Performance Benchmark for Handoff with the Software Defined Network in Cellular Networks: A Simulation Approach

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***Abstract*—In recent times, performance during handoff has derived several optimizations techniques at the Core Network and Radio Access Network domain for Cellular Networks even as operators have moved to high performing LTE and LTE Advanced Networks. With Cloud Computing and ecosystem for Virtualization developed for the Core and Radio Networks SDN open flow seems to be a seamless solution for determining signal flow between mobiles. There have been lot of research going on for deploying SDN Open Flow with the 5G Cellular Network.The current paper perform benchmarks as a feasibility need for implementing SDN open flow for 5G Cellular Network. The Handoff mechanism impacts the scalability required for a cellular network and simulation results can be further used to be deployed the 5G Network v**

Keywords—SDN, LTE, LTE Advanced and 5G

I. INTRODUCTION

An SDN Controllers is a part of the control plane of the SDN Architecture. This can be further understood with elaboration from **[1] [2]** with **Figure 1** as follows:

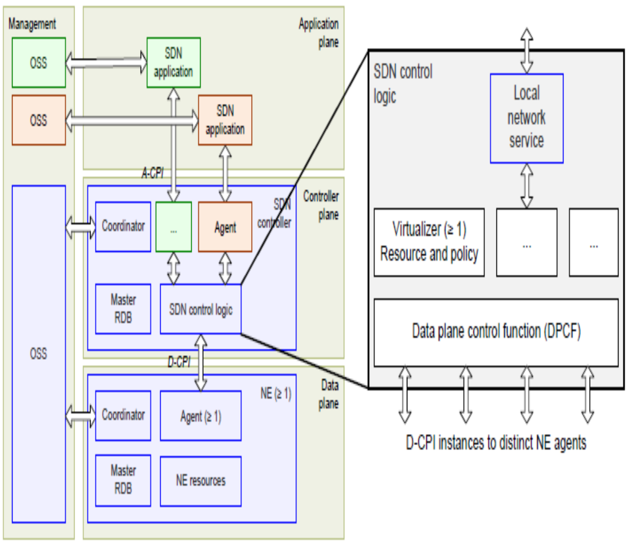


Figure 1: Overview of SDN Architectural plane with the SDN Controller

Here, the A-CPI and D-CPI are the reference points for interfaces of the SDN Controller with the SDN Application and Data plane respectively. An SDN controller can also develop its capability to communicate with the non-SDN plane, other peer SDN Controllers a subordinate SDN Controller can also be further developed. The agent here virtualizes and shares the resources underlying it. The agent also at different level of abstraction exposes control over the network. There can be multiple agents for a Network Element in a SDN controller.

This leads to developing a use case for the SDN provider as with the reclusive virtualized network. The requirement for recursion implies a hierarchical virtual service of the SDN controllers and includes intermediate interfaces called the I-CPI. In this paper we will review different simulation scenarios for HandOff Mechanism with SDN controller giving its advantage of deployment in the 5G Network validating the SDN NFV Ecosystem for the Radio Network Management and Core Network Architecture. Section II will help in determining some of the performance issues of Handoff in the LTE Network. Section III will verify some of the Simulation Models in LTE Advanced and verify performance of the traffic while deploying the LTE Advanced Radio Setup on the SDN Platform.

.DETERMINIG HAND OFF in THE LTE Network

A. HandOff between the LTE and Wifi System

To be able to understand the handoff mechanism between the LTE and WiFi based networks we will need to understand the signaling flow of messages for hand off of UEs between the 3GPP based LTE and non-3GPP based WiFi access systems as specified **in [3]** as follows :

