

# ***Network Slicing from UE to Cloud***

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*Professor, The University of Tokyo*

*Chairman of Network Architecture Committee*

*The Fifth Generation Mobile Network Promotion Forum (5GMF)*



1

# Overview of 5GMF

# 5G in the World

Future IMT Vision in ITU-R WP5D



ITU-T Focus Group on IMT-2020



5G Study Items



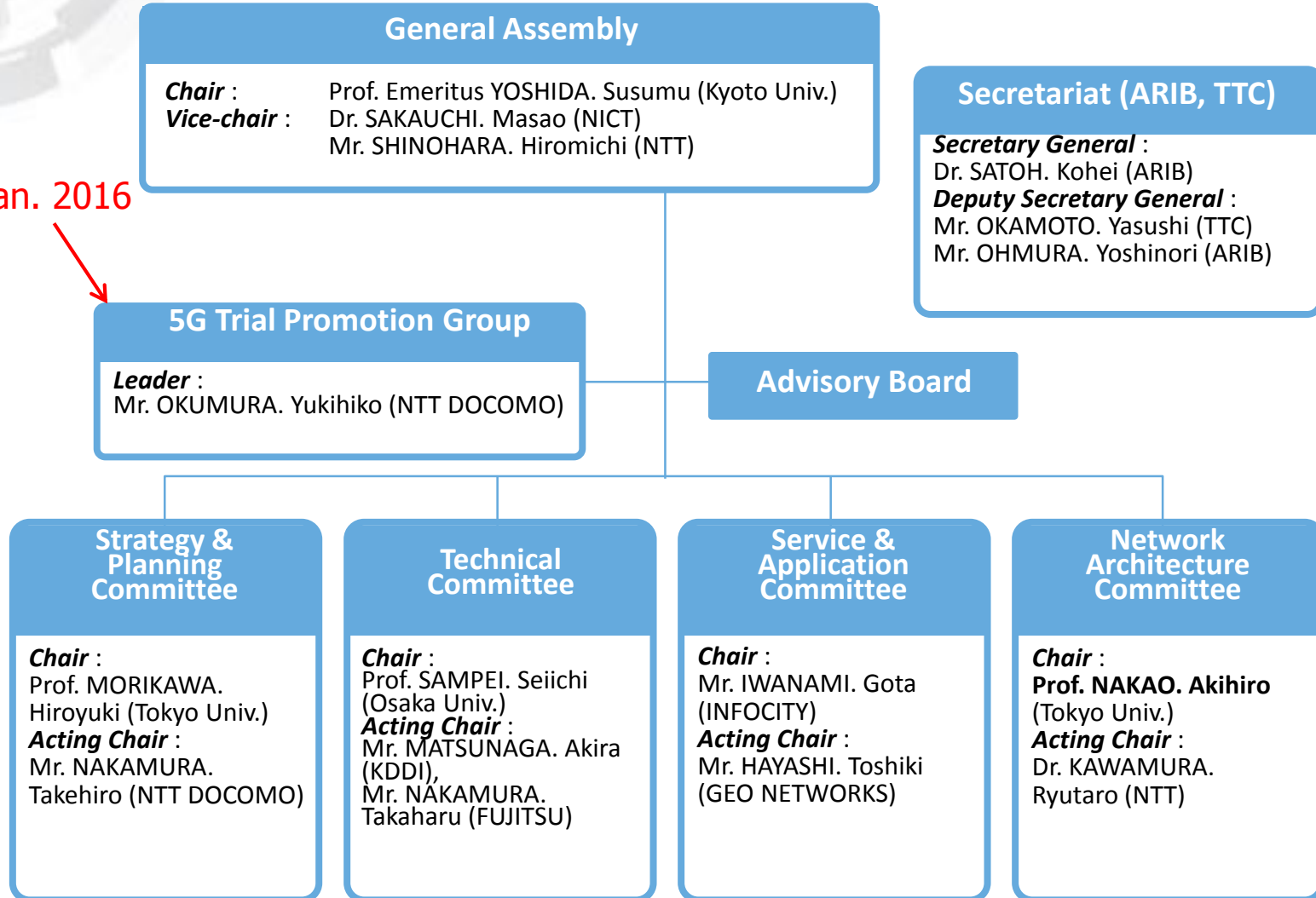
5G Initiative



Vision2020/ Network2020

# Organizational Structure of 5GMF

Jan. 2016



# 5GMF members



Members:93 (as of 12 May 2016)      Ordinary members:74, Individual members:14,  
Special members: 3 (MIC, ARIB, TTC)

# 5GMF White Paper published on 2016/May!

<http://5gmf.jp/news/20160705160541/>

5GMF invited to give a lecture talk among 5GPPP community at EUCNC 2016

**EUCNC 2016**

European Conference on Networks and Communications | Athens, Greece

*The Dawn of 5G*

27 - 30 June 2016

[www.eucnc.eu](http://www.eucnc.eu)



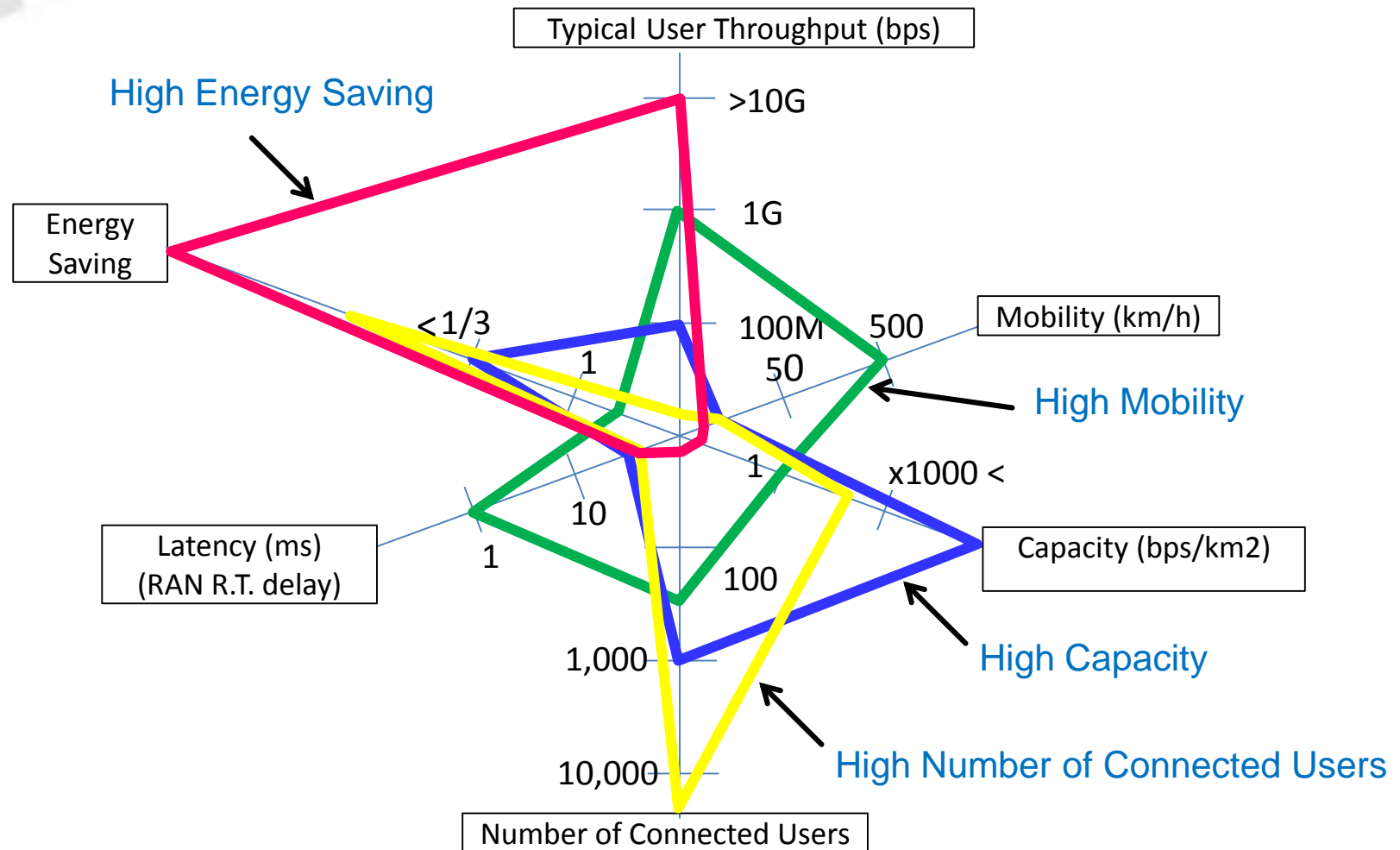
## 2

**What are the architecture design principles and building blocks you are working on for 5G era**



# Requirements For User Scenes (Examples)

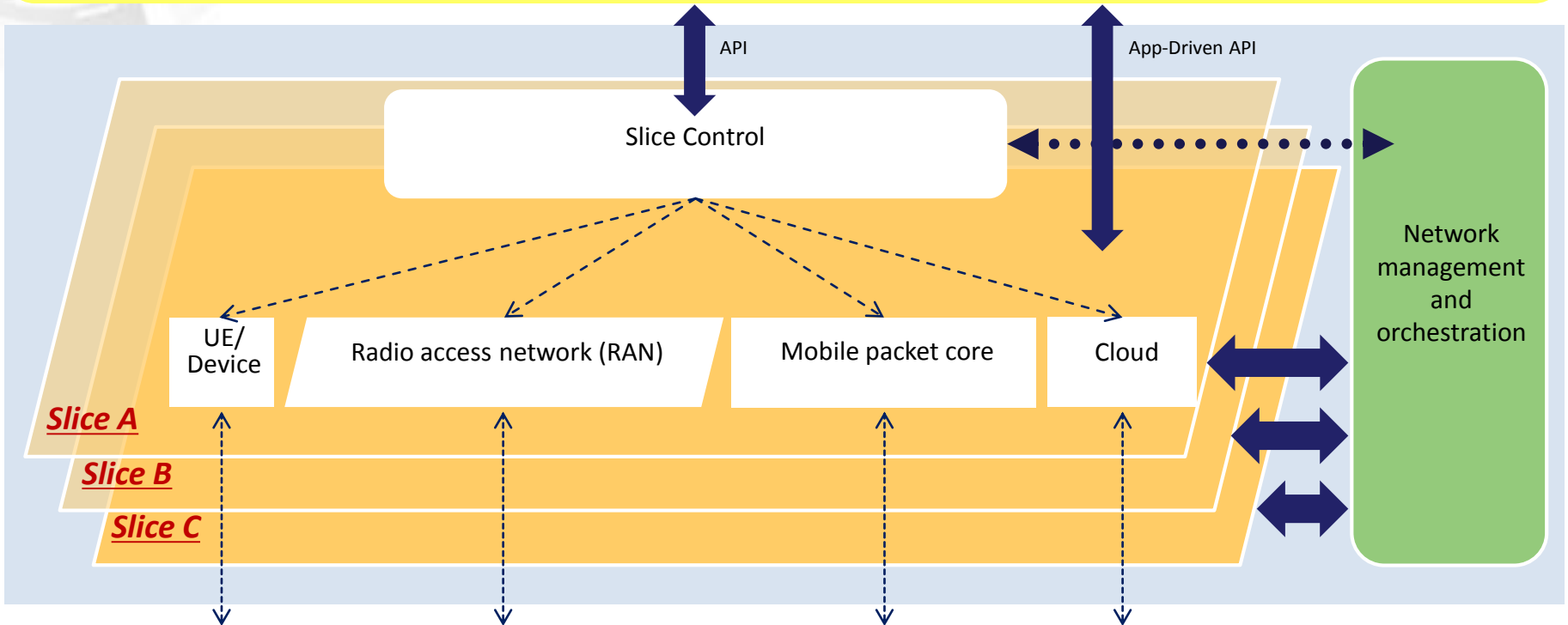
- 5G systems do not always need to achieve their maximum performance.
- 5G systems will be determined based on individual use scene requirements.



