

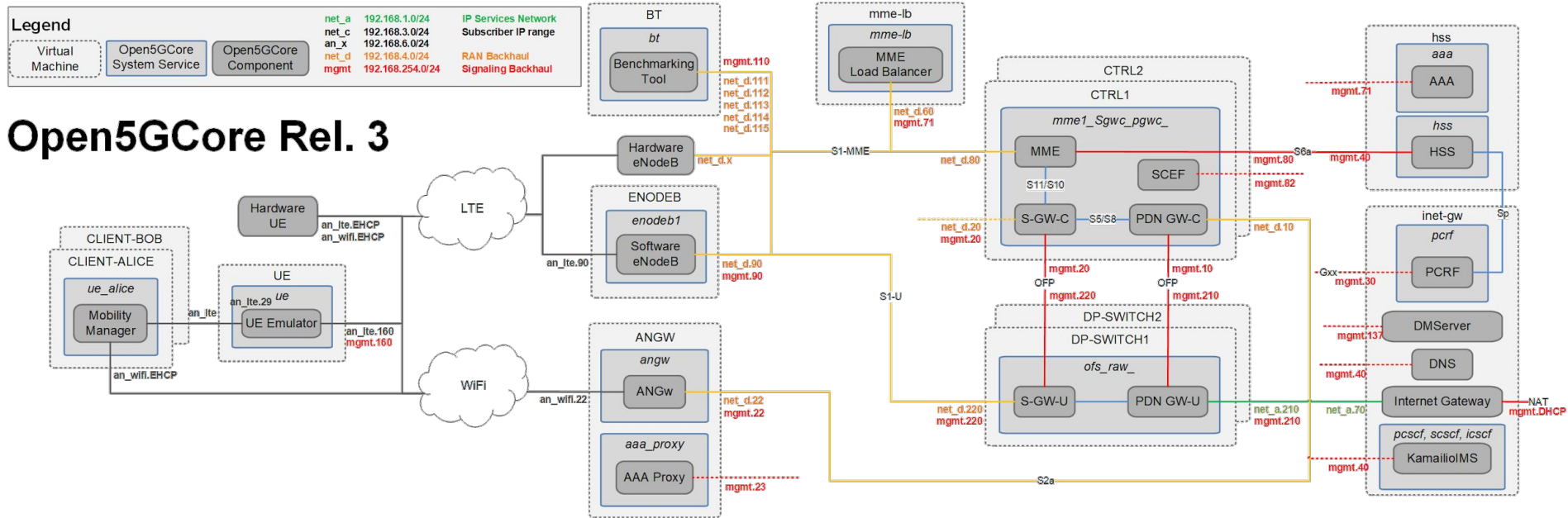


## Fraunhofer Fokus Open5GCore

# Testbed Initiatives

- ▶ We are involved in the establishment of a 5G research testbed.
- ▶ This work is done in collaboration with the CSIR, and the FOKUS Fraunhofer NGNI (Software Based Networks) group.

