SliceNet Webinar
"5G Integrated Multi Domain Slicing Friendly Infrastructure"

WEBINAR HOST: NAVID NIKAEIN, EURECOM

DATE: 19 MAI 2020

TIME: 11:00 CET

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A word about the Webinar

- Webinar Purpose
  - Present SliceNet WP3 on 5G slice friendly Infrastructure
  - Disseminations of SliceNet Technical Achievements and Innovations

- Navid Nikaein
  - Professor, Communication System, Eurecom
  - Coordinator of Mosaic5G.io initiative
  - Board member of OpenAirInterface.org
  - Eurecom Representative in SliceNet

Agenda

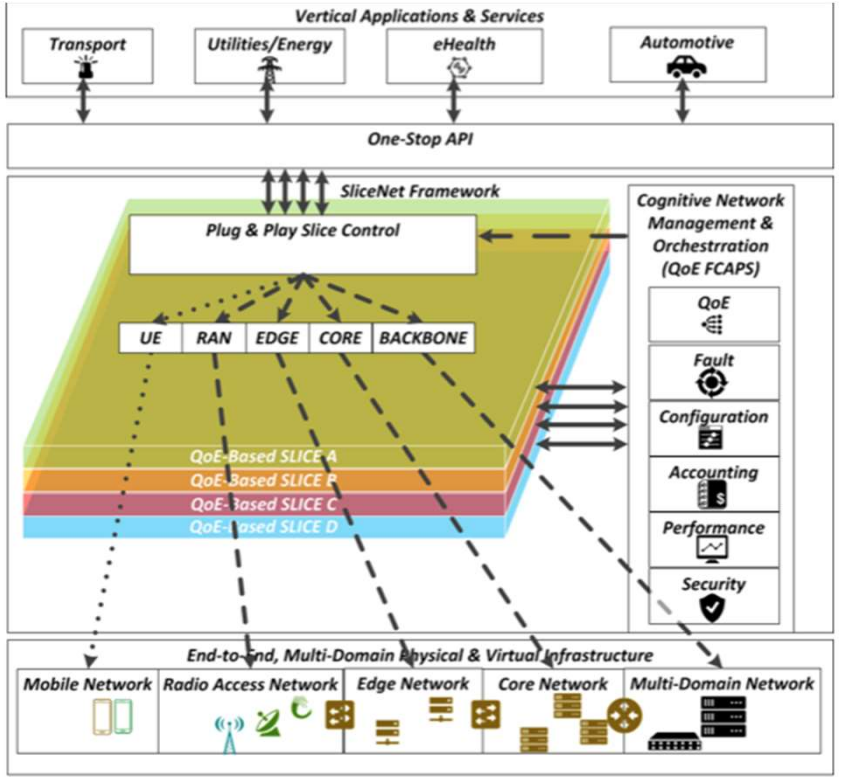
- SliceNet and its 5G infrastructure Objective
- Requirements & Challenges
- Technical Approach for Design & Prototyping
- Technical Achievements
- Major Innovations
- Industry Vertical Applications
- Q&A, References

Acronyms

- API: Application Programming Interface
- CN: Core Networks
- CP: Control Plane
- E2E: End-to-End
- IoT: Internet of Things
- MEC: Multi-access Edge Computing
- MTC: Machine Type Communication
- OVS: Open Virtual Switching
- P&P: Plug-and-Play
- QoS: Quality-of-Service
- QoE: Quality-of-Experience
- RAN: Radio Access Networks
- SDK: Software Development Kit
- UP: User Plane
- UPF: User Plane Function
- xApp: network Control Apps

SliceNet

- Project Objectives
  - One-stop API' 5G slice management framework for vertical businesses
  - Enable extensible, E2E slice FCAPS management across multiple planes and operator domains
  - Establish cognitive, agile QoE management of slices for service assurance of vertical businesses
  - Cross-plane slice-friendly
- Today Focus
  - 5G Integrated Multi Domain Slicing Friendly Infrastructure



Objective of this work

- Establish slice-friendly cross-domain physical and virtual network infrastructure layers and provide an execution foundation for the upper layers
- Design and prototyping of a Control Plane (CP) for supporting network slicing in the RAN, Edge, and CN segments
- Design and prototyping of a slicing-friendly 5G Infrastructure in RAN and CN tailored to different use-cases
  - E.g. e-Health

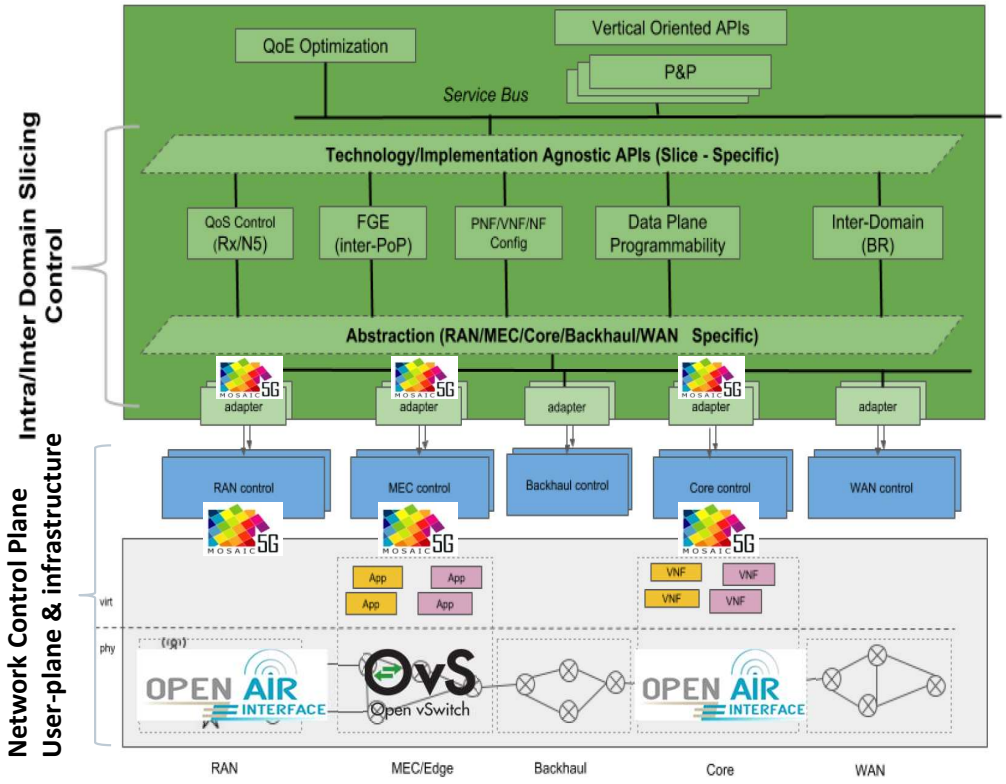
Requirements and Challenges

- RAN-EDGE-CN Slicing
  - Different levels of isolation and sharing in terms of resources, processing, and states
  - Slice orchestration over RAN-EDGE-CN infrastructure

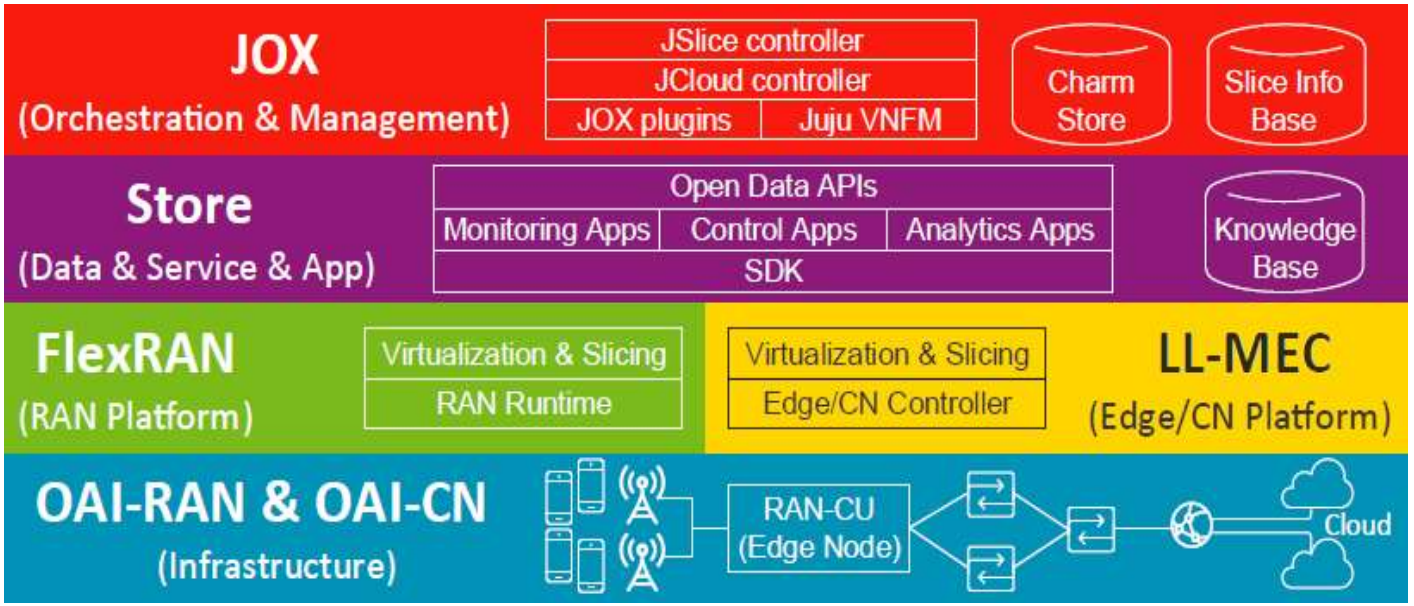
- Customized deployments tailored to different use-cases
  - **eHealth:** Ultra-high data rates and low-latency communication, along with a reliable broadband access to guarantee QoS/QoE requirements.
  - **Smart Grid:** high availability, reliability and ultra low-latency communication capability from the infrastructure that is typically provided by the dedicated communication network managed by the vertical.
  - **Smart City:** support the vertical's capabilities to access specific communication services and application, covered by the massive MTC in IoT areas (with tens or even hundreds of thousands of lighting devices in place).

Technical Approach for Design and Prototyping

- RAN-EDGE-CN infrastructure relies on the existing opensource platforms
  - OpenAirInterface (OAI) & Mosaic-5G
  - Kubernetes, OpenStack, OVS, Docker
- Incremental design and prototyping of SliceNet Infrastructure
  - Instantiate generic infrastructure blueprint
  - Identify requirements of the target use-cases
  - Incrementally customize the infrastructure instances for each target use-case
    - Integration and validation of new entities

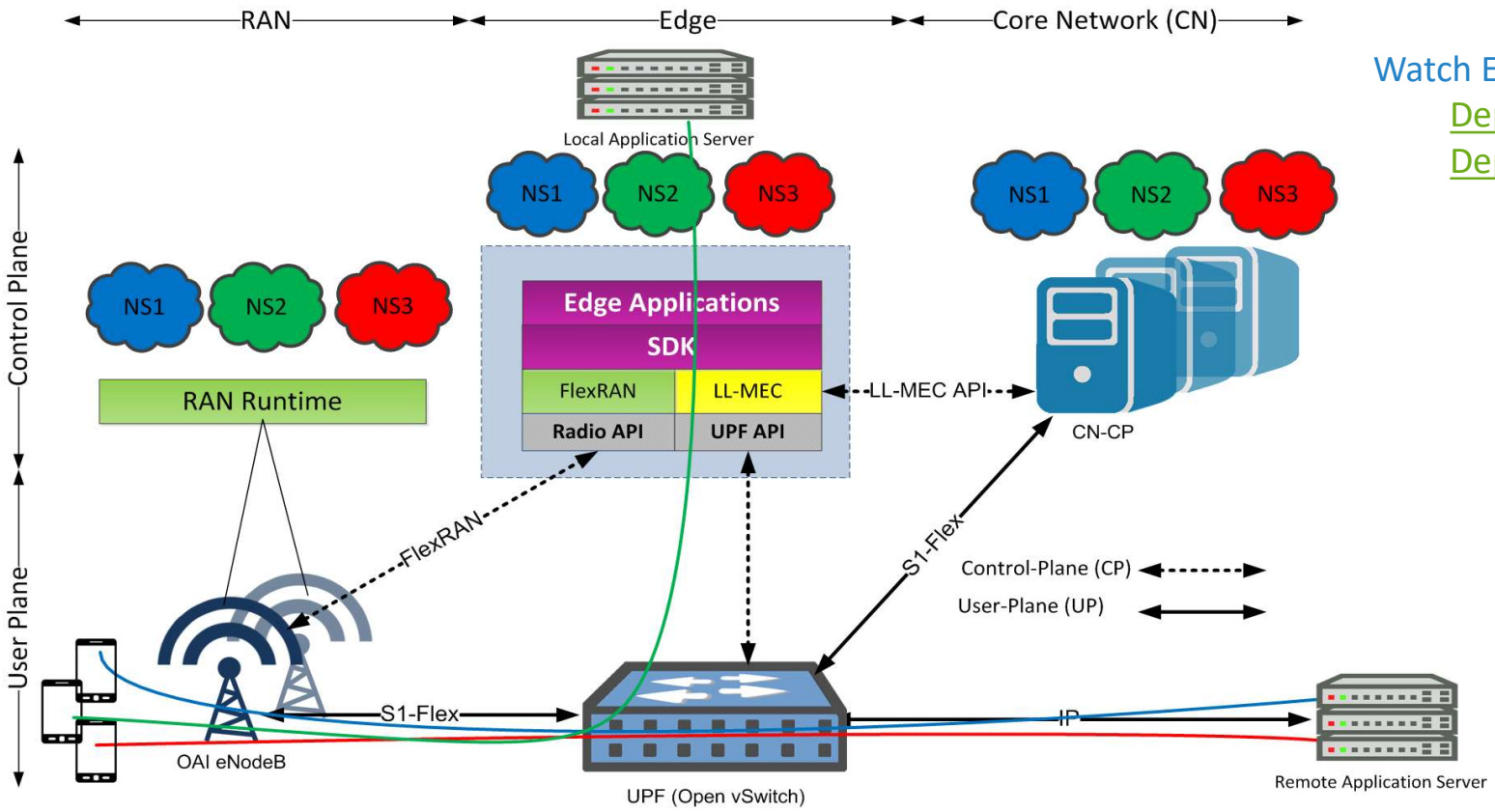


OpenSource Platforms



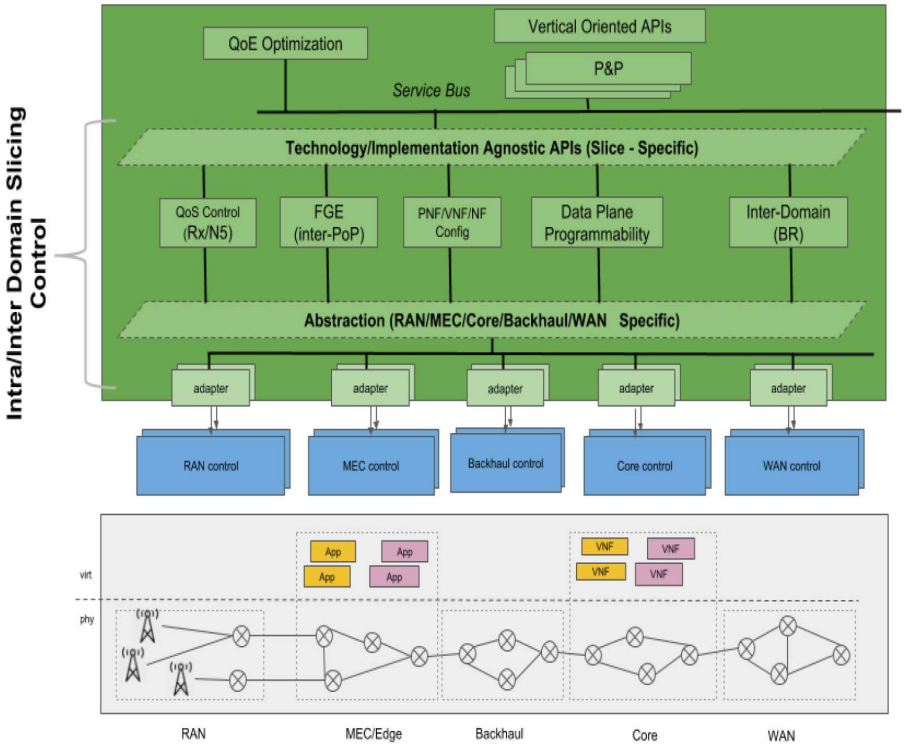
http://mosaic-5g.io
https://www.openairinterface.org

