RESOURCE MANAGEMENT IN 5G MOBILE NETWORKS: SURVEY AND CHALLENGES

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Annotation

With the rapid growth of network traffic, a large number of connected devices, and higher application services, the traditional network is facing several challenges. In addition to improving the current network architecture and hardware specifications, effective resource management means the development trend of 5G. Although many existing potential technologies have been proposed to solve the some of 5G challenges, such as multiple- input multiple-output (MIMO), software-defined networking (SDN), network functions virtualization (NFV), edge computing, millimeter-wave, etc., research studies in 5G continue to enrich its function and move toward B5G

mobile networks. In this paper, focusing on the resource allocation issues of 5G core networks and radio access networks, we address the latest technological developments and discuss the current challenges for resource management in 5G.

Keywords: Cloud Computing, Edge Computing, Network Slicing, Resource Management, 5G, 5G RAN Techniques

Introduction

The rapid development of the Internet of Things (IoT) and high-quality multimedia has led to an exponential increase in data traffic year by year. According to this trend, the cellular network will become more and more congested and the quality of service (QoS) of mobile users will be degraded. As traditional networks cannot carry these service requests, International Mobile Telecommunications-2020 (IMT2020) proposes three major directions for 5G application scenarios, including enhanced mobile broadband (eMBB), massive machine type communications (mMTC) and ultra-reliable low-latency communications (URLLC). The 3rd Generation Partnership Project (3GPP) develops 5G standard specifications based on these three directions too.

Many technologies and architectures also support the development of 5G. In order to reduce the increasing operating pressure of core network equipment, the European Telecommunications Standards Institute (ETSI) proposed the concept of edge computing. The concept of edge computing and fog computing is to put some resources near the UE, such as the base station (BS). Therefore, the user can obtain the data through the BS and does not need to wait for a response from the remote server. In this way, it can reduce transmission latency and obtain better QoS. The remote server does not have to service devices directly. It only needs to process a small amount of information sent by the BS, so it can reduce the burden on the core network. In addition, information-centric networking (ICN) [7-10] has some similar concepts to edge computing and fog computing. It caches data at neighboring network nodes to reduce the latency caused by the UE obtaining data from a remote server.

In order to increase the diverse application requirements of 5G, network slicing [11-14] is a must-have technology today. As early as February 2015, the "5G White Paper" proposed by the Next Generation Mobile Networks (NGMN) mentioned that the concept of network slicing technology was included in it [15]. In the 3GPP TR 22.891 technical report [16], the network slice is described as a collection of logical network functions that can support communication service requirements for specific application scenarios. At the ITU FG-IMT-2020 meeting, the participants also made comments on the network slicing technology, which also discussed the development of SDN and NFV in the 5G network architecture and the importance of network slicing technology.

Therefore, the combination of software-defined networking (SDN) [17-19] and network function virtualization (NFV) [20] is one of the current 5G development trends. SDN separates the control plane and data plane in the traditional network and sent control massage to many network devices through the controller. In this way, the network device only needs to process the packets, which greatly improves the control and the efficiency of network resources. NFV virtualizes the network functions of physical devices, such as firewalls, routers, deep packet inspection, and load balancers.

The implementation by software has excellent flexible configuration characteristics. In addition to increasing the efficiency of network service deployment, it can also reduce the purchase costs of hardware. SDN and NFV are independent of each other and can exist independently in the network system, but the two frameworks are highly complementary. For example, under the SDN architecture, when different services are provided to different users at the same time, customized services need to be deployed quickly. Therefore, NVF technology is required to achieve this; the establishment and communication between NFV require SDN support to achieve. Therefore, SDN restructures network architecture and does not change the functions of the network. NFV changes the type of network equipment without changing the functions of the equipment.