# Complete Architecture

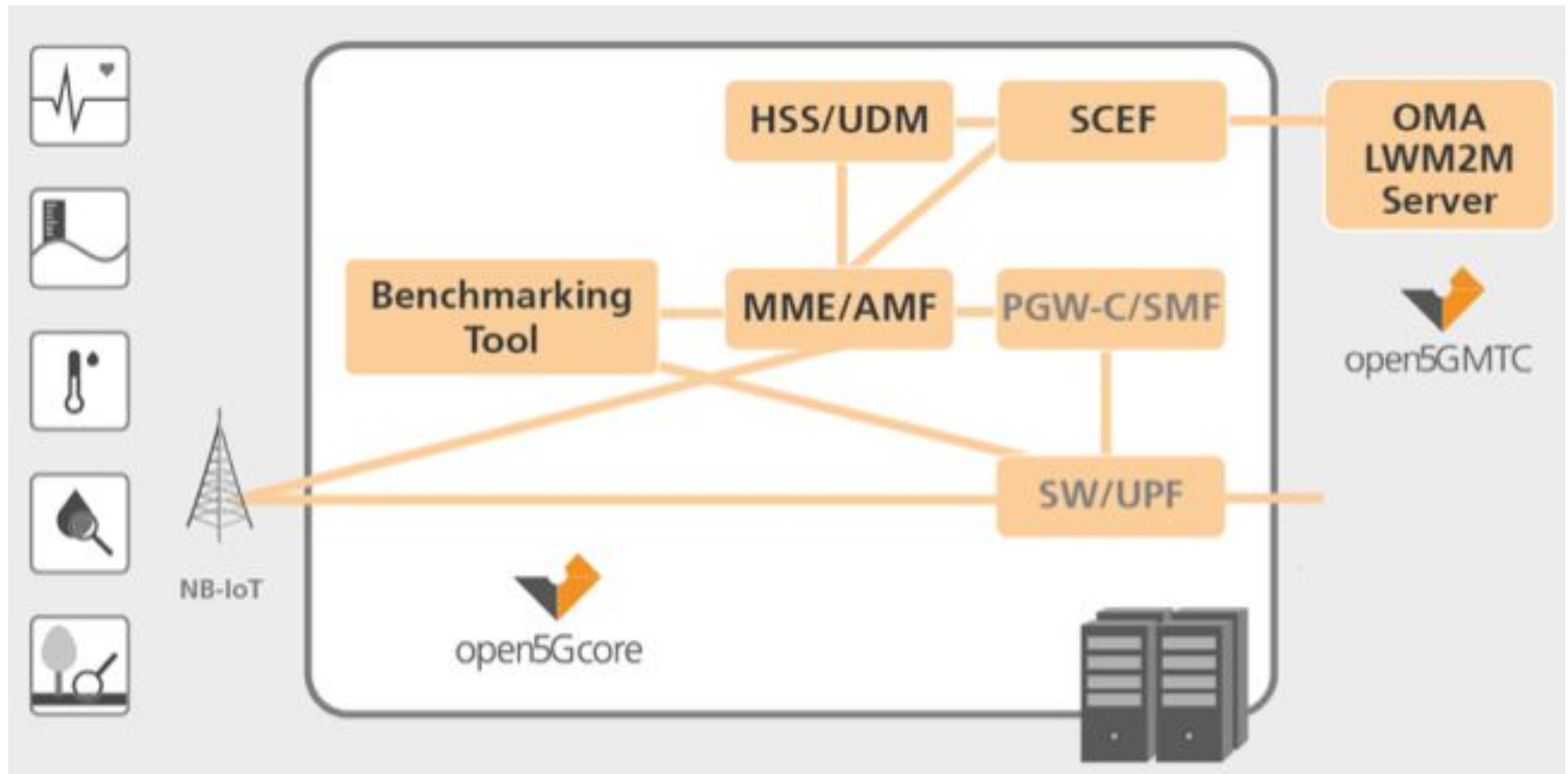


# System Features

- ▶ Narrow Band –IoT
- ▶ Benchmarking tool and GUI
- ▶ MME–Load Balancer
- ▶ SIM Provisioning + supported phones
- ▶ IP Multimedia Subsystem (IMS)
- ▶ UE Mobility Enabler
- ▶ Multiple Deployment Options
- ▶ Interfacing with Access networks

# NB-IoT

The Open5GCore first version prototype of the NB-IoT 3GPP Release 14 optimization for CIoT networks



# NB-IoT

- ▶ A configuration between the OMA LWM2M Server, SCEF and HSS in order to exchange necessary configuration information
- ▶ Up to 500 emulated devices are connecting to the NB-IoT Open5GCore core network with PDN type of “Non IP” for establishing the connection with the SCEF
- ▶ Sensors continuously send non ip data with temperature information to the OMA LWM2M Server that monitors the received values
- ▶ When alarm is detected all the connected devices are immediately notified about the situation of current alarm

# NB-IoT

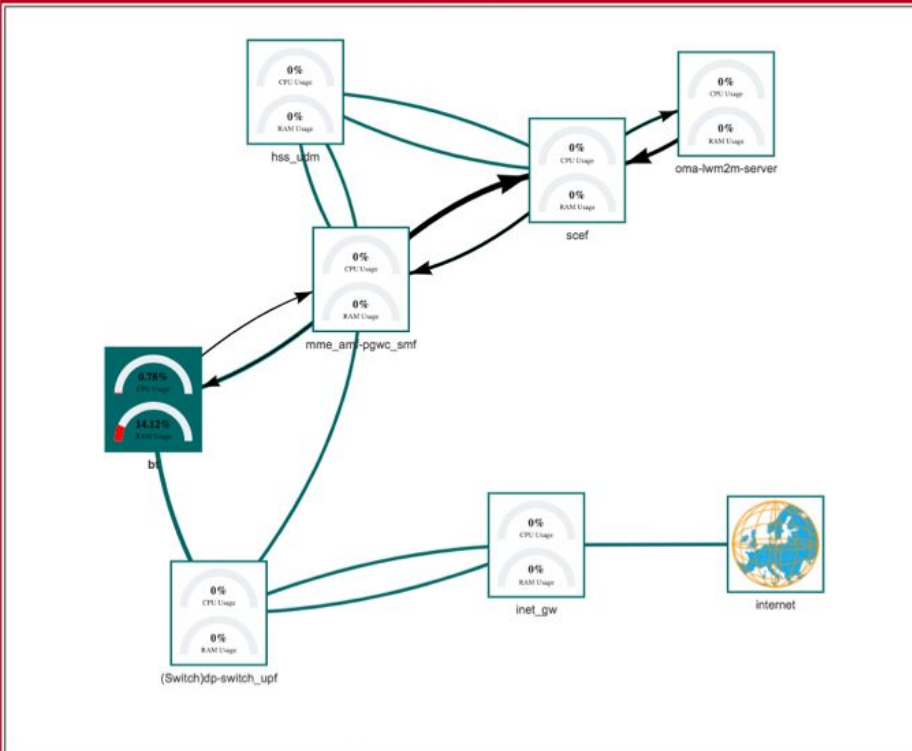
- Open5G GUI
- Infrastructure
- Load Static Topology
- Load Topology from Backend
- Dashboard Settings



