

# How to build your own mobile network

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# INTERNET INSTITUTE Ltd.

- Startup from Ljubljana, Slovenia
- Established in 2014
- Expertise
  - development, deployment and operation of a telco grade Quality Assurance (QA) and monitoring systems
- 2 focus areas
  - Quality assurance of mobile, fixed and cloud systems
  - Solutions for IoT based critical communications (PPDR)



[www.matilda-5g.eu](http://www.matilda-5g.eu)



[5ginfire.eu](http://5ginfire.eu)



# qMON – quality Monitoring

Quality assurance of mobile, fixed and cloud systems – 5G, PPDR

- QoS/QoE measurement and monitoring solution for real-time telco-grade environments
- End-to-end performance assessment and validation of networks, services and apps

# iMON – intervention Monitoring

Intervention monitoring and critical communications – PPDR

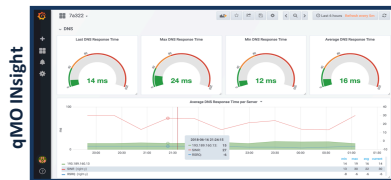
- Common operational picture in real time
- IoT-supported intervention management tools, on-site sensing and tracking
- Survivable, scalable and robust communications from the field

Measurement Agent Deployment in Mobile, Fixed and Cloud

qMON NetworkSensor



Real Time Analysis

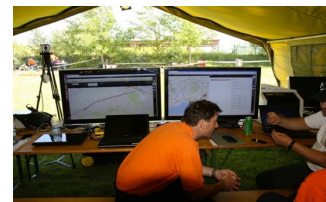
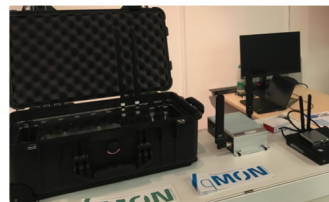
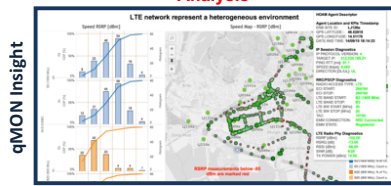


Centralize Results Data Storage

qMON Collector



Advanced Data Analysis

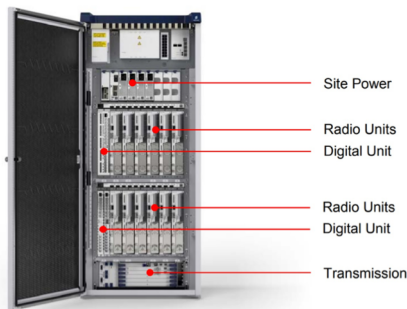


# Mobile network components – Heavyweight

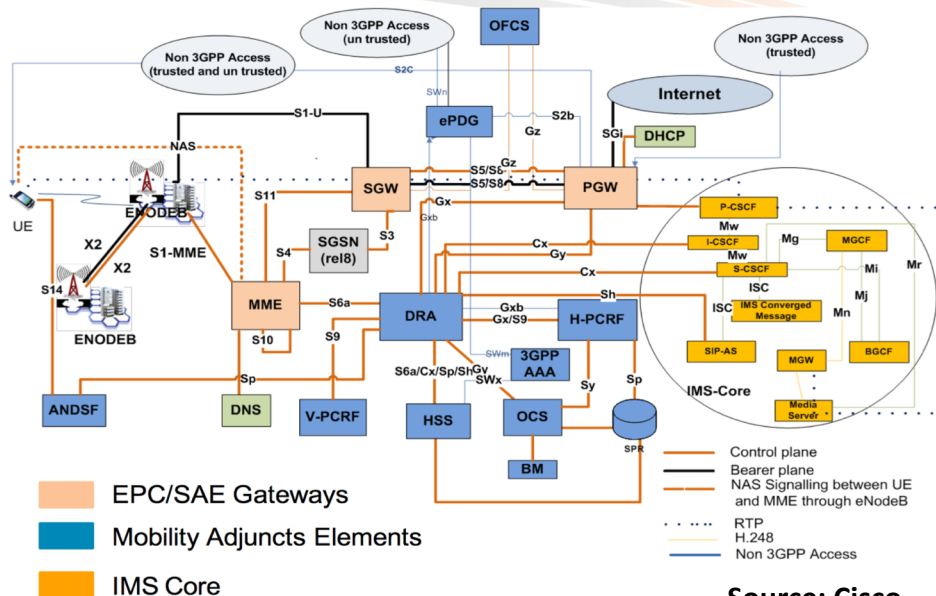
Source: Huawei



Source: Ericsson



## Typical LTE/EPS Architecture – 1,000 Ft View



Source: Cisco

Source: Cisco



Source: Nokia



Vodafone Italia and Telecom Italia each spent €2.4 billion to grab the largest share of spectrum on offer in an Italian auction of 5G-suitable frequencies, which raised €4 billion more than the minimum amount targeted by the government.