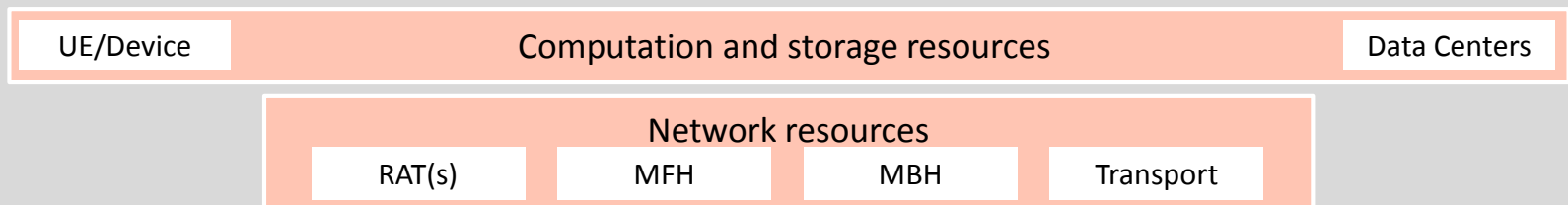


# Network Softwarization and Slicing

Applications & Services with various requirements (M2M/IoT, Content delivery, Tactile)



Physical infrastructure (network, computation and storage resources)



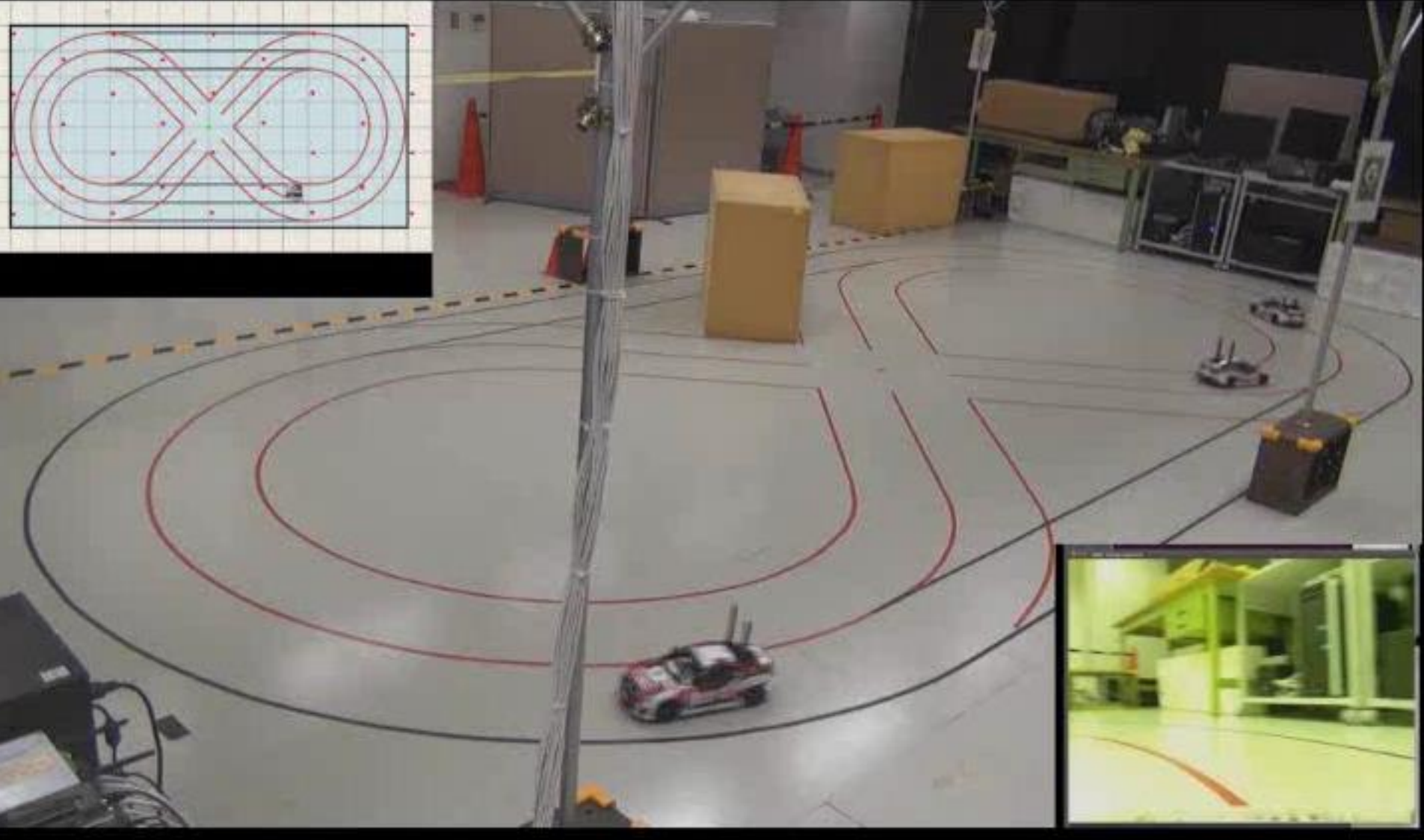
# Definition of Slice

**Slice = An **Isolated** set of **programmable** resources**

**Two important features to be required**

- **Resource Isolation**
- **Programmability**

**Note: virtualization and partitions are aiding techniques for slicing...**



# Internet of **Moving** Things

# Google Maps picks up mapping analytics and visualization startup Urban Engines

Posted Sep 16, 2016 by **Brian Heater (@bheater)**

[Next Story](#)

<https://techcrunch.com/2016/09/16/urban-engines-2/>

3

# On Going Projects on Network Slicing





# EU-Japan Collaboration Project Proposal

## 5G!Pagoda

*"A network slice for every service"*

## 5G! PAGODA

**Federating Japanese and European 5G Testbeds to Explore Relevant Standards and Align Views on 5G Mobile Network Infrastructure Supporting Dynamic Creation and Management of Network Slices for Different Mobile Services.**

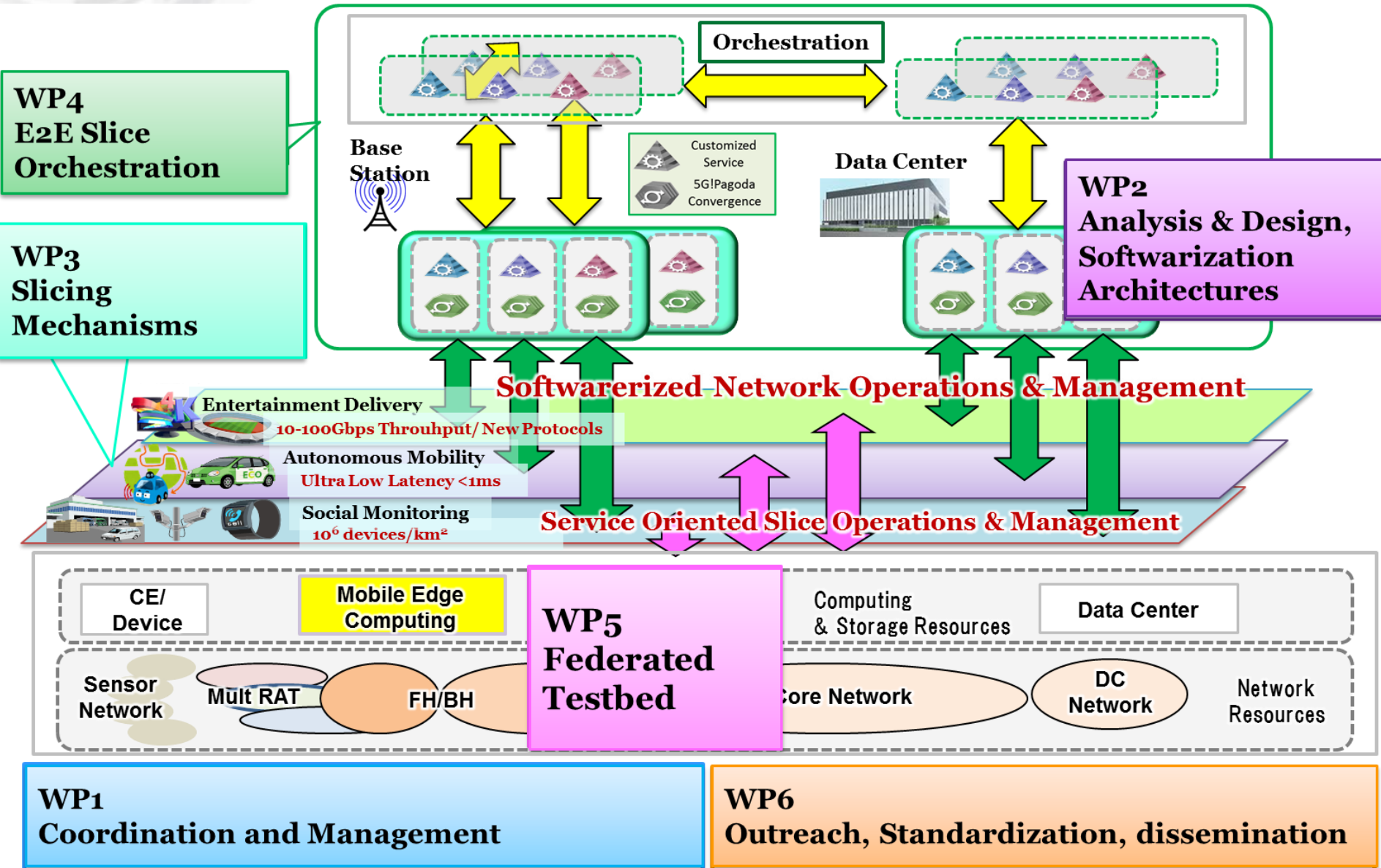
サービスに応じたスライス動的生成・管理機能の実証と標準化を目的とする日欧連携 5G 移動通信基盤テストベッド

**Call:** EUJ1-2016 - 5G - Next Generation Communication Networks  
**Coordinators:** Tarik Taleb and Akihiro Nakao  
**E-mails:** [tarik.taleb@aalto.fi](mailto:tarik.taleb@aalto.fi) and [nakao@nakao-lab.org](mailto:nakao@nakao-lab.org)  
**Phone:** +358-50-435-2325 and +81-3-5841-2384



- ◆ Softwarized Network Realization w/ NFV, SDN and 5G
- ◆ Research-Innovation and Standardization
- ◆ Objectives are
  - i) the development of **a scalable 5G slicing architecture** towards supporting **specialized network slices composed on multi-vendor network functions**, through the development of
  - ii) **a scalable network slice management and orchestration framework** for **distributed, edge dominated network infrastructures**, and convergent software functionality for
  - iii) **lightweight control plane** and
  - iv) **data plane programmability** and their **integration, customization, composition and run-time management** towards different markets.