Generic Infrastructure Blueprint



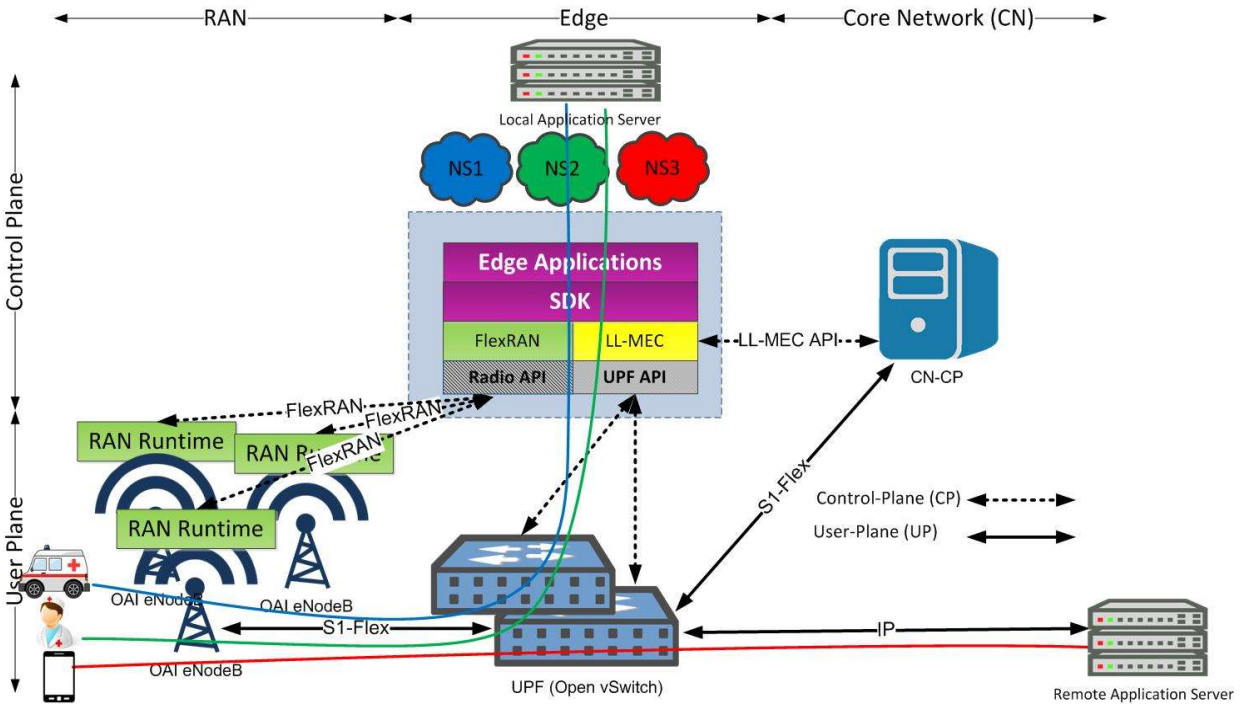
Watch Example Videos:
Deployment 1
Deployment 2

Questions ?


Intra/Inter Domain Slicing Control
QoE Optimization
Vertical Oriented APIs
P&P
Service Bus
Technology/Implementation Agnostic APIs (Slice - Specific)
QoS Control (Rx/N5)
FGE (inter-PoP)
PNF/VNF/NF Config
Data Plane Programmability
Inter-Domain (BR)
Abstraction (RAN/MEC/Core/Backhaul/WAN Specific)
adapter
adapter
adapter
adapter
adapter
RAN control
MEC control
Backhaul control
Core control
WAN control
virt
phy
App
App
App
App
VNF
VNF
VNF
VNF
RAN
MEC/Edge
Backhaul
Core
WAN

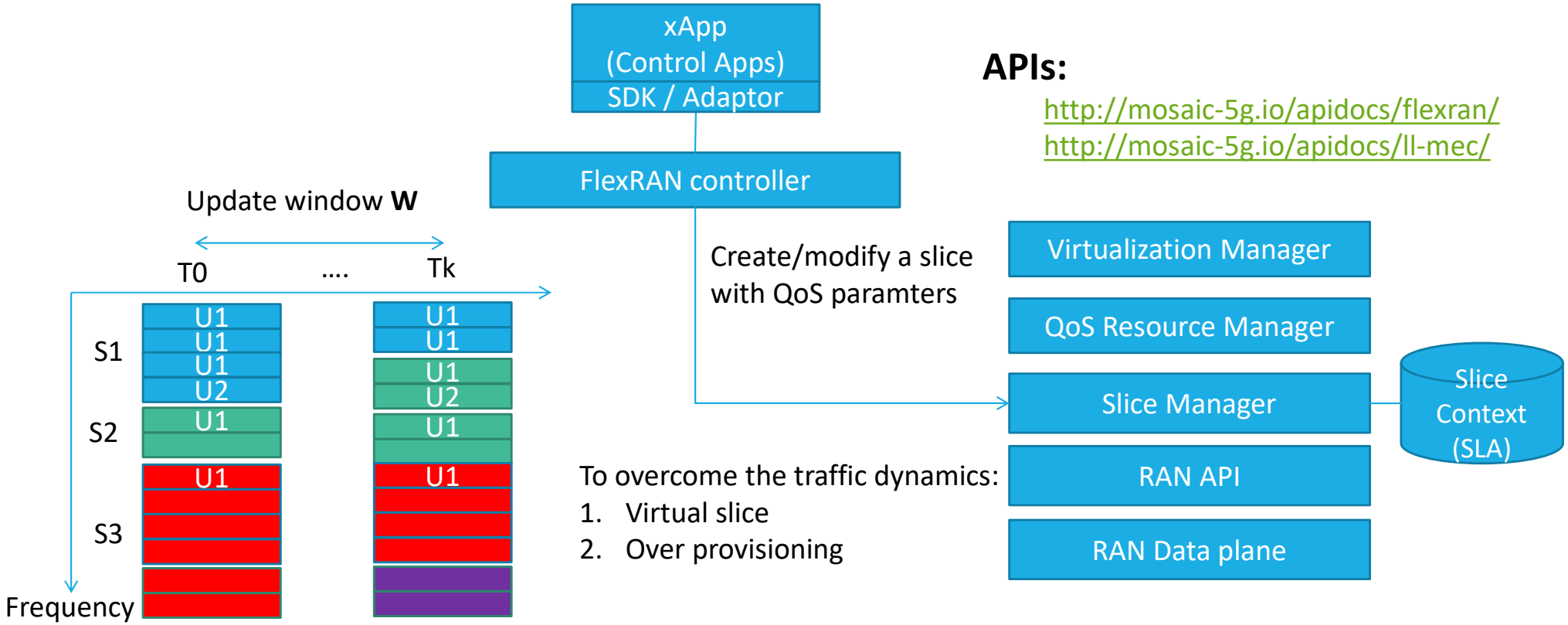
eHealth 5G Infrastructure

- Features
  - Local breakout
  - Slice mobility
  - Proactive Handover
  - QoS/QoE
- Edge Applications
  - Re-routing
  - Traffic forwarding/redirection
  - Caching
  - Content optimization
  - Event monitoring
  - Network-Control Handover



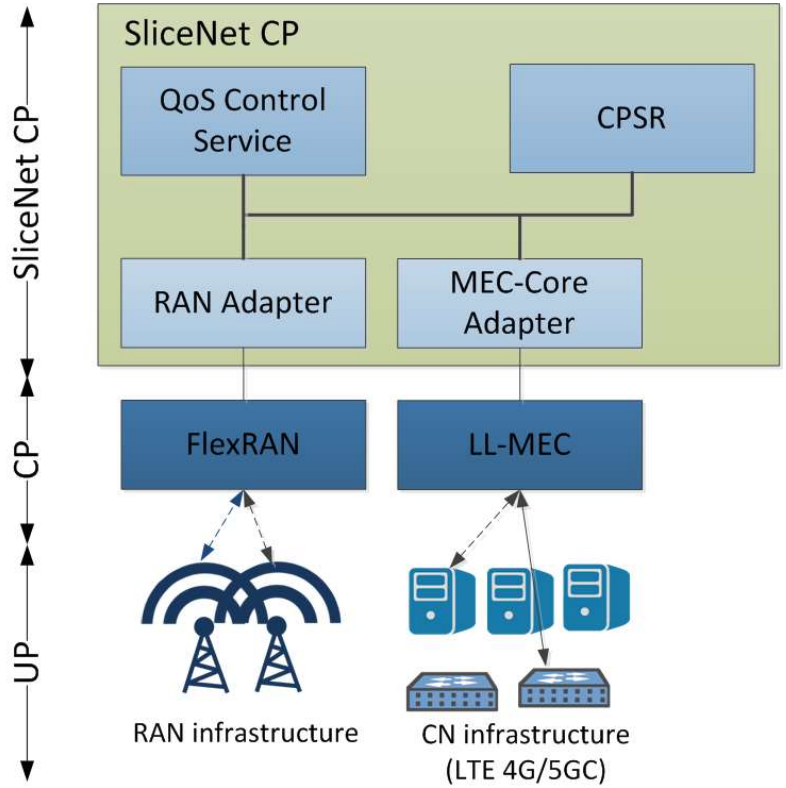
Watch SliceNet EUCNC demo: Click

xApps: CP to support Slice QoS



Customize Network Slices in Runtime

- Adapters allowing to customize the network slices at runtime according to the vertical requirements
  - RAN Adapter exposes the underlying RAN infrastructure to the SliceNet CP services
  - Core Adapter exposes the underlying EDGE-CN infrastructure to the SliceNet CP services



Technical Achievements

- A reproducible SliceNet slice-friendly infrastructure blueprint
  - Leverage opensource platforms
- Design and prototyping of consolidated CP and different programmable UPs at RAN-EDGE-CN in support of network slicing
- Open Interfaces and API definitions for RAN-EDGE-CN
  - Network SDK prototyping
  - Adapters allowing to customize the network slices at runtime according to the vertical requirements

Industry Vertical applications/contributions

- Common components for eHealth, Smart-Grid and Smart City use-cases:
  - 4G/5G software-define network infrastructure
    - OAI RAN, OAI CN, FlexRAN, LL-MEC, RAN Adapter, MEC-CN Adapter, xApps
- **Example xApps**
  - Redirect traffic of a MEC-CN slice
  - Change RAN slice priority of a RAN slice
  - Apply QoS constraints to a RAN slice
  - Network-control proactive handover

Summary of Innovation

- A reproducible SliceNet 4G-5G slice-friendly infrastructure blueprint
  - Network slicing in the RAN, MEC and CN segments
  - Design of a programmable DP and CP and its prototype through OpenFlow and an SDN controller
  - Instantiate for different use-cases

- Definitions of interfaces and APIs of the RAN/MEC-CN Adapters and FlexRAN and LL-MEC controllers
  - To allow the SliceNet CP services to customize the network slices at runtime according to the vertical requirements
  - To make underlying infrastructure (RAN, MEC and CN) is transparent to the upper layers

Prototyping and References

- Delivered SW components prototypes and interfaces
  - OAI RAN: https://gitlab.eurecom.fr/oai/openairinterface5g
  - OAI CN: https://github.com/openairinterface
  - Mosaic-5G: http://mosaic-5g.io/
    - Flex-RAN: https://gitlab.eurecom.fr/flexran/flexran-rtc
    - LL-MEC: https://gitlab.eurecom.fr/mosaic5g/ll-mec
    - Store: https://gitlab.eurecom.fr/mosaic5g/store
    - Jox: https://gitlab.eurecom.fr/mosaic5g/jox
    - RAN/MEC-CN Adapter: https://gitlab.eurecom.fr/mosaic5g/store/tree/feature-adapter-slicenet-integration
- SliceNet Deliverables:
  - Deliverable 3.1 - Design and Prototyping of SliceNet Virtualised Mobile Edge Computing Infrastructure, Mar. 2018. https://doi.org/10.18153/SLIC-761913-D3_1
  - Deliverable 3.2 - Design and Prototyping of SliceNet Virtualised 5G RAN-Core Infrastructure, May. 2018. https://doi.org/10.18153/SLIC-761913-D3_2
  - Deliverable 3.3 - Design and Prototyping of 5G-Connected Virtualized Enterprise Infrastructure and Services, Jun. 2018. https://doi.org/10.18153/SLIC-761913-D3_3
  - Deliverable 3.4 - Design and Prototyping of Integrated Multi-domain SliceNet Architecture, Jul. 2018. https://doi.org/10.18153/SLIC-761913-D3_4
  - Deliverable 4.2 - Network Slicing in 5G RAN-Core, Nov. 2018.

Thank You!

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Further information:
https://slicenet.eu/publications/

SliceNet Open source contributions:
https://slicenet.eu/software-contributions/

Questions ?

Thank You!


