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Emu5GNet : an Open-Source Emulator for 5G Software-Defined Networks

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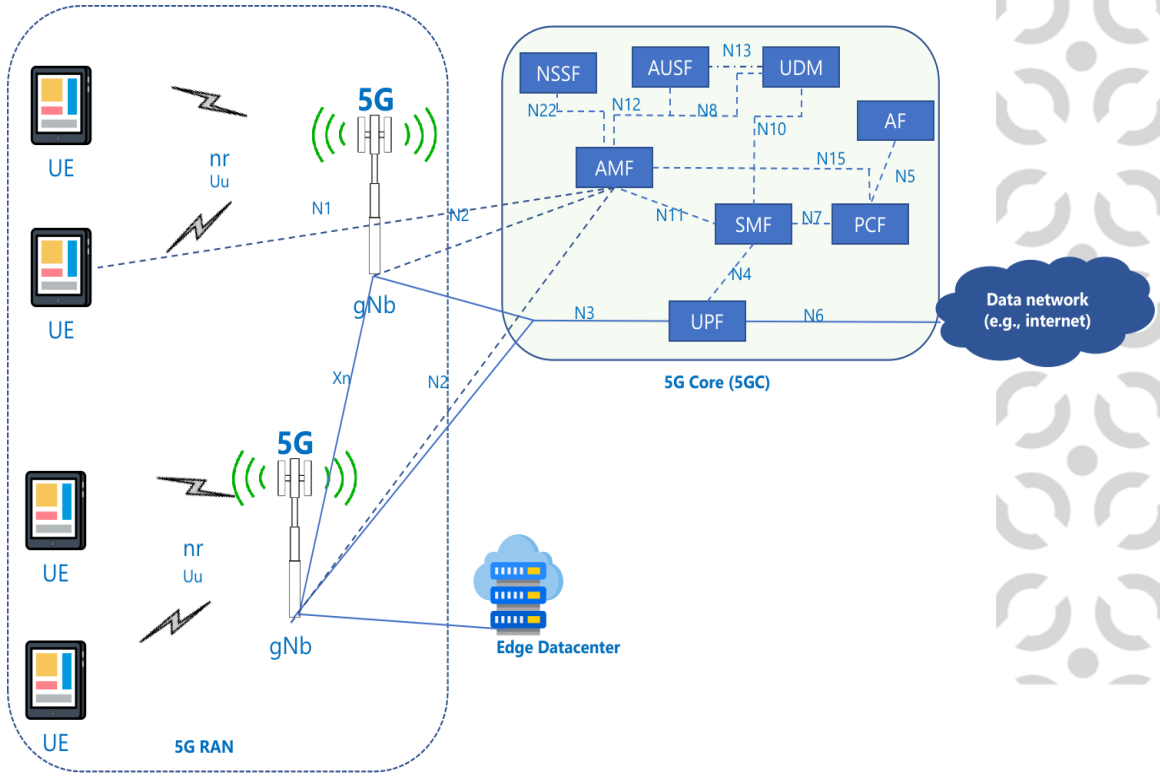
Introduction

- **5G Networks deployment initiated in several country**
- **Research in both industrial and academic is going on**
- **Several issues are still remaining**
  - Networking issues, e.g., Multi-connectivity (5G, LTE, Wifi, ITS-G5, etc.) and VANET integration
  - Data processing issues, e.g., real-time Edge data processing service
- **Prototyping and evaluating such network is a challenging task and is expensive :**
  - Emulators are the best solution for this task

