Chapter 26
Caching Resource Sharing for Network Slicing in 5G Core Network: A Game Theoretic Approach

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ABSTRACT

Network slicing has been considered a promising technology in next generation mobile networks (5G), which can create virtual networks and provide customized service on demand. Most existing works on network slicing mainly focus on virtualization technology, and have not considered in-network caching well. However, in-network caching, as the one of the key technologies for information-centric networking (ICN), has been considered as a significant approach in 5G network to cope with the traffic explosion and network challenges. In this article, the authors jointly consider in-network caching combining with network slicing. They propose an efficient caching resource sharing scheme for network slicing in 5G core network, aiming at solving the problem of how to efficiently share the limited physical caching resource of Infrastructure Provider (InP) among multiple network slices. In addition, from the perspective of network slicing, the authors formulate caching resource sharing problem as a non-cooperative game,

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and propose an iteration algorithm based on caching resource updating to obtain the Nash Equilibrium solution. Simulation results show that the proposed algorithm has good convergence performance, and illustrate the effectiveness of the proposed scheme.

1. INTRODUCTION

With the continuous development of mobile Internet, Internet of things as well as many new network services and applications, such as high-definition video, virtual reality, online gaming, cloud services and so on, future 5G mobile networks will meet various challenges from the perspective of network architecture and key technologies (Gupta et al., 2015; Panwar et al., 2015). In order to flexibly, efficiently and cost-effectively provide customized services for various business scenarios in 5G network, network slicing has been proposed (Alliance, 2015; Ericsson, 2015; Zhou et al, 2016). By using the virtualization technology (Rost et al., 2015; Costa-Requena et al., 2015; Hawilo et al., 2014; Yousaf et al., 2013), a single physical network infrastructure can be abstracted and sliced multiple virtual dedicated networks, which can not only provide end-to-end network services on demand and support various use cases (e.g. smartphones, autonomous driving, massive Internet of Things and so on), but also save capital expenses (CapEx) and operation expenses (OpEx) for infrastructure providers.

Based on the advantage features of network slicing in 5G network, the problem of resource sharing for network slicing in multi-tenant scenario has been widely studied in recent years (Rost et al., 2016; Feng et al., 2015; Zhu et al., 2015; Jiang et al., 2016; An et al., 2016). On the other hand, with the extensive study of another new technology named information-centric networking (ICN) (Xylomenos et al., 2014; Zhang et al., 2014), in-network caching has been considered as a promising technology in 5G network (Wang et al., 2014; Abboud et al., 2015; Poularakis et al., 2016; Hu et al., 2016) to reduce the duplicate content transmission in networks and improve Quality of Experience (QoE) of end-users.

Although some excellent works have been done on network slicing and in-network caching in 5G network, to the best of our knowledge, these two important issues have traditionally been addressed separately in the literature. Through virtualization technology, physical storage resource can be abstracted as virtual caching resource pool. And the infrastructure provider (InP) can build the caching resource slicing according to the tenant requirements. Hence, it is significant to jointly consider these two advanced techniques together to improve the QoE of end-users and the utilization of caching resource in 5G networks.

In this paper, involving in-network caching feature in network slicing, we propose a caching resource sharing scheme for network slicing in 5G core network in order to improve the caching resource utilization and the end-to-end system performance. We consider a multi-tenant scenario under resource constraints, and multiple tenants of network slicing compete for caching resource in 5G core network, so as to maximize the utility of each tenant. The main contributions of this paper are listed as follows:

- We jointly consider the network slicing and in-network caching, and the problem of caching resource sharing for network slicing in 5G core network is studied. For network slicing, we consider that multiple tenants compete for caching resource to maximize the utility of each tenant;
- We formulate the caching resource sharing problem as a non-cooperative game (Osborne & Rubinstein, 1994; Charilas & Panagopoulos, 2010) to efficiently share the sacred physical caching resource of InP among multiple network slices. In addition, we prove the existence of Nash