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RedZinc


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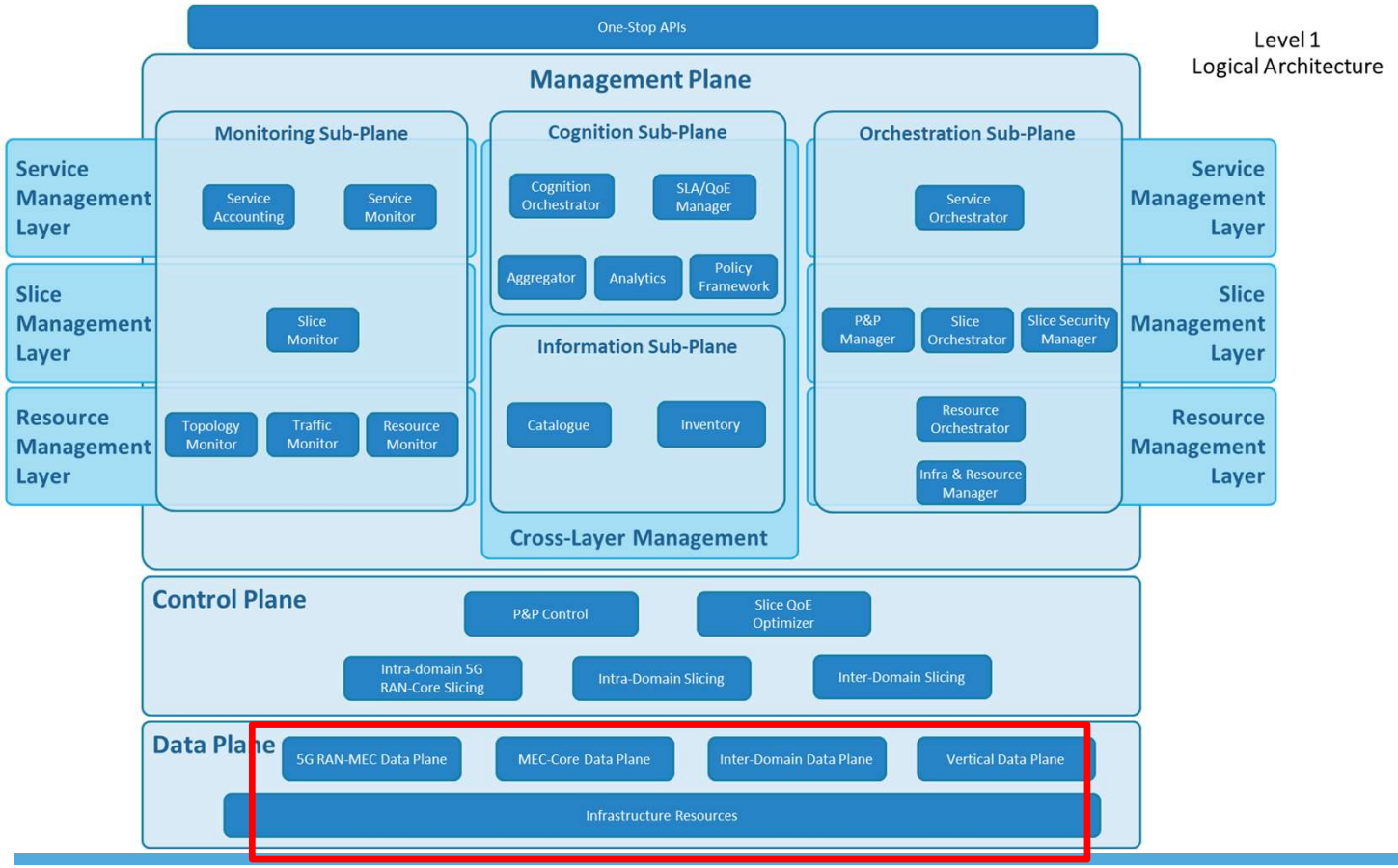
OTE


DELL EMC


Creative Systems
Engineering

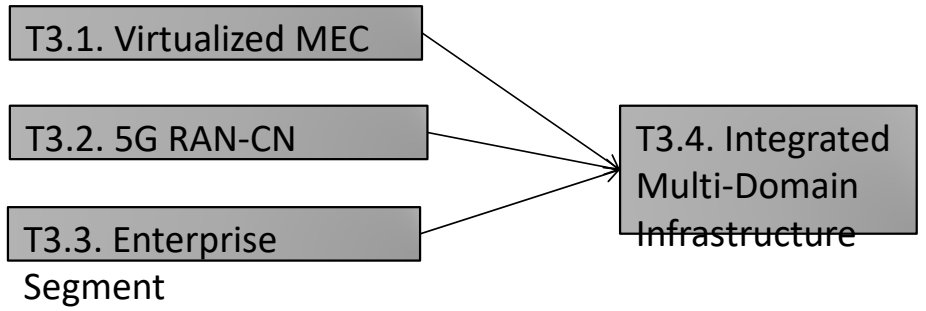
Backup Slides

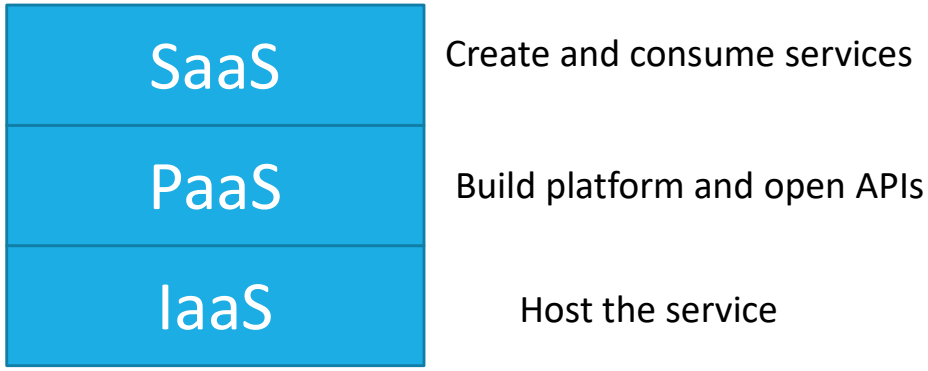
WP3 Contextualization



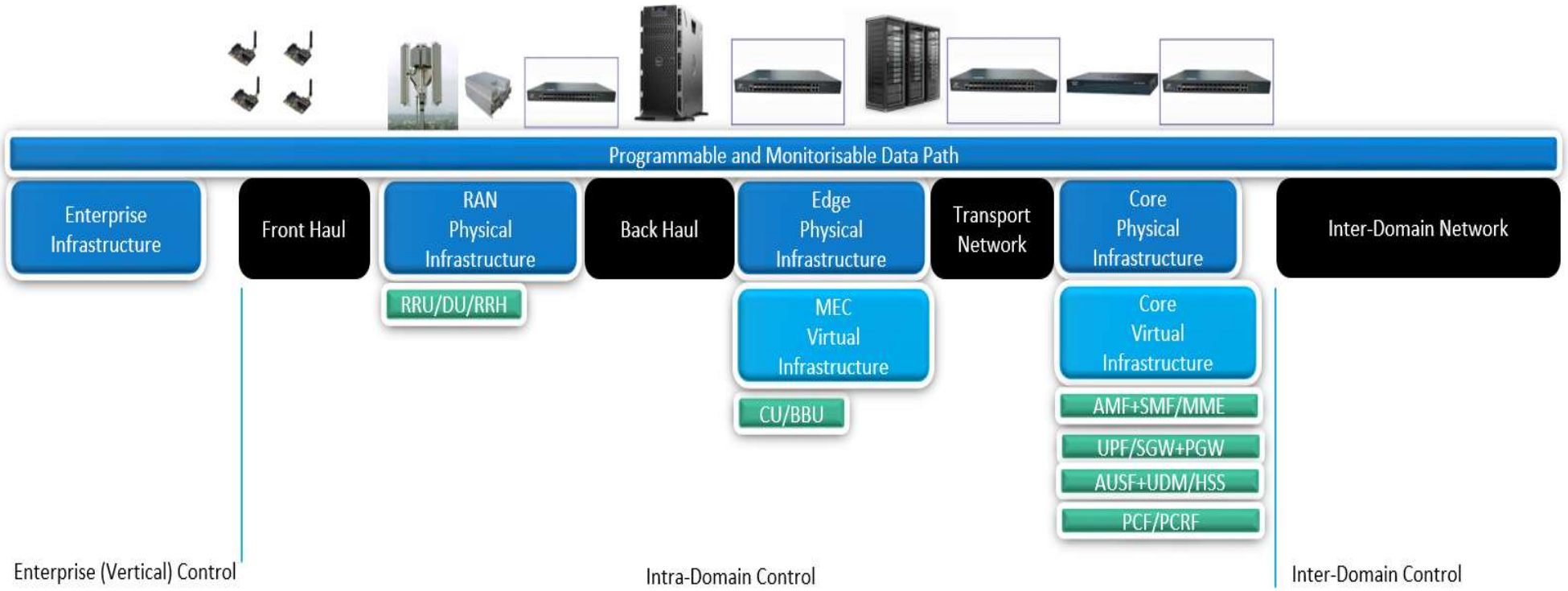
WP3 Technical Approach

- RAN, EDGE, and CN platforms relies on the existing platforms
  - OpenAirInterface, AmariSoft , and Athonet
  - Mosaic-5G
- Coupling with existing open-source communities
  - Kubernetes, OpenStack, Juju, OVS, ODL,
- **Incremental design and prototyping** of SliceNet Infrastructure
  - Replicate the platform in different premises
  - Remote access to testbeds
  - eHealth Hello world

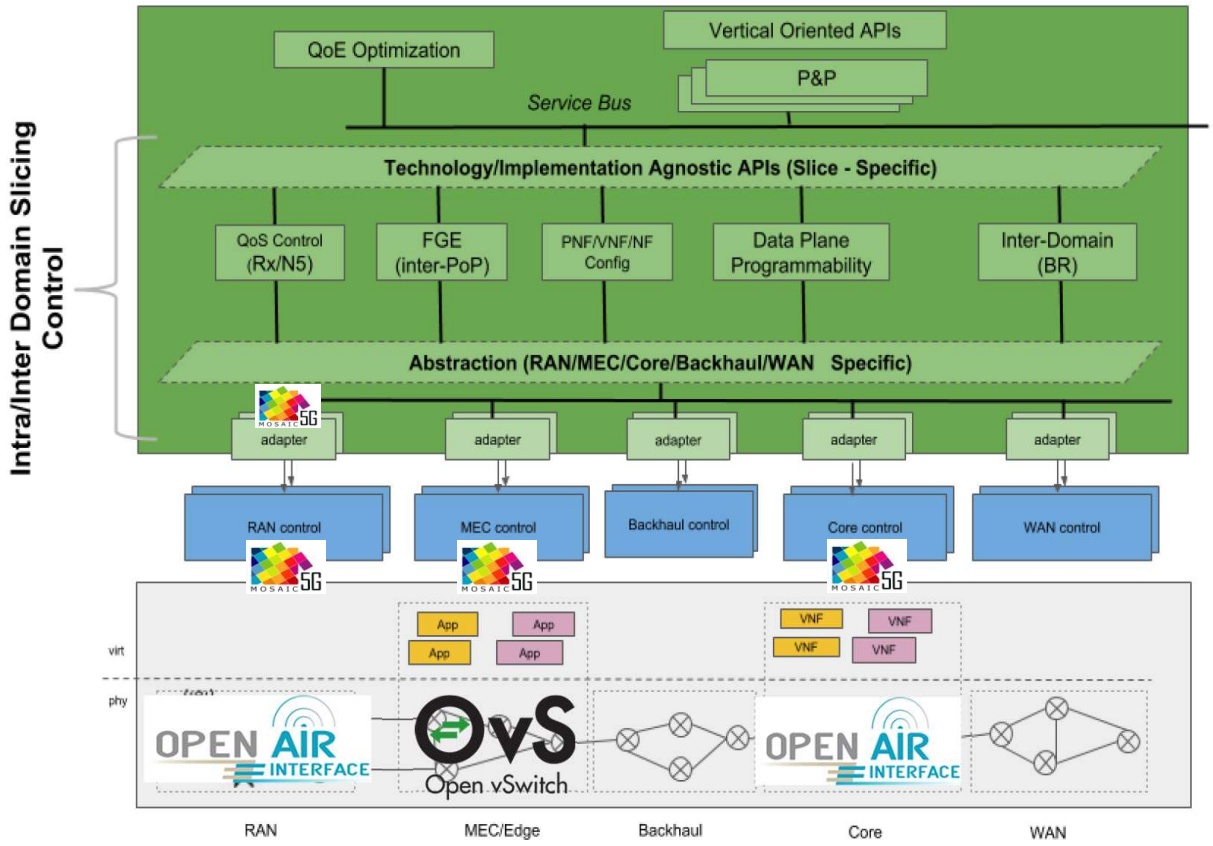




User Plane Programmability



Mapping of SliceNet CP and software components



Network Business Plane

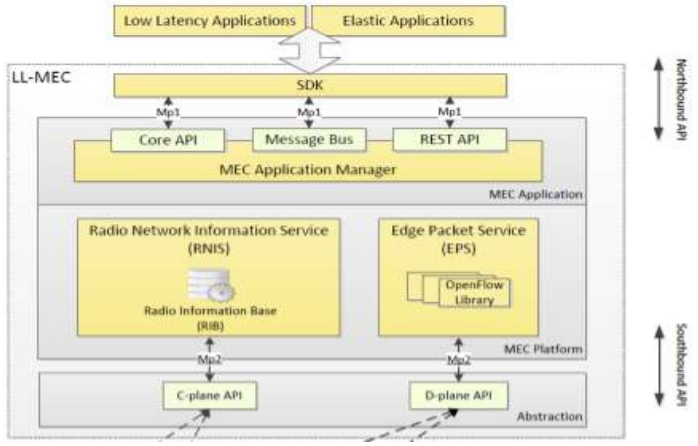
Network Control Application Plane

Network Control Plane

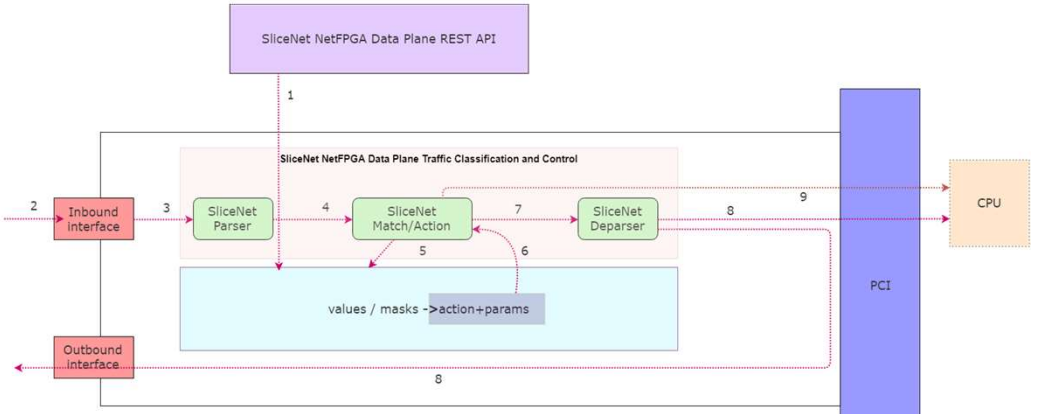
Network User-plane & infrastructure

Virtualised Mobile Edge Computing Infrastructure

- Design and develop an MEC platform aligned to ETSI (ETSI PoC)
  - Slice-aware Low-Latency MEC (LL-MEC) platform
  - Essential MEC services
  - UP programmability via north-bound API and Software Development Kit (SDK)

