5G Framed Route - Adding management of sub-networks on WebGUI

Gonçalo Tavares de Bastos nº2020238997
Leonardo Cordeiro Gonçalves nº2020228071

March 2023

Abstract

Framed routing is a new functionality of Open5GS an opensource 5G Core implementation. It doesn't been validated or tested yet. Management/provision operations are still incomplete on the core. Monitoring such networks can be a challenge and we aim to do that by setting up an emulated environment using Virtual Machines.

1 Introduction

In this section we will define the project, by this it means the context where it is inserted, where we are acting and the final goal we aim for. On the next section we explain the most recent stage in the development of this project, and further more, we specify on how we aim to get there.

When a cellular mobile is connected in a mobile network (PLMN - basically a cellular network) it is normally assigned with a single IP. In some scenarios it is essential that this UE's (User equipment's) work as acces points and share their connectivity with others but this implicates the use of a NAT that basically imposes UE's to be seen with a single IP address, assigned by the 5G core to the UE, for a common user it is enough but for advanced uses, our case, it constitute multiple disadvantages like limits the reachability and the bi directional connectivity.

More advanced scenarios require 5G to behave as a router, this means, allow the connection of multiple computer networks and the communication between them, serving one or more LAN segments, i.e. forwarding traffic from connected devices bypassing NAT, we can do that with 5G by adding the Framed Route functionality.

The main benefit of framed routing is that it simplifies data processing and forwarding for network devices and this functionality can be natively added to

5G. Framed Route [2] [3] enables the deployment of extra IP networks behind a UE, allowing access to a number of IPv4 addresses or IPv6 prefixes through the established 5G PDU Session from external networks like the Internet (s).

2 State-of-the-art

2.1 The Evolution of Networks

The first generation of mobile networks, 1G, only allowed voice calls and was based on analog technology. 2G networks introduced digital voice calls and text messaging, and 3G networks brought faster data speeds and mobile internet access.

With the advent of 4G networks, mobile data speeds increased significantly, enabling the widespread adoption of video streaming and other data-intensive applications. 4G also enabled the development of the Internet of Things (IoT) and machine-to-machine communications.

Now 5G networks are taking network evolution to the next level. With lightning-fast speeds and low latency, 5G has the potential to transform industries such as healthcare, transportation and manufacturing. It will also enable new technologies such as autonomous vehicles, augmented reality and virtual reality.

Overall, the evolution of networks has been driven by the demand for faster, more reliable and more efficient communications. With each generation, new technologies and capabilities have emerged and the possibilities for the future of networking are endless.

2.2 Framed Route

In framed routing, data packets encapsulated in frames are routed through the network. The frames are created on the device sending the data and then routed through the network, with each network function responsible for processing and forwarding the frames to their final destination. The Session Management Function (SMF) is responsible for establishing and maintaining connections between devices on the network and plays a critical role in determining the optimal path for data packets moving through the network.

PDU session management, on the other hand, involves setting up and managing data sessions between devices on the network. A PDU session is a logical connection between a device and the 5G core network and is used to transfer data packets between the two. The SMF is also responsible for managing PDU sessions on the network. It establishes new sessions, manages existing sessions and terminates sessions when they are no longer needed.

Framed routing and PDU session management are critical components of the 5G network architecture that ensure data is transmitted efficiently and reliably between devices in the network. The SMF plays a central role in both components. It helps establish and maintain connections, determine the optimal path for data packets and manage PDU sessions across the network. By leveraging these capabilities, 5G networks are able to provide high-speed, low-latency connections to a wide range of devices and applications, making it an indispensable technology for the modern digital world.

