

# ***Softwarized LTE in FLARE network slices***

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# 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.

# Definition of Slice

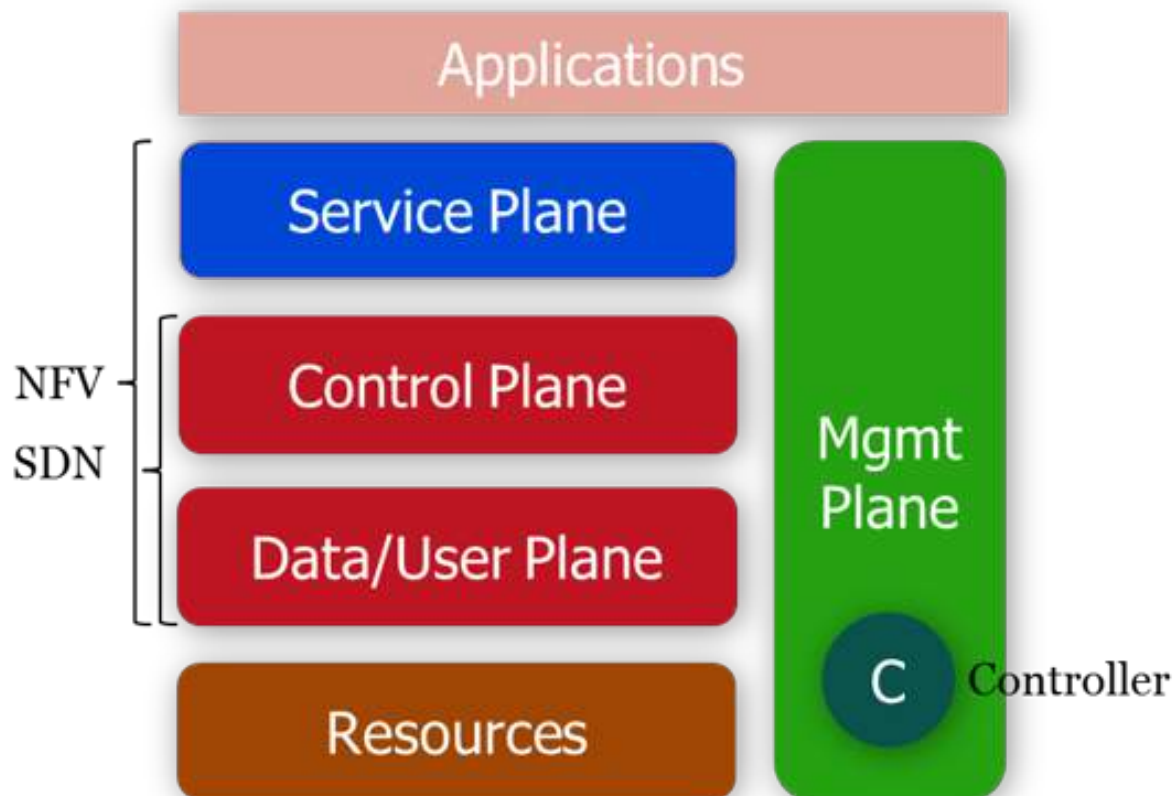
**Slice = An **isolated** set of **programmable** resources to enable **network functions and services****

