Modular virtualization framework for management and support of PNFs and VNFs in the context of vRAN 5G Small Cell Protocols

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Starting point: 5G Essence

- **Classification:** H2020 5G-PPP Phase 2 project
- **Scope:** The project addresses the paradigms of Edge Cloud computing and Small Cell as a Service by fueling the drivers and removing the barriers in the Small Cell market, forecasted to grow at an impressive pace up to 2020 and beyond and to play a key role in the 5G ecosystem.
- **Timeframe:** June 2017-December 2019
- **Partners**

![Partners Logos]
Network architecture transition

**Networks of the past**

OTT service

EPC

**Networks of the future**

vEPC

MEC server

OTT service

SD-RAN

RAN functionality running on specialized hardware and using large and expensive radios

RAN functionality running primarily in the cloud (on MEC servers) and using very simple and cheap radios
Network architecture transition

Networks of the past

EPC cabinet
base station cabinet
base station tower
databases

Networks of the future

MEC server (COTS) including:
vRAN, vEPC, possibly applications
Share among many base stations

Small cell base stations:
RRH, DAS, femto, pico
Network slicing

Slice A: public safety network
Slice B: OTT service provider
Slice C: hospital private network

All virtual resources provided on SaaS basis and running on COTS servers

Physical resources owned by e.g., shopping malls, municipality, church, etc

Network slicing components:
- vEPC
- OTT service
- SD-RAN
- Macrocell
- Small cells, RRHs
5G technical KPIs

Higher system capacity: 1000 x capacity / km²

Energy savings and cost reductions

Reduced latency: < 1 ms

Higher data rate: 100 x typical data rate (even for high mobility)

Massive device connectivity: 100 x connected devices (even in crowded areas)

5G requires completely redefined RAN infrastructure
4G: current situation and problems

- locked to particular hardware (chipset)
- underperforming and overpriced
- does not use radio resource efficiently
- poorly scalable (lack of virtualized components)

Why not to address the new challenges and solve current problems at the same time?
Solution: software-defined RAN

Fully software-defined and NFV-compatible RAN functionality ready to be deployed on physical (base station) or virtual (MEC servers) resources using proprietary technology.
IS-Wireless core technologies

Virtualization framework
- Enables virtual operation and RAN slicing – key technical change in 5G
- Allows for execution on any infrastructure
- Enables easy extensions and customizations
- Allows for various functionality mappings

RAN controller
- Controls whole RAN
- Manages 3D radio resources
- Enables support of various traffic types (e.g., IoT)
- Enables QoS guarantees
- Optimizes latency

3GPP stack
- Realizes standard base station protocol stack functions

Our proprietary core technical assets: **virtualization framework** and **RAN controller** ensure that our solution is future-proof and outperforms competition
Numerous instances of Network Functions to enable RAN slicing
3GPP stack

- Virtualization framework
- RAN controller
- 3GPP stack

- RRC
- PDCP
- RLC
- MAC
- PHY
MANO Overview

Operational and Billing Support System

Virtualized Network Functions (VNFs)
- EM #1
- VNF #1
- EM #2
- VNF #2
- EM #3
- VNF #3

Network Functions Virtualization Infrastructure (NFVI)
- Virtual Compute
- Virtual Storage
- Virtual Network
- Virtualization Layer
- Computing Hardware
- Storage Hardware
- Network Hardware

NFV Management and Orchestration (MANO)
- NFV Orchestrator
- VNF Manager(s) (VNFM)
- Virtualized Infrastructure Manager(s) (VIM)
Area of expertise

Operational and Billing Support System

Virtualized Network Functions (VNFs)
- EM #1
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- VNF #3

Network Functions Virtualization Infrastructure (NFVI)
- Virtual Compute
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Virtualization Layer

Computing Hardware
Storage Hardware
Network Hardware

NFV Management and Orchestration (MANO)
- NFV Orchestrator
- VNF Manager(s) (VNFM)
- Virtualized Infrastructure Manager(s) (VIM)
Framework Highlights

Element Manager:
- for VNFs performs role of EM (ETSI NFV specification)
- for PNFs allows programmatic management of deployed modules

Memory Server:
- shared memory allocation for use with local modules, allows (near) zero-copy
- DPDK compatibility desired for supported platforms

Watchdog:
- software watchdog listening for modules’ heartbeats, enforces failure management

Alarm Server:
- main driver of event-based stacks
- intervals measured in TTIs fed by TTI clock

Settings Server:
- allows for program-driven reconfiguration
- GANA compatibility is desired
Virtualization Framework services for NF

- **Ve-Vnfm-em (MANO)**
- **Element Manager**
  - Lifecycle management
  - Request settings
  - Send keep-ales
- **C API (embedded)**
- **Settings server**
  - Notify of settings updates
  - Provide settings
- **Memory server**
- **Log server**
  - Request shared memory buffer
  - Provide shared memory buffer descriptor
  - Sign, encrypt and hash data
  - Log messages
- **Cryptography server**
- **Watchdog**
  - Request periodic notification
- **Alarm server**
  - Provide periodic notification
- **TTI clock**
  - Provide time change notification
- **Network Function**
  - Log messages
  - Route between neighbours
  - Route uplink/downlink
- **Sidetlink manager**
- **Work manager**
Implementation

ØMQ

protobuf Protocol Buffers

Machine A

- task 0
  - send()
  - data

- task 2
  - recv()
  - data

Machine B

- task 1
  - recv()
  - data

- task 3
  - send()
  - data

network
Why it matters?

Two modules providing a service connect over network.
Why it matters?

Data they exchange is described by Protocol Buffers. Those descriptions are public.
Clients can insert another module using provided interface descriptions.
Why it matters?

Message flow is changed programatically.
Service modification is configuration, not development.
RAN like LEGO bricks

Proprietary stack, public *.proto.
RAN like LEGO bricks

Customized with minimal amount of work.
RAN like LEGO bricks

4G
- IoT
- V2X
- MIMO
- CA
- Rel. 8

5G
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Customization for verticals

Public safety VNF add-ons:
- D2D mode
- Extra protection

Automotive VNF add-ons:
- Latency reduction
- D2D mode

IoT VNF add-ons:
- PHY signaling reduction
- NB IoT support
Software RAN – functional part of 4G/5G RAN

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<th>Value</th>
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<tbody>
<tr>
<td>Lower time-to-market, open new business</td>
<td>licensing rather than development, customization</td>
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<td>Improve RAN performance and use resources efficiently</td>
<td>using proprietary RRM algorithms and Mobile Edge Computing</td>
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<td>Provide single, scalable and robust RAN able to serve multiple verticals</td>
<td>Network Function Virtualization and slicing</td>
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