2.3 5G main building blocks

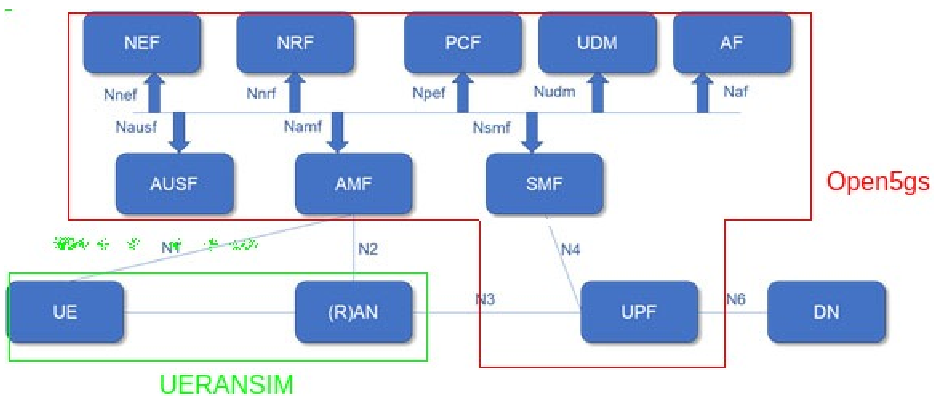

Figure 1: 5G Core Network

At the heart of 5G is the **5G core network**, which is responsible for managing all network functions and services. The 5G core consists of several key blocks, each of which plays a critical role in enabling the advanced features and capabilities of 5G, we can split into two entities, they are Control entities and User plane entities (obs: notice Fig1) .

Open5GS [4] is an open source implementation of the 5G core network. It is a complete implementation of the 5G core network that is compliant with 3GPP standards and provides all the necessary functionality to deploy and manage a 5G network.

At its core, Open5GS is designed to provide a highly scalable, flexible and efficient network architecture that can support a wide range of use cases and applications. It is built on a modular architecture consisting of several functional components, including the Access and Mobility Management Function (AMF), the Session Management Function (SMF), the User Plane Function (UPF) and the Policy Control Function (PCF), among others.

- AMF is responsible for managing the access and mobility of 5G devices within the network. It provides functions such as network registration, authentication and security management, as well as mobility management that allows devices to move seamlessly between different parts of the network.
- SMF is responsible for managing data sessions between 5G devices and the network. It provides functions such as data session creation, modification and termination, as well as policy and charge management.
- PCF is responsible for managing and enforcing policies related to network resource allocation, QoS, and user authentication and authorisation.
- UPF is responsible for managing user data and providing the required connectivity between the 5G devices and the network. It provides functions such as packet filtering, routing and forwarding, and Quality of Service (QoS) management, which ensures that user data is transmitted with the appropriate priority and reliability. It is directly connected to the RAN and the DN and essentially establishes tunnels through which data are exchanged between hosts in the DN and the UE.

UERANSIM [1] is an open-source 5G UE (User Equipment) simulator that allows developers to test their 5G network applications and services in a simulated environment. It provides a realistic emulation of the 5G network architecture, including the core network, radio access network (RAN) and user equipment (UE).

This is done by creating a virtual 5G network that simulate the behavior of a real world network, complete with all the necessary components such as base stations, access points and user equipment.

Some os the key features of UERANSIM is its ability to simulate different network scenarios, such as varying network load, network coverage and network capacity and even support for multiple 5G network protocols, including the 5G New Radio (NR) protocol and the 5G Core Network (CN) protocol. This allows us to test our application across the entire 5G network architecture, from the radio access network to the core network.

2.4 Sub-network managing and WebUI

WebUI Open5GS WebUI is a web-based user interface for the administration and configuration of the Open5GS core network components.

The Open5GS WebUI provides an easy-to-use graphical interface for configuring and monitoring various components of the Open5GS core network, including Subscriber Data Management (SDM), Session Management (SMF), User Plane Function (UPF) and Network Exposure Function (NEF).

Via the WebUI, network administrators can manage subscribers via IMSI, KEY and OPC. With these parameters, we can set up the appropriate PDU sessions, ensuring access to DN for each subscriber via the appropriate interfaces. We can also configure network policies and monitor network traffic. The WebUI simplifies the management and maintenance of the Open5GS core network.

3 Methodology

Here we set the goal, define the strategy to achieve it, present the action plan and enumerate the tasks and even the risks. In the appendix you will find the risk table, the Gant chart and the list of materials for more details.