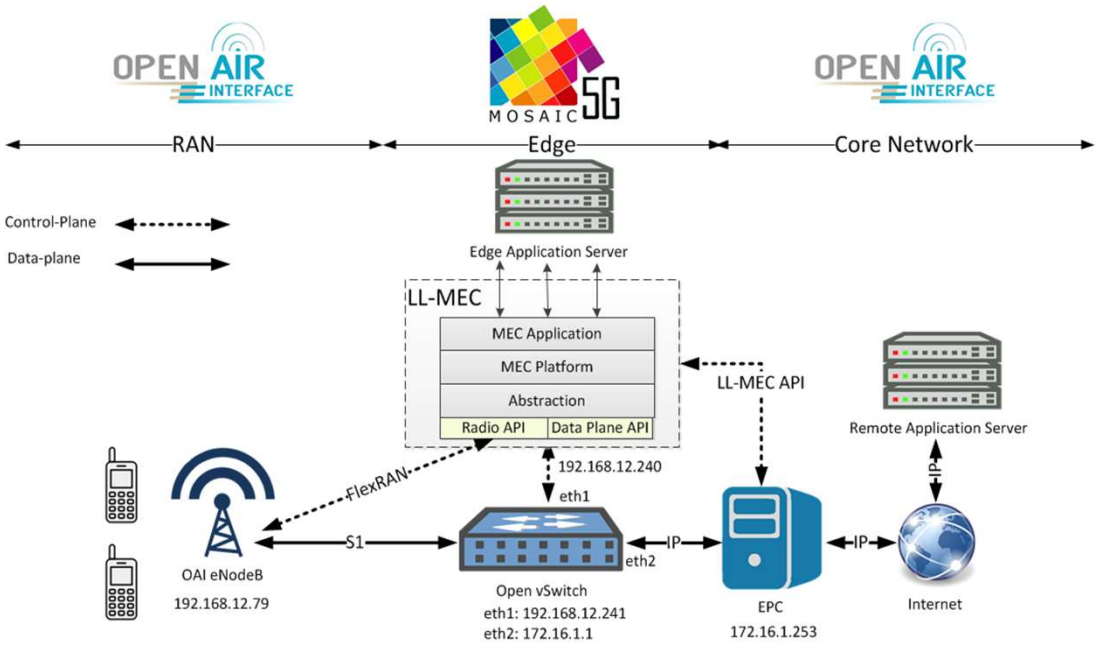


- Design and prototyping of a programmable, multi-tenanted Data Plane
  - Hardware acceleration
  - APIs in support of fine-grain QoS



Virtualised Mobile Edge Computing Infrastructure

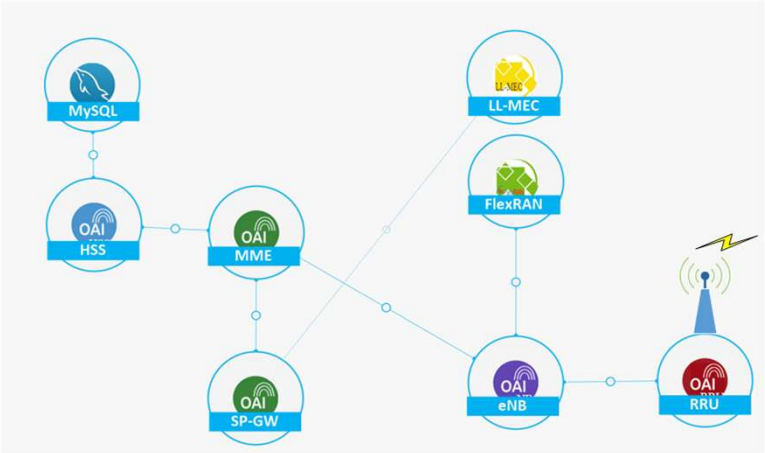
- Analyze the management and orchestration for the MEC system
  - Potentially different subsystems for platform and MEC application
  - Open-source approach openBaton, JoX, OSM

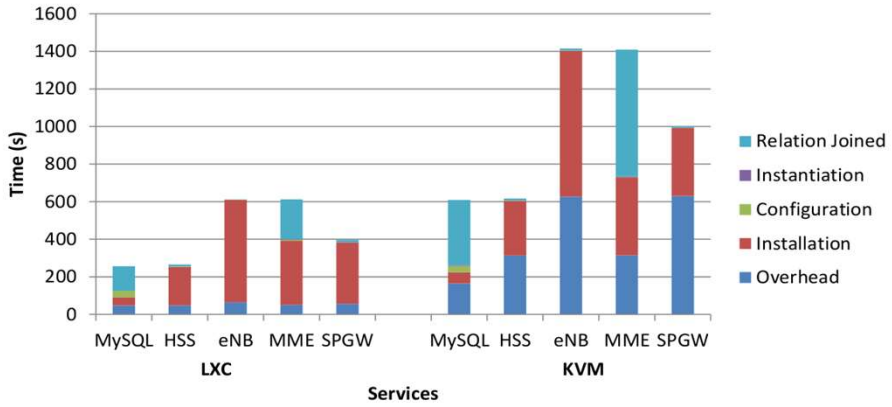


- Case Studies
  - UP Network Slicing
  - RAN aware Video Optimization
  - IoT gateway

Virtualised 5G RAN-Core Infrastructure

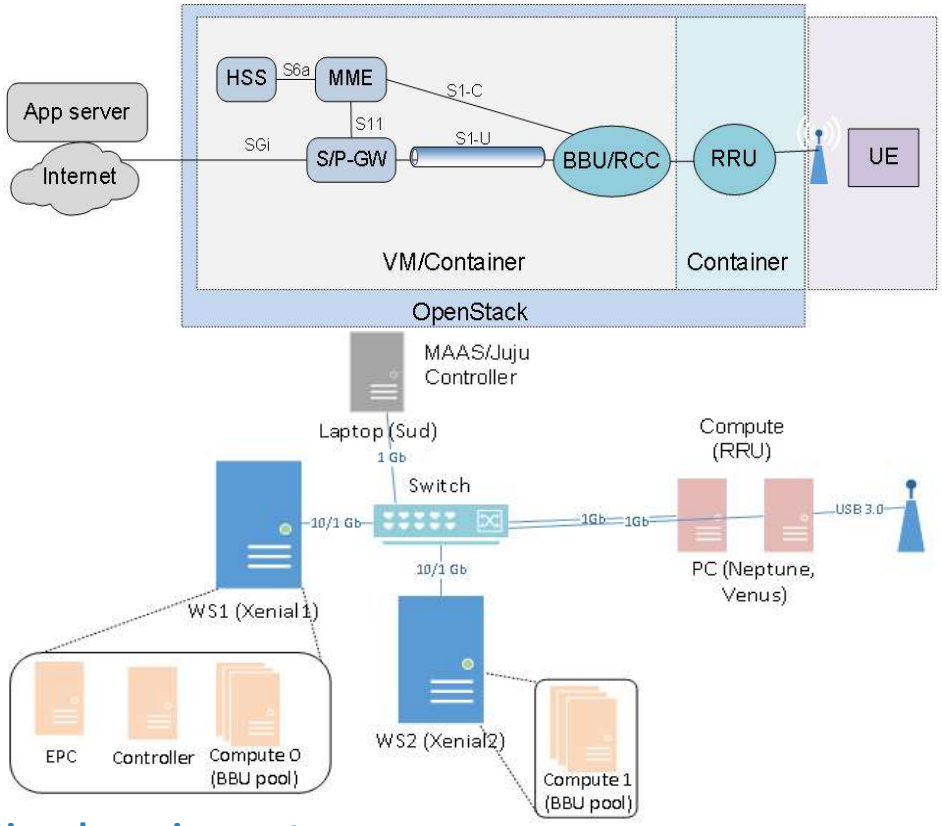
- Automated deployment through JoX/Juju
  - Leverage OAI/M5G Charms and Juju store
  - Rapid deployment of Virtualised 5G RAN-Core Infrastructure
- JoX, a Juju-based orchestrator to support network slicing
  - Slice manifest and Yaml based service bundles
    - https://jujucharms.com/u/navid-nikaein/oai-5g-cran/
  - Northbound APIS
  - Plugins for control subsystems including RAN, CN





Virtualised 5G RAN-Core Infrastructure

- Automated deployment through OpenStack and Heat template (Tacker)
  - Hybrid virtualizations and zones
  - Fronthaul segment
  - Applicable to OPNFV
- Automated deployment through OSM and OpenBaton
  - Possible through Juju and charms
- Automated deployment through ONAP
  - Heavy and not yet easy deployable
- Manual deployment
  - LXC, LKD
  - KVM



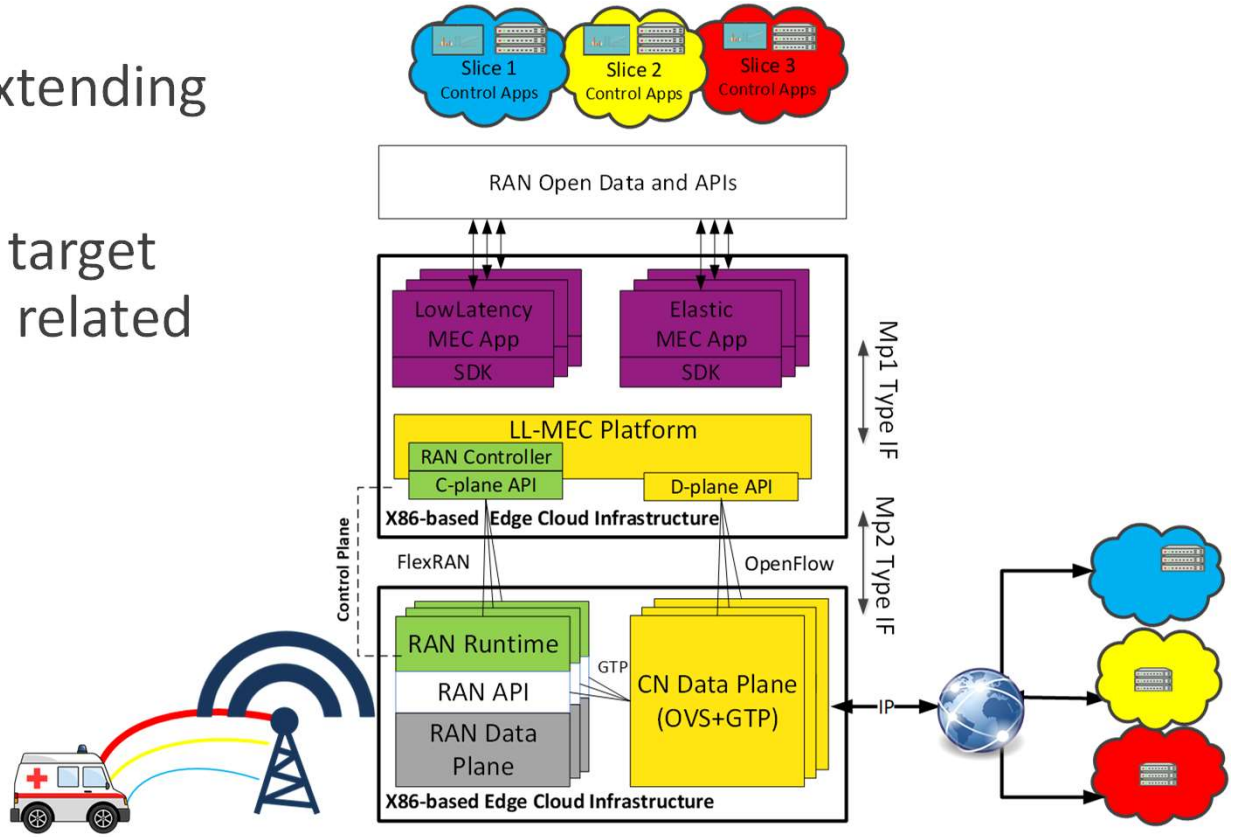
Note: Deployment model will be driven by the UC and operational requirements

5G-Connected Virtualised Enterprise Infrastructure and Services

- Enclosed all the activities related to the deployment of the Enterprise segments of the UC platforms.
- Transition from a traditional enterprise approach to a new virtualized and programmable 5G-ready infrastructure
- 5G enterprise prototype model removing the limitations of the current network infrastructure
- Central office become an edge cloud enabled by MEC
  - e.g. 20K CO in US, and 70k CO in China
- Integration of one-stop API and P&P control

Integrated Multi-Domain SliceNet Infrastructure

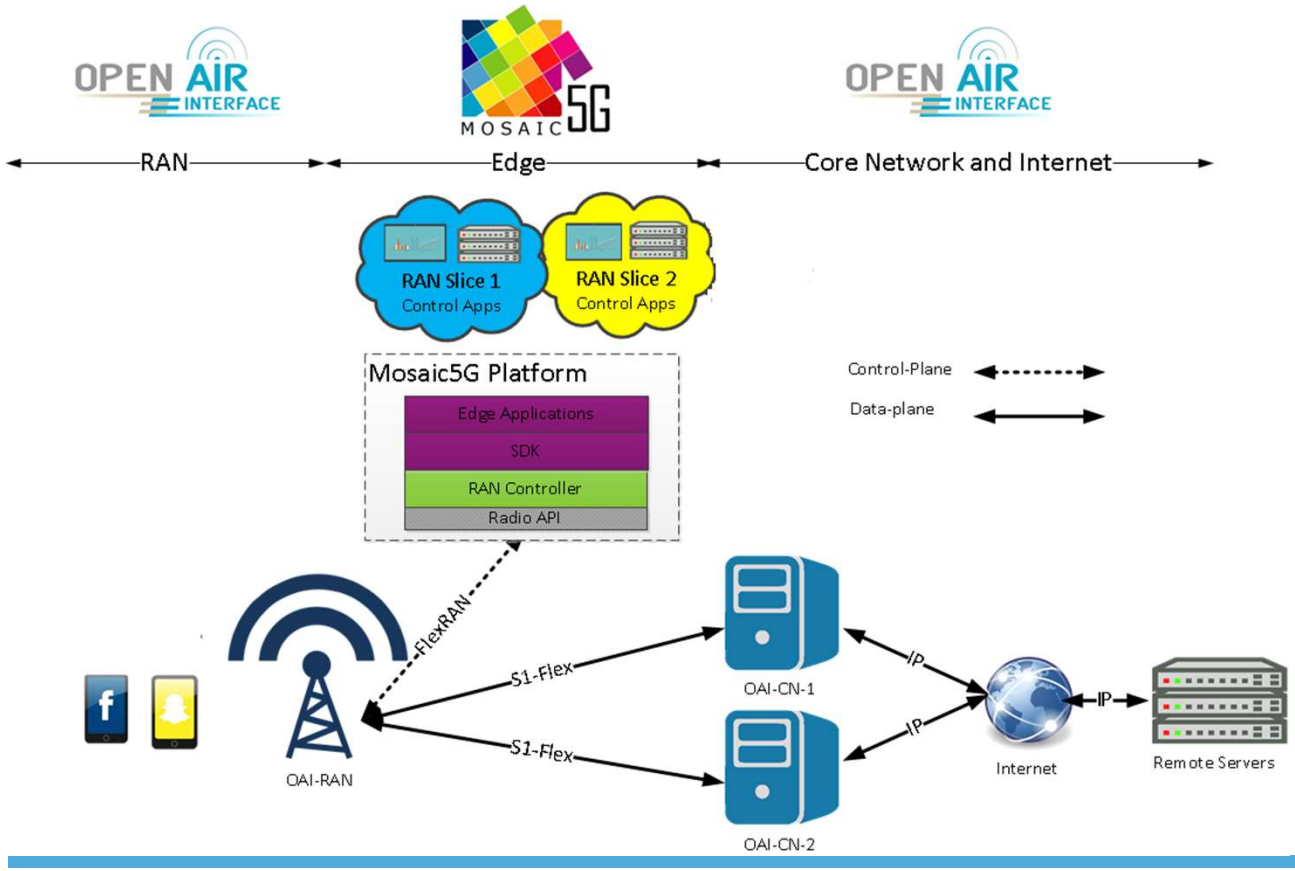
- Sketch a generic SliceNet infrastructure deployment extending existing platform
- Identify requirements of the target use-cases stressing upon the related QoS and QoE aspects.
- Specification of integrated infrastructure instances
  - eHealth
  - Smart Grid
  - Smart City



