Towards Flying Mobile Edge Computing

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Abstract—With the development of mobile edge computing (MEC), many approaches are proposed to improve the computation performance, such as network congestion, transmission latency, and quality of Internet of Things (IoT) services. Although ground MEC system architectures are developed, there are still unsolved problems, such as depending on the ground infrastructure. Therefore, unmanned aerial vehicle (UAV) assisted MEC is considered to address these problems. However, the computation performance is limited by the UAV’s hover model, which is affected by the UAV’s velocity, acceleration, and a variable altitude. Nowadays, a terrestrial-satellite network (STN) plays a role in important 5G network development. The characteristics of an STN integrated with 5G are a low delay, high bandwidth, and ubiquitous coverage. Hence, 5G high-speed satellite-terrestrial assisted mobile edge computing (SMEC) is considered as a flying mobile edge computing, which will be discussed in terms of reasons, advantages, and open issues in this paper.

Index Terms—MEC, unmanned aerial vehicle, UAV-assisted MEC, terrestrial-satellite network, STN-assisted MEC

I. INTRODUCTION

The growing of the Internet of Things (IoTs) application, mobile data traffic is a tremendous change. The challenges are emerged, such as the deficiencies of core network congestion and long transmission latency [1]. Besides, the growth of latency-critical services, such as video stream analysis, augmented reality, and autonomous driving requires extensive real-time computation [2]. Therefore, mobile edge computing (MEC), which is defined as the edge computing services implemented at the base station, is used to improve the computation performance.

The survey about MEC is detailed and comprehensive in [1]–[3]. According to [4]–[6], the typical architectures and main application of MEC in heterogeneous networks include three-tiers architectures: edge device layer, edge layer, and cloud layer, as shown in Fig. 1. Mobile users require the computation-intensive and delay-sensitive applications to enhance the user’s quality of service (QoS). To do that, the mobile user will upload its processing task to existing MEC servers. Next, the corresponding computing resource will allocate and process that task in the edge layer. Consequently, the computation result will send back to the mobile user. Its...
Many approaches are proposed to solve the key problems in MEC, such as offloading decision, resource allocation, mobility management. Computation task models are generally designed to address them. Two major models are known: the partial offloading and the binary offloading. Besides, many computation offloading schemes are also proposed and focused on the energy-efficient and resource-efficient computational service offloading scheme in MEC. For instance, there includes a dynamic computation offloading scheme for MEC [7], energy-efficient resource allocation scheme [8], a task scheduling, and resource allocation scheme for delay-bound MEC platform [9].

The major drawback of MEC is that the locations of MEC servers are usually fixed and cannot be flexibly changed according to the needs of mobile users, which limits MEC’s capability [10]. The reason is that the ground MEC systems depend on the ground infrastructures, which may not work in many scenarios, such as desert areas, emergency response, military training or disaster relief [11]. Moreover, existing MEC techniques cannot handle the wireless network scenario with limited available infrastructures, such as disaster response, emergency relief, military maneuver, or rural environments [12].

II. UNMANNED AERIAL VEHICLE (UAV) ASSISTED MOBILE EDGE COMPUTING

The unmanned aerial vehicle (UAV)-enabled mobile edge computing network is considered as a promising technology to address these challenges, as shown in Fig. 2. The performance of the UAV-enabled MEC network are summarized as follows.

1) UAV-enabled MEC network is more flexible and has a wider application range [13] by using the line-of-sight (LoS) links communication.
2) UAV-enabled MEC can significantly improve the computing performance of the users at the same time [14].

3) The UAV-enabled MEC system provides the benefits of computation offloading in energy-saving and the system computing performance [15].

The current studies are joint optimization of the deployment of UAVs and task scheduling remains scarce. There are three main models: the local execution model, the MEC execution model, and the UAV hover model. The local execution model is used to execute the processing task on its mobile device. If a task is transmitted to the UAV, it will be executed by the MEC server on the UAV. Note that the uploaded task has to upload at a fixed location for some time in the UAV hover model.

The major drawback is that the computation performance is limited by the flight time of the UAV. The reason is that the UAV’s trajectory is affected by the UAV’s velocity and acceleration [16]. In ad hoc network with the multi-UAV and multi-user scenario, the UAV’s trajectory also has an impact of interference with mobile devices and UAV moves with a variable altitude [17].

III. 5G HIGH-SPEED SATELLITE-TERRESTRIAL ASSISTED MOBILE EDGE COMPUTING

The next-generation 5G networks are specific characterizes as ubiquitous connectivity, extremely low latency, and very high-speed data transfer [19], [20]. Recently, satellite technologies are enormously developed into manufacturing, spot-beam antenna, and laser transmission, which make satellites, especially low Earth orbit (LEO) satellites, much more economical, miniaturized, and high-throughput. Additional, the high-speed satellite-terrestrial network (STN) are known to increase demands for a higher quality of services (QoS), such as high data rates, ubiquitous coverage, low communication latency, and low energy cost on data communication and processing [18]. Therefore, 5G STN is important for 5G network development in the future.
Fig. 3 shows a three-tier architecture of 5G high-speed satellite-terrestrial assisted mobile edge computing and main applications [18]. The architecture includes the low Earth orbit (LEO) constellation, geostationary orbit(GEO) backbone network, and terrestrial station.

In STNs, users access the Internet by the relaying of both terrestrial stations and LEO satellites. Therefore, the STNs satellite mobile edge computing (SMEC) server can be deployed in terrestrial stations that are proximal to the users. In LEO satellites, SMEC is included in a terrestrial backbone network (TBN) gateway.

Compared with existing MEC architecture, the advantages of 5G high-speed satellite-terrestrial assisted mobile edge computing are summarized as follows.

1) For resource-limited mobile STN users, SMEC model reduces the delay, since interactions with remote clouds are not needed.
2) For some delay-sensitive applications, the user-perceived delay will be significantly reduced, i.e., gaming and vehicle networks.
3) For some computation-costly applications, the computation capacity is enhanced for mobile user devices. Therefore, energy consumption is also reduced.

Besides, there are some issues as follows.
1) The energy supply and computation capacity are quite limited in LEO constellation.
2) The time of inter-satellite link and space-terrestrial links also need to be considered, which leads to a more complex scheduling model compared to MEC.
3) Energy cost may be caused by terrestrial transmission, space-terrestrial transmission, and inter-satellite communication. Hence, energy cost in SMEC is more complex to model compared to MEC.
4) The throughput of a LEO satellite is usually not much larger than that of eNBs. Therefore, compared to MEC, the delay constraint should be relatively looser [18].

IV. CONCLUSION

In this paper, we investigated and discussed future mobile edge computing. Compared with ground MEC server, the flying MEC sever out-performances in terms of energy consumption, high throughput, ubiquitous coverage, low communication latency, and low energy cost on data communication and processing. However, the MEC has open issues, such as a complex SMEC model for energy cost and time of the inter-satellite link and space-terrestrial link.

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