3.1 Objectives and overview of the selected strategy

The main goal of the project is to validate and test the Framed Route feature in Open5GS and add the management functionality of subnets in the WebGUI API.

The solution must enable the assignment and the management of IPv4/v6 prefixes for each UE through the WebGUI and this change has to be reflected in the user database (MongoDB) and so on to the 5G Core network functions in charge of the PDU session establishment procedure (SMF, UDM and UPF), in the case of UPF it must also be able to receive the framed route TLVs from the SMF (through the PFCP protocol).

Packets directed to any address associated with the specified prefixes and received at the UPF N6 interface will be routed to the appropriate UE through the corresponding GTP tunnel, without involving any NAT operations.

The development project will employ the UERANSIM simulator to replicate the RAN and UE's and Open5gs to replicate the core and the UPF.

3.2 Plan of action

1. Installation and configuration of the Virtual Machines.

2. Validate the framed routing functionality in a state of the art open source 5G core implementation (Open5GS) by setting up an emulated environment (VirtualBox in our case).

Note: Validation should be done end to end, i.e. from an emulated client behind an emulated 5G UE to the internet/N6 (both IPv4 and IPv6 prefixes).

3. Investigate 3GPP standardised Northbound APIs (e.g. CAPIF) to validate whether the Open5Gs UE Provision API complies with current standards (and possible framed route "touchpoints").

4. Improve/develop the management web interface of the 5G core by adding support for static framed route provisioning (currently only available in db tools).

5. Check and improve possible validations for overlapping routes.

6. Investigate 3GPP standards for possible options for framed route monitoring/charging (e.g. PFCP Session Report requests/response).

7. Validate the scenario on a real 5G network (Altice Labs campus).

4

References

[1] URL https://github.com/aligungr/UERANSIM.

[2] . URL https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?spe

[3] . URL https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?spe

[4] URL https://github.com/open5gs/open5gs.

5 Acknowledgements

We would like to express our gratitude to the University of Coimbra, especially lecturers Maria do Carmo Raposo de Medeiros and Henrique Leonel Gomes, as well as Altice Labs engineers Francisco Fontes and Miguel Freitas.

6 Anex's

Risk Description	Likelihood of the risk occuring	Impact if the risk occurs
1- Lack of knowledge and information about the 5G Framed Route Tecnhology		
2- Studied and developed projects for the first time in this simulation environment		
3- Difficulties in Code Implementation		

Figure 2: Risk and mitigation measures

5G Framed Route

Mar 8, 2023

Tasks

2

Nome	Data de início	Data de fim
Study: Simulation Enviroments; 5G Technology, Concepts	2/9/23	3/2/23
Project Proposal	3/3/23	3/7/23
Validate Frame Routing Funcionality	2/28/23	4/6/23
Prepare the synthesis work 1 (Project Pitch)	3/30/23	4/4/23
Investigate 3GPP standardized northbound APIs	4/13/23	4/23/23
Submission of the mid-term progress technical report 1	4/13/23	4/18/23
Develop the management web-interface of the 5G core	4/20/23	5/13/23
Prepare the syntnesiss work 2	5/8/23	5/11/23
Final assesement of the Laboratory Notebook	5/16/23	5/18/23
Improve or Complete unfinished tasks	5/19/23	6/16/23
Prepare the technical report of the prototype	6/22/23	6/24/23
Prepare the prototype presentation	6/26/23	6/29/23

