

Introduction

The evolution of mobile networks has continuously enhanced connectivity, enabling new uses with every generation. 5G, the latest iteration, introduces high-speed communication, ultra-low latency, and a capacity to handle a massive number of devices. It supports advanced technologies such as IoT (Internet of Things), remote medical services, and smart cities.

As part of our third year in Networks and Telecommunications, we undertook a project aimed at implementing a standalone 5G network. This involved designing a system capable of connecting a simulated base station (gNB) to a mobile phone through a core network, using tools such as Open5GS and SRS RAN. The main objectives were to understand the architecture of a 5G network, explore its various components, and gain hands-on experience with technologies like EPC (Evolved Packet Core), gNB, and UE (User Equipment).

Tools and Equipment

The success of the project relied on a set of specific tools and hardware, as detailed below:

Open5GS :

An open-source software used to simulate the 5G core network. It provides functionalities such as mobility management, authentication, session handling, and user data transport.

SRS RAN Project :

An open-source platform to configure and manage the radio access network (RAN). It was used to program the base station (gNB) to emit at specified power and frequency levels.

USRP B210 :

A software-defined radio transceiver that bridges the core network and the wireless signal for the user equipment.

PySim :

A Python-based tool for programming and configuring SIM cards, ensuring they carry all necessary subscriber information (IMSI, Ki, etc.).

Additional equipment :

A 5G-compatible mobile phone, programmable SIM card, and the Omni Key 6121 card reader to access and configure the SIM parameters.

The entire setup required specific configurations to simulate the core network, connect the base station, and enable communication with a mobile phone.

Deployment Process

Core Network Configuration with Open5GS :

- Open5GS was installed on an Ubuntu 22.04 system, ensuring compatibility with required libraries. MongoDB was used as the database for managing subscriber information.
- Multiple components such as AMF (Access and Mobility Management Function), UPF (User Plane Function), and SMF (Session Management Function) were configured. These components ensured user authentication, session handling, and data transport.
- YAML configuration files were customized to define network-specific parameters, including the APN ("FLNETWORK"), PLMN ID, and TAC (Tracking Area Code).

Base Station Setup Using SRS RAN :

- The gNB was configured to interface with the AMF via port 38412. Parameters like PLMN ID and TAC were aligned with the core network's configuration to ensure seamless communication.
- Frequency bands and power levels were defined to establish an efficient radio signal for user equipment connection.

SIM Card Programming with PySim :

- Using PySim, SIM cards were programmed with essential information, including IMSI (unique subscriber identifier), MCC (Mobile Country Code), MNC (Mobile Network Code), and Ki (authentication key).
- This ensured proper integration of the SIM card with the Open5GS core network.

Handover Implementation :

- A Handover scenario was simulated, enabling a user to switch from one gNB to another without interruption. This was achieved by setting up two base stations with different IP addresses and reducing signal strength in one while increasing it in the other.

- Packet routing was monitored to ensure proper handover between the antennas.

Experimental Results

The implemented 5G network successfully established a connection between a mobile phone and the core network. Key steps in achieving this included:

- **APN Configuration** : The phone was set up with the custom APN "FLNETWORK," allowing it to register on the network.
- **Testing Network Performance** : Using applications like PingTools, the phone's connectivity was tested. Results demonstrated low latency and reliable data transmission.
- **Handover Verification**: The handover process was successfully executed, showing seamless transition between two antennas without service disruption.

The experiments were conducted in a controlled environment (classroom), with adjustments to signal gain parameters (tx_gain and rx_gain) to define the range of each antenna. The success of the handover validated the robustness of the network setup.

Project Management

We adopted the Agile Scrum methodology for effective project organization. The methodology suited the constraints of the project, as equipment access was limited to the university premises. Work was organized into two sprints :

- **Sprint 1** : Focused on documentation, initial setup of Open5GS and SRS RAN, and testing the basic functionality of the network.
- **Sprint 2** : Concentrated on refining the network, implementing the handover feature, and preparing the final project report and presentation.

The roles within the team were distributed as follows:

- **Product Owner**: Ensured alignment with project objectives and requirements.
- **Scrum Master** : Facilitated the sprint process and addressed any obstacles.
- **Development Team** : Carried out configuration, testing, and documentation.

Conclusion and Future Perspectives

This project demonstrated the feasibility of implementing a standalone 5G network using open-source tools and accessible hardware. It provided a deep understanding of the architecture and operational principles of 5G technology. Key outcomes included:

- Successful configuration of a 5G core network and base station.
- Establishment of a functional connection between the gNB and user equipment.
- Execution of a seamless handover between antennas.

Future enhancements could include expanding network coverage, improving quality of service, and exploring additional features such as enhanced handovers and network slicing. This hands-on experience has not only enriched our technical expertise but also prepared us for challenges in real-world telecommunication environments.