Virtualized C-RAN with Mininet and OAI Supporting Flexible Network Topologies

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***Abstract*— System virtualization ensures greater flexibility in telecommunications networks when compared to physical solutions. The centralized radio access network (C-RAN) architecture allows a virtualized mobile network deployment, and it uses fronthaul and backhaul links for component communication. Physical fronthaul and backhaul topologies are a problematic point, as they require the configuration and purchase of multiple routers and switches. This article proposes a C-RAN deployment using the OpenAirInterface platform with virtualized fronthaul and backhaul using Mininet, thus creating a flexible configuration of fronthaul and backhaul topologies for researches.**

***Keywords*— SDN, fronthaul, backhaul, OpenAirInterface, Mininet.**

I. Introduction

The radio access network (RAN) virtualization is a key enabler to improve resources usage efficiency, massive subscribes and high reliability expected by the fifth-generation (5G) of mobile communications. Virtualization brings better management of computational resources, resulting in an effective method of allocating processes in data centers [1]. The centralized radio access network (C-RAN) architecture consists of base station (BS) division between baseband units (BBU) and remote radio heads (RRH). The first realize all baseband process and the later process radio functions, these two units communicate through fronthaul link [2]. The core network is called evolved packet core (EPC) in 4G scenarios, it is usually allocated in data centers, as well as BBU pools. EPC and BBU pools communicate through a backhaul link. In virtualized data centers, they share computing resources with other services, thus saving deployment costs. The C-RAN architecture allows the development of an innovative network organization, but the cost to have an experiment with such flexibility deploying real equipment for the fronthaul and backhaul links is an obstacle to make researches. It needs numerous routers and switches, and also is necessary to configure individual equipment and physical connection between them. The software defined-network (SDN) and network function virtualization turn these research scenarios more accessible, facilitating the deployment of virtualized networks in realistic scenarios [3].

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The Mininet software creates manageable and monitorable SDN networks for the fronthaul and backhaul links, whereas the OpensAirInterface (OAI) platform emulates a mobile network (Core Network, RAN, and User Equipment). The integration of these software generates a flexible mobile network, capable of being deployed with different fronthaul and backhaul topologies. This paper proposes the virtualization of fronthaul and backhaul networks using Mininet and its integration with OAI platform to enable research studies in realistic implementations, and reduce the costs to implement SDN network topologies to the fronthaul and backhaul.

II. OpenAirInterface and Mininet

The OAI is an open-source software that implements the main modules of 4G/5G Networks. OAI include core network functions with home subscriber server (HSS), mobility management entity (MME) and SPGW as a combination of packet data network gateway (PGW) and serving gateway (SGW). OAI has different RAN architectures modes, one of them is the complete eNodeB in a single module. In another, the C-RAN model, the eNodeB is partitioned in remote radio unit (RRU) and radio cloud center (RCC) modules that work as BBU and RRH, respectively [4].

Mininet is an open-source software able to create an SDN network based on virtual hosts and switches. Mininet hosts are virtualized with firewall policies and namespaces isolated from the host machine (the computer which is running Mininet software). The communication between Mininet hosts occurs through virtual switches builded by the Open VSwitch tool, where each instance uses the OpenFlow protocol. Virtual switches are monitored and managed by an SDN controller, that can change routes, configure packets filters and other actions enabled in a SDN network. Mininet hosts have no communication with the internet or host machine (outside Mininet virtualization). There is a network address translation (NAT) mode which makes Mininet hosts communicate outside the virtualized network, such as the internet and host machine network, but it just allows communication from Mininet hosts to outside and not the reverse. So, hosts outside Mininet virtualization cannot communicate with Mininet hosts [5]. Moreover, each Mininet host has an isolated namespace which grant controlling its network functions separated from other Mininet hosts and the host machine. Mininet deploys network topologies using scripts or using graphic tools as Miniedit. Such tools allow the definition of the network topology and how the communication among routers and switches works into the virtualized network.