# Mobile network components – Lightweight

- LTE base station
  - SDR Radio, eNb SW (femto site)
  - BBU with CPRI & RRH, eNb SW (macro site)
- EPC mobile core
  - EPC SW
- OpenStack based IaaS
  - KVM virtualization
- OSM 4|5 for network orchestration
- Compute power
  - "at least" Intel Core i7-7700K CPU @ 4.20GHz





# PPDR ONE Facility

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**5G/NFV enabled development, testing and verification facility for experimentation with 5G network architectures and services for Public Protection and Disaster Relief (PPDR)**



CONSORTIUM

# 5G-ORIENTED EXPERIMENTAL PLAYGROUND FOR VERTICAL INDUSTRIES

- H2020 EU project, GA no. 732497
- Time frame: 1.1.2017 - 31.12.2019
- Open calls: <https://5ginfire.eu/open-calls/>
- Info: [www.5ginfire.eu](http://www.5ginfire.eu)



University of São Paulo  
Brazil



uc3m | Universidad Carlos III de Madrid



# PPDR ONE Facility Features

- **PPDR ONE stationary mobile system**

- **Indoor experimentation site**

- laboratory-based testing in all LTE/4G operational frequencies from 70 MHz up to 6 GHz

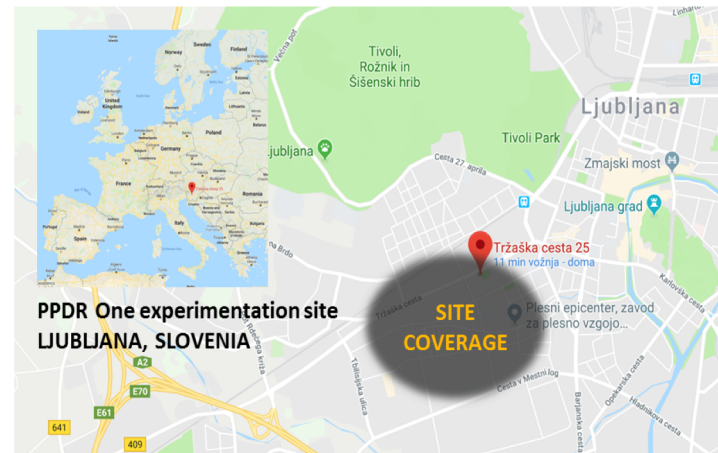
- **Outdoor experimentation site**

- field operation in the 5G pioneering band (3.6 GHz, 5G band n78) and 4G band (3.6 GHz, b42)

