# Bachelor Thesis/Project Work

## « Performance evaluation of a handover enabled 5G communication system »

### Background

5G new radio (NR), the 5th generation of mobile networks came into play in the year 2019 as a new global wireless standard after the 4G LTE technology. The key expectations of 5G are to deliver high data rates with large network capacity, ultra-reliable low latency communication and the support of massive machine type communications. 5G is designed to provide more connectivity than the previous mobile generations ever had provided and the developments in the context of 5G are still underway. The 3GPP (3rd Generation Partnership project), which is a standards organization, develops specifications for mobile telecommunications. Since their release 15 of the specification, they are focused on 5G NR and have come up with the protocols that apply in terms of developing 5G communication systems. In the specification, they define the standalone mode architecture where 5G RAN is directly connected to the 5G Core network (CN) as depicted in the figure. In this project, we are focusing on the same network implementation. In-detail information regarding the deployment can be found in the release 15: **3GPP TR 21.915 V15.0.0**. Accordingly, an infrastructure-based communication system establishes the connection from a user equipment (UE) to the CN via the RAN. In 5G, the RAN is referred to as the NG-RAN and incudes the gNodeB (base station in 5G). gNodeB is connected to the CN via an interface referred to as NG and in between the gNodeB nodes, connections are established via Xn interface.

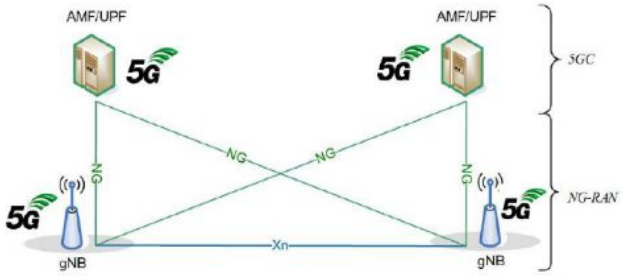


*Figure: 5G SA architecture (source: 3GPP Release 15)*

***Handover:*** When it comes to wireless communication systems, one major characteristic that made it vital is the mobility. When the UE nodes become mobile, attention must be paid towards how to manage and continue the communication in case these nodes move out of the coverage range of the base station that they are originally served by. In such cases, the principle of handover is applied, which refers to the process of shifting an ongoing session of the mobile node from one gNodeB to another meaning the data/call connection is being transferred from one RAN to another to offer an uninterrupted service continuation for the user. There are different types of handovers based on the interfaces involved and in this project the focus is towards the Xn-based handover. Further information about the Xn interface can be found in the 3GPP technical specifications 38.300 and 38.420.

***OMNeT ++ and Simu5G:*** In order to simulate our network scenario, we employ the simulator OMNeT ++, which is a C++ based discrete event simulator. To simulate 5G related components; Simu5G, which is an OMNeT++ based framework for simulating the data plane of the 5G NR RAN and CN is used. It provides modules and interfaces required in building different communication scenarios in the 5G communication context. Simu5G provides modules to model the 3GPP compliant 5G NR protocol stack and even include realistic customizable channel models for the physical layer. It also includes all the models from INET framework such that the basic TCP/IP networks could be simulated.

## Your Tasks

The use case of this project is the UE being an air taxi. There is no requirement to implement any air taxi specific conditions, yet attention must be paid to the factors of altitude and speed of the UE. Thus, the main objective is to evaluate the performance of the system when the UE is an air taxi in a realistic environment. Therefore, the following tasks are required to be completed.

1. Getting familiar with OMNeT ++ and simu5G
2. Getting familiar with Xn-based handover in 5G systems
3. Implementing Xn-based handover in simu5G
4. Performance evaluation of the system when the UE is operating in a non-ideal realistic environment under the impact of the factors:
    - number of UE nodes served by a gNodeB
    - speed and altitude of the UE
    - mobility pattern used

    Performance evaluation criteria:
    - latency
    - data delivery ratio
    - handover success rate
    - total amount of data being exchanged

***Scenario:*** A simple scenario with four gNodeB nodes in a realistic ground environment (channel model should consider shadowing, fading etc) should be simulated with a variable number of UE nodes in simu5G. The gNodeB nodes are interconnected via the Xn interface and to establish connection to the CN, each is connected to the UPF (User Plane Function). From the UPF via a router connection a control station (server) must be implemented. Each UE must transmit a message to the control station periodically. UE nodes are mobile nodes and hence Xn-based handover must be initiated to support an uninterrupted service. Refer to the example scenario provided in simu5g: simu5g/simulations/NR/dualConnectivity_multicell

## Your Profile

- Basic knowledge on 5G communication
- Knowledge and experience in working with OMNeT ++ discrete event simulator

## Useful References

- ***5G:*** 3GPP Release 15- https://www.3gpp.org/release-15
- ***Xn Inerface*** : TS38.300: https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3191
  TS38.420:https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3225
- ***Simu5G*** : https://ieeexplore.ieee.org/document/9211504

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