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# Improving QoS by SDN based Handover Management in 5G Networks

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**Abstract**
**Purpose**
The purpose of this article is to enhance handover procedure in small cell based Ultra-Dense 5G Networks. The large number of small cells in dense heterogeneous 5G networks may result in unnecessary, frequent, and back and forth handovers with additional problems related to increased delay and total failure of handover process. Additionally, due to the separation of control and data signaling in 5G technology, the handover operation must be executed in both tiers. In this article we propose an SDN based approach to enhance handover mechanism.
The simulated results for E2E delay and throughput are compared with mininet based emulator The proposed strategy reduces the handover delay and failures by 36 and 24 percent respectively.

***Keywords***- 5GC, SDN, Throughput, E2E, NetSim

## 1. Introduction

### 1.1 Background

The increasing number of mobile users, devices and cellular traffic result in new challenges for the cellular networks. This work is focused on the handover management during mobility using software defined netwrking. A large number of mobile nodes in obviously leads to an increased number of handovers. In many cases there is a large accumulation of unnecessary and frequent handovers. If these frequent handovers occur among the target and presently serving cells continuously, a back and-forth signaling storm (the so-called ping-pong handover problem) is observed. Network resources are consumed at a high rate due to the control traffic spike, which can lead to handover failures, and large handover latencies.

**Overview of 5G Architecture**

A brief background on 5G architecture and software defined networking are presented in this section, in order to assist in understanding the basic concepts of these technologies.
In 5G service based architecture (SBA) network functions that are part of the control plane are Network Slice Selection Function (NSSF), Access and Mobility Management Function (AMF), Authentication Server Function (AUSF), Session Management Function (SMF), Unified Data Management (UDM), and Policy Control Function (PCF). The other entities are Application Function (AF), Data Network (DN), User Plane Function (UPF), (Radio) Access Network ((R)AN), which is also known as Next Generation Radio Access Network (NG-RAN), and User Equipment (UE).

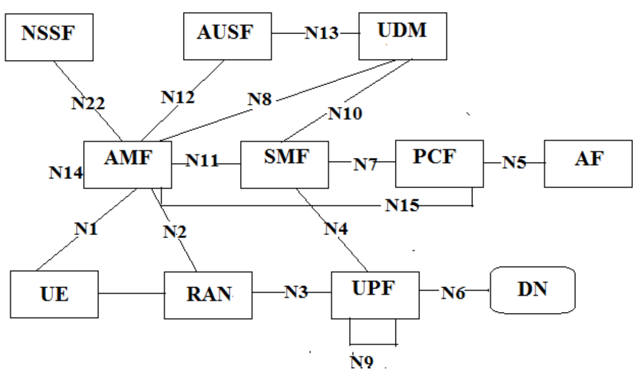


Fig.1 5G Service Based Architecture [5]

**Role of SDN in 5G**

In the SDN network, the controller is responsible to decide which actions should be performed on the packets, like forwarding or dropping, and install these rules in the forwarding elements, e.g., switches. These rules are termed as flow rules and each forwarding element maintains these rules in a table known as flow table. This flow table dictates the operation of a forwarding device. SDN controller communicates with the forwarding devices on the southbound interface and the communication protocol used is known as OpenFlow protocol.

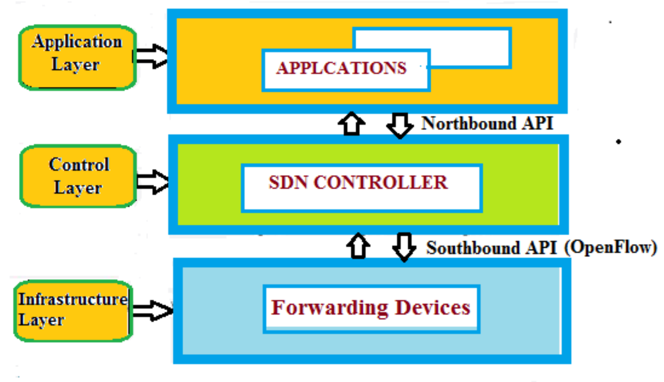


Fig.2 SDN Architecture

## 1.2 Research Objective

The mail objective of this work is to enhance the Handover procedure in 5G using SDN in terms of E2E delay.