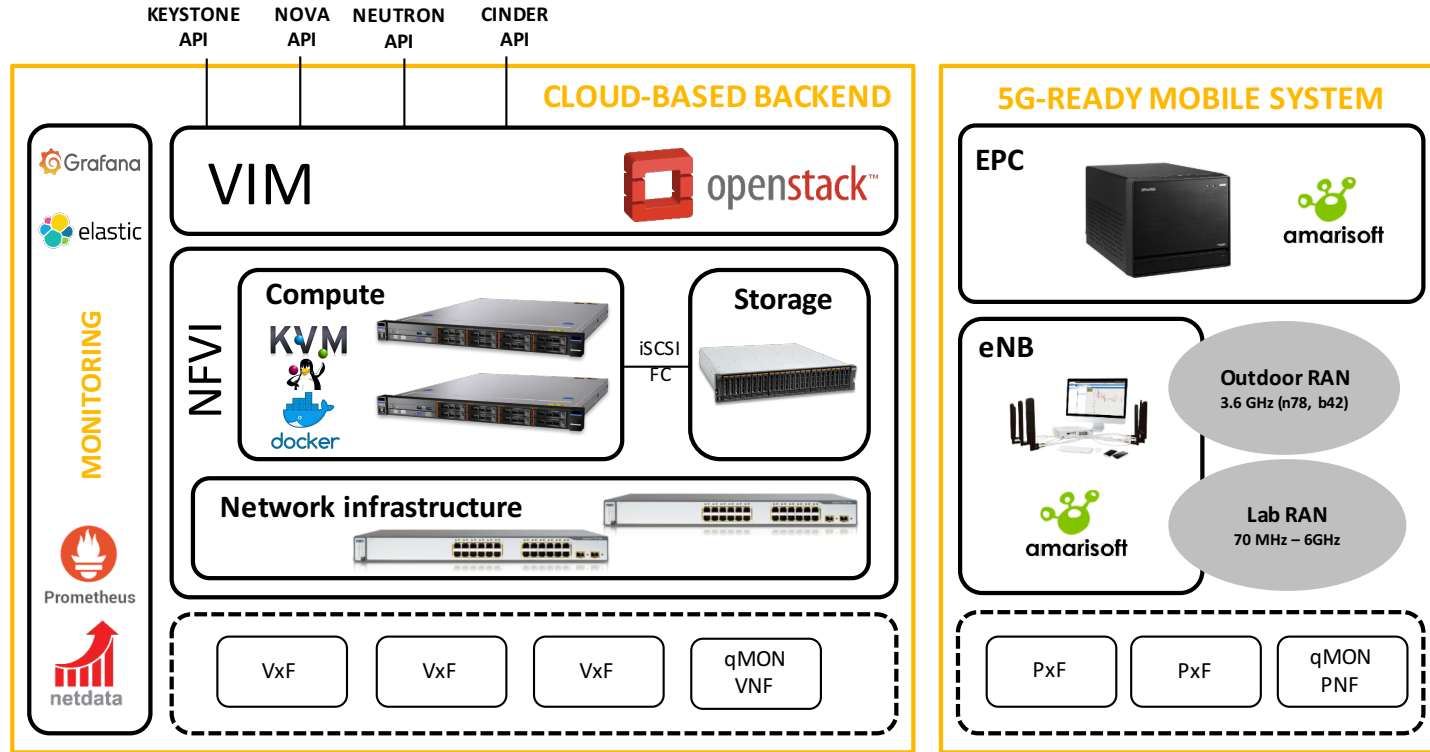
- **PPDR ONE portable mobile node**

- **A portable compact mobile system**

- can be shipped and deployed on the experimenter's test site
    - covering indoor scenarios (bands from 70 MHz and up to 6.0 GHz) and field operation

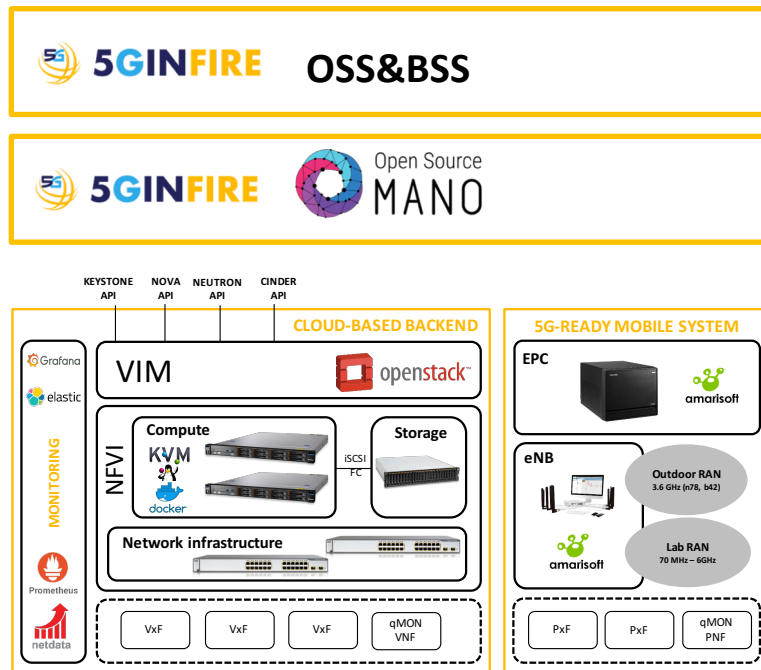


# PPDR ONE Facility Overview



# PPDR ONE Facility Overview

- 5G-ready mobile system
  - SDR-based eNb and virtual EPC
- OpenStack-based IaaS backend
- PPDR apps, demonstration and user/IoT devices
  - iMON: PPDR services toolset for demonstration and evaluation
  - rMON: IoT based remote measurement automation system
- Network and services testing toolset
  - qMON: Network and service testing, verification and benchmarking toolset