Highlights and Achievements

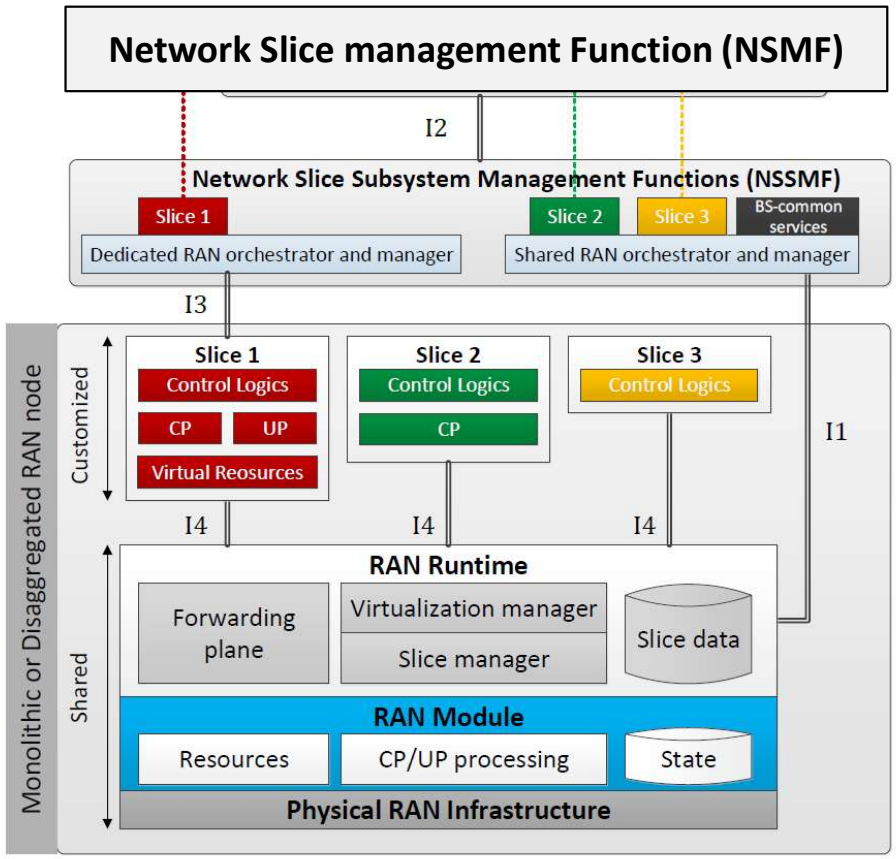
- Leveraging and extending the existing platforms : IaaS → PAAS
- Demo of LL-MEC for the hello world e-Health UC (Mobicom)
- Incremental design and prototyping

SliceNet Prototyped RAN-CORE Slicing

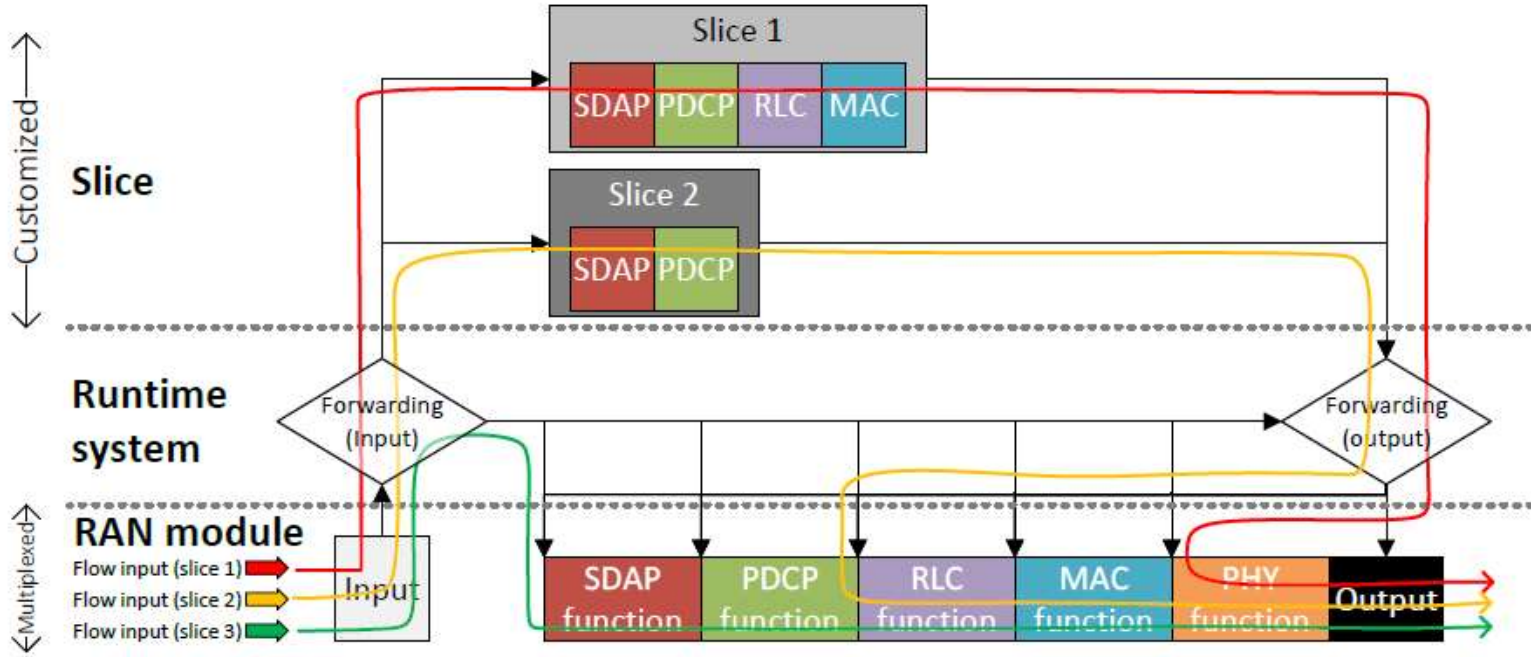


SliceNet Prototyped RAN-CORE Slicing

- flexible execution environment
  - to run multiple virtualized RAN instances
  - with the required level of isolation and sharing of the underlying RAN modules and resources
- Service provider
  - Create and manage slice
  - Custom control logics
  - Request and consume radio resources
- Infra provider:
  - Manage underlying RAN
  - Enforce slice-specific policy
  - Admission and access control
- Interfaces (I1 to I4) used for the communication between RAN-domain service orchestration entities.

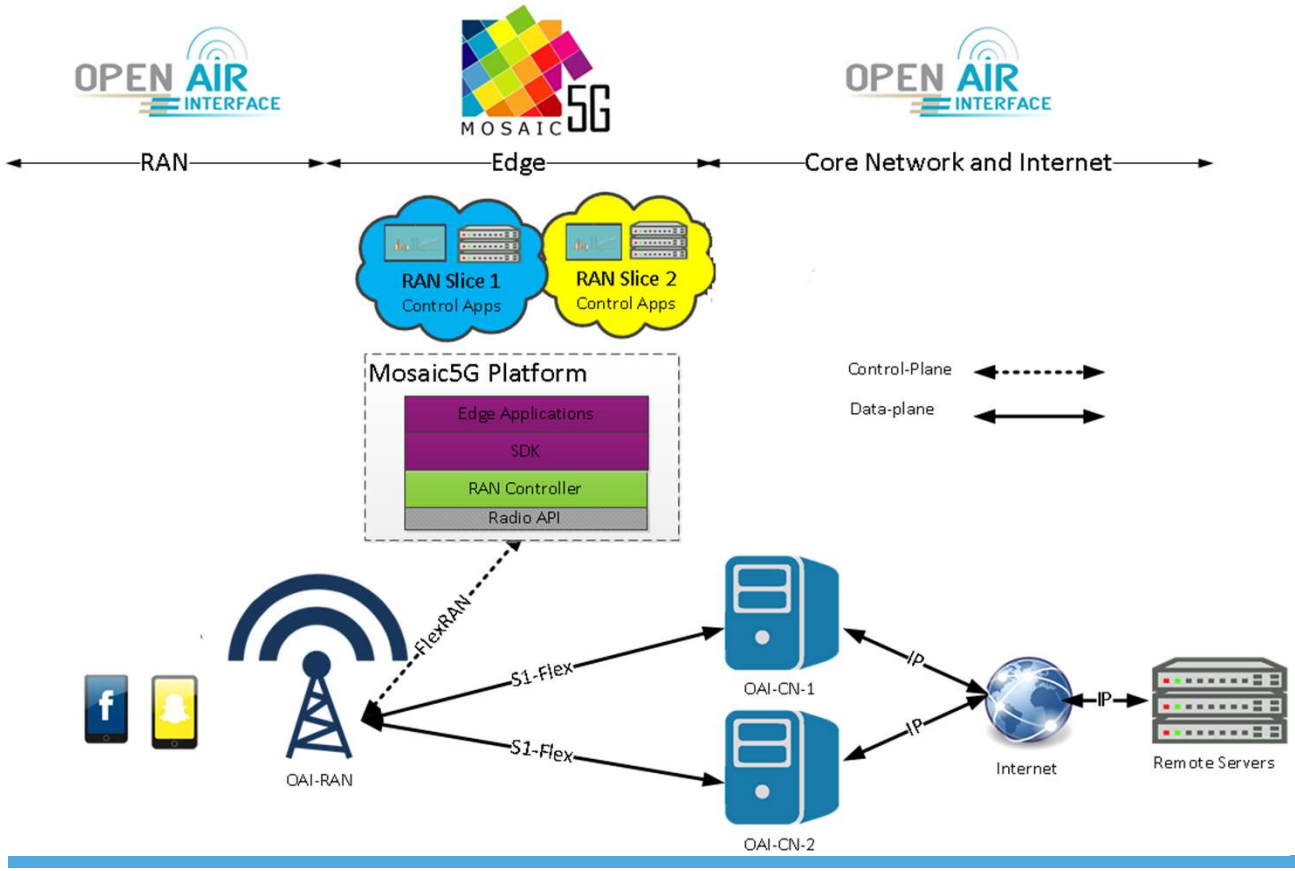


Deployment example



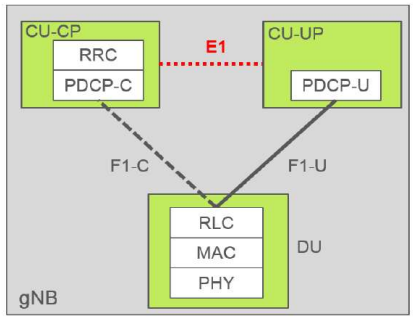
Maximize the multiplexing gain, Isolate tenants resources, Customize tenant service

SliceNet Demo RAN-CORE Slicing

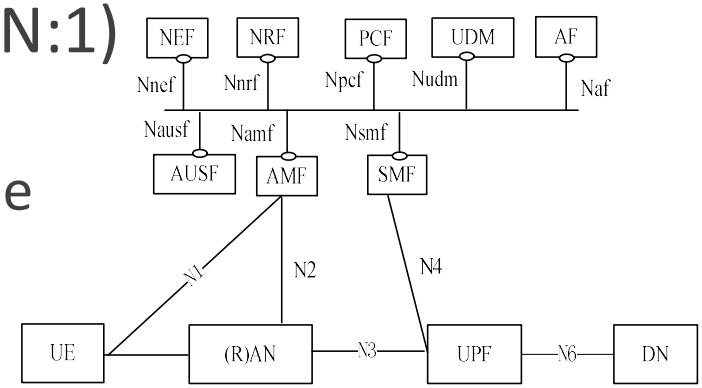


3GPP re-architects RAN and CN

- RAN: a 3 tier architecture (CU0 → DU[0-n] → RRU[0-m])
  - Functional split between CU and DU
  - Functional split between DU and RRU
  - Functional split between c-plane and d-plane

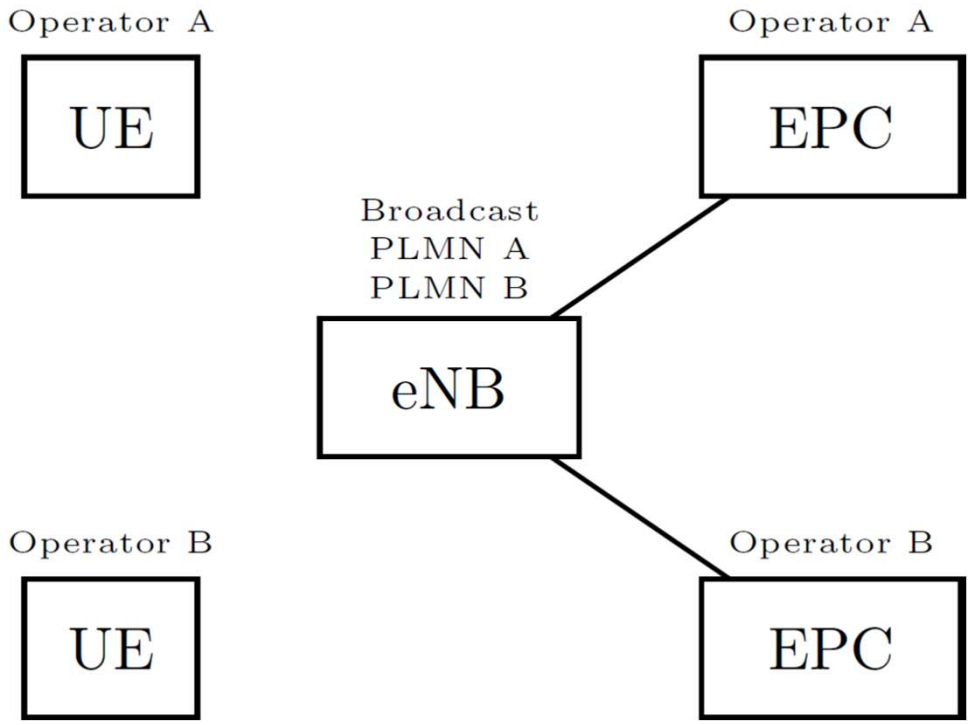


- CN: a service-centric architecture (1:N, N:1)
  - Network Service catalog and discovery
  - Functional split between c-plane and d-plane