**Two important features to be required**

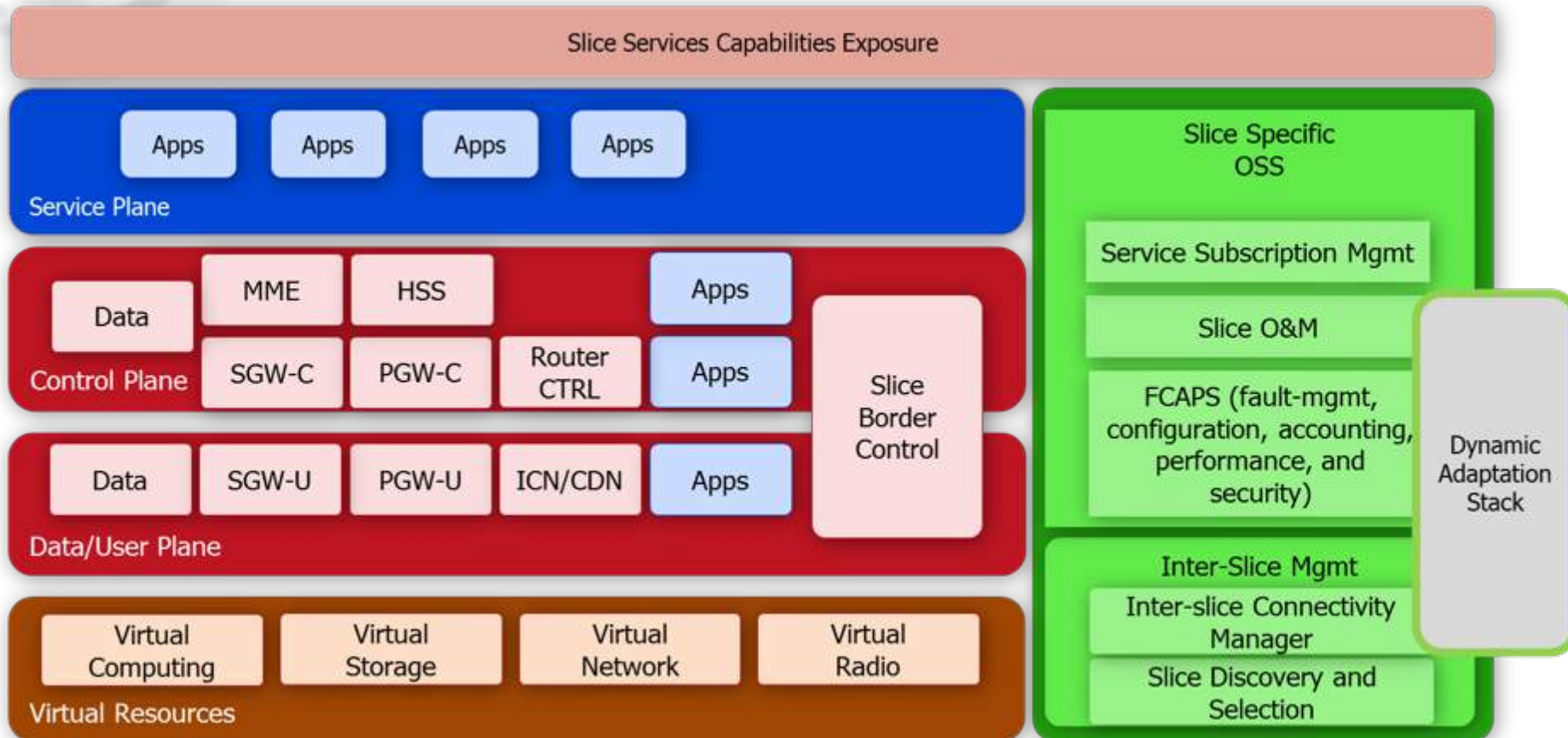
- **Resource Isolation**
- **Programmability**