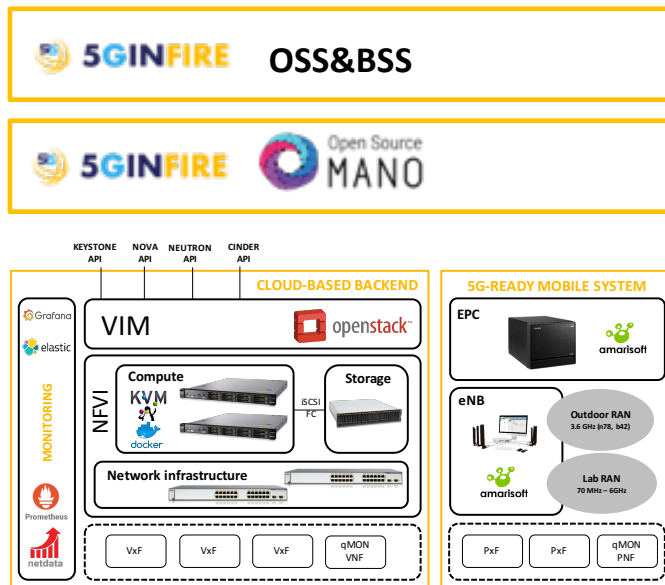




# 5G-ready Mobile System

## 5G-ready mobile system (indoor/outdoor)

- SDR-based mobile system (Rel.14)
- 5G NSA operation planned, pending vendor SW release and support
- Support for: LTE, LTE-Advanced, NB-IoT, LAA
- Supported mobile radio frequencies, from 70 MHz and up to 6.0 GHz including PPDR band 700 Mhz<sup>1</sup>
- flexible RF channel bandwidth from 200 kHz (NB-IoT) and up to 56 MHz
- Up to 3 x carrier aggregation
- Supported services: EPC, eMBMS and VoLTE