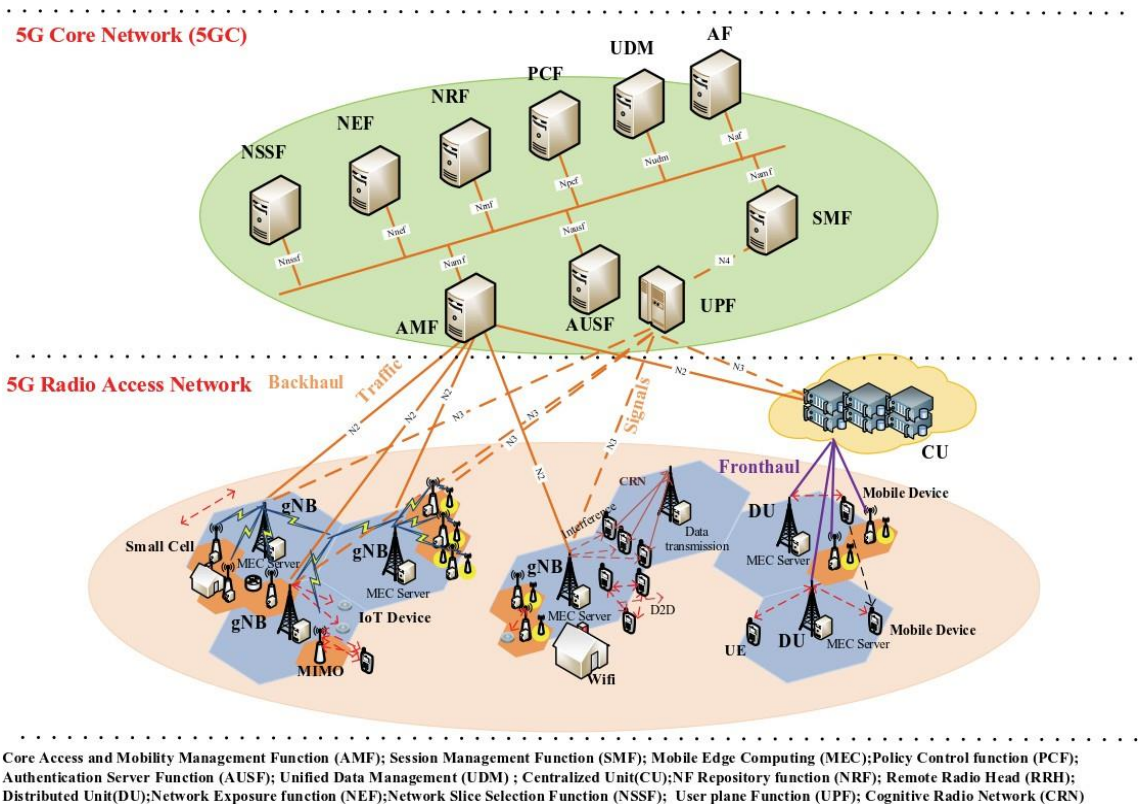

Fig. 1. The 5G architecture diagram.

In addition to the 5G RAN system, the current mobile networks also coexist with different communication protocols such as 4G (LTE), WLAN (Wi-Fi), UMTS, and LoRa, gradually becoming a true World Wide Wireless Web (WWWW) system that is supported by millimeter-wave, filter bank multi- carrier, massive multiple-input multiple-output (MIMO) [21], D2D communication [22], co-frequency co-time full-duplex (CCFD) [23], ultra-dense networks (UDN) [24], and network slicing. In addition, 5G base stations are composed of macro cells and small cells (micro-BS, pico-BS, femto-BS). Some base stations use the cloud radio access network (C-RAN) architecture [25,26], which divides traditional BS into centralized unit (CU) and distribute unit (DU) to improve the flexibility of resource allocation. The core network has evolved into service-based architecture (SBA). On the whole, 5G will form a complex and flexible heterogeneous network architecture (HetNet) [27]. Fig. 1 shows a 5G architecture diagram. With such huge network traffic and computational resource requirements, resource management (RM) is very important for 5G. RM can not only effectively improve the utilization of spectrum resources but also reduce transmission latency and save energy consumption through effective resource allocation. Therefore, the goal of this paper is to provide an introductory guide to the development of resource allocation in 5G. We review RM in 5G of the existing works and provide a comprehensive classification of them. According to different network architecture, RM issues in 5G can be divided into two main categories: radio access network (RAN) and 5G core network (5GC). The goal of RM in RAN is mainly to improve spectrum efficiency (SE) and energy efficiency (EE). According to the communication type, the SE is divided into two sub-categories: cognitive radio network (CRN) and 5G. Among them, 5G RAN can be divided into fog radio access network (F-RAN) and C-RAN/H-RAN (hierarchical radio access network) according to the network architecture.

Besides, according to the core network architecture, RM in 5GC is divided into two sub-categories: RM in 5GC with cloud and RM in 5GC with mobile edge computing (MEC). The picture of the proposed hierarchical or graded classification is shown in Fig. 2 together with the associated literature. The main contributions can be summarized as follows:

- We review the recent development of resource allocation in 5G both radio access network and core network.

- We classify existing works from a multidimensional perspective, including application goals, service type, resource type, etc.
- We compare and analyze recent works and discuss their advantages and drawbacks.
- We discuss some open issues and challenges in 5G resource allocation, and outline some important future research directions.

The rest of the paper is organized as follows: Sections 2 and 3 introduces the development and the challenge of resource allocation in 5G RAN and core networks. In Section 4, we provide some important future research directions. Section 5 concludes this survey.