# Slice high-level architecture Templates

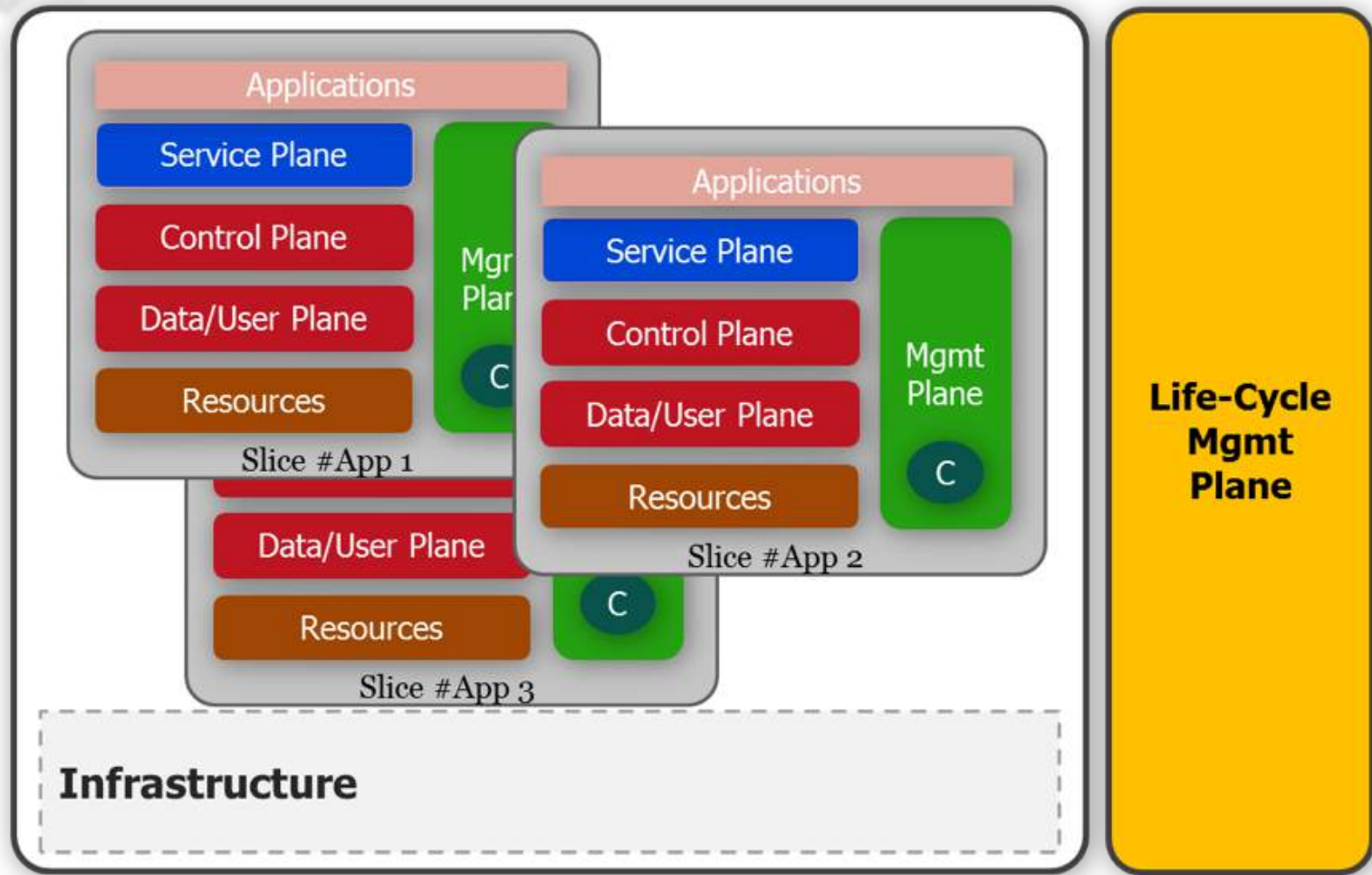
**OKI**



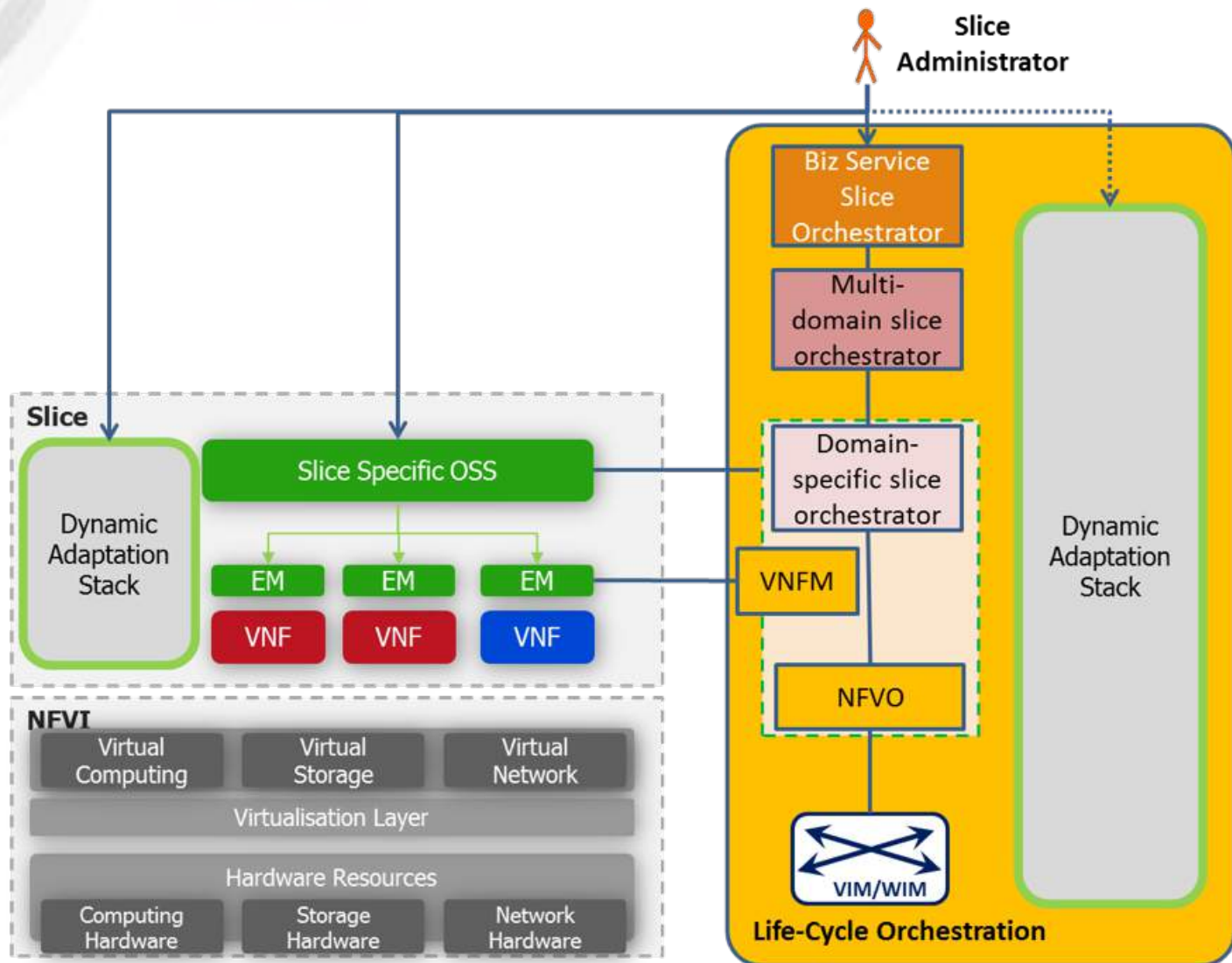