## ◆ Open Source based Network Softwarization Platform

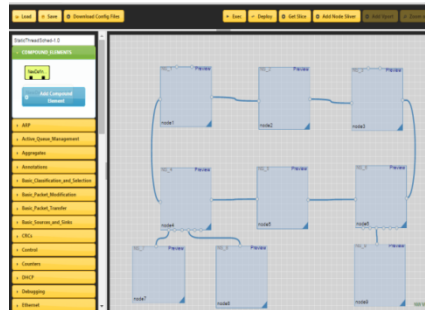
Click!

Click!

Open Source  
Optimization

**TILERA** SDK

**Network Functions  
Software Defined  
Data Plane**



**Toy-Block  
Networking GUI**

**FLARE Project** **FLARE Central** edit primary links

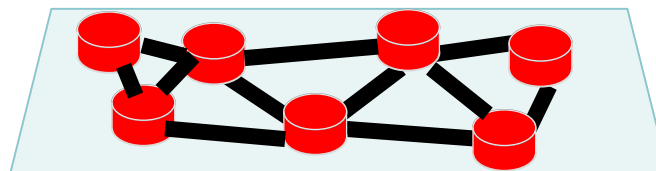
shu@iili.u-tokyo.ac.jp

Home

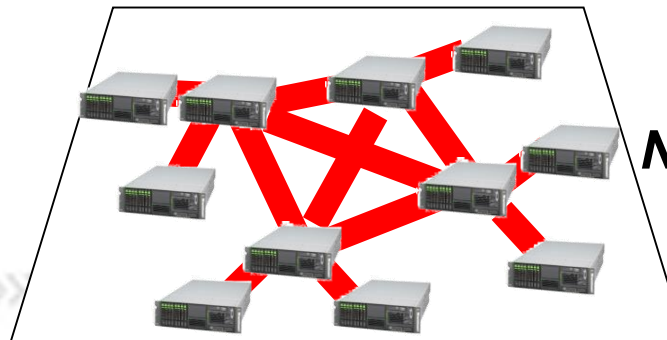
Nodes on site FLARE Central Central

nodename	Hostname	Node_type
13	flare-sw1.hokusan.nakao-lab.org	FlareSwitch
14	flare-sw2.hokusan.nakao-lab.org	FlareSwitch
12	flare-sw1.hokurika.nakao-lab.org	FlareSwitch
487	flare-sw2.komaba.nakao-lab.org	FlareSwitch
36	flare-sw1.komaba.nakao-lab.org	FlareSwitch
46	flare2-sw1.komaba.nakao-lab.org	FlareSwitch
41	flare2-sw2.komaba.nakao-lab.org	FlareSwitch
62	flare2-sw3.komaba.nakao-lab.org	FlareSwitch
34	flare2-sw5.komaba.nakao-lab.org	FlareSwitch
47	flare-sw1.komaba.nakao-lab.org	FlareSwitch02
68	flare2-sw1.hokurika.nakao-lab.org	FlareSwitch
62	testnode209.nakao-lab.org	FlareSwitch
23	v1511.nakao-lab.org	FlareSwitch
24	v1512.nakao-lab.org	FlareSwitch
25	v1513.nakao-lab.org	FlareSwitch
26	v1514.nakao-lab.org	FlareSwitch
28	v1517.nakao-lab.org	FlareSwitch
15	v1518.nakao-lab.org	FlareSwitch

**Resource  
Management  
Center**



**Slice  
(Logical NW View)**



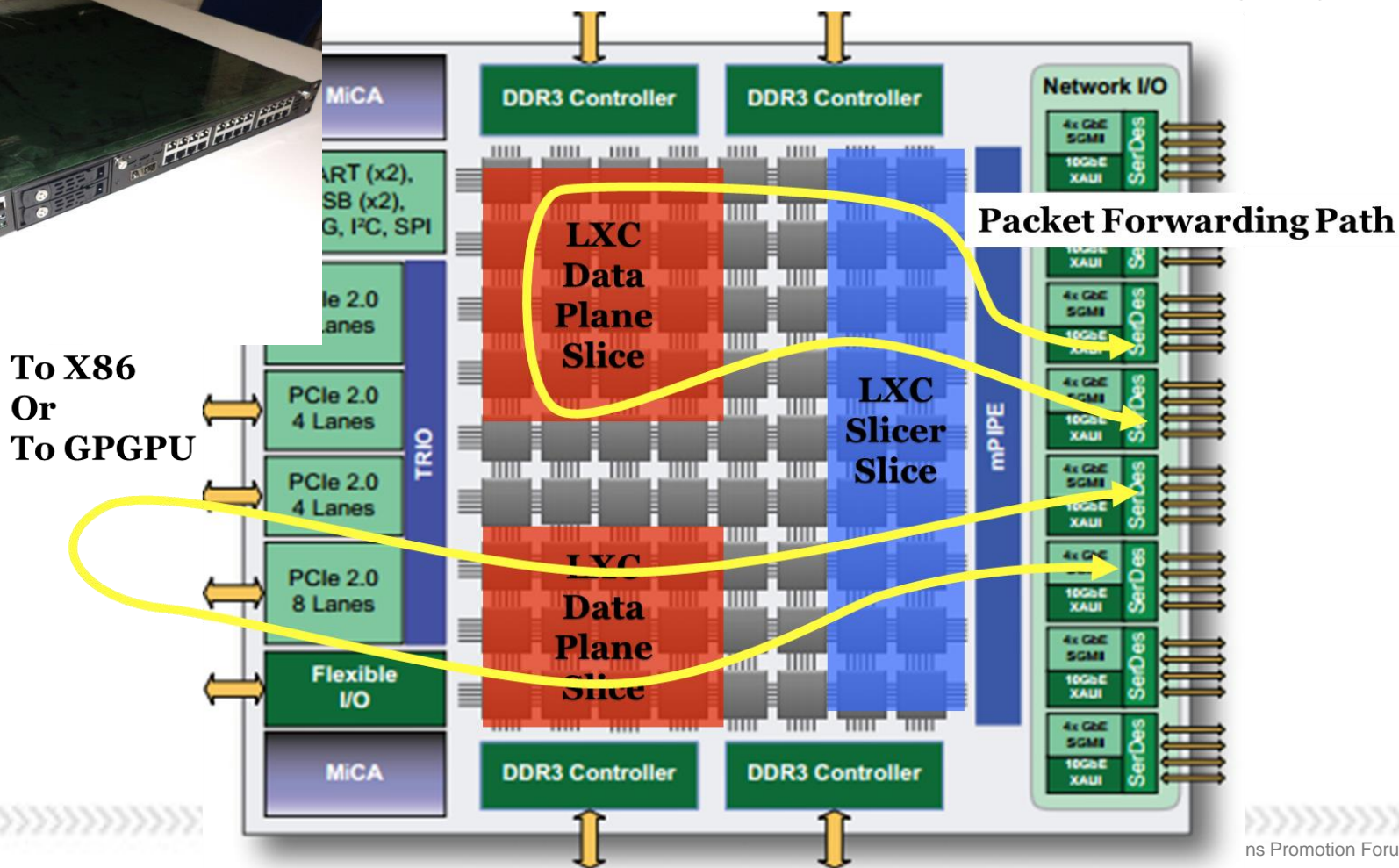
**Network of FLARE nodes  
(Physical NW View)**

## ◆ *FLARE Platform will be enhanced towards 5G Slicing*

Current Spec: 72 core EZ-Chip Network processor, GbE: 24 ports and 10GbE SFP+: 2 ports, Up to 128GB memory / 1TB SSD, Redundant Power supply



**LXC: Linux Container on Zero Overhead Linux (ZOL)**



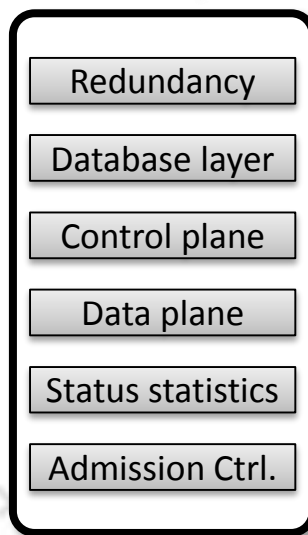
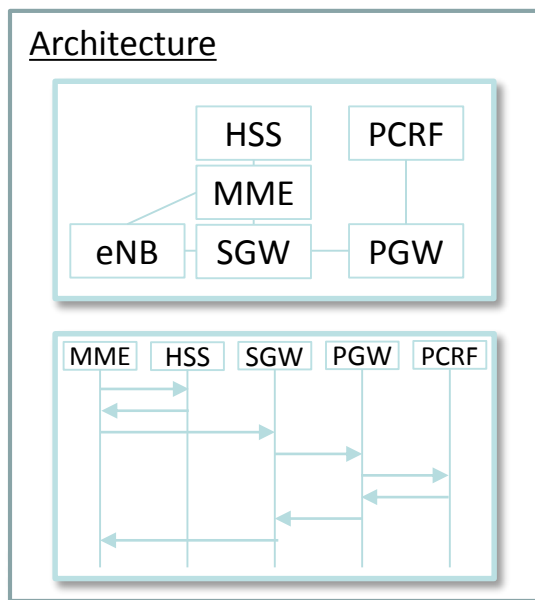
## ◆ Developing a platform allowing **Automatic Implementation of Comm. Systems** from architecture.