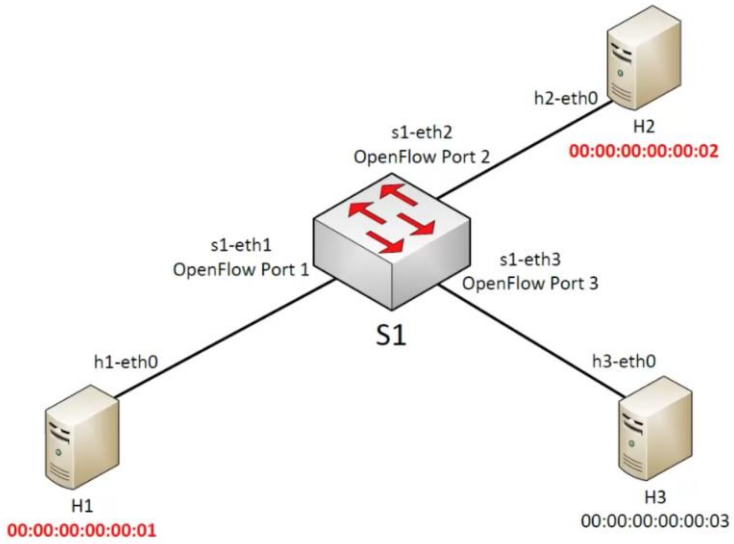


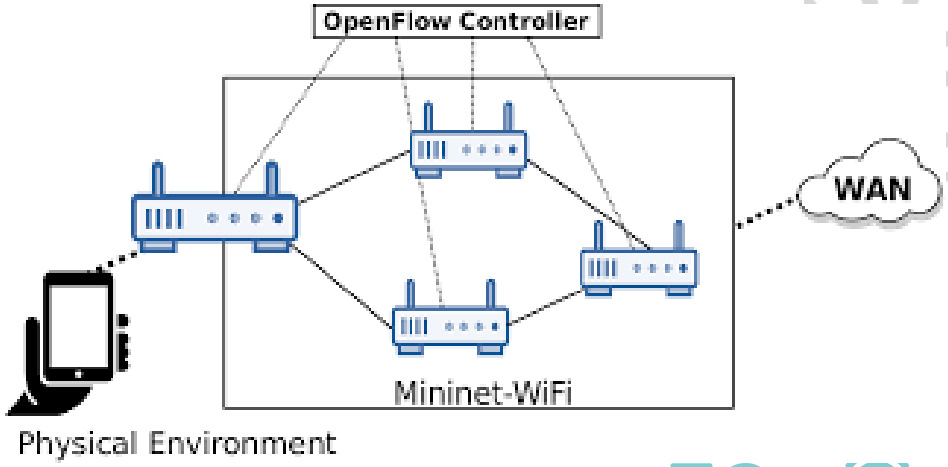
Context

- **Emulators are used to prototype and evaluate these systems**
  - Better than simulators as they enable more realistic environments
- **5G prototyping and evaluation need the integration of different elements to provide a complete environment**
- **Such an environment must fulfill the following requirements :**
  - Emulation of several Radio Access Technologies (RAT) and the associated network cores, e.g., 5G core
  - Deployment of mobile nodes (pedestrians, cars, trains, etc.)
  - Deployment of Edge servers
  - Implementation of Software-Defined Network/Network Function Virtualization (SDN/NFV) architecture

State-of-the-art

- **Several existing solutions**
- **Many network emulators have been proposed for 5G networks :**
  - Emulator for wired or wireless SDN networks
  - Emulator for SDN/NFV integrated architectures
  - Realistic nodes mobility emulation and wireless communications
- **None of the existing emulation platform allow to realize complex scenarios that integrate the above elements**





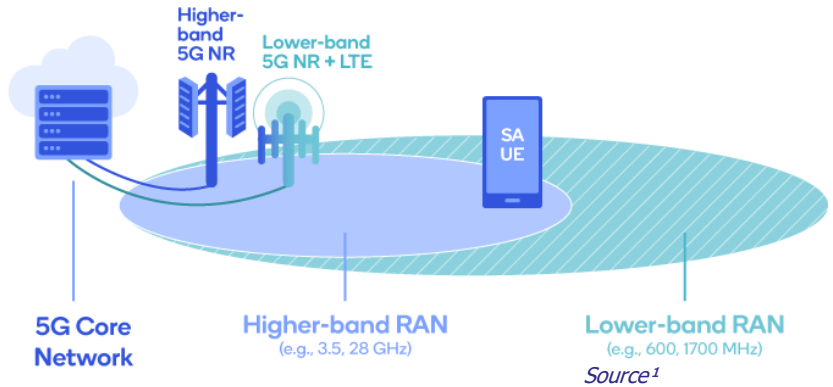
Source[1]

1 - https://hal.inria.fr/hal-01480973/document

Proposition

- **New emulation platform for 5G networks**
  - Allowing integration of SDN/NFV systems, Edge computing infrastructures, SA and NSA 5G access and core networks
  - Allowing multiple RATs connectivity for nodes (even simultanously)
  - Allowing urban mobility simulation (car, trains, tramways, pedestrian, etc.)
  - Enables multiple operators scenarios, e.g., roaming

