Radio Access Network Slicing in 5G

Jinjin Gong[1], Lu Ge[2], Xin Su[2], and Jie Zeng[2(✉)]

[1] Broadband Wireless Access Laboratory, Chongqing University of Posts and Telecommunications, Chongqing, China
[2] Tsinghua National Laboratory for Information Science and Technology, Research Institute of Information Technology, Tsinghua University, Beijing, China
zengjie@tsinghua.edu.cn

Abstract. Network slicing is one of the key technologies for 5th-Generation (5G). It enables operators to construct network slices with similar qualities as dedicated stand-alone networks, but to realize them on a common physical platform. Meanwhile, the isolation among logical network slices can keep them from the negative impacts of other network slices. In this paper, we give an overview of the radio access network (RAN) slicing, and present some viewpoints on three categories of network slices. Moreover, an approach, which dynamically creates RAN slice to meet specific business and service requirements, is proposed. It does not only optimize performance and maximize resources utilization, but also shorten the creating time of slices.

Keywords: 5G · Network slicing · Radio Access Network · Core network · Virtualization

1 Introduction

In future network, abundant application scenario whose requirements in capacity, bandwidth, latency, reliability, etc., are distinct from each other, will emerge [1]. In 5G, only one network is difficult to satisfy all of these requirements, or the costs of construction and operation are unacceptable for operators. Network slicing provides a solution to solve these problems. It constructs different logical networks on a unified physical infrastructure via virtualization technologies [2]. A logical network is a network slice that contains a number of network functions, network topology and communication links, etc., and slices are logically independent of each other.

The 3rd Generation Partnership Project (3GPP) clearly claimed that the next generation system shall support network slicing [3]. At the moment, 3GPP focuses on CN slicing, whereas RAN slicing is still in discussion. Specific impacts and requirements on the RAN in 5G urge to slice RAN like CN, and RAN slicing is trying to create new business opportunities. In RAN slicing solution, the slices run on the wireless platform

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which contains radio hardware and baseband resource pool [4]. It allows operators to construct a logical network with similar qualities as a dedicated stand-alone network but realizes it by using shared resources, such as spectrums, sites, transport. Allowing efficient resource sharing between RAN slices can maximize utilization and achieve a high level of energy and cost efficiency.

Virtualization is the key technology of RAN slicing. [5, 6] introduce long term evolution (LTE) virtualization, and a hypervisor taking responsibility of virtualizing eNodeB into several virtual eNodeBs. [7] is able to dynamically allocate network resources to different slices in order to maximize the satisfaction of users. The approaches above share a unified physical infrastructure, but there are no common functions shared between virtual eNodeBs.

The remainder of this paper is organized as follows: Sect. 2 introduces RAN slicing overview. Section 3 describes an approach to implement RAN slicing. Section 4 gives the conclusion of this paper.

2 RAN Slicing Overview

Three categories of network slices are envisioned to be supported by 3GPP. They are massive machine type communications (MMTC), ultra-reliable and low latency communications (URLLC), and enhanced mobile broadband (EMBB) [8]. MMTC (e.g., slice 1 in Fig. 1.) represents a kind of scenario which has a high requirement in density connections, like smart city. In this scheme, direct communication between terminal can avoid long-distance transmission between base station and terminal, and reduce energy consumption effectively. In addition, new multiple access technology can exponentially increase system capability of devices connection via information overlay transmission for multi-user.

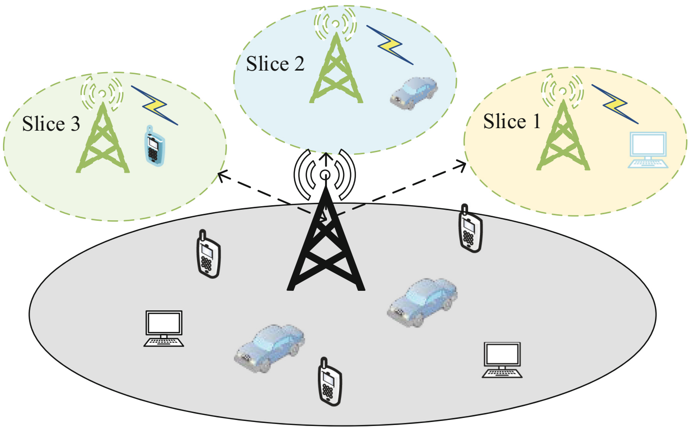

Fig. 1. A framework of RAN slices.