- ✓ Common features as software libraries: database, and control- and data-planes
- ✓ Common Orchestrator to control and manage multiple comm. systems

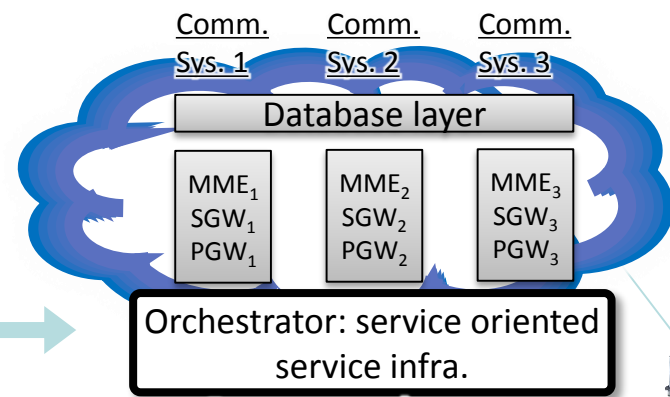
Platform **automatically generates** and evaluates the state machine from the given architecture, and implement **the execution codes** without the fatal failure of the system

System designer provide architecture of comm.  
System to Platform

Platform automatically implements  
comm. system



**Softwarized mobile core**



**Common orchestrator**  
**rapidly sensing state change by distributed OSS included**

# Contribution from Waseda University



Waseda University

## ◆ *ICN(an Emerging Network Architecture) slice* realization on 5GPagoda frame work

- ✓ Smooth connection mechanism with RAN
- ✓ New protocol set for automatic FIB configuration
- ✓ Name structure, Node naming, Mobility

## ◆ *Demonstration of an application service on ICN*

- ✓ Candidate will be **IoT related**

## ◆ *Standardization activities*

- ✓ Mainly in ITU-T(FG IMT-2020 etc.)
- ✓ Already contributed one document to FG IMT-2020



## Performance

- Network Slicing R&D
- Slice Deployment in our MVNO

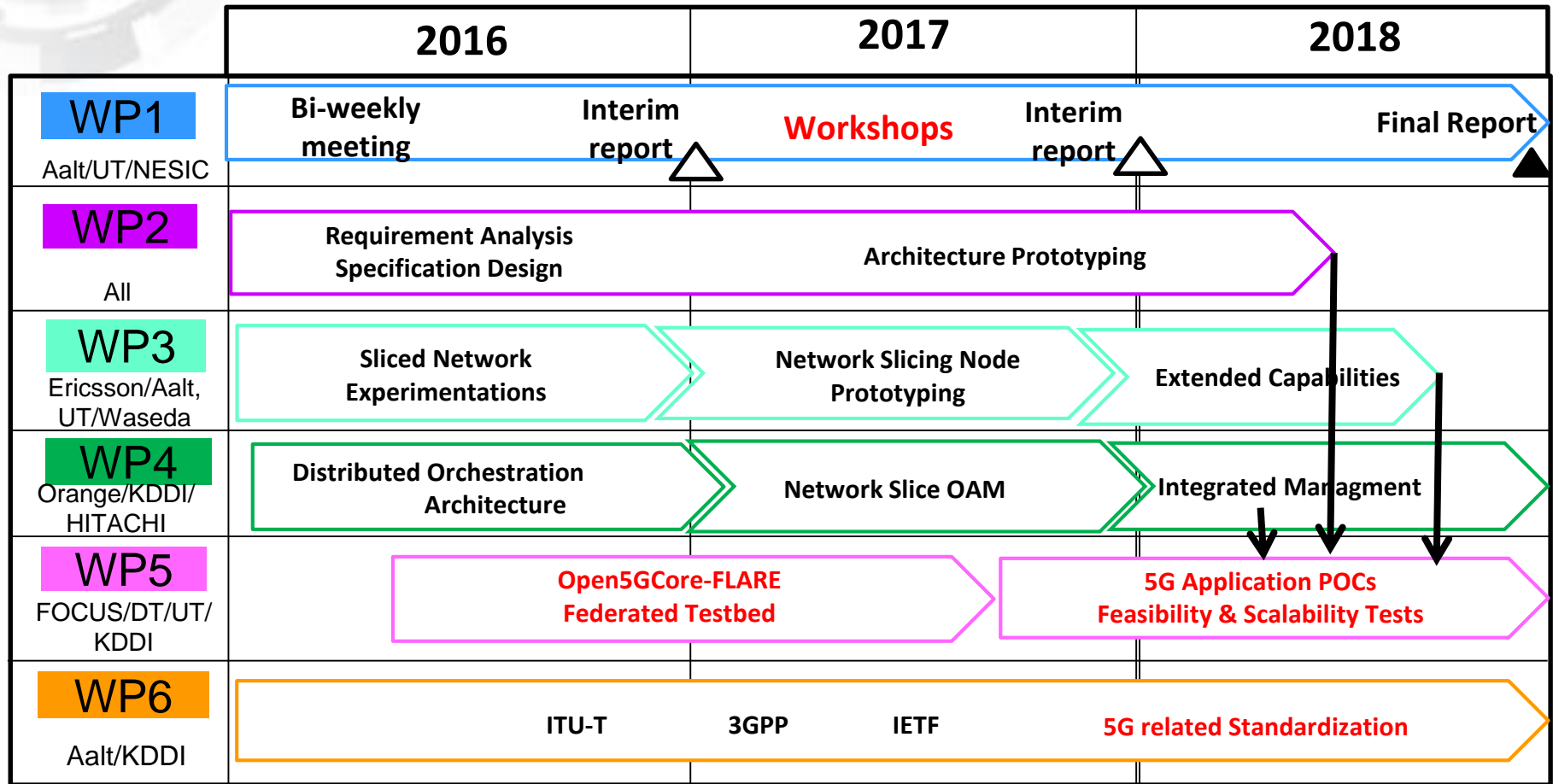


- Lots of Experiences on carrier NFV & SDN PoC

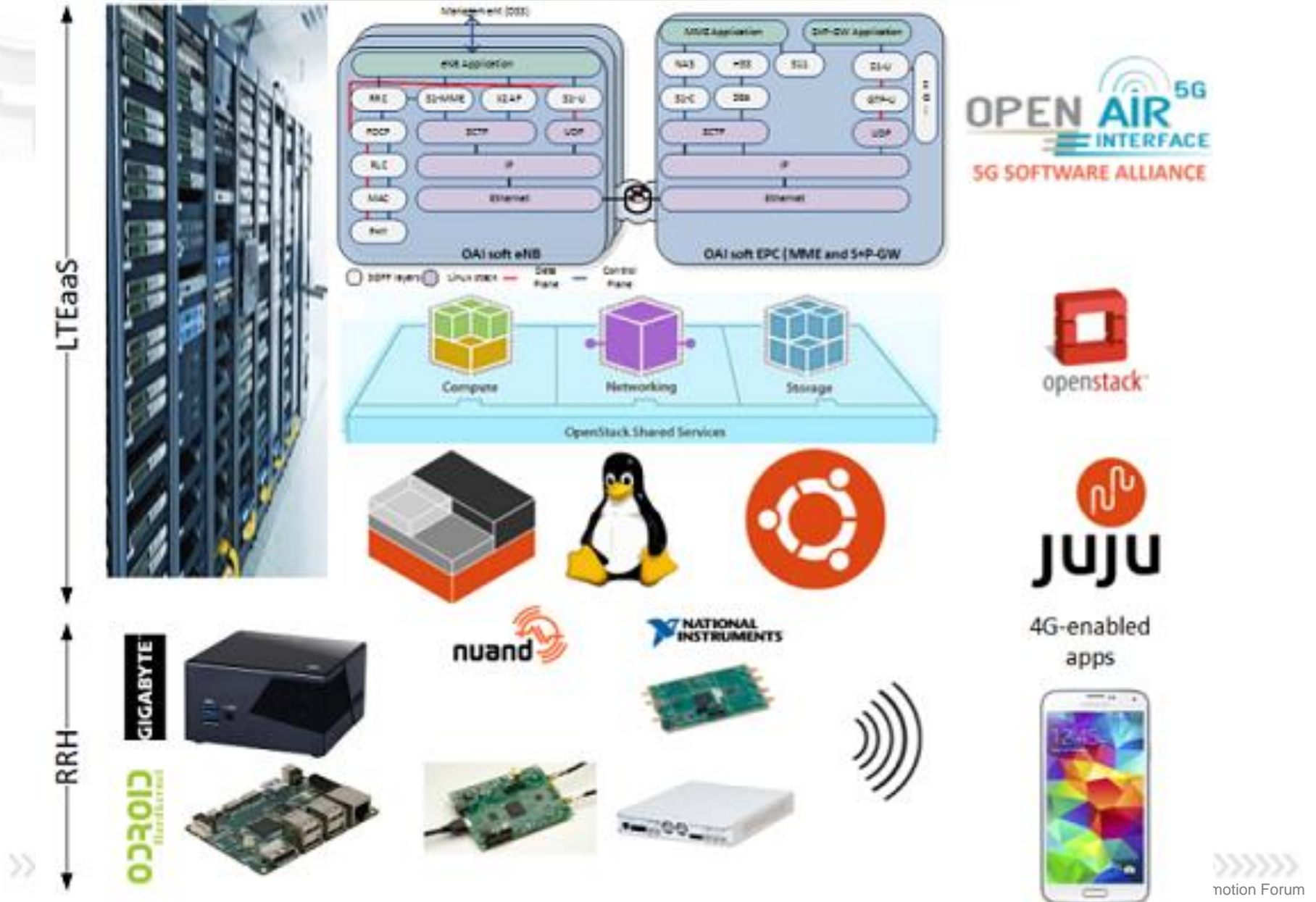
## Know-how

- **MVNO Operations & Management**
- **IoT service Experience**
- SI skills on reliable Carrier NW
- Collaborative FLARE R&D since 2014