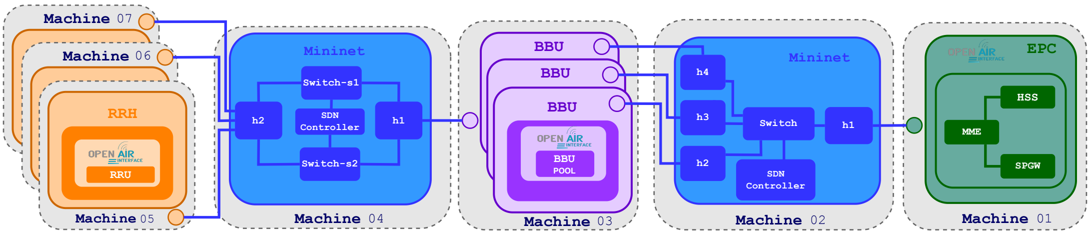

Fig. 1. Three RRHs connected to three BBUs scenario with fronthaul traffic forwarded through Mininet network, splitting the fronthaul traffic between Switch-s1 and Switch-s2 of Machine 04.

The fronthaul and backhaul are the virtualized network created by Mininet, giving the flexibility to define any topology simply using a defined script or using a graphical tool. OAI implements RRU, BBU and core network. Their fronthaul and backhaul traffic needs to be forwarded through the Mininet network to reach their destination. But, as explained before, there is no communication link between machine and Mininet hosts.

III. System Description and Experimental Results

The testbed deploys a scenario following the Fig. 1, where three BBUs communicate with an EPC through a backhaul with topology constituted by four Mininet Hosts and one OpenFlow switch. In the fronthaul, three RRHs communicates with three BBUs in BBU pool through the Mininet network with two Hosts and two OpenFlow switches.

Virtual ethernets (VETHs) were used to connect host machines and Mininet hosts establishing a link for communication, where all traffic coming into the link on Mininet host is forwarded to the host machine and vice-versa. The process identifications (PIDs) of running Mininet hosts was used to create a symbolic link between namespaces from Mininet hosts and the host machine, enabling to manipulate network functions of the Mininet emulated network into host machines and create VETHs between them. Therefore, traffic from a machine can be forwarded through Mininet network topology, as illustrated in Fig. 1, where a VETH which connects h2 Mininet host to the interface from machine 4, enabling h2 to communicate with RRH machines. The same applies to h1 to communicate with BBUs in the fronthaul and Mininet hosts on the backhaul. VETHs only needs to be created on Mininet hosts which need to communicate with external machines.

Firewall rules were adapted to accept forwarding packets through Mininet network. The network topology is specified in Fig. 1, but any network topology could be deployed using Mininet scripts. The Routing tables from Mininet and machines were manipulated to enable the forwarding of packets through the Mininet network, forcing packets to use VETHs.

Fig. 2 shows the traffic from switches of the fronthaul and BBU pool (which represents all fronthaul traffic). During the first fifteen seconds, all traffic between the BBU pool and the RRHs pass-through switch S1, while after the route with machine 5 changed to communicate through switch S2 by using SDN controller commands. From the results shown in the graphic, it is possible to conclude that the traffic was split correctly using SDN controller commands. Therefore,

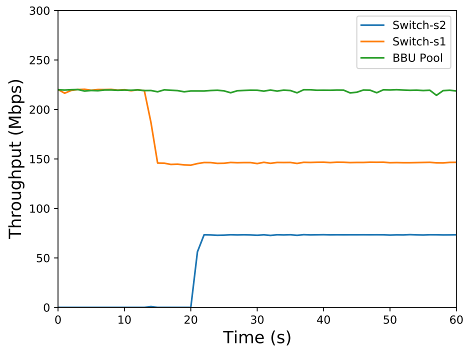

Fig. 2. Throughput (Mbps) of All BBU pool traffic and Switches s1 and s2 in sixty seconds

Mininet network can substitute real switches in mobile network researches to reduce costs with real OpenFlow switches given more flexibility to deploy any network topology and providing SDN functions. Different scenarios can be deployed in the testbed using the proposed method to integrate Mininet virtualized networks and OAI, enabling realistic scenarios for experimentation of different strategies for fronthaul congestion control, QoS metrics and resource managements under different scenarios and conditions.

IV. Conclusions

This paper presented a deployment and implementation of a C-RAN architecture scenario using OpenAirInterface with a virtualized fronthaul and backhaul network topologies. The proposed method decreased the complexity of fronthaul and backhaul deployment for research scenarios, facilitated tests in differents topologies and integrated SDN functions to fronthaul and backhaul through Mininet.

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