Slicing Architecture for Managing User Mobility in Next-Generation Heterogeneous Wireless Networks

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***Abstract*—Heterogeneous environment in next-generation wireless networks poses several challenges in terms of mobility management includes the seamless mobility and the handover. Network slicing appears as a promising technology to meet different network requirements. Due to the diversity of future network application scenarios and users density in the access network, new mobility management is needed to control seamless handover for user mobility in heterogeneous radio access networks. In this paper, we utilize the network slicing model to build a network architecture for managing a user mobility among different Radio Access Technologies (RATs). The simulation results show that the proposed architecture capable to handle user mobility, where all the users belong to a particular network slice. Moreover, the slice enables to manage a user's seamless mobility between different RANs.**

***Index Terms*—5G network, LTE, WiFi, Slicing network, Mobility management.**

I. Introduction

When network development moves towards 5G network, the access network seems to become more heterogeneous. Therefore, a key feature of 5G networks can be the integration between various Radio Access Networks (RANs), providing a mobile device with a 5G-enabler (e.g., at mmWave frequencies) along with other network interfaces, such as 4G LTE network, even with possibility of LTE-Unsilenced [1] and WiFi network, that turn out to be great in terms of increasing opportunity to introduce innovative connectivity services to enhance users Quality of Experience (QoE). In contrast, to determine the RAN to which a user should be associated is truly a big challenge for the network. Determining the optimal user connection can be a complex combination problem that can depended on considering many matrices simultaneously, such as the Signal to Interference and Noise Ratio (SIRN) at every user to every Base Station (BS), or the current load at each BS. Increasingly the densification and heterogeneity of access networks rise as a big challenge in terms of support mobility and always-on-connectivity, because it is difficult to measure the impact of mobility on network performance [1], [2]. Accordingly, it is very important to reduce the number of user handovers between different BSs. As 5G network builds on the theory of network slicing architecture which divides a shared network infrastructure into multiple logical networks [3]. As noted by the U.K-Ofcom, there are more than 81% of users loading the internet via WiFi network [4], therefore cellular operators pay attention to the role of WiFi network for offloading the data traffic of the mobile access network. Accordingly, as a network slicing architecture, it is very important that each slice can managed the network resources at different access networks to reduce the impact of user mobility in terms of frequent handover. The main goal of this paper is to design network slicing architecture, which is capable of managing a user mobility in different RANs and maintaining the continuity of network services during the mobility (seamless connectivity).The results evaluation demonstrate that the proposed architecture successfully manages the seamless handover for a user between WiFi and LTE networks and under a slice control.

Next, we discuss the related work, then later will give brif explnation abuttheproposed solution. Finally, will conclude the paper.

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II. Related Work

5G network is up to date topic, therefore many researchers are interested to contribute, especially when the 5G networks utilizes the network slicing architecture to empower the core network. The authors in [5], [6] proposed mobility management procedure to optimize the selection of anchor node, where they consider the low latency mechanisms to select between the edge nodes. However, this mechanism is capable of providing an efficient solution to enhance mobility management by considering handover latency as a key concept, but it did not take into consideration the case of heterogeneous access network, which is considered one of the challenges of emerging wireless networks. In [7], [8], the authors proposed a Connectivity Management as a Service (CMaaS) where integrates the mobility and routing management to introduce hierarchical network architecture based on the SDN network to allow performance compatibility at different network levels. The CMaaS enabled the service providers to work on the top of application services to manage their customers at different level of prices. In [9], [10], the LTE handover procedure was developed according to grid system theory. As a use case, they apply the handover procedure to manage the channel interference between the users in the railway system. The authors in [11], [12] introduced a hybrid mechanism to manage the dense areas in 5G network where is the increasing traffic demands affect on the user mobility. This mechanism considers the network caching to distribute the system base stations. The effectiveness of this solution is that it provides efficient energy cost and better Quality of Experience (QoE). The solution in [13] considered Individual Mobility Model (IMM) scheme to investigate the impact of human interaction for the user mobility in 5G small cell networks. In [14] the authors proposed a new mechanism for resource allocation based on mobility management in 5G networks for video service. The algorithm is designed based on a Markov model to select the optimal routes for user mobility patterns between serving nodes. The handover approach is energy-based and the results show a reduction in the handover latency compared with the existing solutions. Most of the existing research efforts are promising. They have ability to provide efficient control and mobility management solutions, but these approaches are not focusing on mobility management in the concept of network slicing for heterogeneous wireless access networks.