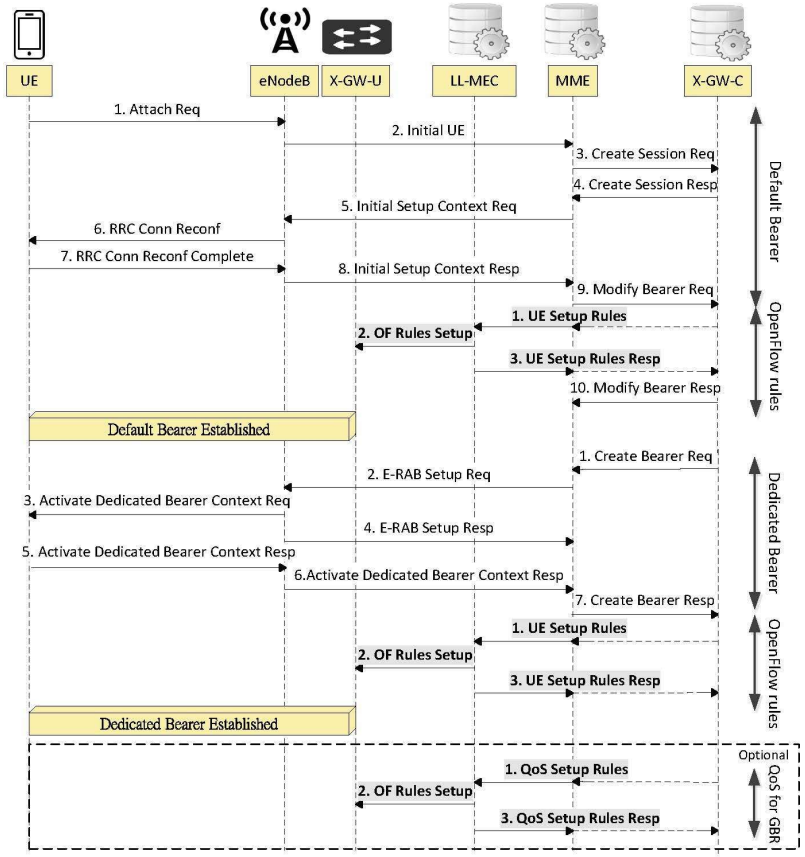


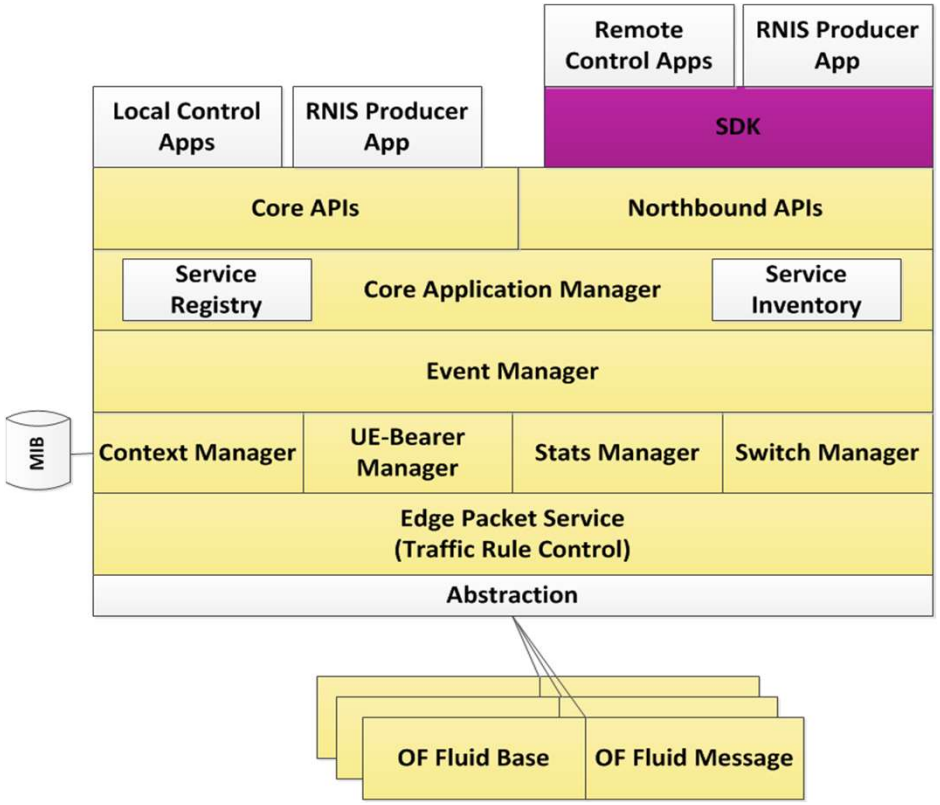
Core Network Slicing

- Dedicated core network through S1-Flex interface
  - System Information Block 1 (SIB1) contains list of PLMNs
  - In connection setup, UE indicates chosen PLMN(standard-compliant)
  - MME (EPC)-selection is handled transparently for UE

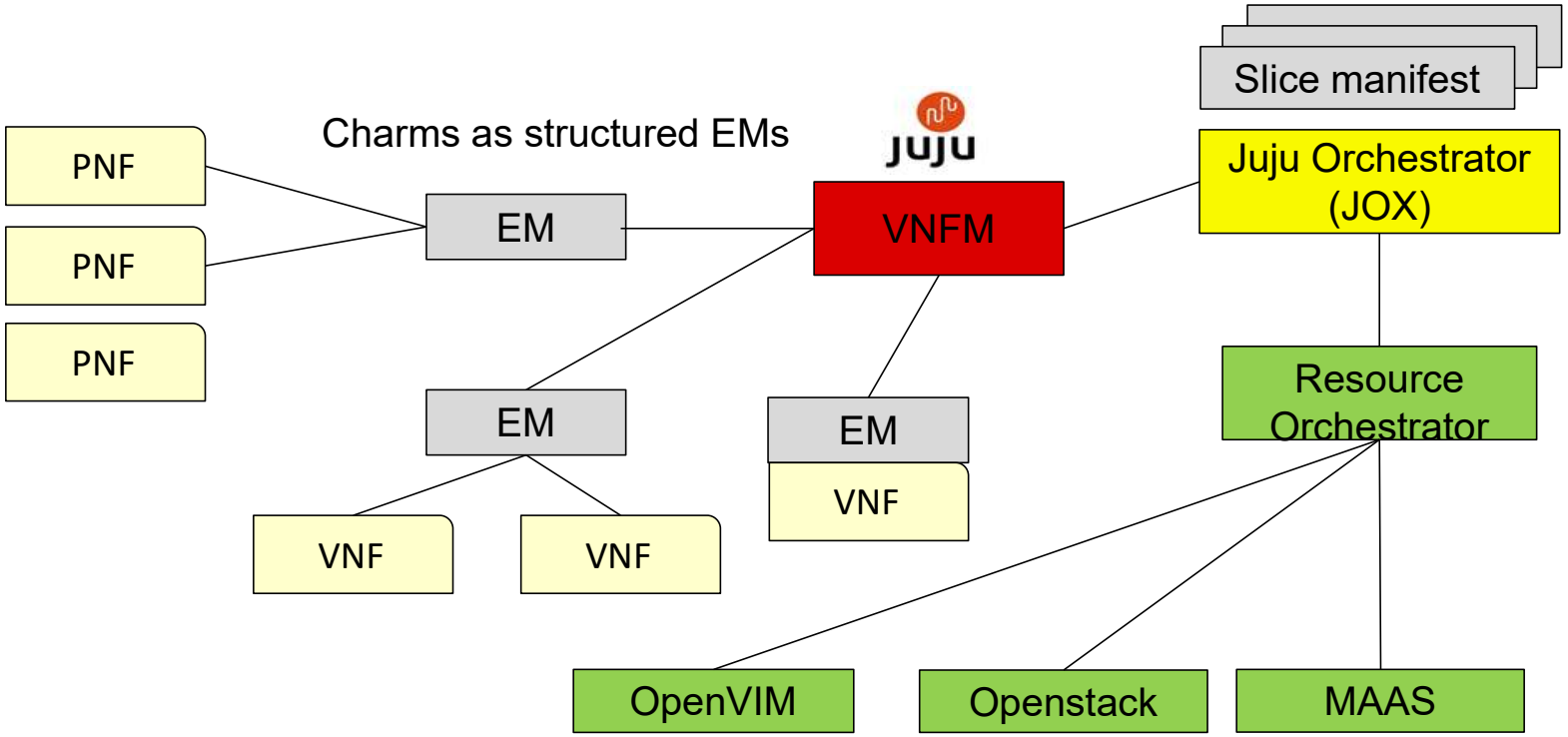


LL-MEC Details



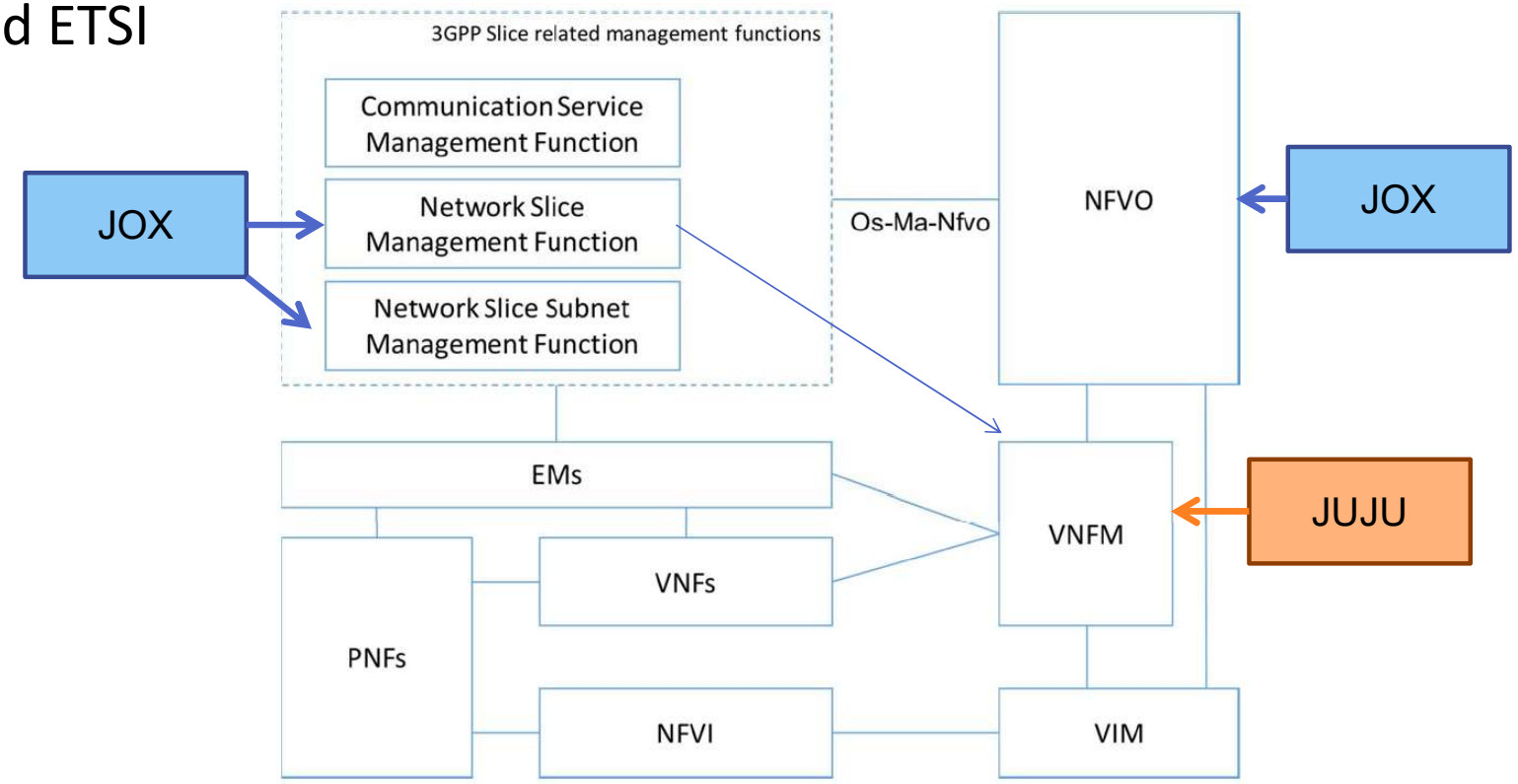


JoX and Juju


Slice manifest
Charms as structured EMs
juju
PNF
PNF
PNF
EM
VNFM
Juju Orchestrator (JOX)
Resource Orchestrator
EM
EM
VNF
VNF
VNF
OpenVIM
Openstack
MAAS

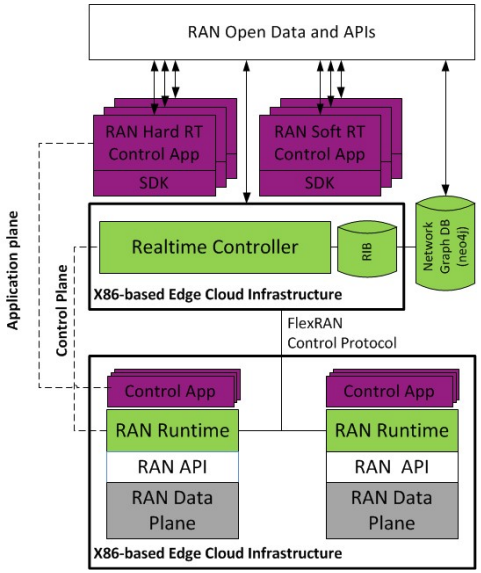
Task 2: Virtualised 5G RAN-Core Infrastructure

JoX within 3GPP and ETSI

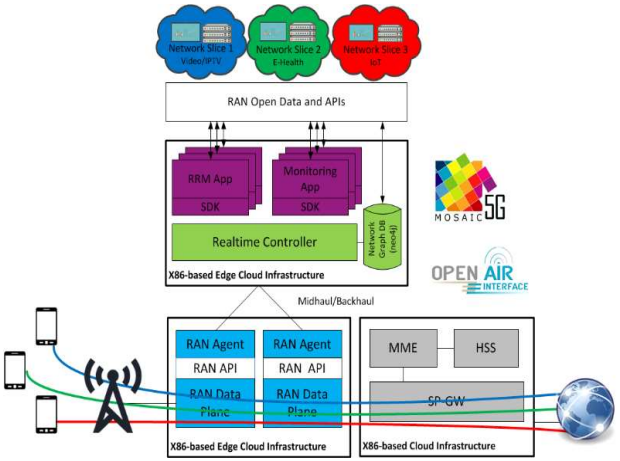


Task 2: Virtualised 5G RAN-Core Infrastructure

- Main achievements
- A 5G RAN-Core slicing-friendly infrastructure that could be extended to cover different SliceNet use cases
- The design of a programmable Data and Control Plane and its prototype through OpenFlow and an SDN controller, as a part of OAI-CN and OAI-RAN implementation
- Various methods for deploying a virtualized 5G infrastructure
- Different virtualized RAN-Core infrastructures, which have been prototyped and tested with experimental empirical results, to achieve slicing-friendly infrastructure