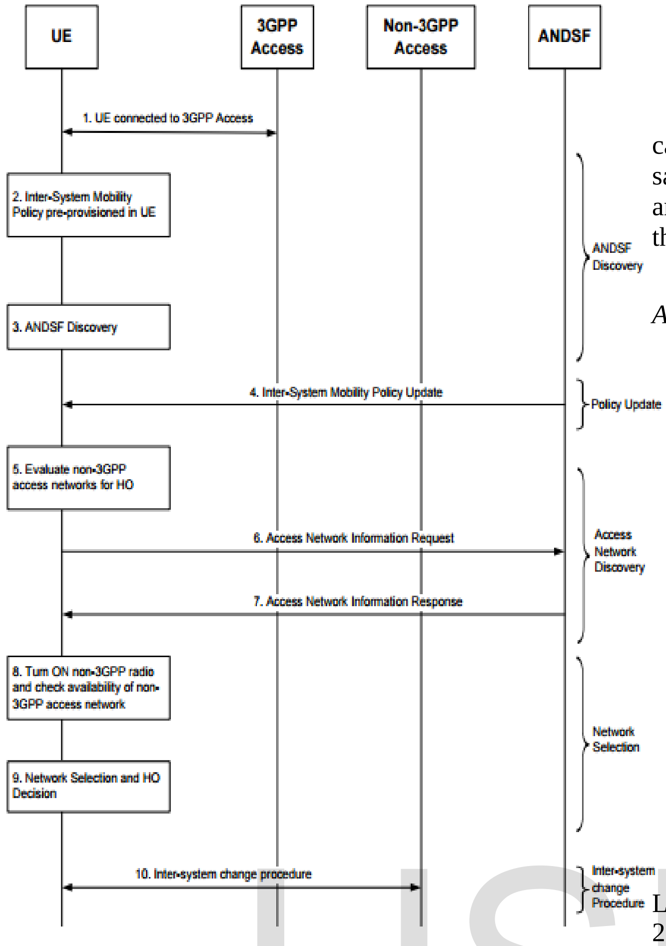


Figure 2: The Intersystem Handover between LTE and WiFi based System

The Intersystem Handover between LTE and WiFi based System for Trusted access is best understood as we move from our Home WiFi Access Network in side our residential building to the Cellular Mobile Network as we move away from our residential building and go to an open area or a market.

B. Drawbacks with the 4G Network Handoff Mechanism

Based on the handover a scenario as explained in Figure 2 it is observed: The reselection of the WiFi access point that has strong signals may provide lesser bandwidth thus reducing user experience for QoS.

- There is ping pong experience of the UE for selection and reselection of the WiFi access points and the LTE eNodeBs or Base stations. This is further increased with interference condition triggered with these wireless systems.
- During the path switching from 3GPP based LTE network to non-3GPP based WiFi network there is also a possibility of latency and packet loss.

Further deploying SDN will enable reducing latency and packet loss based on its deployment schemes. The traffic routing mechanisms based on QoS can also be achieved by deploying SDN controller at the PDN Gateway

II. PERFORMANCE EVALUATION OF 4G AND SDN NETWORK

In this section we will traffic performance of packet data calls from the Live Network in Sydney and simulate the same setup in Mininet Emulator and make comparative analysis of the performance for analyzing its deployment in the 5G Network

A. 4G Live Network Handoff Scenario

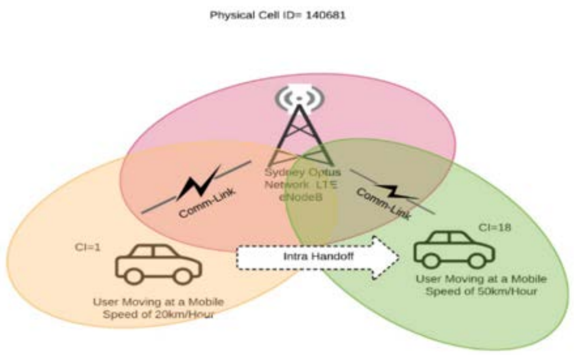


Figure 3: Network Topology for Intracellular Handoff with the Sydney Optus LTE Network