Datacenter View / Slice View

Slice Visualization Time Series Massive IoT Emulation

MIoT\_NB\_slice



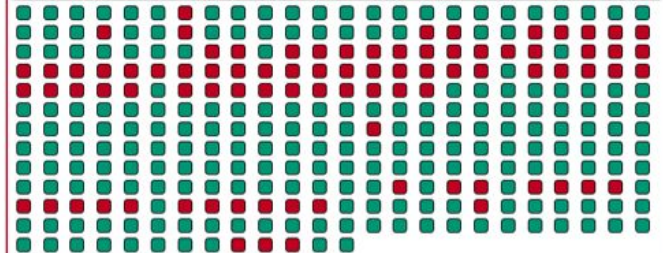
Export CSV Data Import CSV Data Show Relations Show Flowmon

Time Series Pie Diagram



Benchmark Massive IoT

Total number of registered clients: 301



Temperature Threshold: 80



# Benchmarking Tool

**Benchmark**

**Status**  
**Start**

	<b>Attach</b>	<b>Detach</b>	<b>Handover</b>	<b>TAUs</b>	<b>Paging</b>	<b>Idle</b>	<b>Traffic</b>
<b>Duration</b>						13	
<b>Ops per Second</b>							10
	30	20	50	10	20	0	0

**NB-IoT Sensors**

Value	No. of Requests	Operations/sec	NB-IoT MO Data	Enabled
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The screenshot displays a benchmarking tool interface. At the top, there is a 'Benchmark' tab and a 'Status' section with a green 'Start' button. Below this, a table lists seven operations: Attach, Detach, Handover, TAUs, Paging, Idle, and Traffic. Each operation has a numerical value in a box above a vertical slider. The 'Duration' and 'Ops per Second' are also shown as numerical values in boxes. At the bottom, there is an 'NB-IoT Sensors' section with five buttons: 'Value', 'No. of Requests', 'Operations/sec', 'NB-IoT MO Data', and 'Enabled'.