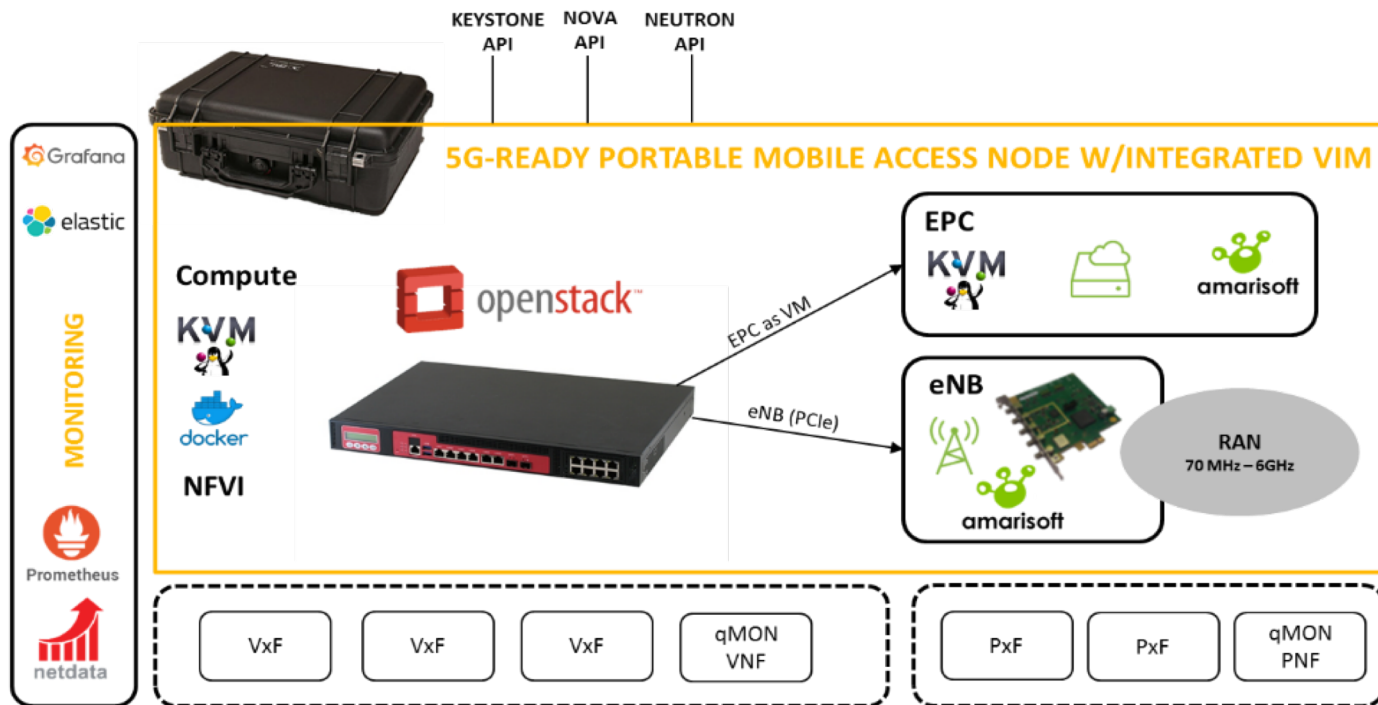
# OpenStack based IaaS

## OpenStack-based IaaS backend

- CPU: 80 x CORE (Intel(R) Xeon(R) CPU series)
- Memory: 256 GB RAM
- Storage: Up to 10 TB SAN (iSCSI/FC)
- Virtualization: KVM-based
- Openstack version: Queens (updated at regular intervals, 3 months after release)
- Openstack services: Keystone v3, Nova, Neutron, Cinder, Glance
- Openstack networking: provider and self-service
- Container support: Docker, LXD/LXC



# Compact PPDR ONE node



# Compact PPDR ONE node

## Compact portable PPDR ONE node

- Compact portable 5G-ready mobile radio, core and cloud node to be deployed in the field
- Includes all 5G-ready mobile system capabilities, with supported mobile radio frequencies from 70 MHz and up to 6.0 GHz
- Includes all OpenStack-based IaaS backend capabilities, with internal storage only
- Prepared for in-vehicle and field use, ruggedized



# User/IoT devices

## User terminals and IoT devices

- Commercial and Ruggedized Android mobile phones with dual USIM capabilities
- Ruggedized industrial platforms (Advantech ARK and Beagle board) with mobile radio support (LTE/LTE-A/LTE-A Pro, NB-IoT) for deployment of experimenters' docker containers
- Wearable cameras and vital signs sensors
- Environmental sensors (water level)

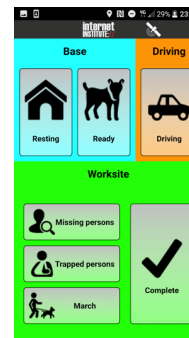
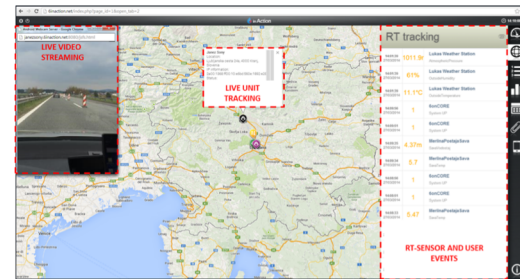


# PPDR services toolset

## PPDR services toolset for demonstration and evaluation

iMON Intervention Monitoring solution = services and apps for intervention monitoring and filed operations; developed in tight cooperation with PPDR end-users (TRL8)

- Common operational picture (with a dashboard)
- Real-time video streaming
  - o from body worn cameras
  - o from drones
- Unit and asset tracking services
- Environmental monitoring/sensing (water level)
- Filed reporting services