# Instantiated 5G slices



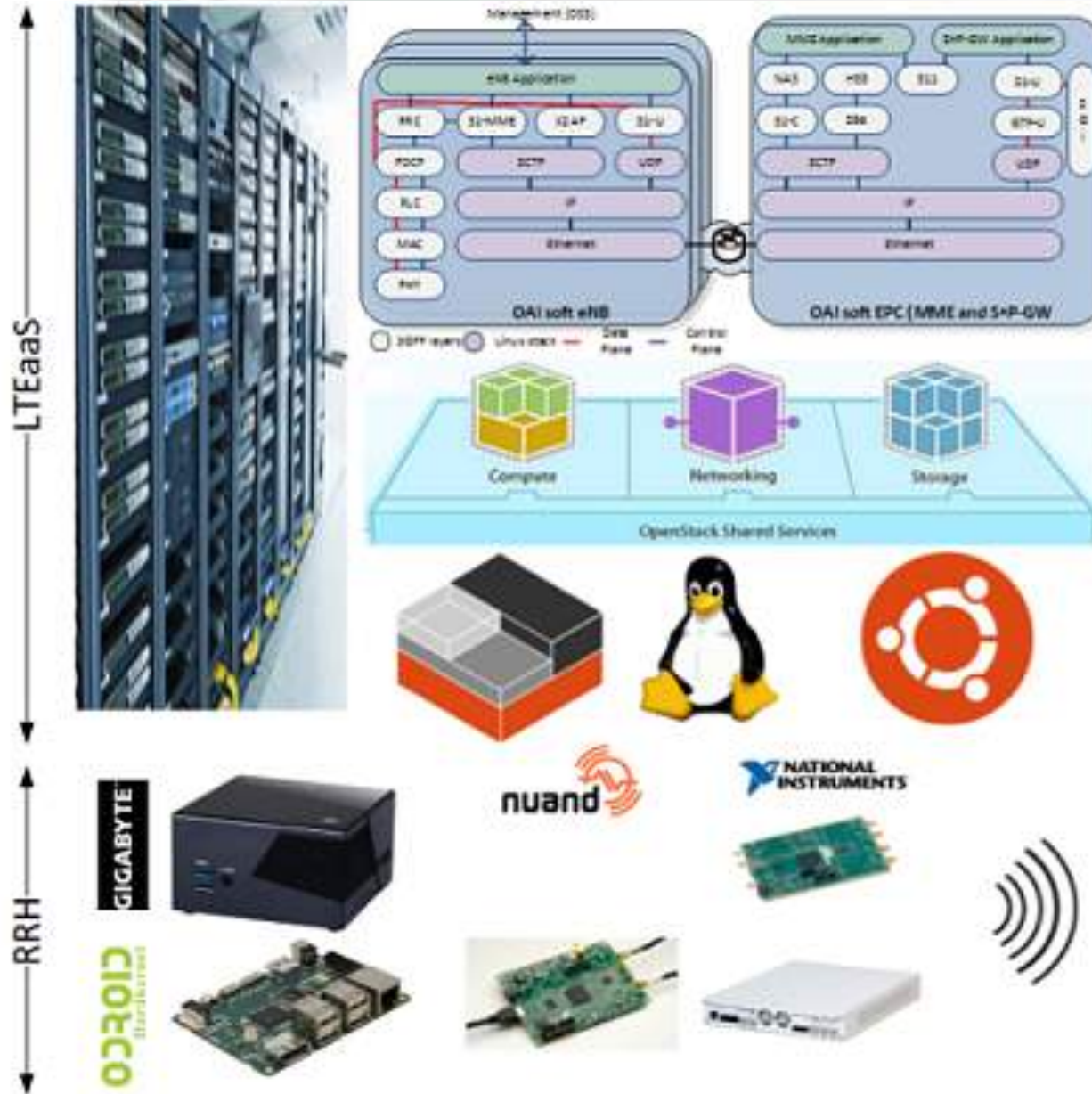
# Instantiated 5G slices