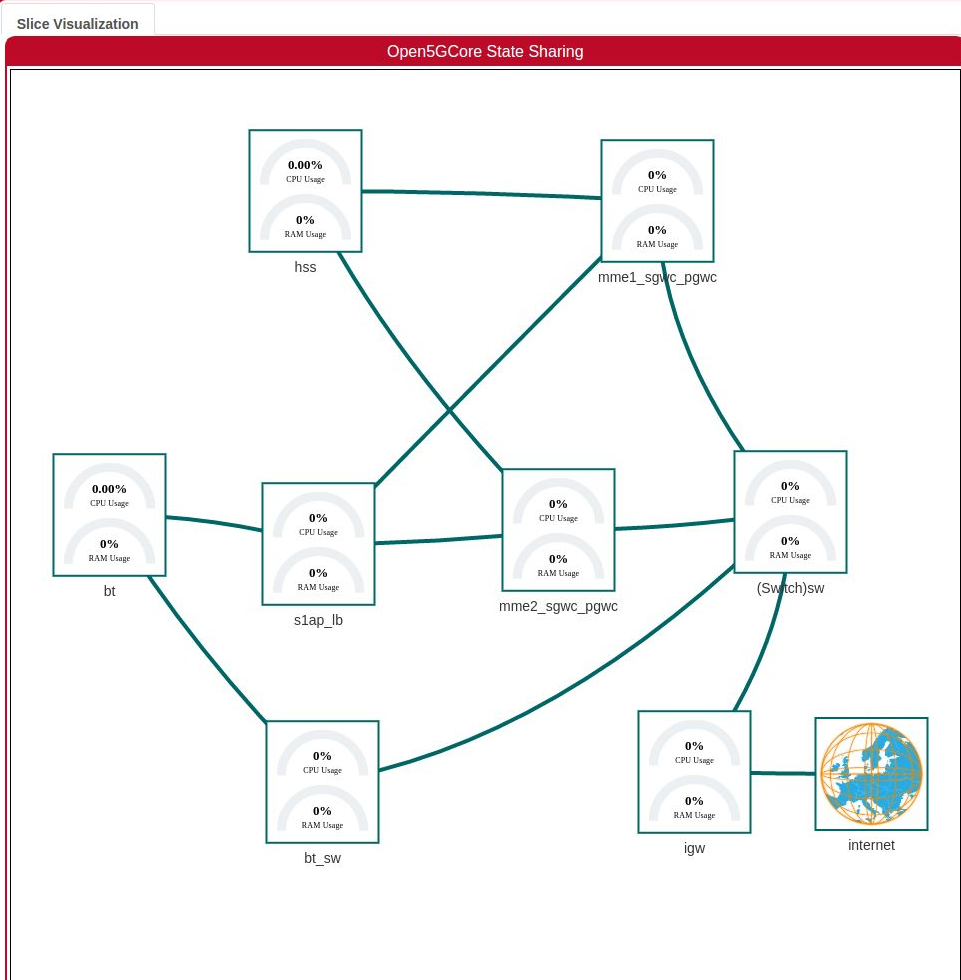


# Open5GCore S1-Load Balancing

- HSS: connected to both MMEs
- MME1: where the Redis server is running
- MME2: can be hot standby copy or active component
- S1AP-LB: a round robin mechanism is used for the dispatch of the requests
- SWICTH1: connected to both MME controllers
- BT: emulates five EnBs and up to 1000 UEs
- BT-OFS: used for traffic generation

- Infrastructure
- Load Static Topology
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Datacenter View / Slice View



**Time Series** | [Pie Diagram](#)

**Benchmark**

Status: Start

	Attach	Detach	Handover	TAUs	Paging	Idle	Traffic
Value	30	20	50	10	20	0	0

Duration: 13 | Ops per Second: 10

**NB-IoT Sensors**

Value	No. of Requests	Operations/sec	NB-IoT MO Data	Enabled
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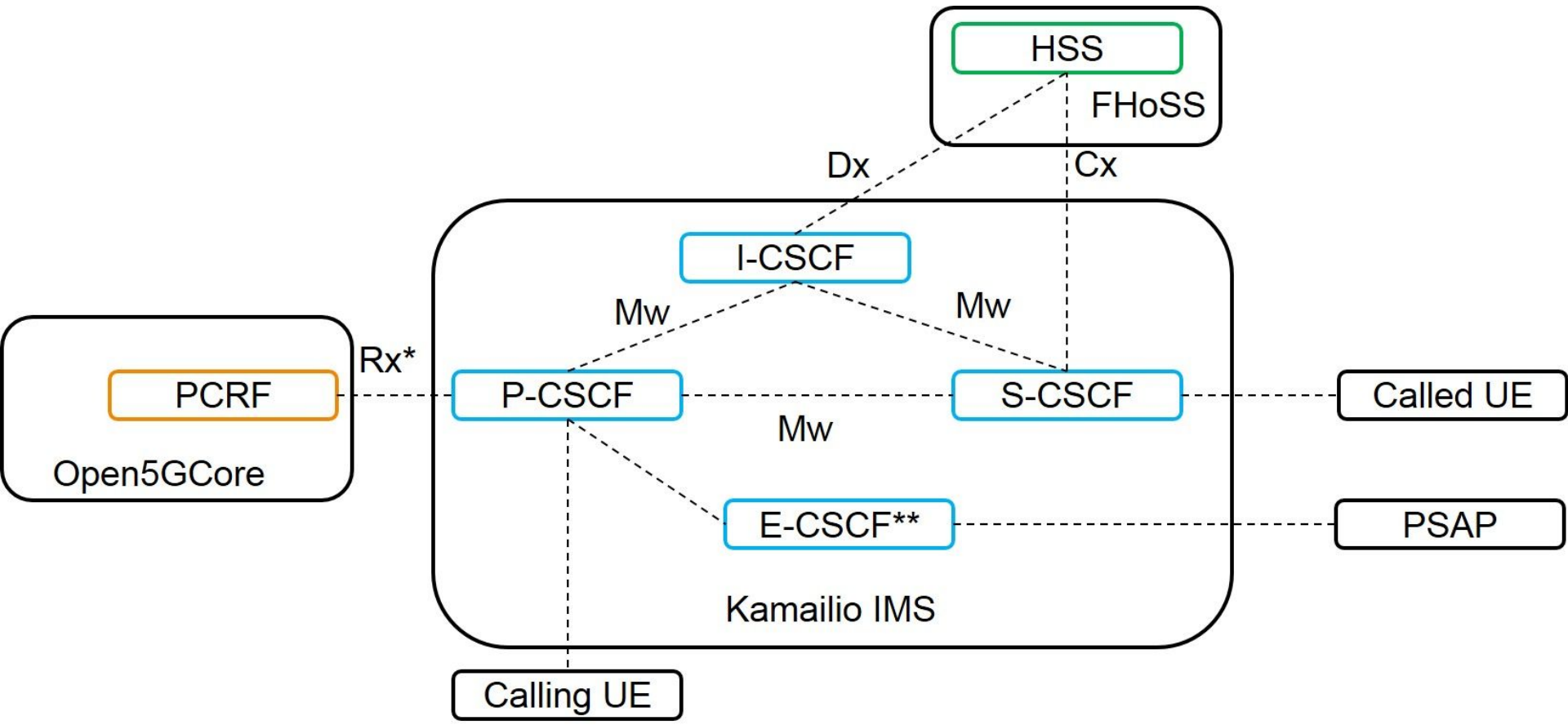
Export CSV Data | Import CSV Data | Show Relations | Hide Flowmon