III. System Model of Proposed Mobility Management Architecture

Currently, many challenges have to solve by the network operators such as expanding the network coverage area, increasing mobile data traffic load and channel interference in dense areas. Therefore, these issues need new mechanisms to find solve or mitigate their impact on the network performance. Different mechanisms can be applied to offload data traffic include reducing user data and using the auxiliary network as a way of offload data from current access network to another access network. According to [15], the indoor data traffic through the WiFi network is around 60% and for the outdoor data traffic via WiFi network is around 20%, therefore the WiFi network has a vital role in terms of data traffic offload. Therefore, the WiFi network represents a suitable approach of cellular network operators to offload data traffic.

The flexibility of shared resource allocation in the network slicing enables the 5G network to manage heterogeneous infrastructure, where different resources of RANs are unified in a programmable platform to abstracting radio resources for different network slicing as illustrated in Figure 1. Different RANs resources are collected by the abstraction platform and various network slices can access to the shared resource, where all the users belong to a slice are controlled by a slice controller across different RANs (e.g. LTE, 5G, WiFi). As depicted in the figure, the mobility manager has the ability of central controlling over mobility management. Each of the slices has its own agent unit residing in the mobility manager and all the resources reachable by the agents. Therefore, the mobility of a slice across different RANs is managed by an agent and this results to optimize network resource allocation and data offloading in the access network. The main requirements of our proposed solution to offloading among networks illustrate as follows:

- The network architecture enables to manage the seamless connectivity among the networks, for example, controlling a user seamlessness between the licensed network (e.g. LTE) and the unlicensed network (e.g. WiFi).
- The users mobile device has multi-interface to detect and manage different network connections simultaneously.
- The latency has a negative effect on the network services, therefore selecting a suitable latency mechanism reduce the effectiveness of delay for a current network service during the offload process, e.g., considering the short path mechanism [16].
  Sharing heterogeneous resources consider different parameters for network offloading, therefore each network has different parameters when abstracting radio access network resources and most of these parameters drive from the network physical layer.

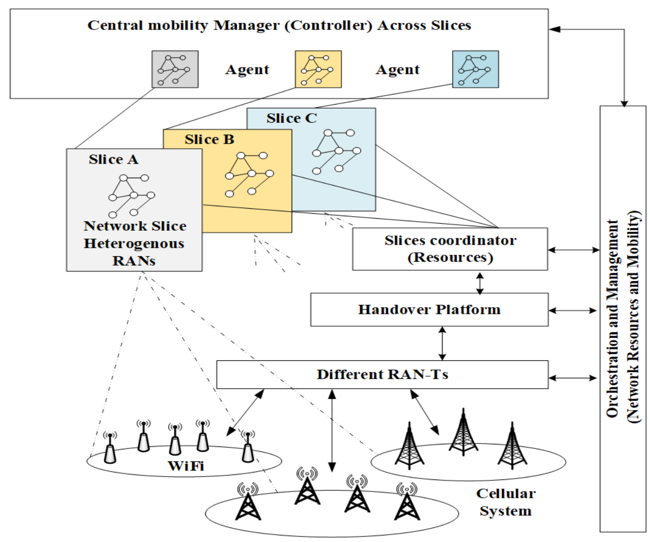

Fig. 1. The mobility management architecture.

Below, we define the fundamental parameters of abstraction according to a particular network interface. [17].