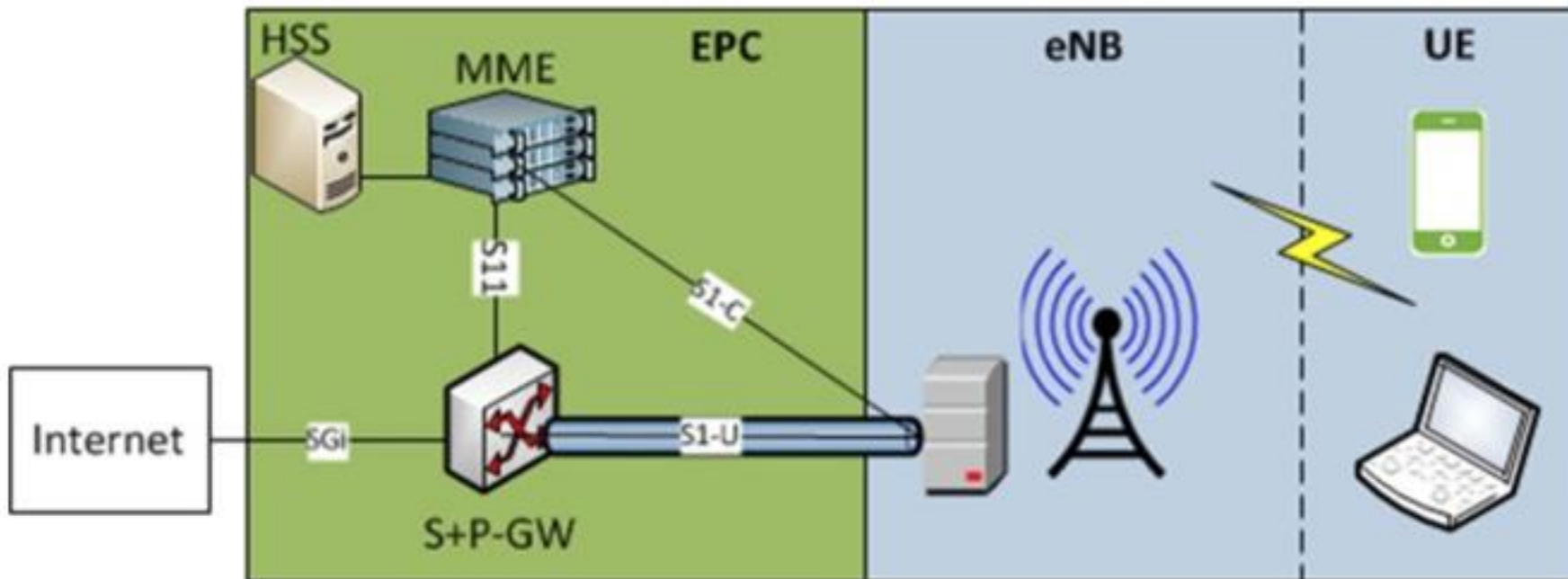
- ① Contribute to a specification of network slice operations w/ edge computing functions, a prototype development, and field trials
- ② Verifies on “**Time To Market**” and “**E2E Quality Satisfaction**” capability







# Software Defined Radio



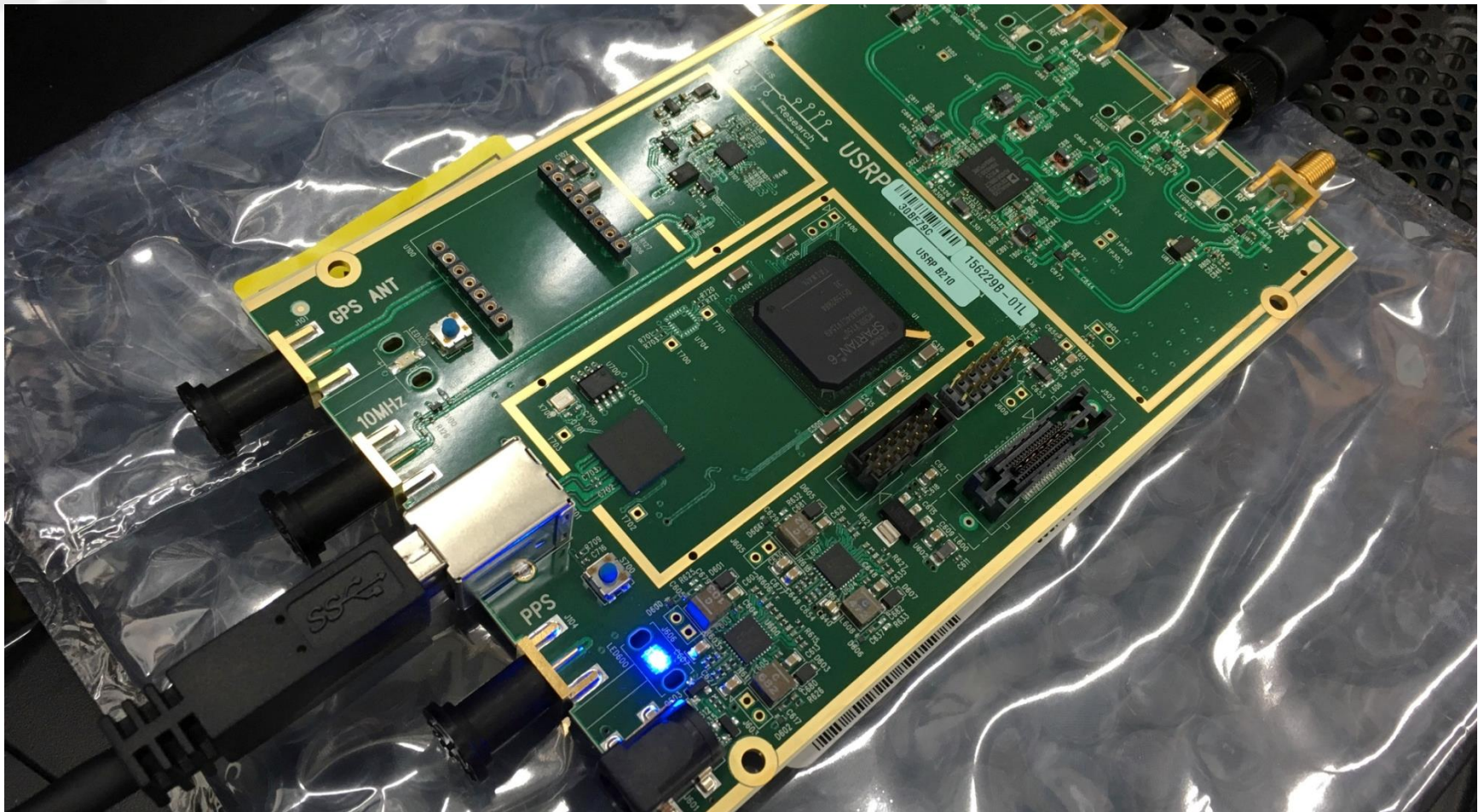
Software Defined LTE/5G Network !