. Here, the G-NetTrack logs were captured for Sydney LTE Network as follows with an average *Mobile Speed* from 20Km/hr to 50 Km/hour we have tried to capture logs for Intracellular Hand off(i.e handoff of mobile user between different cell ids of the same eNodeB) based on the network topology in Figure 3. At the Signal- to-Noise Ratio (*SNR*) at 20 the DL and UL throughput for the packet data Network at 100Kbps for both UL and DL. We can also see that at an *SNR* 16 the DL Throughput is 10Mbps and UL Throughput is 1Mbps. This was captured when mobile speeds where varying with *SNR* at 20 with *Mobile Speed* at 50Km/hour and at lower *SNR* at 16 shows the average mobile speed was 20Km/hour.

B. Generating Live Traffic Scenario on SDN Open Flow Setup

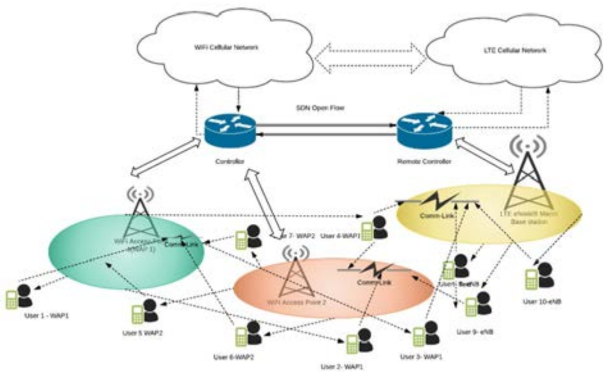


Figure 4: Schematic for Simulating Traffic load on Mininet with Open Flow version 1.3 using Ryu controller

In this section we will consider mobile traffic behaviour in Figure 3 to implement the SDN Open Flow Controllers. It was observed that the latency for mobiles during the handoff with the controllers is less as compared to the LTE live network even if the distance is higher between the two mobiles in a Multi SDN Controller setup.

C. SDN Controller for LTE Advanced Setup

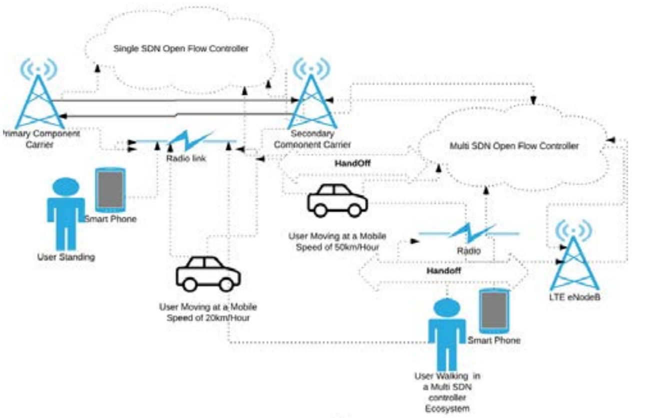


Figure 5: A schematic for simulating SDN controllers for LTE Advanced and LTE Networks

An LTE Advanced Network includes two Radio Nodes including the Primary Component Carrier and Secondary Component Carrier both are deployed under a single SDN Open Flow Controller. Further, LTE eNodeB are deployed under another SDN Controller setup to recreate a Multi SDN Controller setup.

During the handoff no packet loss was observed for the access point 1 and 2 with the same SDN and linked to each other and few packets losses were seen during handoff for the access point 3 while moving towards access point 1

III. RESULT AND DISCUSSIONS

A. Analysing the Results of SDN Controller vs the LTE Network

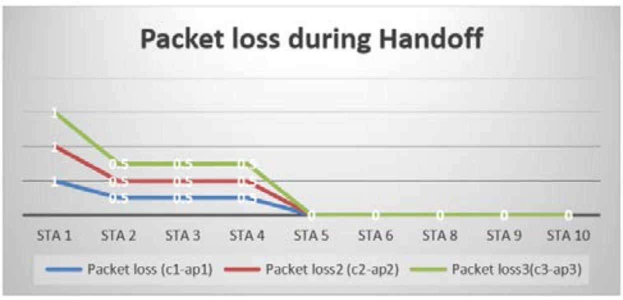


Figure 6: Packet Loss SDN vs LTE Network during handoff

The increase in traffic showed marginal packet loss during handoff in a Multi SDN setup of 0.5 to 1% as compared to the LTE Netwok. Also, throughput based on mobile speeds can be seen here at Figure 7.