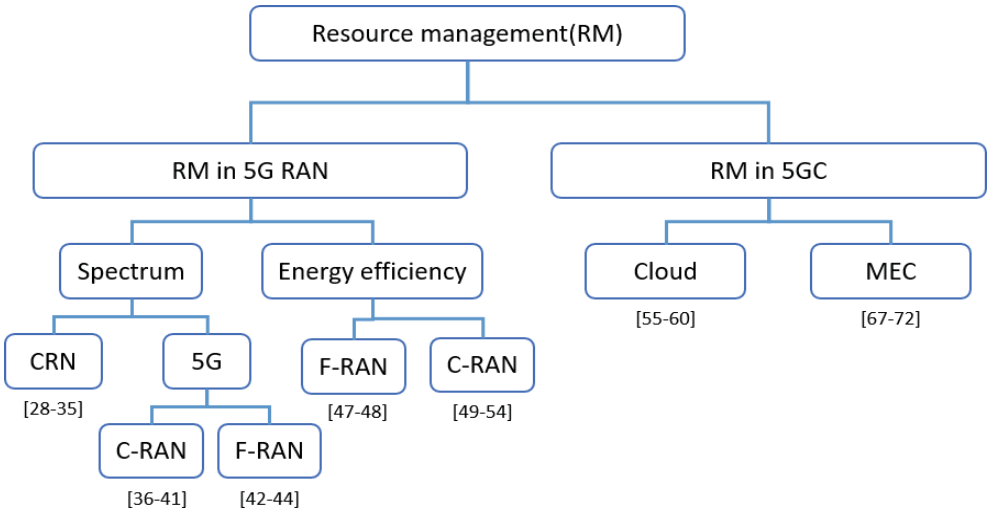

Fig. 2. Hierarchical classification of the resource allocation in 5G literature.

Open Issues and Future Trends

In the part of RM in 5G RAN, there are some issues that need to be solved. On the spectrum, dynamic spectrum allocation is a popular issue. At this issue, the method of spectrum sensing and spectrum sharing in CRN is very important. When PUs leaves the licensed channel to find the idle time slot, and the SUs can access licensed channel to achieve the spectrum sharing. Although the spectrum sharing and dynamic spectrum access can achieve the maximum SE, the SUs will make the interference to PUs also need to consider. On the other hand, the MIMO and new radio modulation technology is an important issue in 5G RAN. Hence, most of the literature used network slicing to help solve this problem.

In addition to spectrum resource allocation, the EE is also important in 5G. According to the network architecture for 5G, it is complex than the traditional cellular network. Due to this reason, it will also affect the power consumption increase. At the EE, the BBU pool resource allocation is a problem in C- RAN. Most of the paper has been formulated the problem can meet the game theory and using the iterative algorithm to find the sub-optimal solution. On the other hand, F-RAN also is a good idea to solve the disadvantage of centralized management. However, the F-RAN also will be faced with the problem, such as caching capacity, throughput. Therefore, how to offload or select the cache node is an important issue in F-RAN. At the same time, joint the D2D communication in C-RAN or F-RAN may be a solution to improve the SE. But using D2D communication has a high probability increase in energy consumption. Hence, how to allocate the bandwidth resource and power is one of the issues in 5G RAN.

In the part of RM in 5GC, the combination of network slicing and MEC is the current network architecture trend. Operators can deploy some VNFs into edge servers to reduce the delay of obtaining data from the remote cloud server. Compared with cloud architecture, MEC can provide more immediate services. However, how to achieve energy-saving and high utilization efficiency deployment is a challenge. In addition, as user mobility affects bearer and resource allocation of VNF, dynamic and immediate resource allocation needs to be considered to maximize 5G resource efficiency.

We review the resource allocation in 5G RAN and 5GC and provide some trends we

observed. First, in order to satisfy the three requirements in 5G RAN, the relationship between the licensed band and the unlicensed band should be considered. By doing this way, we can utilize the spectrum more efficiently. Second, the H-CRAN or F-RAN will be a promising network architecture in 5G. On the other hand, the

D2D communication may be joint into the H-CRAN or F-RAN to enhance the SE. Third, network slicing is an important technique that dynamic spectrum and computing resource allocation in 5G RAN and 5GC can be implemented. Fourth, there are more and more research using learning algorithm, such as RL, long short-term memory (LSTM), and convolutional neural network (CNN), to make resource allocation more intelligence. Fifth, integrating edge computing and cloud computing to reduce computational time for real-time resource allocation is a trend for complex network architecture.

Conclusions

Multimedia, augmented reality (AR), virtual reality (VR), IoT, and other applications are continually developing. Traditional networks cannot support current network requirements. It is also difficult to solve the bandwidth and data requirements of a large number of UEs by upgrading the hardware specifications. Therefore, effective resource management is a promising solution for limited resources, including frequency resources, computing resources, and deployment costs. To achieve high elasticity and high flexibility resource management, network slicing is an indispensable technology. In addition, MEC has become one of the necessary network architecture to achieve complex and difficult application scenarios. This study investigates the resources management in 5G, including the core network and RAN, and systematically follows the network architecture, application scenarios, and research goals to classify recent works. According to the survey, challenges for related research is proposed. We also provide readers with some future research trends and hope to promote more researchers to master 5G resource allocation.

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