FlexRAN protocol

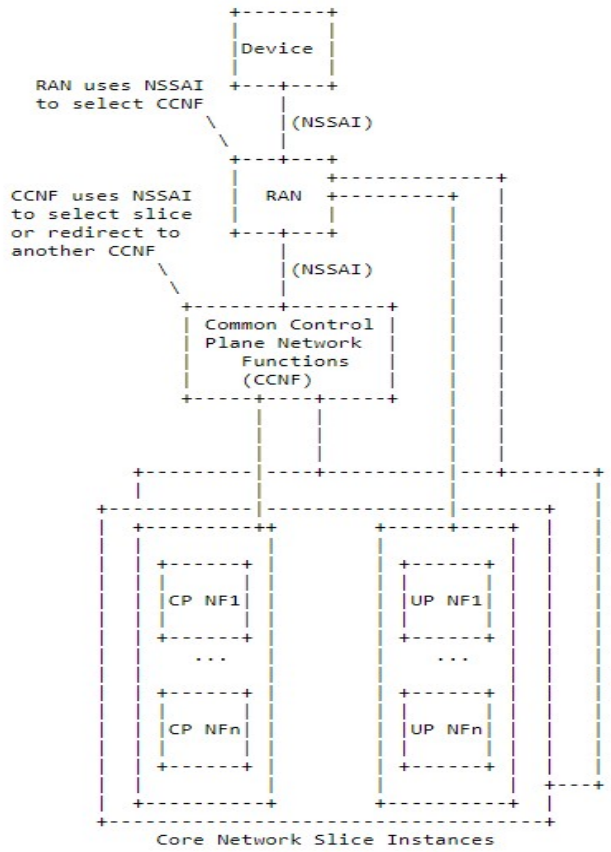


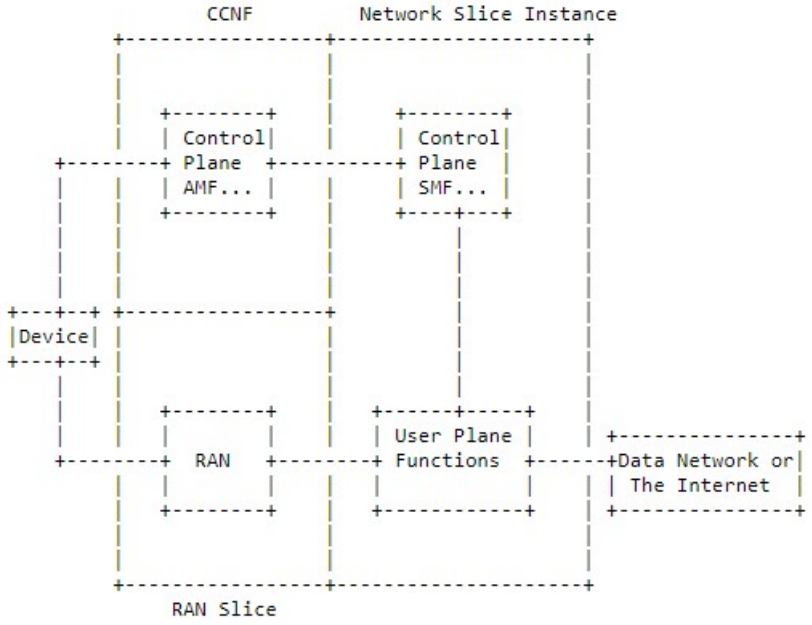
Different slice services in FlexRA

3GPP Network Sharing and Slicing Models

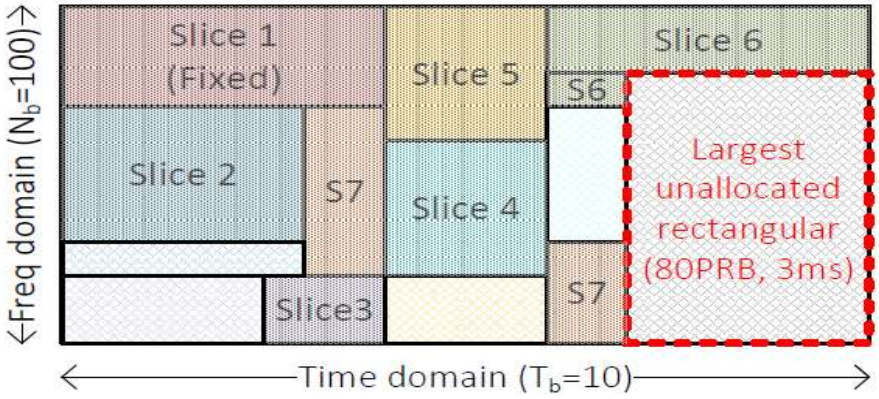
- Multi-operator RAN(MORAN)
  - Shared RAN nodes, dedicated spectrum, but separated CN per operator
- Multi-operator CN (MOCN)
  - Shared RAN nodes and spectrum, but separated CN per operator with proprietary services
- Gateway CN (GWCN)
  - shared RAN and part of core networks
- Dedicated core (DECOR)
  - deploy multiple dedicated CNs (DCNs) within a single operator network
  - one or multiple MMEs and SGWs/PGWs, each element potentially featuring different characteristics and functions
- Evolved DECOR (eDECOR)
  - Improvement in DCN selection and allocation procedures, as well as isolation among DCNs
  - UE assisted DCN selection
  - Network Node Selection Function (NNSF) at RAN to select directly the proper DCN towards which the NAS signaling needs to be forwarded
  - Congestion control and load balancing among multiple DCN with shared MME