Programmable SIM



# Software Defined Radio

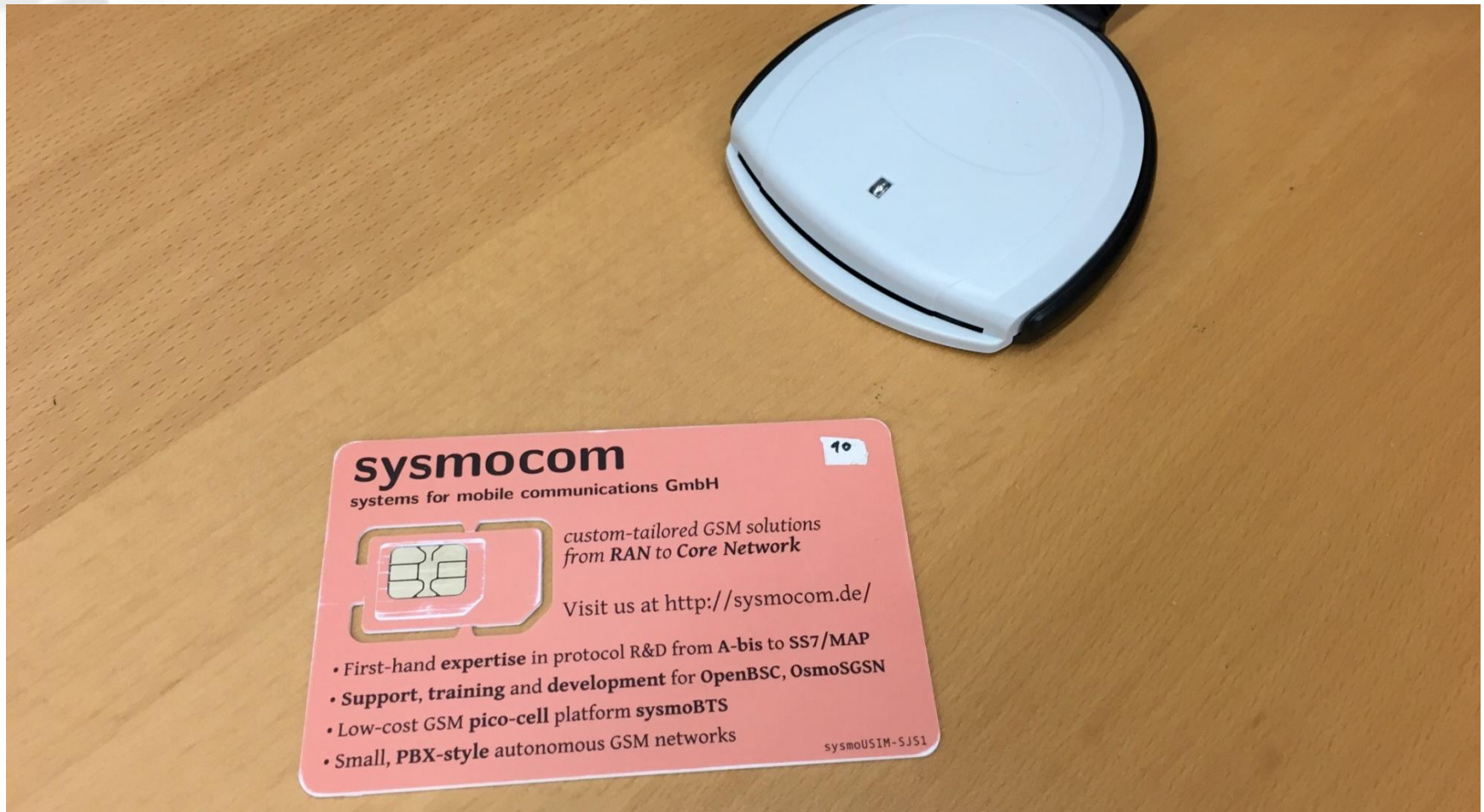




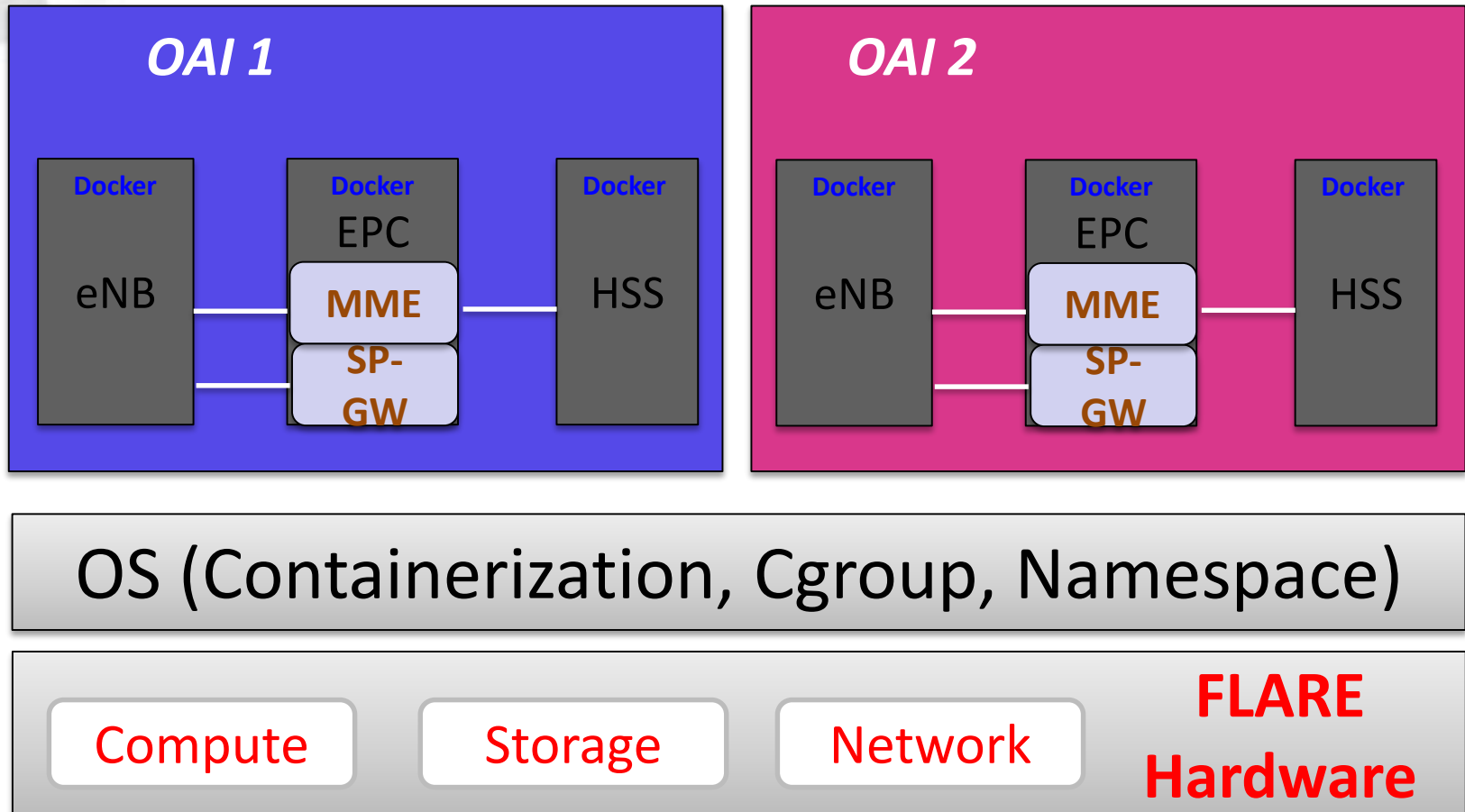
# Software Defined Radio



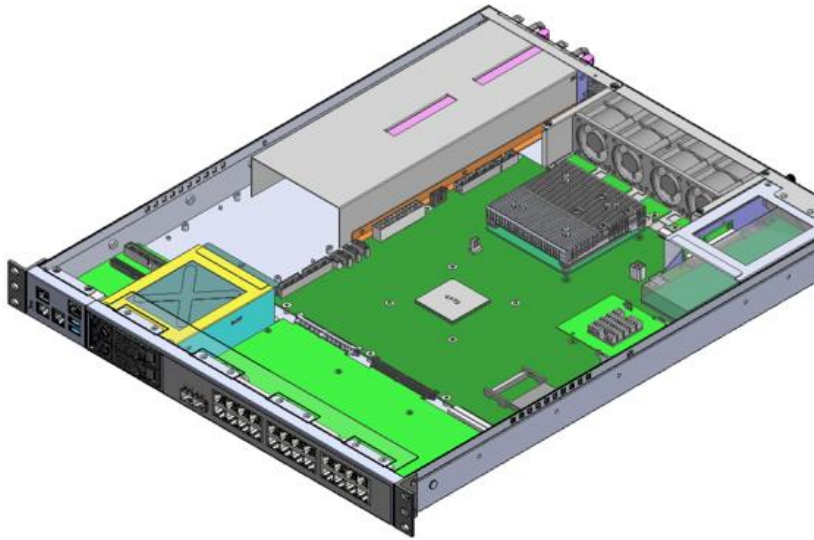
# Programmable SIM



# Architecture of OAI Slicing in FLARE



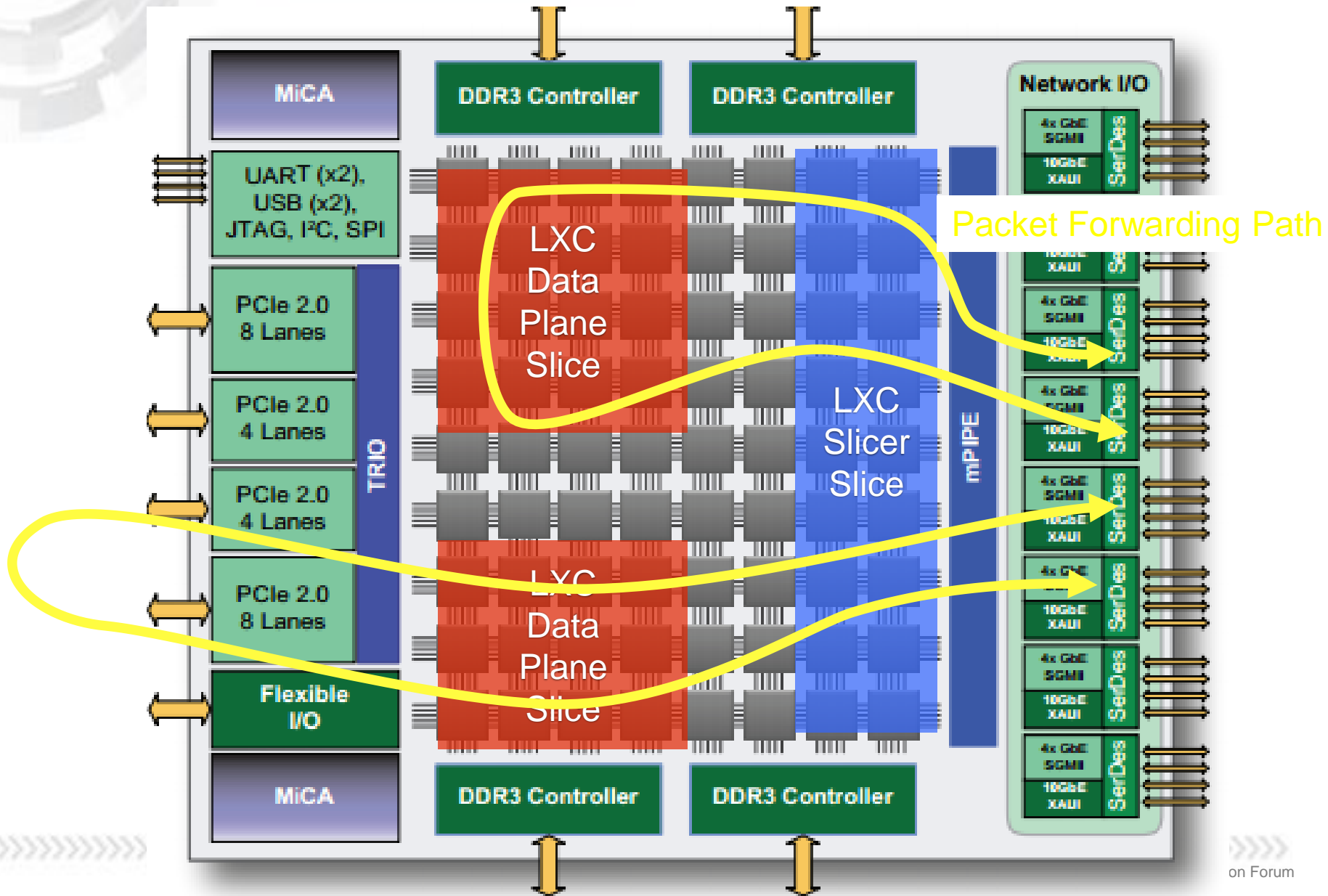




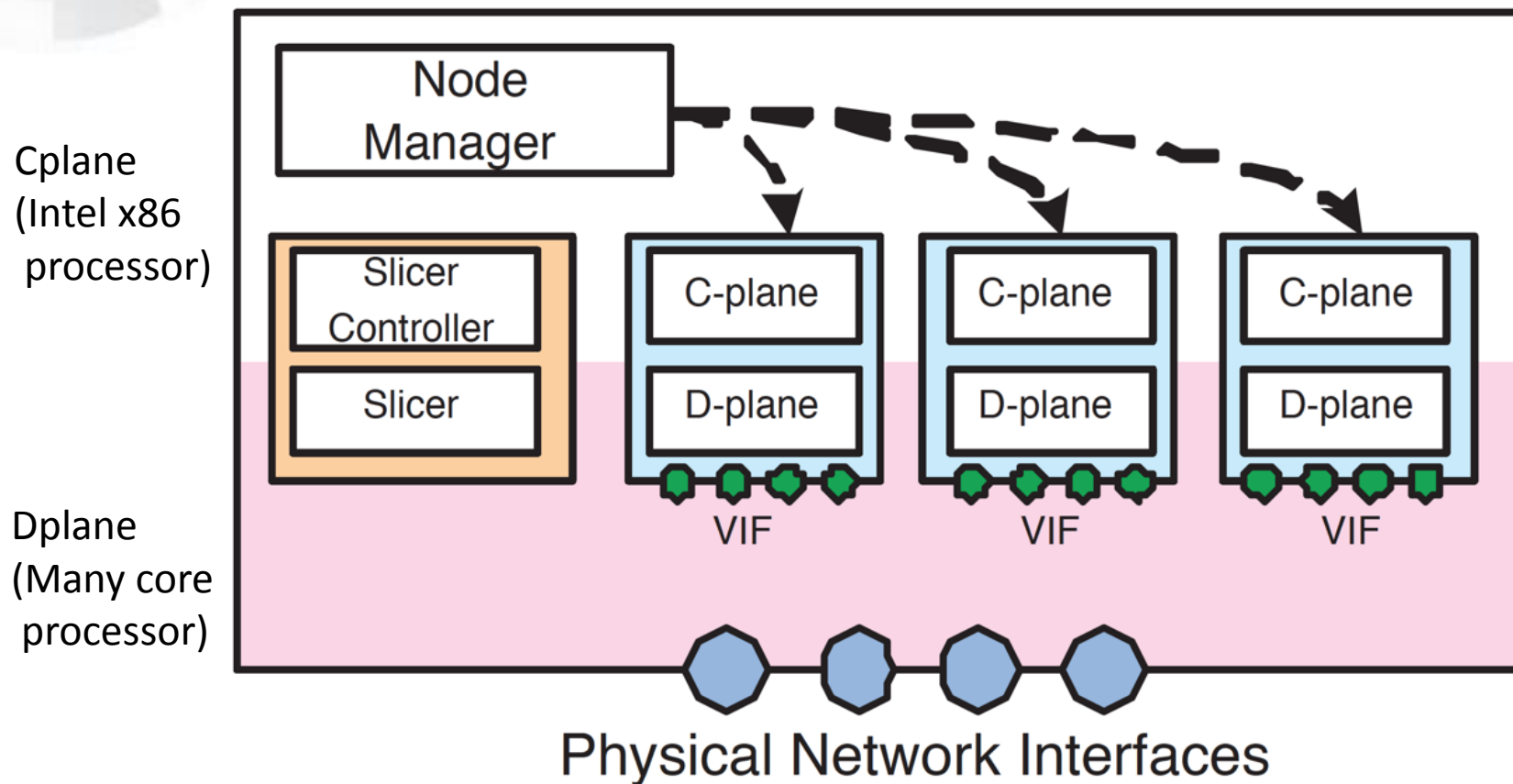
- 72 core EZ-Chip Network processor
- GbE: 24 ports and 10GbE SFP+: 2 ports
- Up to 128GB memory / 1TB SSD
- Redundant Power supply