To choose and assign the most optimal gNBs to the OpenFlow tables of the mobile nodes virtually before the need for an actual connection using SDN approach.

## 1.3 Organization of Paper

In Section 1 brief background of the research topic is provided. It also overviews 5G architecture and role of SDN, while Section 2 explains the related work present in the literature which highlights important studies done in this area, methods used for investigation and research gaps. Section 3 describes our proposed architecture, and simulation. Modeling details and implementation of the proposed architecture are presented in this section. Section 4 presents results of the simulation and discussion. It also details comparison of proposed architecture with the traditional 5G architecture and explains the effect of various factors on the results. Section 5 concludes with future scope.

# 2. Literature Review

## 2.1 Important studies done in this area

In this section, the most relevant work is presented that implements SDN concept to 5G network. Most of the research work present in literature tries to incorporate SDN based 5G architecture. Whereas some articles propose a clean slate architecture, and some integrate SDN with the standardized 5G architecture. In this article we propose an SDN-based mobility and available resource estimation strategy to solve the handover delay problem.

Bilen, Berk Canberk, Kaushik Choudhuri in [1] proposed an SDN-based mobility and available resource estimation strategy to solve the handover delay problem. They developed mathematically elegant framework to select the optimal eNBs and assigned these to mobile nodes virtually, with all connections completed through the use of OpenFlow tables. They compared the conventional and proposed handover strategies by analyzing the observed delays according to the densification ratio parameter. Also, analyzed the handover failure ratios of both strategies according to the user number.

A. Abdulaziz, M. Ashraf and A. Marwan and Tarek Sheltami in [2] provided, the explanation of initial attachment and handover procedures in the proposed architecture. They built network simulator to evaluate the performance of proposed architecture, in terms of end-to-end delay, throughput and resource utilization of controller, under different network factors. A performance comparison, in terms of end-to-end delay, between proposed SDN based 5G architecture and traditional 5G architecture is provided. Results show that the proposed architecture provides 18% to 62% less end-to-end delay, under different factors for different procedures, compared to the traditional 5G architecture.

S. Kuklinski, Y. Li, and K. T. Dinh in [4] proposes a new SDN based handover scheme to satisfy the delay requirement of less than 1ms, which is the main requirement of 5G network. In this work, LP (Linear Programming) problem solving technique is applied to reduce calculation amount in the next cell selection. In addition, a channel would be allocated in advance to selected cell, thereby reducing time required for handover and providing fast and seamless service. Simulation results show that the proposed method find cells with strong signal strength, long

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sojourn time and low cell load according to the movement direction.

### 2.2 Methods typically used for investigating Network Initiated 5G Handover

UE performs quality measurements on BRSs (Beam Reference Signals) from neighbour cells and sends measurement report to Serving gNB which replies with handover command containing RRC connection reconfiguration along with target cell Target gNB. UE completes handover with Target gNB.

**UE Initiated Handover**

UE performs quality measurements on BRSs from neighbouring cells and sends measurement report to Serving gNB. Serving gNB responds UE with list of possible neighbouring cells to complete the handover. From the list of cells, UE selects the best cell for handover.

## 3. Research Methodology

### 3.1 Proposed Architecture

**Basic Xn Interface based Handover Procedure**

In the basic handover procedure UE will send measurement report to the serving gNB which includes serving and neighbouring cell signal strength after every 120 ms. Here Serving gNB will send Handover Request to the Target gNB. After checking availability of the resources Target gNB will send back Handover Request ACK. Serving gNB will issue Handover Command to UE which will set RRC configuration. After that Target gNB will send PATH SWITCH packet to the AMF which is a functional entity who resides in the control part of mobile core. After receiving this packet, AMF will send MODIFY BEARER RESQUEST to SMF which will reply back with acknowledgement. On receiving acknowledgement from SMF, AMF will send back PATH SWITCH ACK packet back to the Target gNB. Target gNB will ask Serving gNB for resource release through CONTEXT RELEASE which will be followed by CONTEXT RELEASE ACK.