# Network & service testing

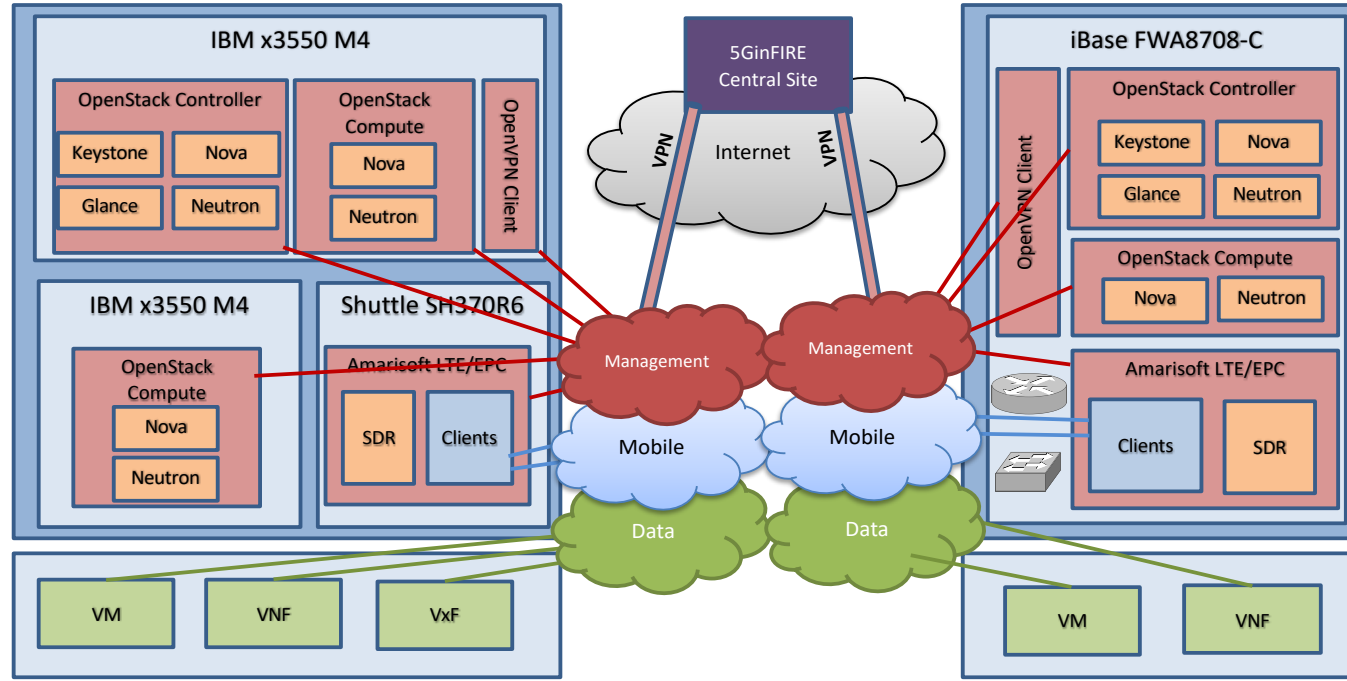
## Network and service testing, verification and benchmarking toolset

qMON Intervention Monitoring solution = telco-grade 5G-ready measurement automation system for mobile, fixed and cloud environments (TRL9)

- Probes, management backend and analytics tools
- Live network and service tests/troubleshooting
- Real-time performance and SLS/SLA monitoring
- Drive and benchmark testing for broadband PPDR networks (LTE/4G and 5G)
- PPDR network coverage and mission critical application performance assessment
- QoE/QoS prediction in live BB PPDR networks



# Integration into 5GINFIRE



# Integration into 5GINFIRE

- PPDR ONE: VIM and NFVI provider
- Secure VPN connection (e.g., site-to-site IPsec) with the 5TONIC core site
- MANO connects to PPDR ONE VIM via the OpenStack APIs
- The EPC/eNB provisioning via predefined mobile profiles
- different frequency bands, bandwidth, QoS profiles
- Selection of mobile profiles to be integrated into the 5GINFIRE portal to enable remote on-demand 5G slice provisioning for the experiments
- Compute monitoring (e.g. CPU/RAM) and network monitoring (e.g. RTT, DL/UL speed) will be offered as a cloud-based service in Grafana/Kibana

# PPDR ONE is operational!



# Mobile System Performance



**Max speed 354 Mbps**  
**Cat18 Mobile**  
**3 x LTE CA**  
**BW 55 Mhz**

# Mobile System Debugging

← → ↻ Not Secure | 10.154.105.75/ite

Amarisoft LTE Web GUI 2019-02-05

Log: 5194 Client Stats

URL Add server Load file Export

Time origin: 0:00:00.000 Group UE ID:

Search

| Time         | Diff   | ENB  | MME | UE ID | Info | Message                                      |
|--------------|--------|------|-----|-------|------|--|
| 17:39:53.574 | +1.880 | RRC  |     | 104   | CCCH | RRC Connection Request                       |
| -            | -      | RRC  |     | 104   | CCCH | RRC Connection Setup                         |
| 17:39:54.043 | +0.469 | NAS  |     | 100   | EMM  | Attach request                               |
| -            | -      | NAS  |     | 100   |      | EPS encryption caps=0xf0 integrity caps=0xf0 |
| -            | -      | NAS  |     | 100   |      | GUTI not found                               |
| -            | -      | NAS  |     | 100   | EMM  | Identity request                             |
| -            | -      | RRC  |     | 104   | DCCH | RRC Connection Setup Complete                |
| -            | -      | NAS  |     | 104   | EMM  | Attach request                               |
| -            | -      | SIAP |     |       |      | 127.0.1.100:36412 Initial UE message         |
| -            | -      | SIAP |     |       |      | 127.0.1.1:33081 Initial UE message           |
| -            | -      | NAS  |     | 100   | EMM  | Attach request                               |
| -            | -      | NAS  |     | 100   |      | EPS encryption caps=0xf0 integrity caps=0xf0 |
| -            | -      | NAS  |     | 100   |      | GUTI not found                               |
| -            | -      | NAS  |     | 100   | EMM  | Identity request                             |
| -            | -      | SIAP |     |       |      | 127.0.1.1:33081 Downlink nas transport       |
| 17:39:54.044 | +0.001 | SIAP |     |       |      | 127.0.1.100:36412 Downlink nas transport     |
| -            | -      | NAS  |     | 104   | EMM  | Identity request                             |
| -            | -      | RRC  |     | 104   | DCCH | DL Information Transfer                      |
| 17:39:54.067 | +0.023 | NAS  |     | 100   | EMM  | Identity response                            |
| -            | -      | NAS  |     | 100   | EMM  | Authentication request                       |
| -            | -      | RRC  |     | 104   | DCCH | UL Information Transfer                      |
| -            | -      | NAS  |     | 104   | EMM  | Identity response                            |
| -            | -      | SIAP |     |       |      | 127.0.1.100:36412 Uplink nas transport       |
| -            | -      | SIAP |     |       |      | 127.0.1.1:33081 Uplink nas transport         |
| -            | -      | NAS  |     | 100   | EMM  | Identity response                            |
| -            | -      | NAS  |     | 100   | EMM  | Authentication request                       |
| -            | -      | SIAP |     |       |      | 127.0.1.1:33081 Downlink nas transport       |
| 17:39:54.068 | +0.001 | SIAP |     |       |      | 127.0.1.100:36412 Downlink nas transport     |
| -            | -      | NAS  |     | 104   | EMM  | Authentication request                       |
| -            | -      | RRC  |     | 104   | DCCH | DL Information Transfer                      |

MME Group ID = 32769  
MME Code = 1  
M-TMSI = 0xb323db61

UE network capability:  
0xf0 (EIA0=1, 128-EIA1=1, 128-EIA2=1, 128-EIA3=1, EIA4=0, EIA5=0, EIA6=0, EIA7=0)  
0xf0 (EIA0=1, 128-EIA1=1, 128-EIA2=1, 128-EIA3=1, EIA4=0, EIA5=0, EIA6=0, EIA7=0)  
0xc0 (UEA0=1, UEA1=1, UEA2=0, UEA3=0, UEA4=0, UEA5=0, UEA6=0, UEA7=0)  
0x40 (UCS2=0, UIA1=1, UIA2=0, UIA3=0, UIA4=0, UIA5=0, UIA6=0, UIA7=0)  
0x10 (ProSe-dd=0, ProSe=0, H.245-ASH=0, ACC-CSFB=1, LPP=0, LCS=0, 1xSRVCC=0, NF=0)

ESM message container:  
Protocol discriminator = 0x2 (EPS Session Management)  
EPS bearer identity = 0  
Procedure transaction identity = 1  
Message type = 0xd0 (PDN connectivity request)  
Request type = 1 (initial request)  
PDN type = 1 (IPv4)  
ESM information transfer flag = 1  
Protocol configuration options:  
Ext = 1  
Configuration protocol = 0  
Protocol ID = 0x8021 (IPCP)  
Data = 01 00 00 10 81 06 00 00 00 83 06 00 00 00 00  
Protocol ID = 0x000d (DNS Server IPv4 Address Request)  
Data =  
Protocol ID = 0x000a (IP address allocation via NAS signalling)  
Data =  
Protocol ID = 0x0005 (MS Support of Network Requested Bearer Control indicator)  
Data =  
Protocol ID = 0x0010 (IPv4 Link MTU Request)  
Data =  
Device properties = 0x00 (not configured for NAS signalling low priority)