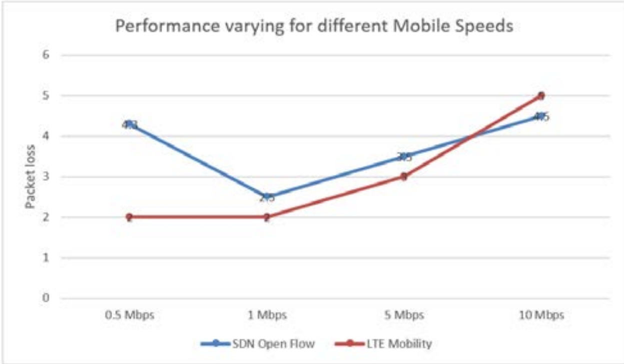


Figure 7: Packet loss at varying mobile speeds LTE vs SDN

It can be seen that the probability of packet loss is marginally higher in the LTE Network as compared to SDN when we achieve a throughput at the DL around 10 Mbps,

A comparative analysis was also done with handoff scenarios was also done between the different SDN controllers like "Ryu" for a Multi SDN setup. It was observed that incase there are channel constraints with the SDN Controllers there is a possibility of increased packet loss in handoff. Thus leading to deploy solutions for resolving scalability issues with the SDN Controller in Figure 8.

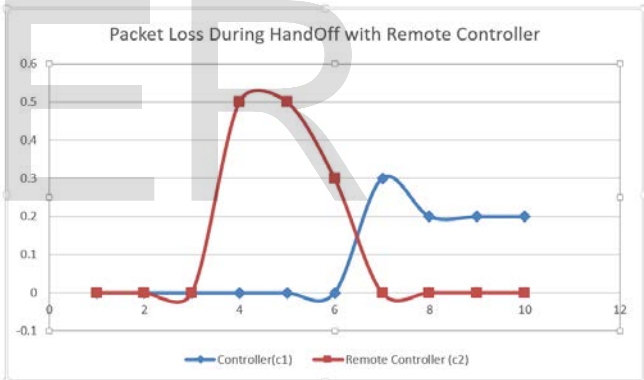
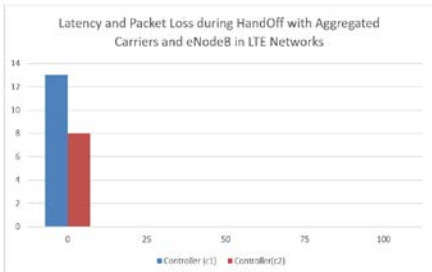
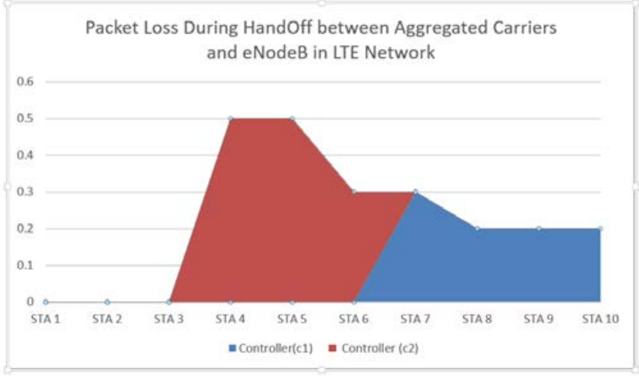


Figure 8: Packet loss with Remote Controllers during the Increased Handoff traffic load