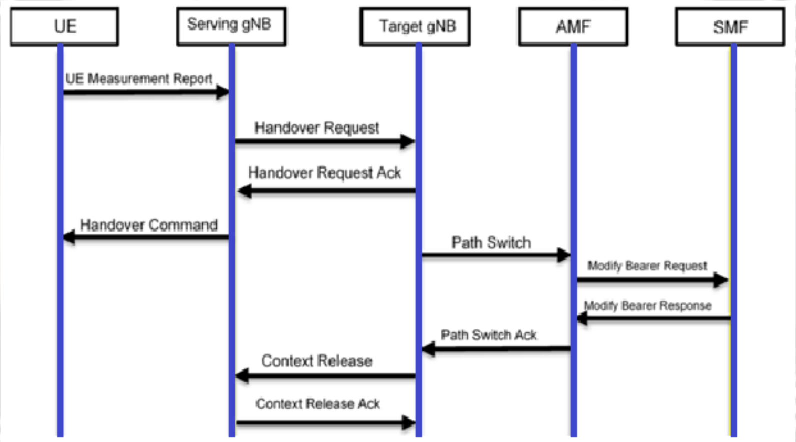


Fig.3 Basic 5G Handover Process

**Proposed SDN Controlled Xn Interface Based Inter UPF Handover**

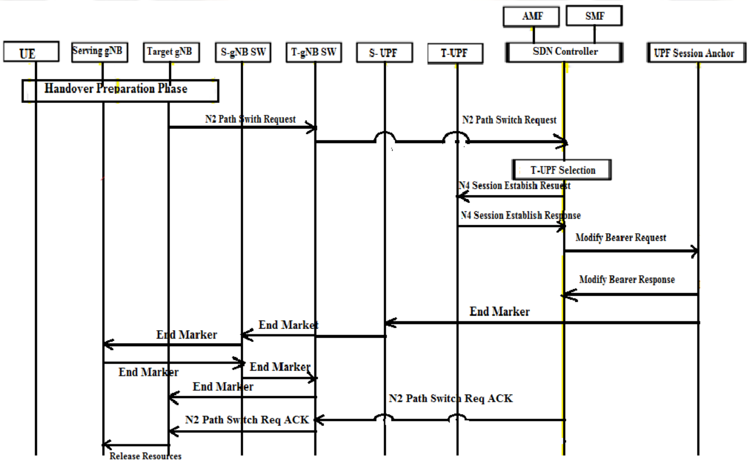


Fig.4 SDN Based 5G Handover Process

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In this scenario both the target and source gNBs are connected to different UPFs. Similar to the previous handover procedure, the Target-gNB (T-RAN) will send path switch request to the AMF. However, in this case, the UE has moved out of the serving area of the UPF connected to the Serving-gNB (S-RAN), so the SMF has to select a target UPF connected to the Target-gNB and then sending a session establishment request to the selected UPF. T-UPF then responds with a session establishment response message. After that, SMF will exchange session modification messages with the PDU UPF session anchor in order to switch the PDU sessions. The End marker will be sent by the PDU UPF session anchor on the old path indicating that a new downlink is established, and the downlink traffic will be forwarded on the new path. The AMF will then send a path switch request ACK to the Target gNB. Target gNB will inform Serving gNB to release its resources once the handover procedure is complete.

**3.2 Simulation**

**Network Scenario in NetSim**

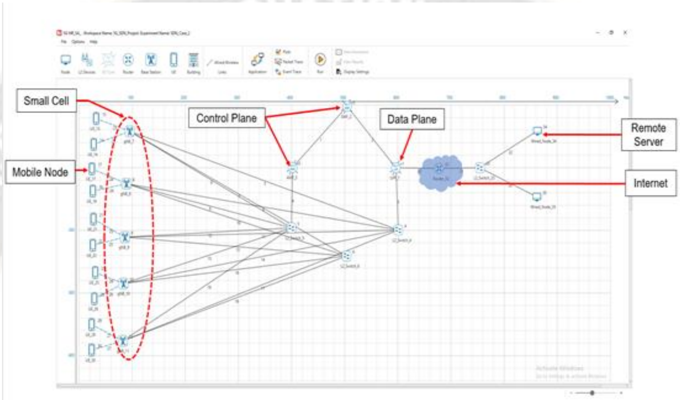


Fig.5 Network topology diagram showing a large number of small cells.