5G SA



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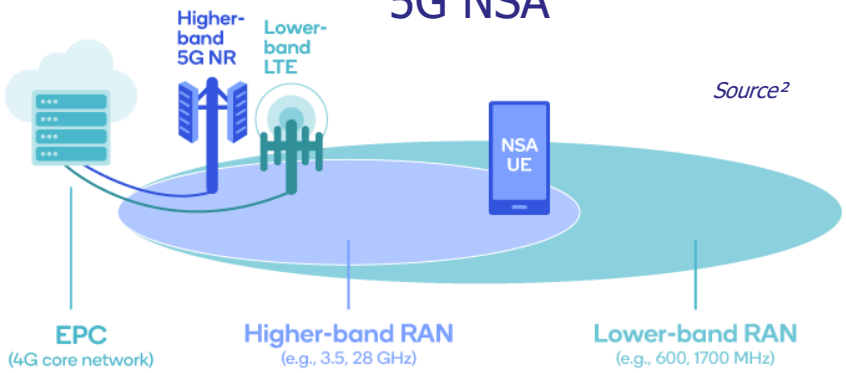
5G NSA



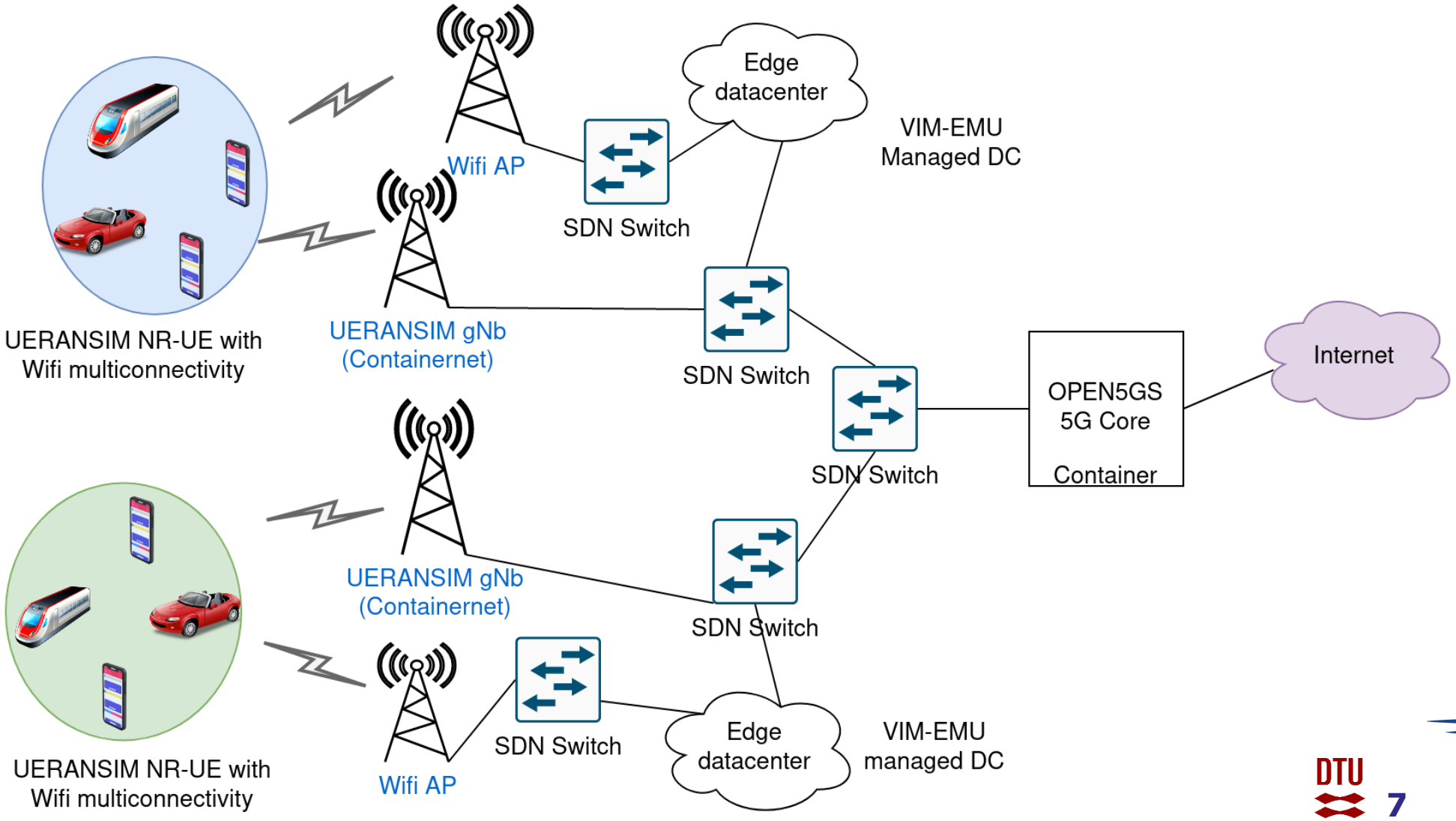
Source[2]