# Showcasing with Real Devices

Mobile phones or SIM enabled IoT devices




- ▶ ICCID = integrated circuit chip ID [can be any 19 digit number]
- ▶ IMSI = International Mobile Subscriber Identity [mcc+mnc+number]
- ▶ K = user specific Key
- ▶ OP = Operator Key (on the sim the OPc) is stored
- ▶ OPc = Crypted Operator Key
- ▶ SQN = Authentication Sequence number (values in HSS and USIM need to match)

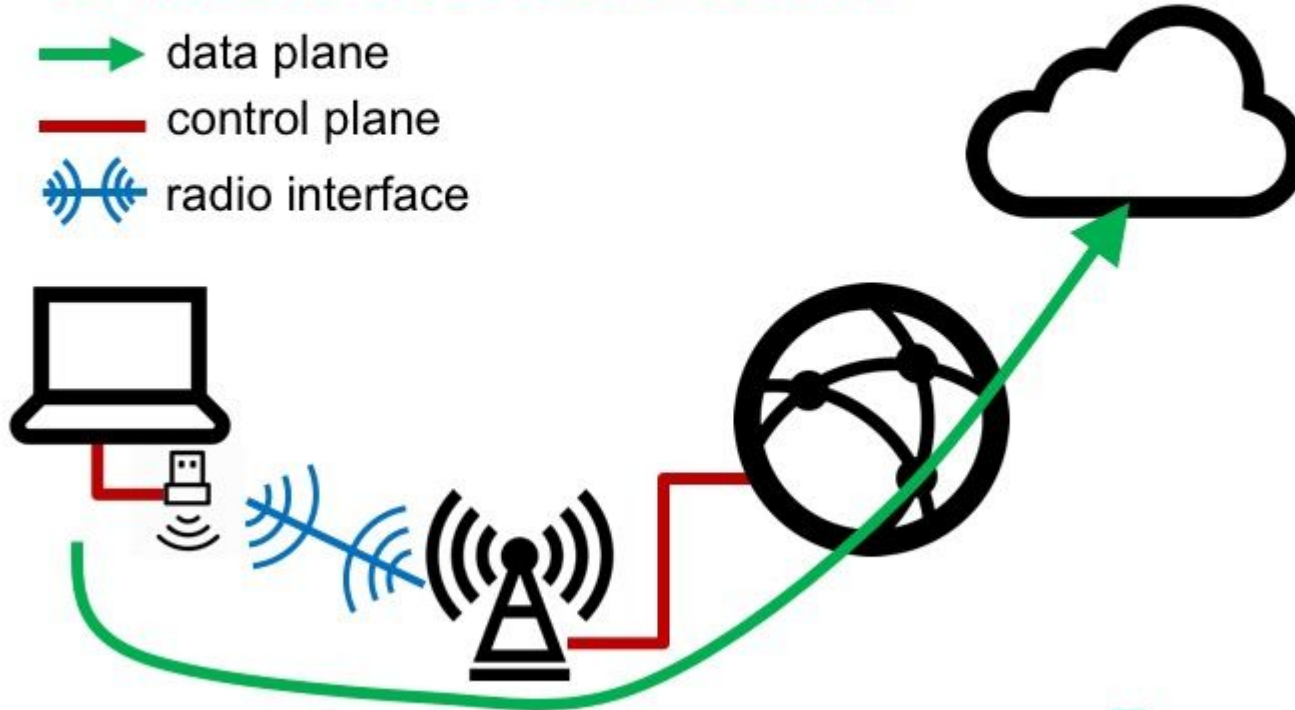
# IP Multimedia Subsystem Integration



# UE Mobility Enabler

## Connection to a Core Network

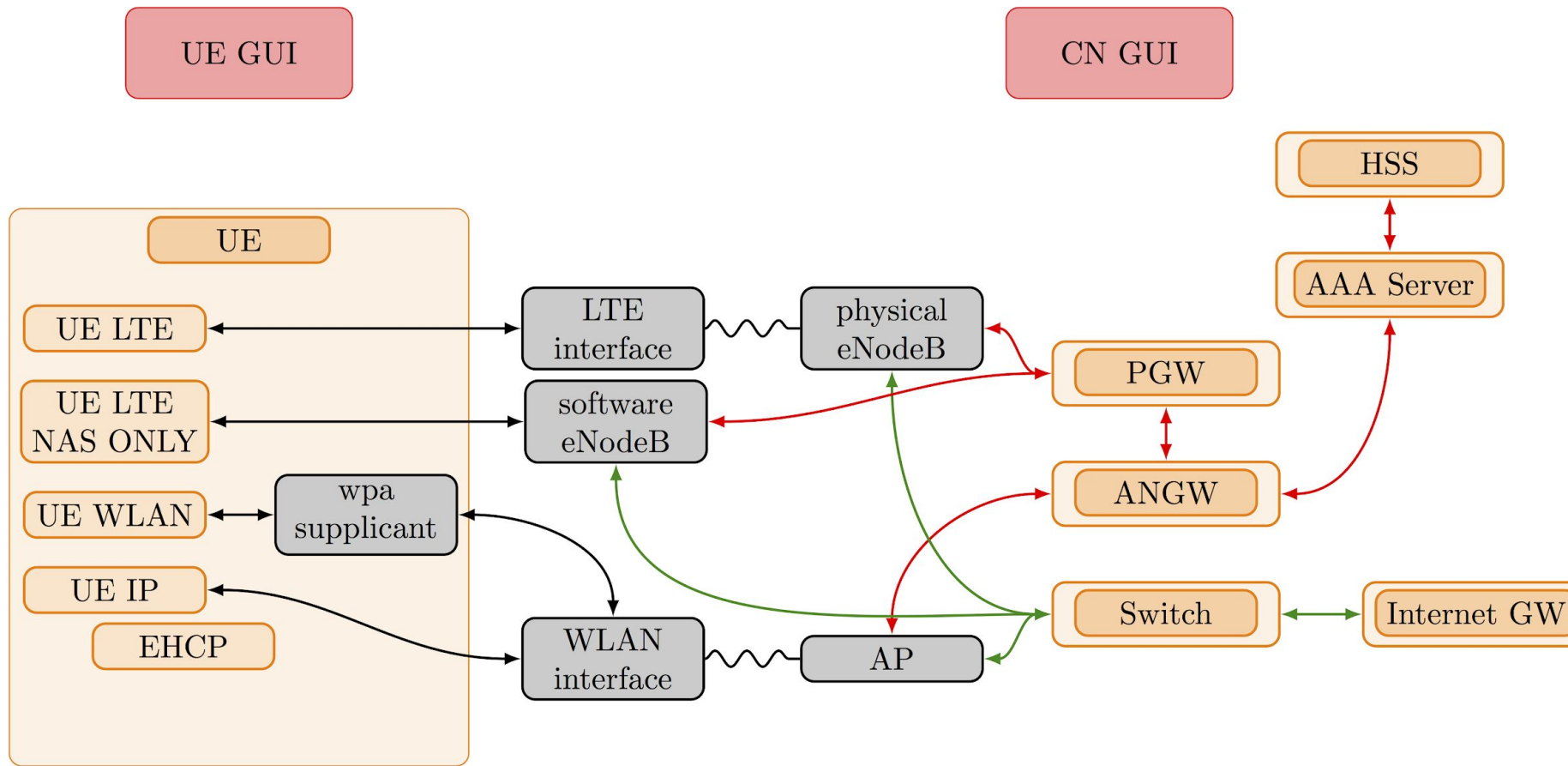
-  data plane
-  control plane
-  radio interface