URLLC (e.g., slice 2 in Fig. 1.), for example, autonomous vehicles, remote control, requires ultra-low latency and ultra-reliability. In this scenario, separation between control plane and data plane is optional. The control plane optimizes data transmission path, and the data plane is responsible for forwarding data in high speed. Meanwhile, it can apply shorter frame structure and optimize signaling procedure. In order to improve transmission reliability, it can utilize advanced modulation coding and retransmission mechanisms as well.

In contrast, scenarios of EMBB (e.g., slice 3 in Fig. 1.) focus on high broadband, such as high resolution video, virtual reality, etc., which has high traffic density and high speed for user experience. Control plane decoupling from data plane is required in this scenario, since the data plane is concentrated on forwarding data in high speed. Moreover, ultra-dense network (UDN), which reuse frequency resources effectively, and greatly enhance the efficiency of unit area frequency reuse, is suitable for this slice. In addition, multiple low density parity check code, new bit mapping technology and ultra-Nyquist modulation can be used.

According to the application scenarios' requirements, network slicing customizes the required network functions and flexible networking to optimize the business process and data routing. The network has the ability for dynamic allocation resources to improve the utilization of network resources.

3 An Approach to Implement RAN Slicing

A RAN slice contains access coverage and signal processors, which can be shared by another RAN slice. Access coverage includes the kinds of access forms, such as macro cell, small cell, micro cell, etc. Coverage of different slices can be established through a combination of those. Signal processors as a sub-slice is the critical part of a RAN slice. Each RAN slice has different signal processors sub-slice, according to the type of the application scenario.

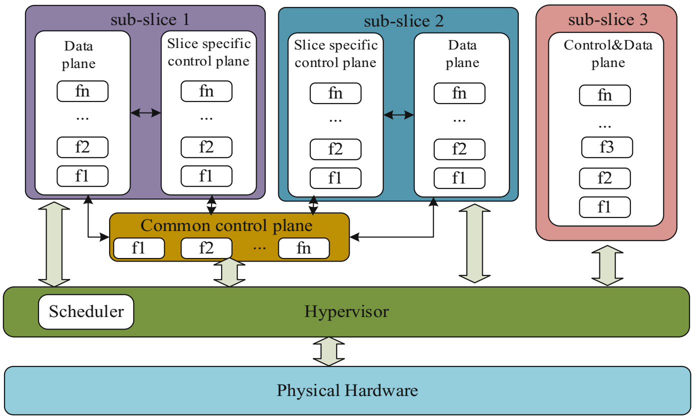

Fig. 2. RAN slicing implementation via virtualization.

In fact, the requirements of different application scenarios in resources utilization, isolation and latency are different. Each base station contains several protocols which can implement different functions. As showed in Fig. 2, we divide functions into control plane functions and data plane functions. Moreover, the control plane functions are divided into slice specific functions and common functions which can be shared among sub-slices. Hypervisor is responsible for virtualizing physical resources into virtual computing resources, virtual storage resources, virtual network resources, and allocating physical/virtual resources to sub-slices. The functions of sub-slices are distinct from each other. A RAN slice is a logical network that contains all functions needed, and can provide the corresponding network services.

As mentioned above, each RAN slice has a different sub-slice. If the application scenarios of sub-slice 1 and sub-slice 2 are not strictly isolated and require high speed, then they can share some common functions, and the control plane is split from the data plane. It is benefits to shorten the time of sub-slice creation, and improve resources utilization. However, the control plane and data plane of sub-slice 3 can be tightly coupled. Sub-slices of RAN slices are running on common physical hardware, and the network functions of sub-slices are customizable, scalable and sustainable, etc. What functions and technologies of each slice should be deployed are already introduced in Sect. 2.

4 Conclusion

In this paper, we introduce the concept of network slicing. Network slicing is the foundation for 5G network to support diverse application scenarios. According to the three categories of network slices' characteristics, we give some perspectives designs. Meanwhile, we propose an approach to implement RAN slicing. Signal processors as a sub-slice is the critical part of a RAN slice, and each sub-slice's control plane can be split from data plane, and shares common functions. It is beneficial to shorten the time of slice's creation, optimize performance and maximize resources utilization. RAN slices can be customizable and scalable according to the requirements.

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