Last visited registered TAI:  
MCC = 001  
MNC = 01  
TAC = 0x0001

DRX parameter:  
Data = 10 04

MS network capability:  
Length = 3  
Data = 65 e0 34

Old location area identification:  
Data = 00 f1 10 00 01

Mobile station classmark 2:  
Length = 3  
Data = 57 58 82

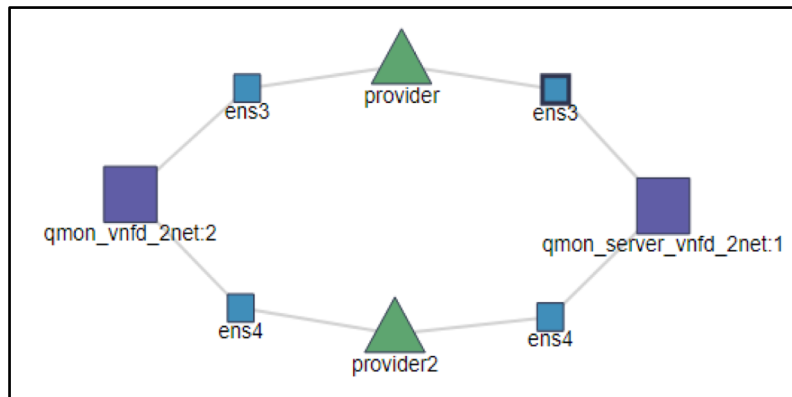
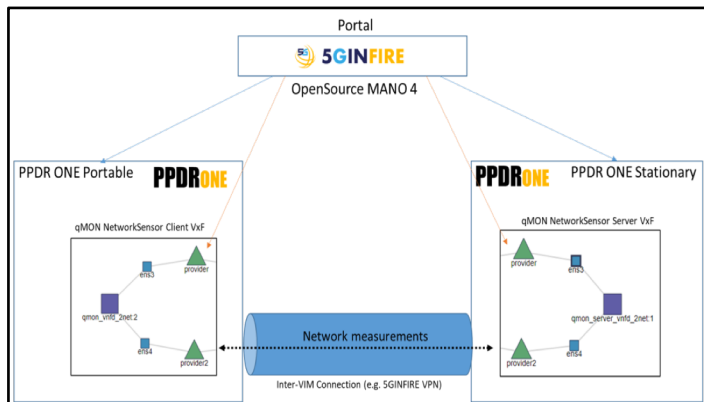
Voice domain preference and UE's usage setting = 0x00 (CS voice only, Voice centric)  
Old GUTI type = 0

MS network feature support = 0x01 (MS supports the extended periodic timer in this domain)

TMSI based NR1 container:  
Length = 2  
Data = db 00



# qMON VNF deployment example



5GINFIRE portal Experiments VNFs Deployments Admin

## All registered available VxVs

View and manage registered vxfs

[Upload new VNF](#)

| ID  | Name             | Published | Certified | Certified by | Trainer         | Description                     | Owner | Packaging Format | Onboarding Status | Images          | Categories | Supported MANO platforms |
|-----|------------------|-----------|-----------|--------------|-----------------|---------------------------------|-------|------------------|-------------------|-----------------|------------|--------------------------|
| 345 | qmon_client_vnfd | false     | false     |              | qmon_client_vnf | qMON Cloud Agent VNF            | lukak | OSMANFOUR        | ONBOARDED         | qmon_vnf        | Networking | Package                  |
| 346 | qmon_server_vnfd | false     | false     |              | qmon_server_vnf | qMON Cloud Reference Server VNF | lukak | OSMANFOUR        | ONBOARDED         | qmon_server_vnf | Networking | Package                  |

internet INSTITUTE// Version 1.0

5GINFIRE portal Experiments VNFs Deployments Admin

## Admin all Deployed Experiments

View and manage all active deployed Experiments (assigned as Mentor)

[View all Active](#) [View all Completed](#) [View all Rejected](#) [View all Failed](#)

| ID  | Name       | Experiment              | Requested at Local Time | Requested Local Start Time | Requested Local End Time | Start Local Time    | End Local Time      | Owner       | Mentor      | Operational Status | Config Status | Detailed Status | VNF IPs                    | Status | manage                 |
|-----|------------|-------------------------|-------------------------|----------------------------|--------------------------|---------------------|---------------------|-------------|-------------|--------------------|---------------|-----------------|----------------------------|--------|------------------------|
| 151 | First test | qmon_client_server_vnfd | 24-04-2019 22:30:04     | 24-04-2019 22:40:00        | 24-04-2019 23:20:00      | 24-04-2019 22:40:00 | 24-04-2019 23:20:00 | Luka Korisc | Luka Korisc | running            | configured    | done            | 10.154.97.57, 10.154.97.55 | Active | <a href="#">manage</a> |

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1 / 1 displayed, 1 in total

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# Thanks!