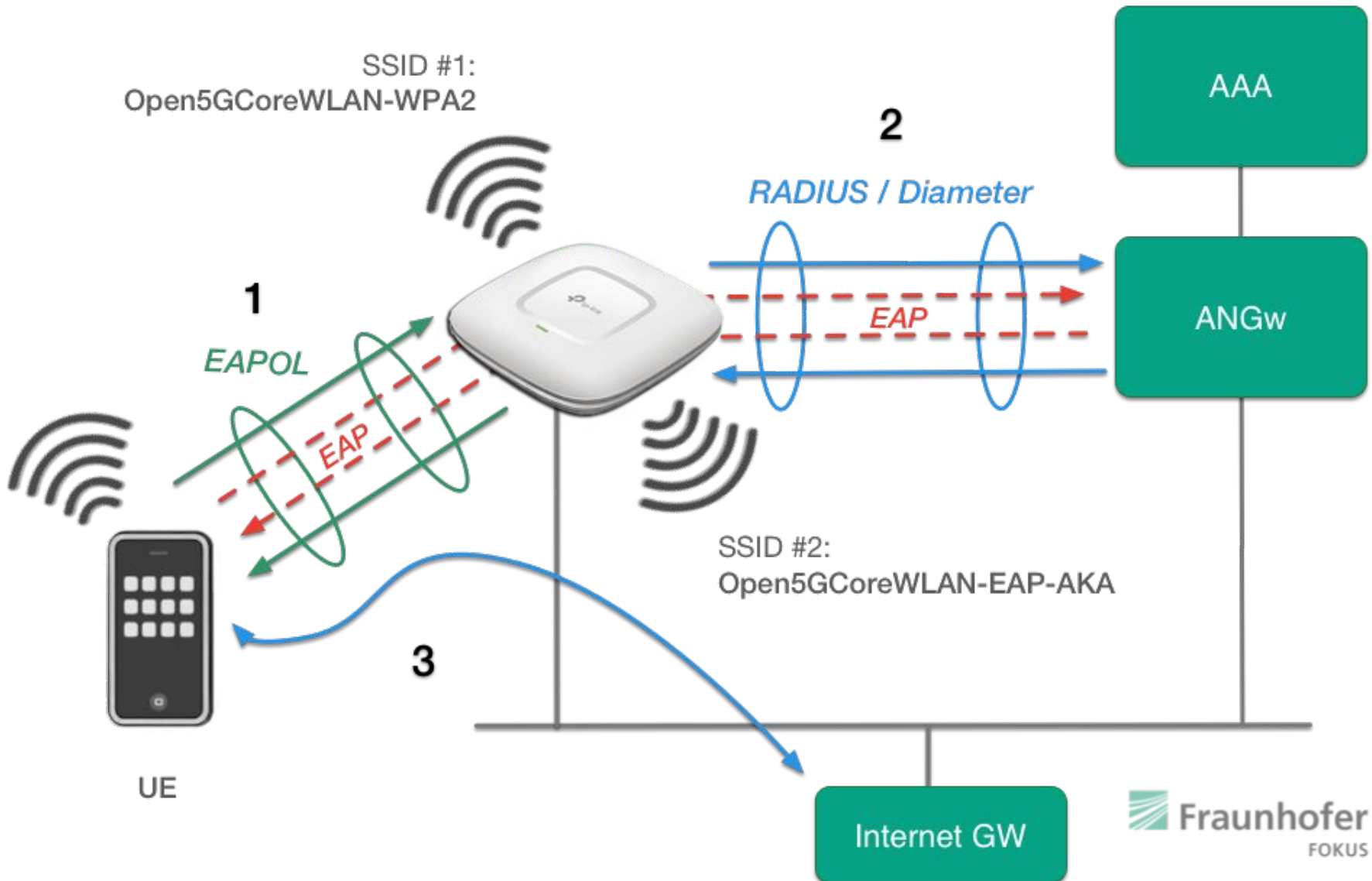
# UE Mobility Enabler

- ▶ Besides connect and disconnect functions, UE Mobility Enabler features frequent signal quality updates on radio quality.
- ▶ Supported access types are LTE (ue\_lte), WLAN (ue\_wlan) and LTE on top of IP (lte\_nas\_only).
- ▶ Usability of UE Mobility Enabler is ensured by the developed UDP interface to Web GUI.