Figure 3: Tasks ans Date Table

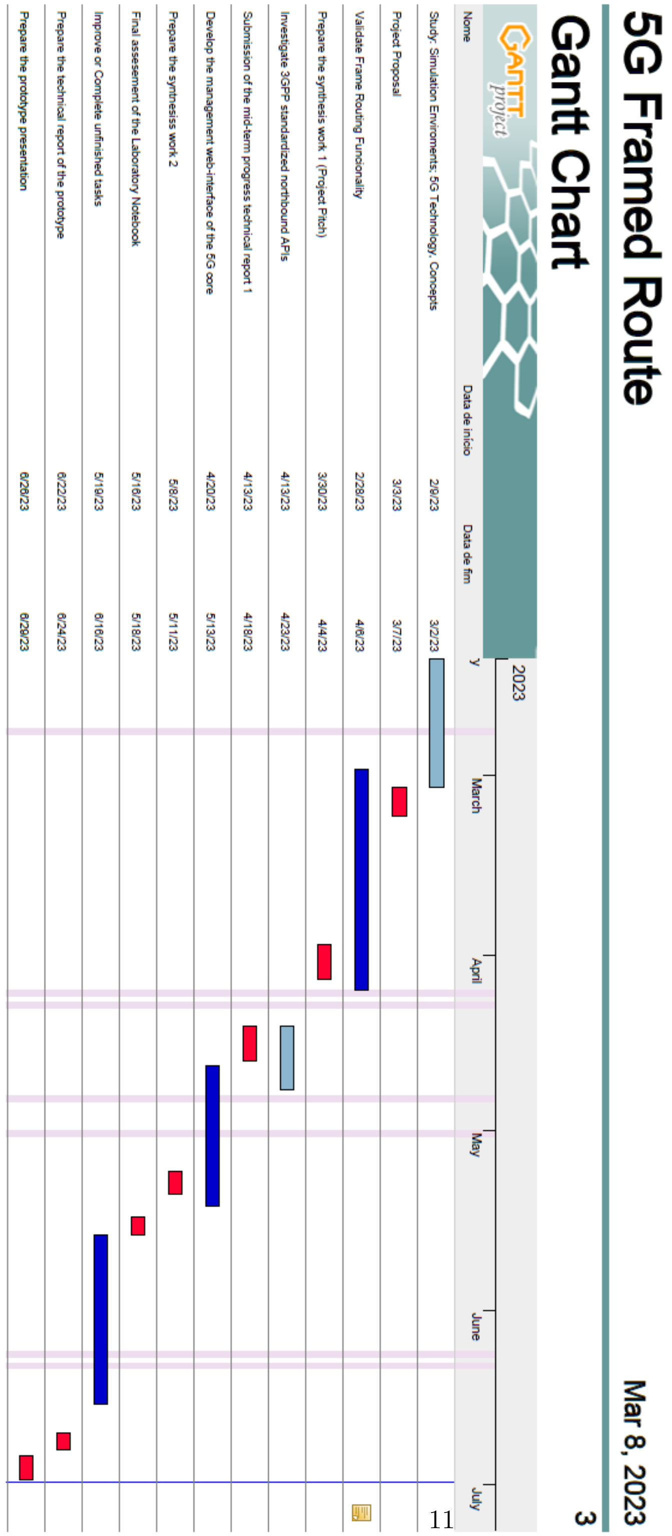

Figure 4: Risk and mitigation measures

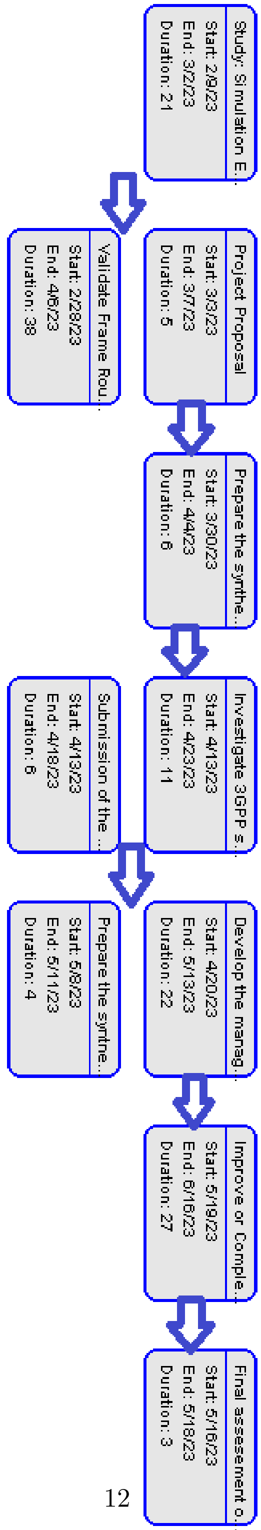

Figure 5: Pert Diagram