- Abstraction parameters are distinct based on the access network technology as an example, we consider the LTE and WiFi networks, regarding the LTE network the fundamental parameters of abstraction include the Reference Signal Received Quality (RSRQ), Quality of service Class Identifier (QCI), Reference Signals Received Power (RSRP) and Physical Resource Block (PRB), whereas in the WiFi network the fundamental abstraction parameters involve power transmission, Received Signal Strength Indicator (RSSI) and frequency bandwidth.
- One of the important aspects of available bandwidth, that indicates the actual remaining of available resource

in radio node of a potential access network such as backhaul network load, channel capacity and the current requirement of quality of service (QoS).

- The capacity of transmitting which is the bandwidth bit-rate over the spectral (bps/Hz).
- Node capacity, that illustrates a combination of available node bandwidth and spectral bandwidth.

In next section, we provide brief discussion of the result of seamless mobility management among various RANs. Moreover, in our results we focus on the LTE and WiFi network to show the proposed effeteness.

IV. Results Evaluation

This section is describing the performance evaluation of proposed solution utilizing OPNET simulation to implement the network topology. Table 1 represents the simulation parameters [18].

TABLE I
SIMULATION PARAMETERS

Parameter Name	Value
Simulation run time	720 (in seconds)
Network Slicing	2 networks
Mobility model	Random Way Point (RWP).
Channel Model	Path loss: 128.1 + 37.6 log10 (R), R is in km [19]. Slow fading: Correlated Log normal, zero mean, 8db, std. and 50 m correlation distance. Fast fading: Jake's like model.
Users speed	5 km/h
CQI reporting	Ideal
Modulation schemes	QPSK, 16 QAM, 64 QAM
eNodeB coverage area	Circular with one cell, R = 300 meters
Link-2-System interface	Effective Exponential SINR mapping
FTP traffic model	File size: constant 3 MByte, Inter-arrival time: exponential (20s)
Video traffic model	24 Frames/sec, frame size: 1562 bytes (300 kbps)
VoIP Traffic model	Encoder Scheme: G. 711 (64 kbps) Talk period / Silence period: exponential (3s)

We show the link continues of an MN under certain slice control, during a mobility management for the MN movement. As mentioned earlier, when any MN is assigned to a certain slice it receives a list of names (IDs), which represents the slice IDs use as a SSIDs when the MN moves to the WiFi coverage area during the handover.

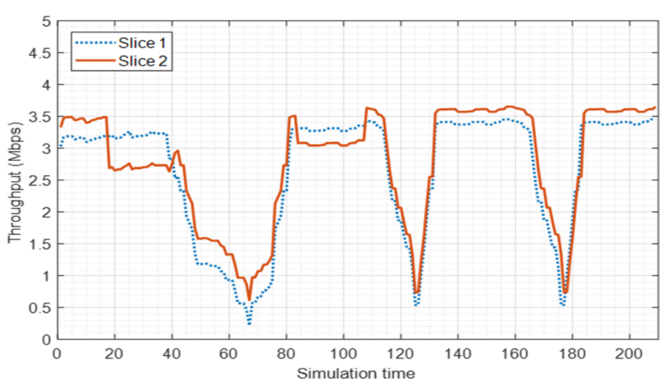

Fig. 2. The network topology in OMNeT++ simulator.

Figure 2 shows the scenario for two different slices, the first slice (slice 1) has sharing resources in all WiFi APs, which means it has SSIDs with all APs. While, in the second slice (slice 2), it also has sharing resources with all WiFi APs except one AP, meaning that there is no SSID for the slice 2 with this AP. This resulting, there is no service for the slice 2 when its MNs move across this AP. In the figure we observe that there is no throughput for the MNs of slice 2 in the second handover, due to no SSID for slice 2 with the AP. Notice that, the throughput packets for the MNs of slice in the third handover as shown in the figure. However, the seamless links session for the MNs of slice 1 are continuous across all three handover.

V. Conclusion

A new mobility architecture is proposed to manage a user mobility between different radio access networks in a 5G network environment. Our proposed architecture enables each network slicing to control individual user seamless across different heterogeneous access networks.

As a future work, we intend to investigate a user mobility in terms of location awareness, to predict the user resource that needs during the mobility procedure according a current service. Moreover, we are planning to study the network scalability with a particular network slice.

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