# UE Mobility Enabler

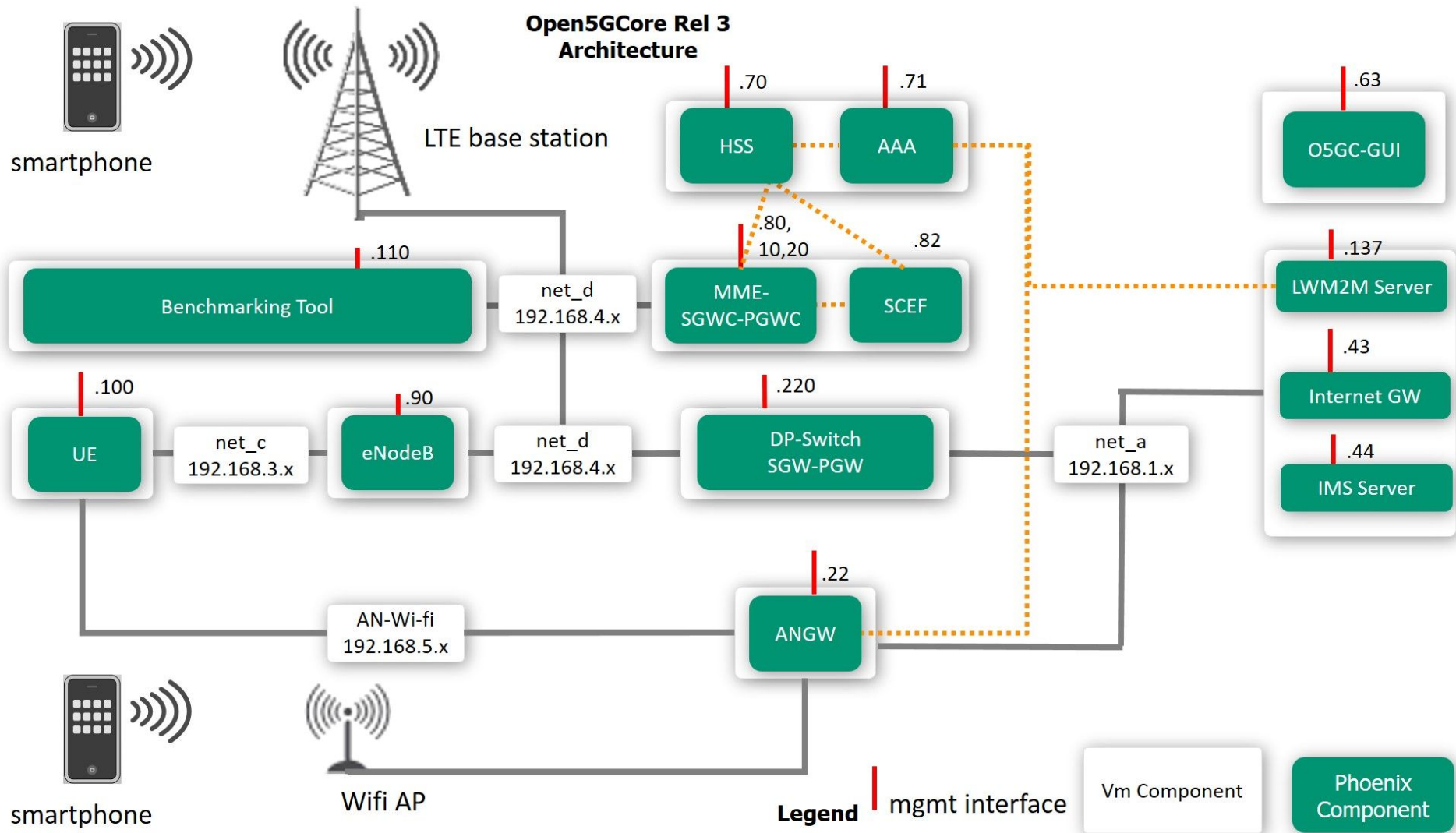


# UE Mobility Enabler





# Deployment Options



# Deployment Options

- ▶ Each function a virtual machine
  - KVM
  - VMWARE
  - OpenStack
- ▶ Each function a physical machine
- ▶ All in one setup (in one virtual machine)
  - linux containers
  - namespaces and cgroups
  - docker containers
- ▶ Can even be deployed on a raspberry pi

# Integration with Real Access

- ▶ Nokia Airscale Base Station
- ▶ Nokia Femto Cells
- ▶ OpenAir Interface



Thanks for listening!