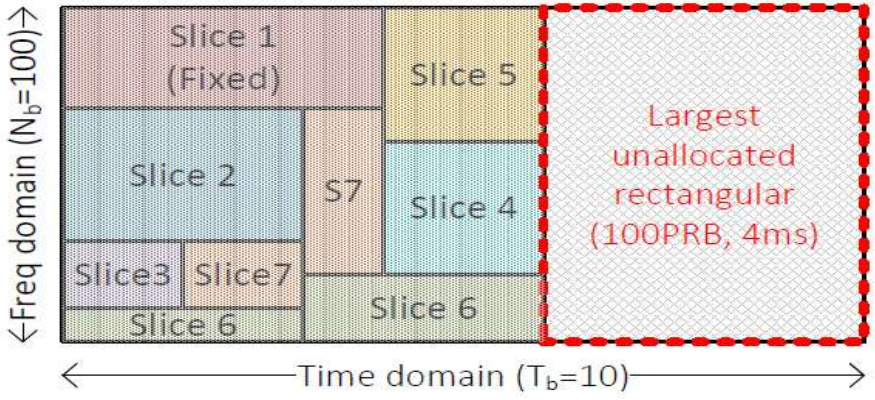
3GPP Network Slicing

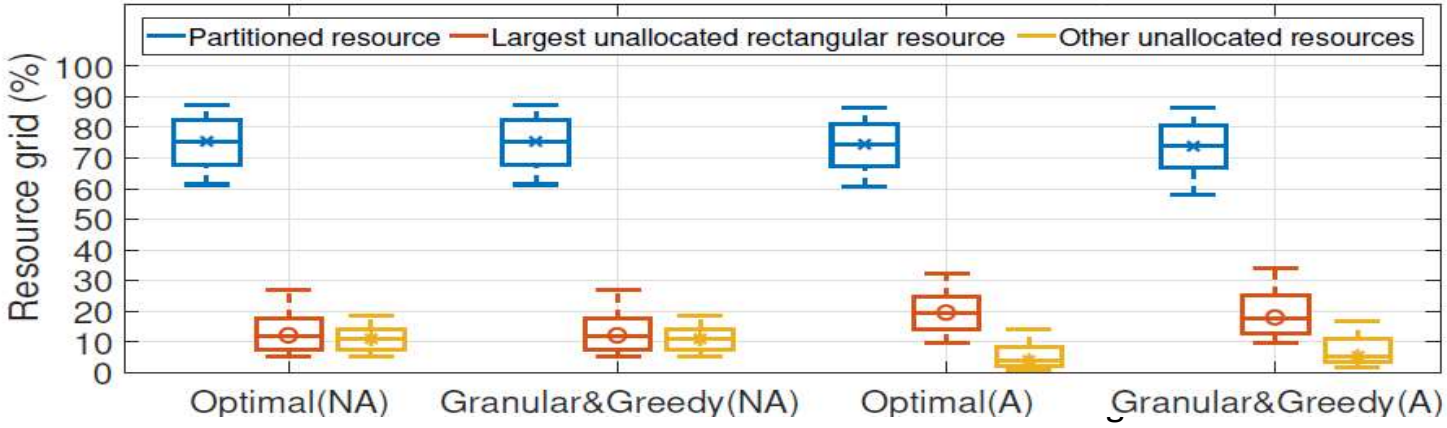


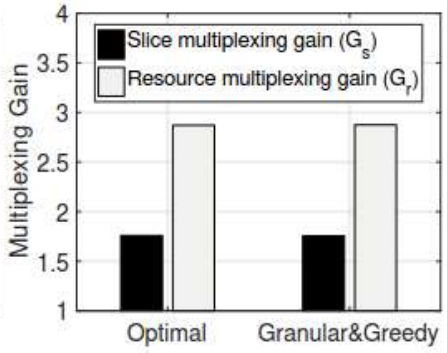


Virtual Resources → Multiplexing Gain



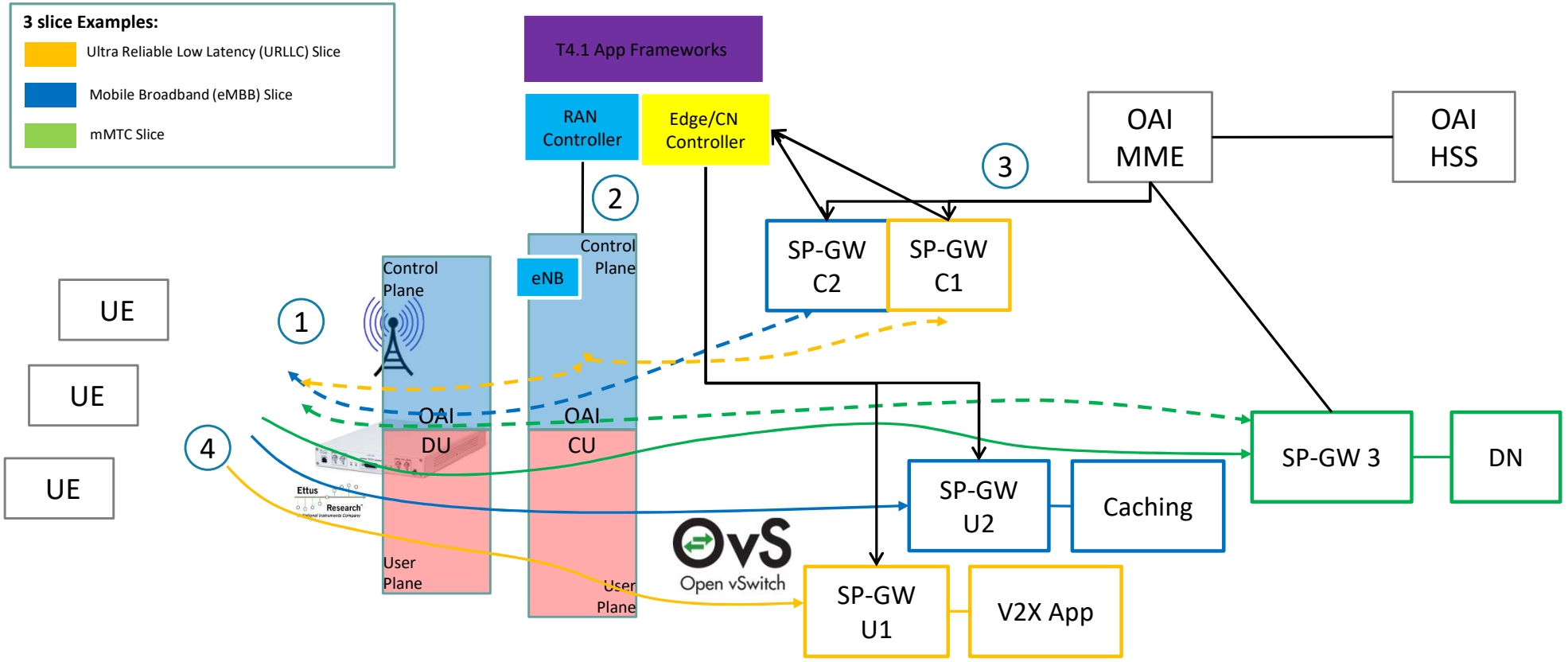




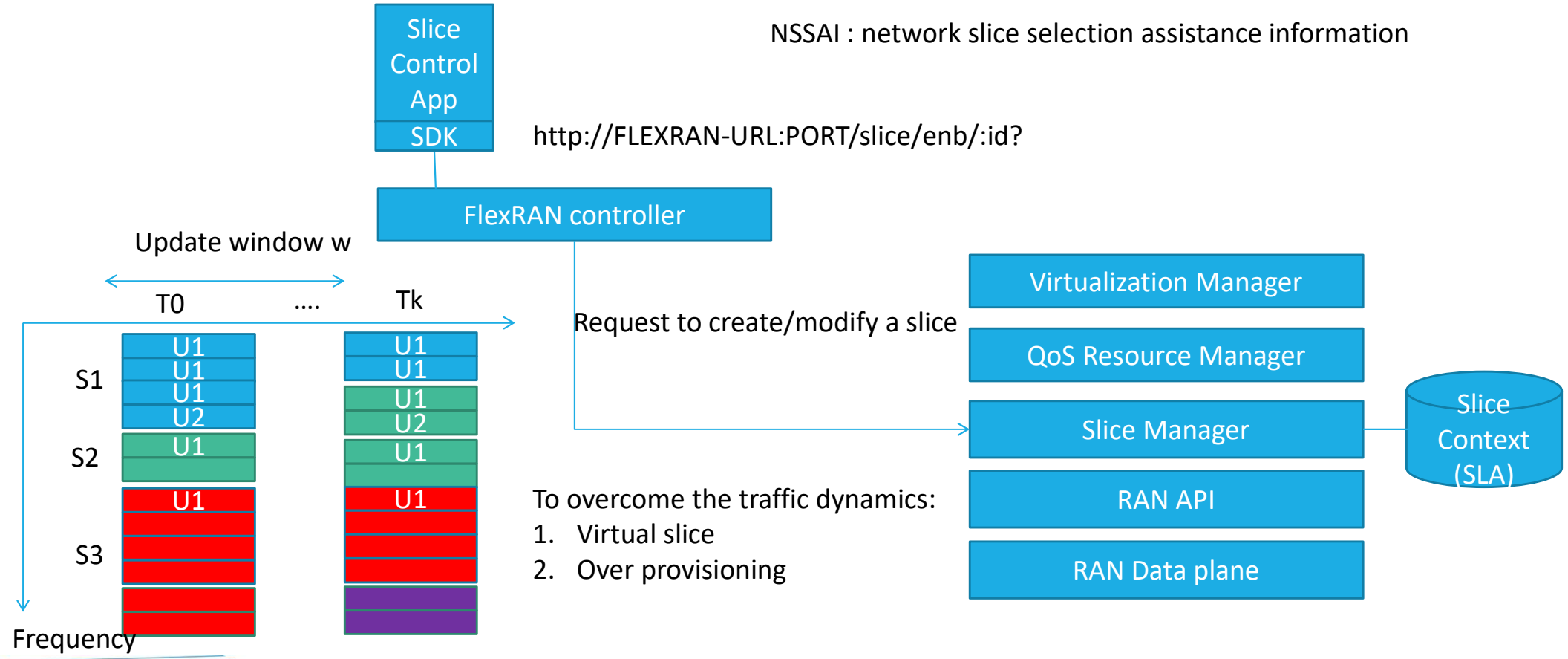


Low traffic arrival rate

SliceNet Prototyped RAN-CORE Slicing

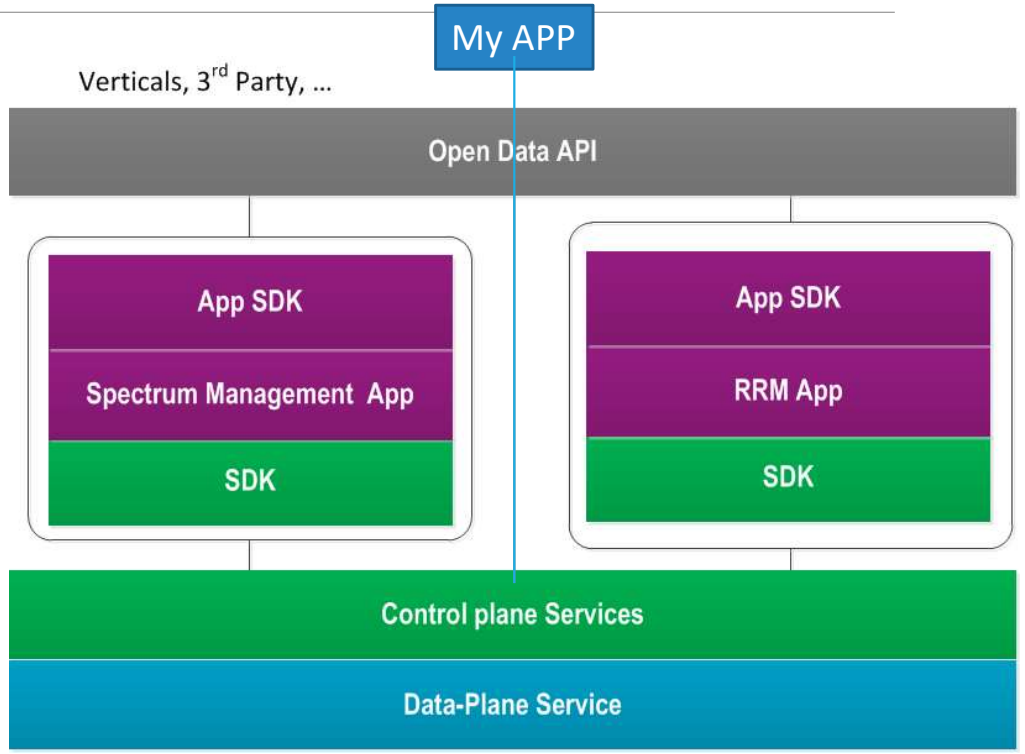


RAN Slicing with QoS support



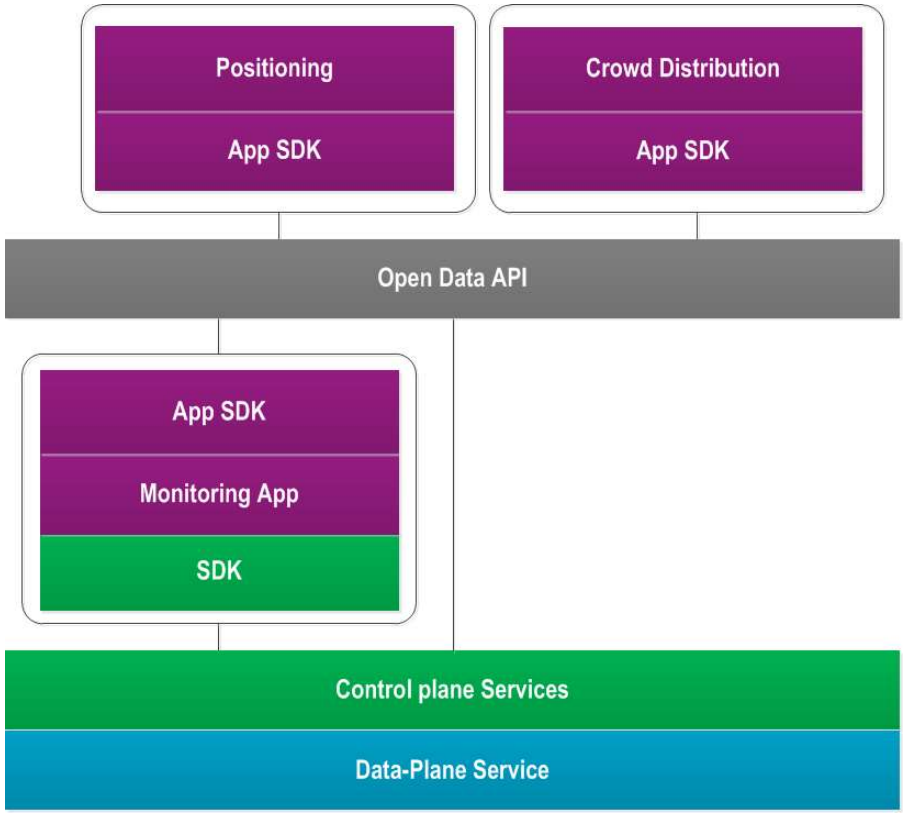
Open Data APIs

- Example of interaction between two control apps
  - **Spectrum management** decides the bands on a large time scale
  - **RRM** decides user/slice/cell performance
    - Scheduling policy
    - Handover
- Each control app is **self-contained**, it has
  - Instance of domain-specific SDKS (RAN and EDGE/CN)
  - Its own execution environment
  - Its own process and lifecycle



Open Data APIs

- Example of interaction between different control apps
  - Monitoring produces network information with desired level of granularity
  - Positioning consumes the monitoring information to determine the relative position of the user
  - Crowd distribution consumes the positioning information to generate crowd distribution



RAN Data Model

Platform SDK

Control plane Services

Data-Plane Service

API	Target	Direction	Example	Applications
Configuration (Synchronous)	eNB, UE, Slice	Controller → RAN	• UL/DL cell bandwidth, Reconfigure DRB, • RSRP/RSRQ/TA	• Monitoring • Reconfiguration • SON → cognition
Stats, Measurements (Asynchronous)	eNB, UE, Slice	RAN → Controller	• CQI measurements • SINR measurements • UL/DL performance	• Monitoring, • Optimization, • SON → cognition
Commands (Synchronous)	RAN Agent	Controller → RAN	• Scheduling decisions • Admission control • Handover initiation • Slice created/destroyed	• Hard real-time control • Soft real-time control • SON → cognition
Event Trigger	Controller	RAN → Controller	• Per TTI • UE attachment • Scheduling request • Slice created/destroyed	• Monitoring, • Control actions
Control delegation	RAN Agent	Controller → RAN	• Update DL/UL scheduling • Update HO algorithm	• Programmability, • Multi-service

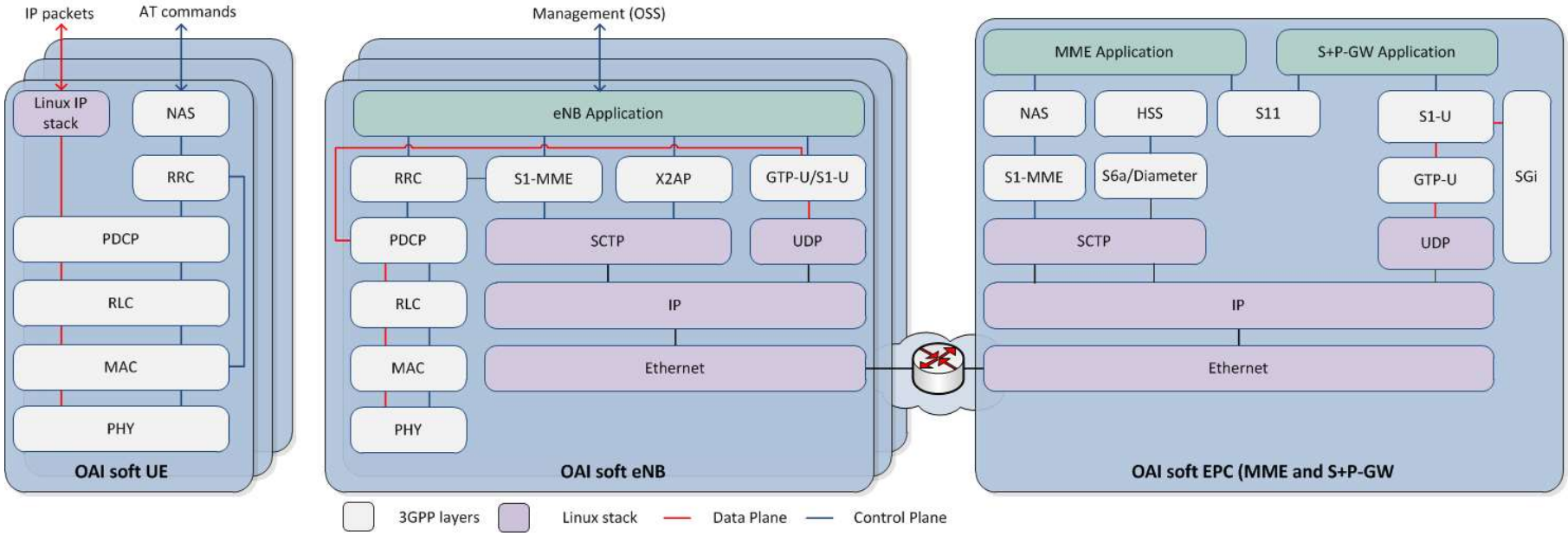
Slice Data Models

- API type/style:
  - RESTful: for soft-realtime APIs
  - CORE C : Hard Realtime control apps
- Language : JSON
- Parameters and data type
  - Example : Create a slice
    - curl -X POST http://PUBLIC_IP_ADDR:PORT/slice/enb/:id --data-binary "@file.json"

```
{
  "dl": [
    {
      "id": 0,
      "percentage": 25,
      "maxmcs": 28
    }
  ],
  "ul": [
    {
      "id": 0,
      "percentage": 25,
      "maxmcs": 20
    }
  ]
}
```

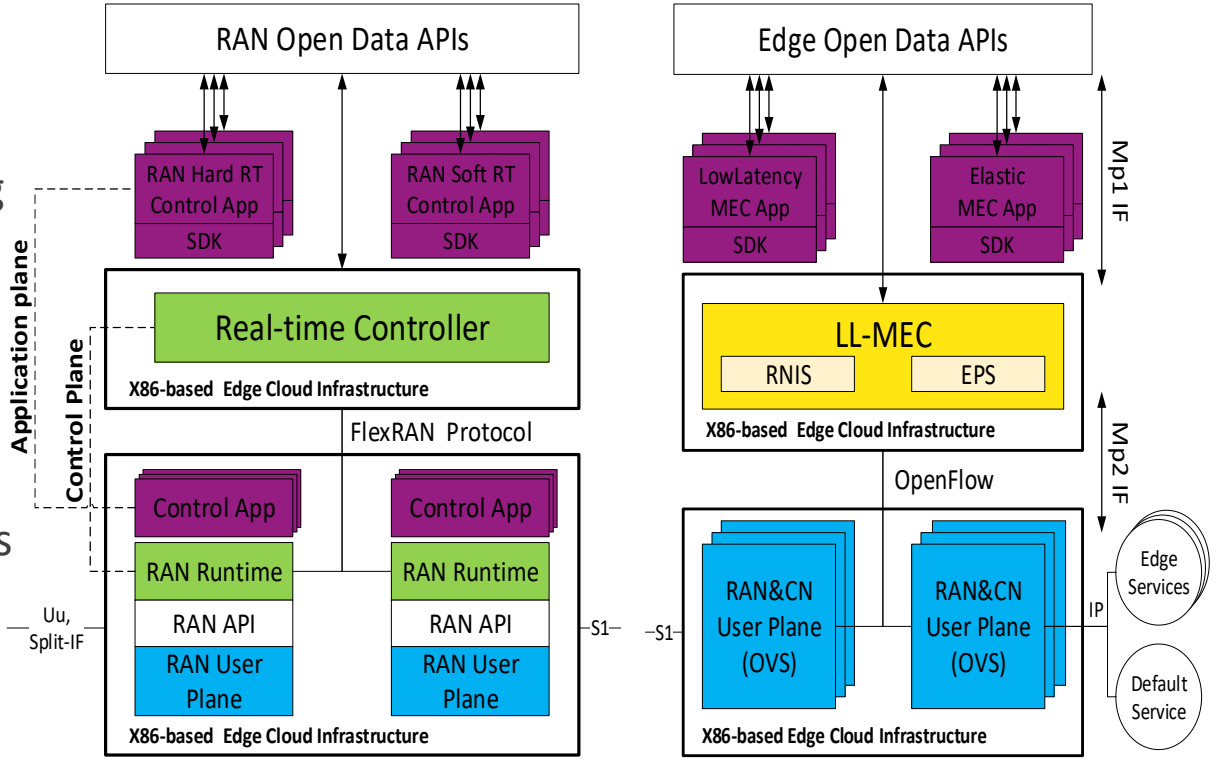
OpenAirInterface (OAI) RAN and OAI CN

- **OAI RAN** and **OAI CN** platform offers an open-source software-based implementation of a subset of the 4G-5G systems spanning the full protocol stack of 3GPP standard in both E-UTRAN and EPC



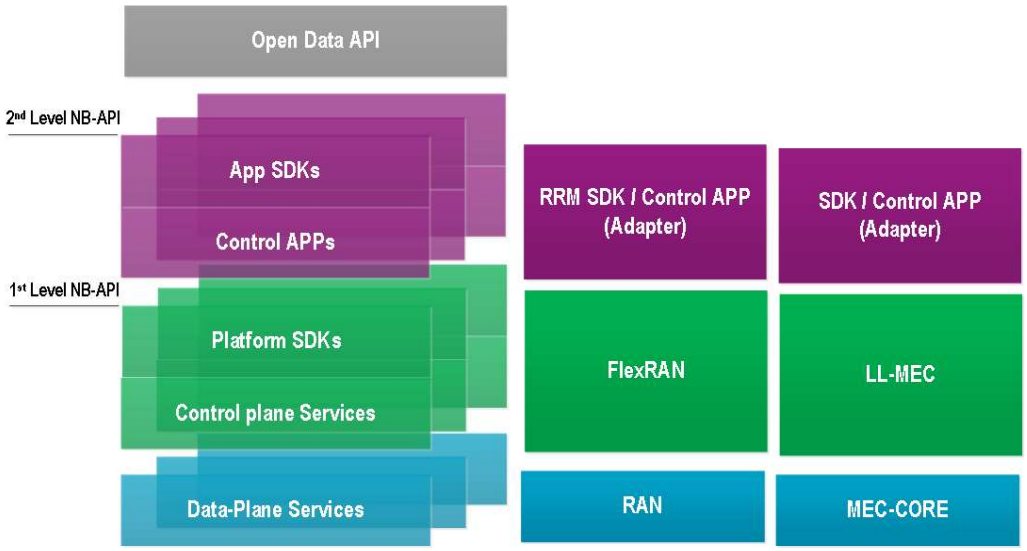
Mosaic-5G – A lightweight 5G service delivery platform

- **RAN runtime slicing system** enables the dynamic creation of slices with QoS support, while providing functional and resource isolation among different slices;
- **FlexRAN Controller** enables monitoring, control and programmability in the RAN domain;
- **LL-MEC Controller** leverages the SDN principle to separate user plane processing from its control logics at the edge and core networks to enable user plane programmability as per slice requirements;



Interfaces and APIs

- Definitions of interfaces and APIs of the RAN-Core Adapters, FlexRAN and LL-MEC controllers to ease their integration within the SliceNet platform and to allow the SliceNet CP services to customize the network slices at runtime according to the vertical requirements
  - RAN/Core Adapter translates the high-level abstracted request to the specific commands foreseen by the underlying RAN and MEC/Core controllers



Abstraction scheme supporting monitoring, control and programmability