B. Analysing the Results of SDN Controller deployed in the LTE Advanced Network



(a)



(b)

Figure 9: Latency and Packet loss for Controllers implemented for aggregated carrier vs non-aggregated carrier

It is possible to achieve low latency even with higher distance as was observed for few UEs in the controller for aggregated carriers and UEs in the controller of non-aggregated carriers during handoff with different mobility speed in a multi SDN setup. This is unlike the observation in the Sydney Network where at low mobility speed we were seeing low throughput and there was no impact or packet loss observed. Timing Advance is also another factor to determine packet loss which is taken care with SDN implementation and has no impact on the throughput and latency as observed when packets are shared between UEs of controllers with aggregated carriers and UEs of controller with non-aggregated carriers during handoff.

C. Traffic Load Scenarios

The feasibility of Traffic load behaviour for SDN setup were carried keeping in view the mobile speeds, packet loss, latency and TCP and UDP Throughput. Also it was very difficult to capture the fixed packet lengths because of the dynamic network environment in which the Simulation Tests were carried out using the Mininet. The details are as follows:

Table I: Traffic Load Scenarios for Various SDN Controller Setups

Traffic Load Scenarios	Packet loss	Latency	UDP Throughput	TCP Throughput
(6 mobiles)	0%	17.72 ms(Avg.)	6.4 Mbps	8.00Mbps
(Simulating LTE live network on SDN Platform) (10 Mobiles)	0.5-1% with varying mobile speeds the packet loss was 4.5% compared to the LTE Network which was 5%.	8ms (Avg) for SDN Network 73ms (Avg.) in a 4G Network -	As determined with the throughput of around 10 Mbps for both LTE and SDN Mobility. :	
(Remote Controller) (10 Mobiles)	1%	8ms (Avg.)	0.5% (varying mobile speeds)	6.5 Mbps (with the highest mobile speed)
(Simulating SDN for 4G+ Network) (10 Mobiles)	0.5% for Aggregated Carriers, 0.3% for non-aggregated carriers	8 ms -13ms (Avg.)	Higher the mobile speeds throughput was low at 4.7 Mbps	Lower the mobile speeds throughput was high at 6.5Mbps

IV. CONCLUSIONS

While determining the QoS framework for SDN some of the key criteria that will need to be considered based on these experiments is to check the Signal to Noise Ratio (SNR) for the SDN being deployed for Mobile. Further, it has been observed that for Handoff scenario TCP connection works the best as compared to UDP with a QoS advantage in media streaming which in the case of lower mobile speeds showed better throughput. However, these results are subject to change based on varying experimental setup environment. Further, the author concludes that an SDN based Radio Network Slicing may be proposed in line to TR-526 SDN Architecture in [4] and the schematic for the Network Topology for Mininet Extension to be used is in Figure 4 as follows on which the setup can be built and also extended for 5G network which the author may like to carry forward as a future scope of work:

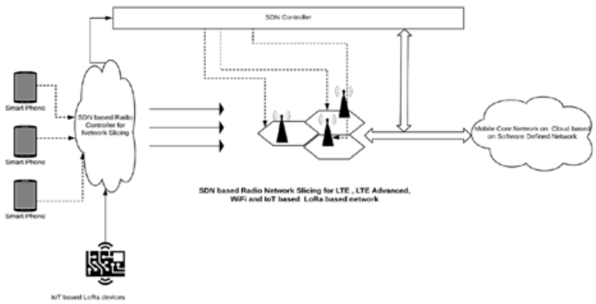


Figure 10: Schematic of the SDN based Radio Network Slicing in 5G.

Here in the diagram the author(s) have taken IoT based LoRa devices a low power wireless platform deployed along with the other Cellular Networks like LTE-Advanced, LTE or WiFi. The SDN mobiles with UEs of different categories supported by the relevant 4G and 4G+technologies via SDN open flow using the concept of Network Slicing can support different radio specifications and different bands.

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