1 - https://www.everythingrf.com/community/what-is-standalone-5g
2 - https://www.everythingrf.com/community/what-is-non-standalone-5g

Emu5GNet Architecture and components

- **Mininet Wifi and Containernet**
  - Wired & Wireless SDN network emulation, Docker containers as hosts
- **Vim-emu**
  - Based on Containernet and designed for NFV platform emulation (prototyping, testing, and beyond)
- **UERANSIM**
  - Open source state-of-the-art 5G UE and RAN (gNodeB) simulator
- **Open5GS**
  - Open source implementation for 5G Core and EPC
- **SUMO**
  - Allows modelling of intermodal traffic systems including road vehicles, public transport and pedestrians

Emu5GNet Architecture and components

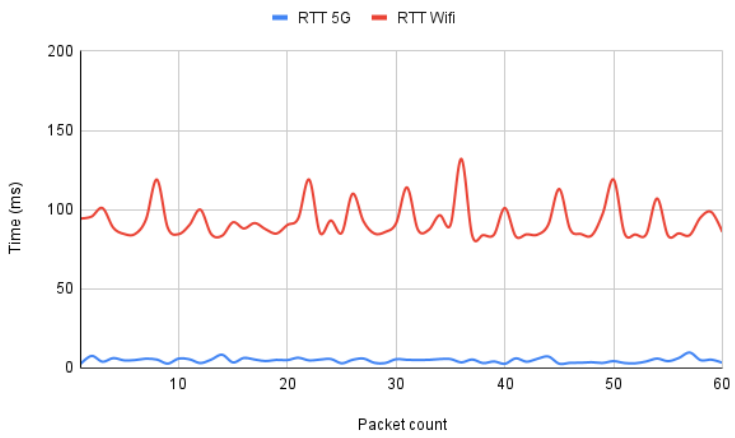


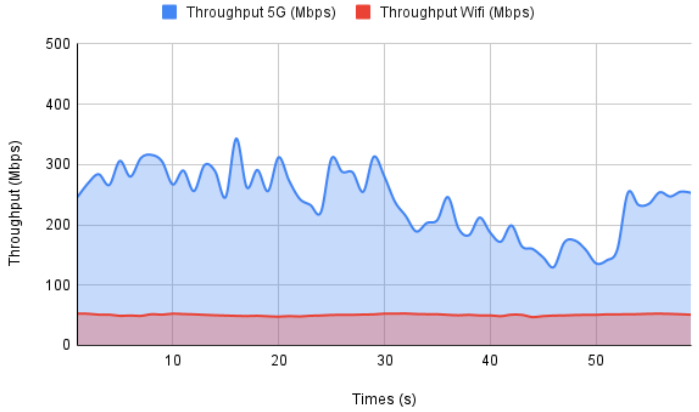
Uses cases

- **Research on 5G communications performance :**
  - End to end delay, slicing, throughput under high mobility
- **Research on multi-Radio Access Technologies architectures**
  - Multi-connectivity in vehicular and train networks (5G, LTE, Wifi and ITS-G5)
- **Research on Edge data centers management for 5G networks**
  - Edge server placement, management and performance evaluation
- **Research on 5G, SDN-based and NFV-based architectures**
  - Realistic edge services orchestration for 5G networks : Augmented reality, artificial intelligence service, CDNs (Content Delivery Networks) and content caching
  - IoT edge services orchestration based on mobility

Use case : Trains and Cars communications coexistence in 5G

- **Simple scenario based on SUMO simulator :**
  - ✓ 3 km^2 map, we considered a variable number of cars (random trip) and a dozen of trains
  - ✓ Each node generating constant volumes of data (iperf) and connected to 17 access points (5G + Wi-Fi 802.11n) uniformly distributed on the map.
  - ✓ Three edge data centers are distributed on the map.
  - ✓ Data generated by vehicles is automatically transmitted to the nearest data center.





Open questions

- **How to overcome emulator host performance issues ?**
  - Docker bottleneck
  - Mininet performance issues when nodes numbers increase.
    - How to use cluster in such environment ?
- **How is managed multiple interconnected 5G networks ?**

- **How to manage 5G UE external to emulator platform ?**

Thanks for your attention.

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