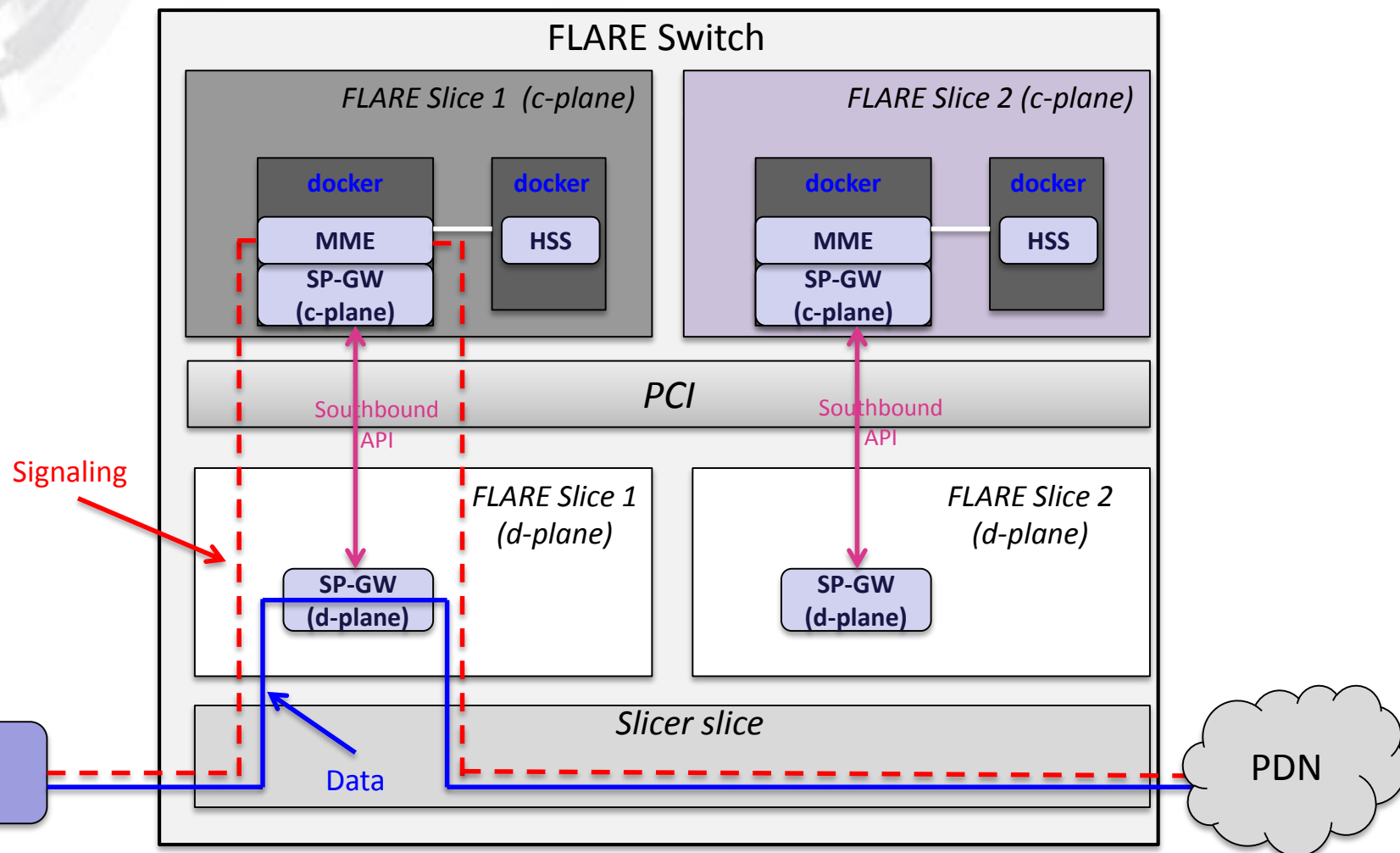
# Sliceable Data Plane in FLARE Node



# FLARE Node Architecture



# Dockerized EPC on FLARE Node

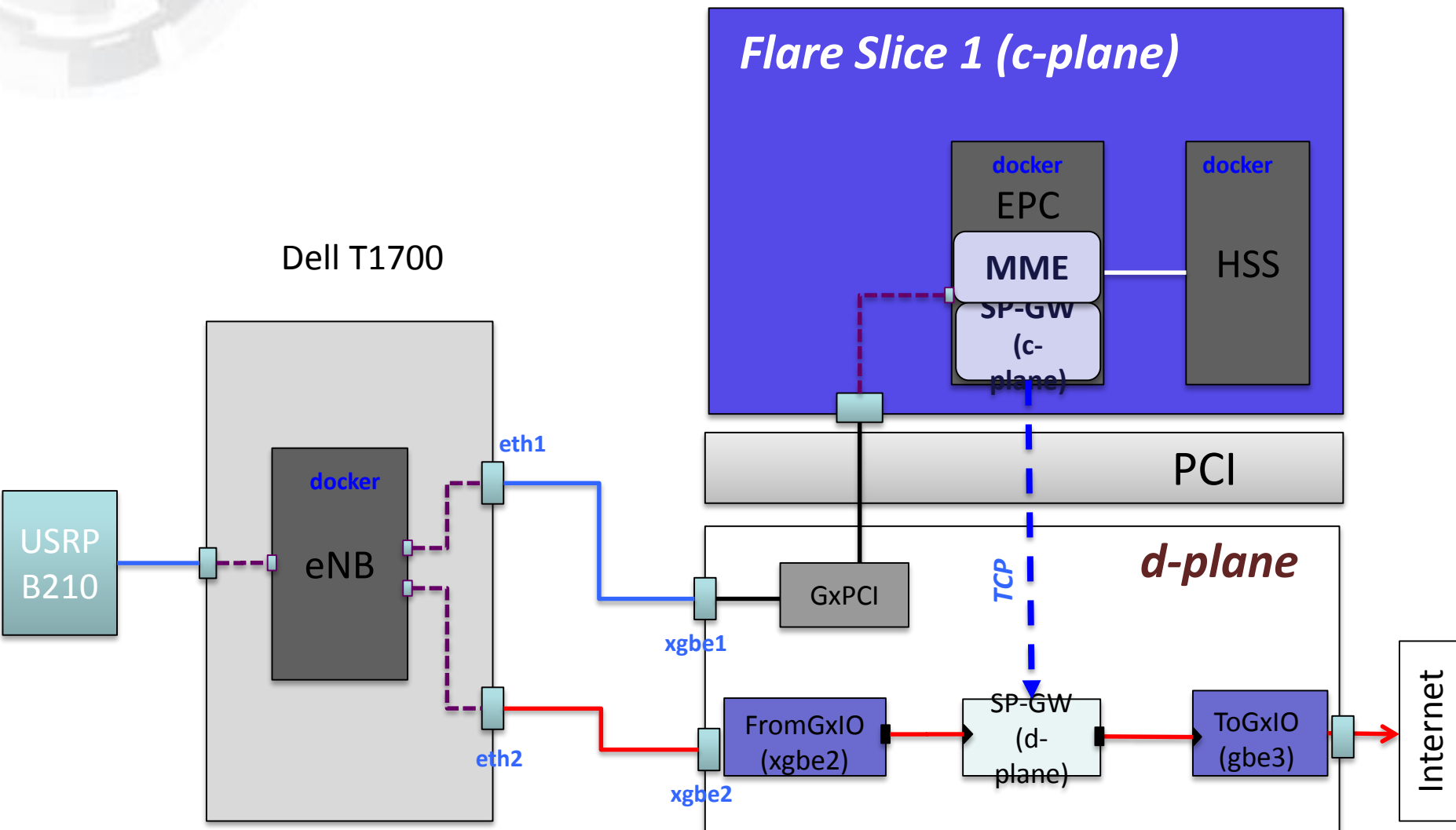


# Dockerized EPC on FLARE Node

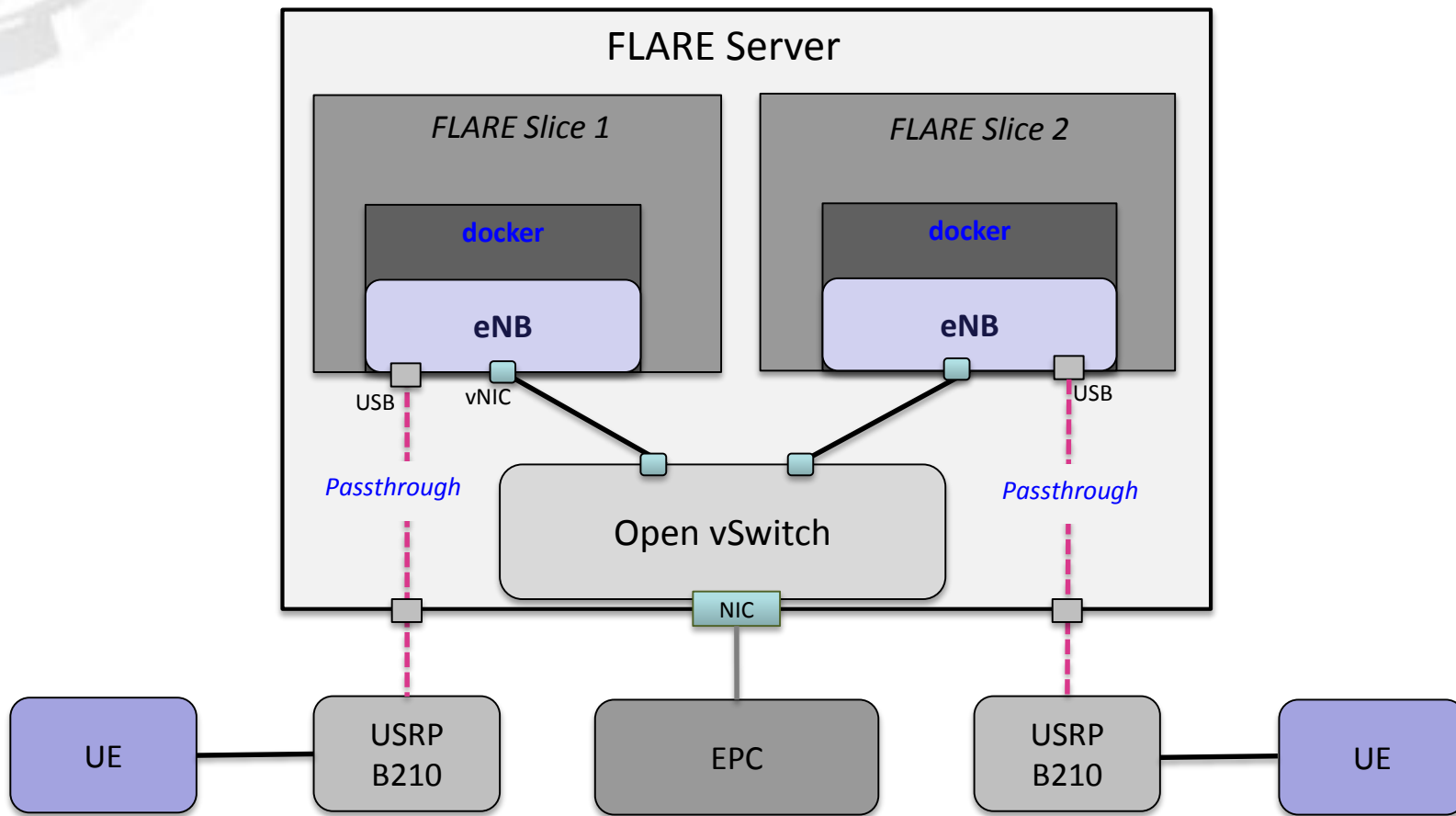
FLARE

*Flare Slice 1 (c-plane)*

Dell T1700



# OAI eNB Integration in FLARE Node



## LTE in A Slice in Operation

## eNB docker instance

[illegible]

## EPC D-plane docker instance

```

root@testnode218:~ root@testnode218
Configuring fg_gtpu (FromGxIO: xgbe2): tid:2(0x1ffe
g:17, cpu:5
Configuring fg_pci (FromGxIO: gxpci): tid:4(0x1ffe
:19, cpu:11
Configuring tg_outer (ToGxIO: gbe3): tid:0(0x1fff7f
2
Configuring tg_pci (ToGxIO: gxpci): tid:0(0x1fff7f5
Configuring tg_gtpc (ToGxIO: xgbe1): tid:0(0x1fff7f
2
Configuring tg_gtpu (ToGxIO: xgbe2): tid:0(0x1fff7f
2
Configuring fg_outer (FromGxIO: gbe): tid:3(0x1ffe
:18, cpu:10
Flushing table
Adding rule: 192.188.2.2 3396329693
Updating rule: 192.188.2.2 3396329693

```

UE



## Sharing our Future

17,764 views



docomoOfficial  
81,963 subscribers



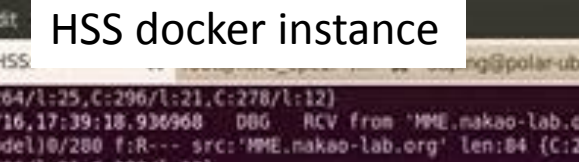
Up next

Autoplay ☒

歩きスマホ参勤交代 / Samurai Smartphone...  
docomoOfficial  
1M views

【NTT研究所】Future +

## HSS docker instance



```
root@HSS: ~
File Edit
root@HSS: ~ ng@polar-ub64

12,C:264/l:25,C:296/l:21,C:278/l:12}
11/01/16,17:39:18.936968 DBG RCV from 'MME.nakao-lab.org':
(no model)0/280 f:R--- src:'MME.nakao-lab.org' len:84 {C:264/l:
25,C:296/l:21,C:278/l:12}
11/01/16,17:39:18.937853 DBG SENT to 'MME.nakao-lab.org':