The control plane action is handled by the AMF and SMF in the 5GC while the data plane functionality is taken care by the UPF in the 5GC. In NetSim we are unable to produce plots but we can track the packet exchange and see the logs in the Log window. But as we can see in figure 8 that the signalling in the network increases as the number users increases in a particular given area. So we have proposed the following architecture which is based on SDN and uses Markovian Chain Process at the controller.

## 4. Results and Discussion

**Delay analysis of SDN Based Target gNB Selection and Mobility Model**

We evaluate the delays of the proposed and conventional handover approaches according to number of mobile nodes or handover requests. In this situation, waiting time in the queue increases with increase in handover requests in the conventional handover mechanism. On the other hand, in the proposed approach, handover count increases because of the growing number of OpenFlow table entries. This observed delay is less than the conventional mechanism. Therefore, as shown in Fig.9, we observe almost 51 percent fewer handover delays in the proposed approach compared to the conventional mechanism.

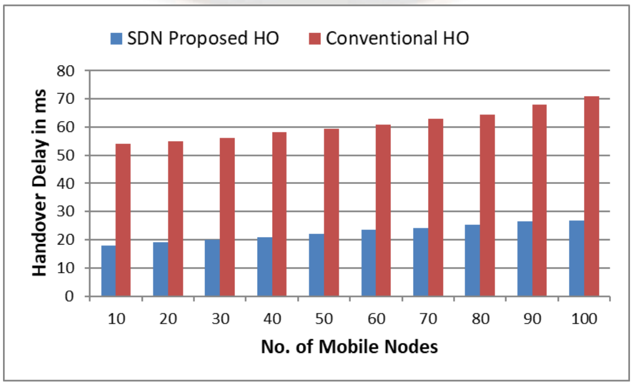


Fig 8 Delay analysis according to No. of mobile users/Handover Requests

**Handover failure analysis according to no. of mobile users**

We analysed the handover failure ratio of the proposed and conventional approaches according to the increased user number and handover requests. Accordingly, in two strategies, the number of handover failures is divided by the total handover number to find the handover failure ratio. As shown in Fig.10, the handover failure ratios of the proposed approach are 27 percent less than the conventional mechanism.

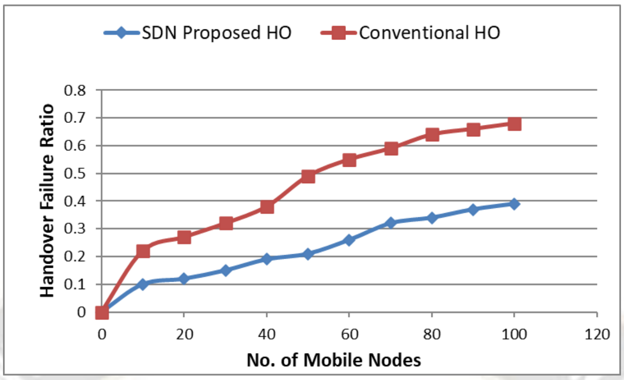


Fig 9 Handover failure analysis according to no. of mobile users

## 5. Conclusion and Future Scope

In this paper, we explain the basic operation of the standard 5G core architecture and propose software defined networking (SDN) based handover management procedure. A comparison of basic handover procedures in 5G architecture and the proposed SDN based 5G architecture is provided. We have specifically developed NetSim based simulator to evaluate the performance of the proposed SDN based 5G architecture and the traditional 5G architecture. Different scenarios were considered for simulations which helped to evaluate the performance in terms of end-to-end delay of handover requests, throughput at controller. The proposed architecture outperforms traditional 5G architecture with 36% reduced delay and 24% handover failure ratio for UPF handover.

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