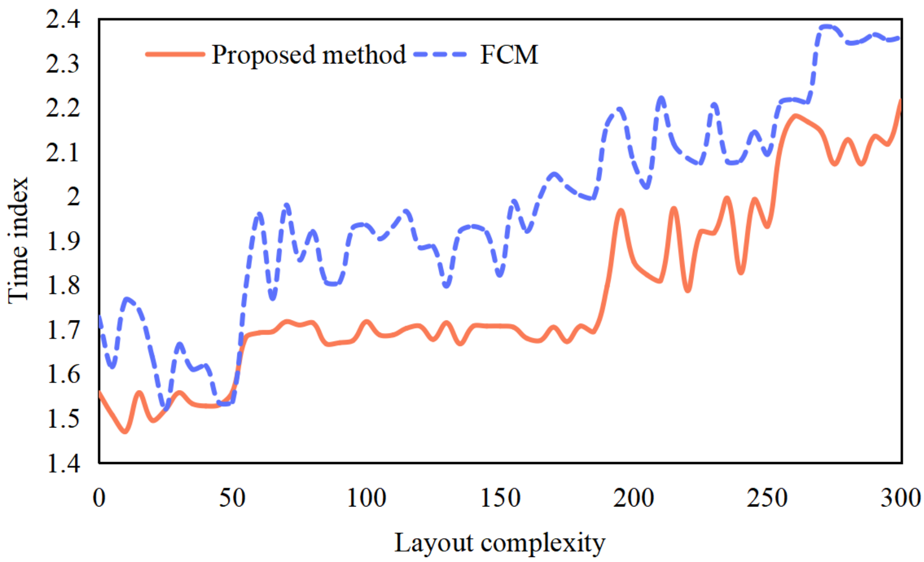

Figure 1 Comparison of simulation running time of different MEC unloading algorithms

It can be seen that although this method did not show obvious advantages in the initial stage, when the complexity of information is increasing, this method shows high operating efficiency. Compared with the remote cloud, offloading some tasks to the edge server for processing can facilitate the acquisition of key information for processing and analyzing data, reduce the time delay, and bring better service experience to users. Moreover, the distributed deployment of the edge server can also effectively reduce the communication load in the core network and relieve the pressure of information processing. Computing tasks offloaded by mobile devices are offloaded through their nearest wireless access points. Mobile devices can offload tasks to the mobile edge cloud server or to the central cloud through the mobile edge cloud, and the total bandwidth of wireless transmission of the system is certain. By offloading some computing data to the edge of the network near users, the task offloading strategy can not only reduce the computing energy consumption and network transmission energy consumption in cloud computing, but also reduce the equipment energy consumption, thus prolonging the battery life of mobile devices.

Adjustment and optimization are not limited to the channel layer, and optimization in the transmission medium layer can ensure that the time slots of high-order channels and low-order channels in the channel layer are redistributed, and many low-order channels are converted into single high-order channels, thus realizing network optimization. Edge computing can shorten the transmission distance of data uploaded by terminal equipment, and greatly save the energy consumed by task unloading and data transmission. In the practical application of the algorithm, we constantly explore how to improve the algorithm to achieve better search results. The fitness function used in the algorithm plays a very good role in optimization, and at the same time, it designs the existing models and plans the selection of crossover and mutation operators. Compared with the traditional cloud computing center, the servers of edge computing are distributed, and the storage and computing capacity of a single server is limited, so the information value is low and it is not easy to become the target of attack. The safety comparison results of different schemes are shown in Figure 2.

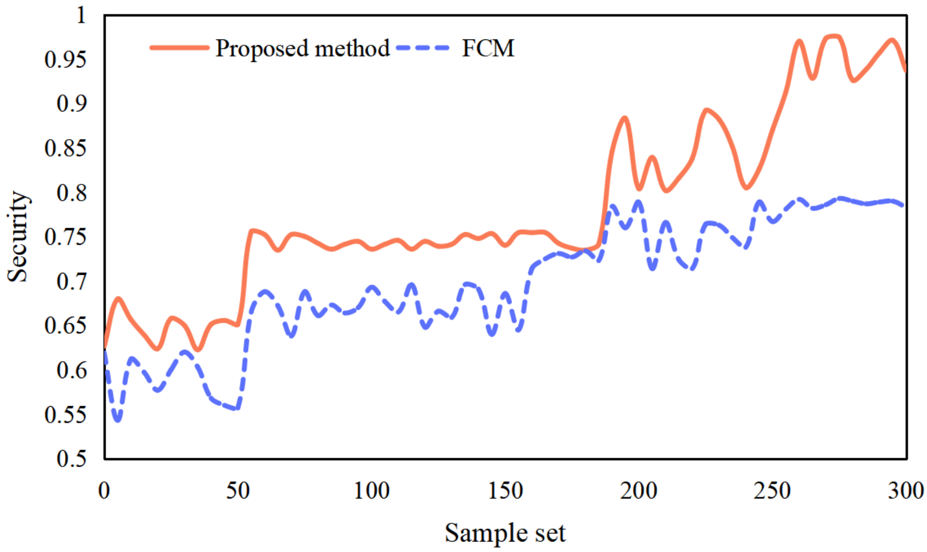

Figure 2 Security comparison of different schemes

In the traditional cloud computing architecture, the centralized management of data information resources makes it more likely to be invaded by attackers, which leads to frequent security problems. In MEC architecture, edge servers are isolated from each other, and their deployment directions are scattered, so edge servers are not easy to become targets of malicious attacks. According to the data in Figure 2, this method is safe and has certain practical application value. Simulation results show that, compared with the traditional FCM algorithm, this algorithm has the least number of protection routes and total link length, and the lowest resource occupancy, which effectively improves the resource utilization and robustness of the emergency disaster relief network, and makes the data center network more survivable. Edge servers can be divided into several private clouds to reduce the frequency of private information flow and reduce the risk of leakage.

4. Conclusions

Due to the growth of wireless communication technology and the arrival of the 5G era, the concept of MEC has been widely put forward, and users can get more computing resources from the resource sharing pool at the mobile edge to enhance the user experience. Aiming at the problem of high latency caused by mobile terminals with insufficient computing power in MEC network when dealing with low latency and high reliability applications, this article proposes a joint optimization strategy of computing unloading and resource allocation based on game theory. In the future, this study plans to further optimize the task execution matrix by jointly optimizing the delay and energy consumption, and explore the dynamic prediction and evaluation of the utilization of computing resources and service quality by combining artificial intelligence technology in the 5G network environment.

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