Device-Watchdog-Answer'0/280 f:---- src: '(nil)' len:96 {C:268/l
:12,C:264/l:25,C:296/l:21,C:278/l:12}
11/01/16,17:39:48.851968 DBG RCV from 'MME.nakao-lab.org':
(no model)0/280 f:R--- src:'MME.nakao-lab.org' len:84 {C:264/l:
25,C:296/l:21,C:278/l:12}
11/01/16,17:39:48.852051 DBG SENT to 'MME.nakao-lab.org':
Device-Watchdog-Answer'0/280 f:---- src: '(nil)' len:96 {C:268/l
:12,C:264/l:25,C:296/l:21,C:278/l:12}
```

## EPC C-plane docker instance

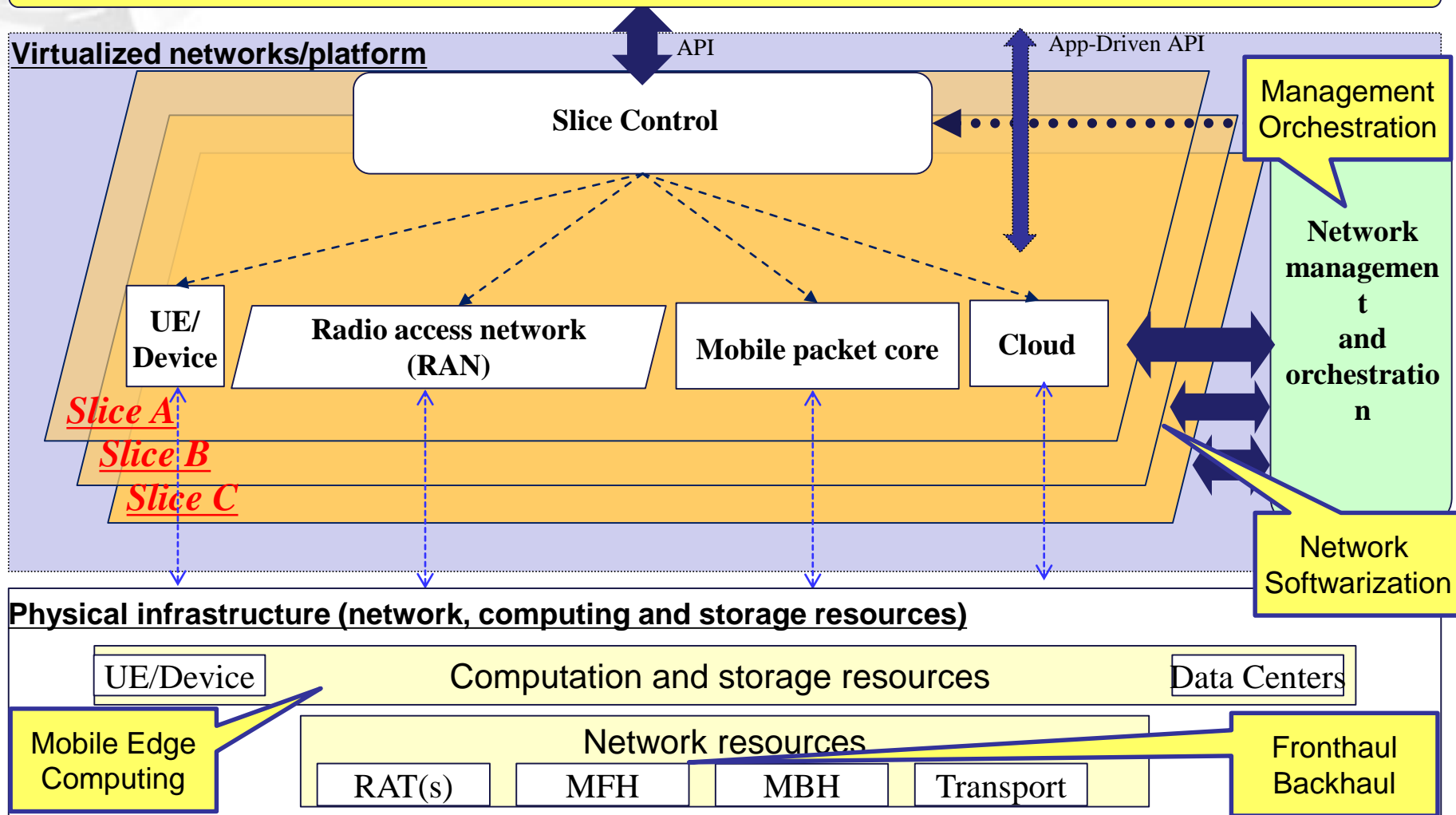
```
001657 00510:942529 7F3D41169700 DEBUG MME-AP SRC/MME
istics.c:0037 | Global | Since last d
001658 00510:942539 7F3D41169700 DEBUG MME-AP SRC/MME
istics.c:0038 UE | 1 |
001659 00510:942541 7F3D41169700 DEBUG MME-AP SRC/MME
istics.c:0039 Bearers | 1 |
001660 00520:942520 7F3D41169700 DEBUG MME-AP SRC/MME
istics.c:0036 ***** Statistics *****
001661 00520:942538 7F3D41169700 DEBUG MME-AP SRC/MME
istics.c:0037 | Global | Since last
001662 00520:942540 7F3D41169700 DEBUG MME-AP SRC/MME
istics.c:0038 UE | 1 |
001663 00520:942541 7F3D41169700 DEBUG MME-AP SRC/MME
istics.c:0039 Bearers | 1 |
```



# Network Softwarization view of 5G mobile network

**Goal : End-to-End Quality and Extreme Flexibility to Accommodate Various**

**Applications & Services with various requirements (M2M/IoT, Content delivery, Tactile)**





# Conclusion

- Network Softwarization / Network Slicing is key technology for 5G mobile applications
- Edge computing is essential for IoT communication
- Network isolation for different handling for eMBB, mMTC and URLLC services