# Life-cycle orchestration for multi-domain architecture



# Open Air Interface (OAI)

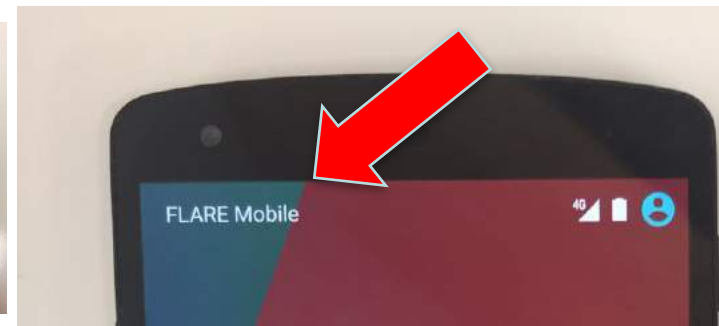
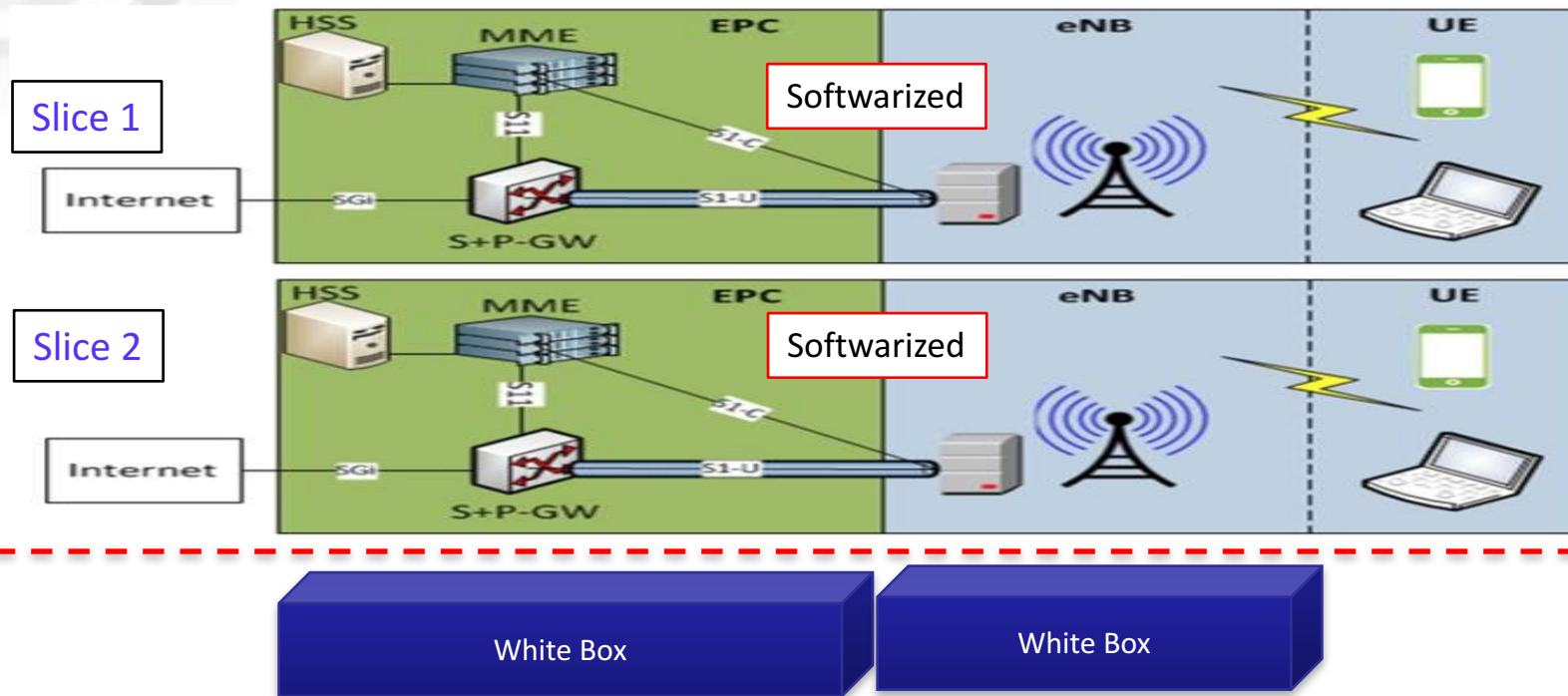


4G-enabled apps



# Softwarized LTE in A Slice

**OKI**

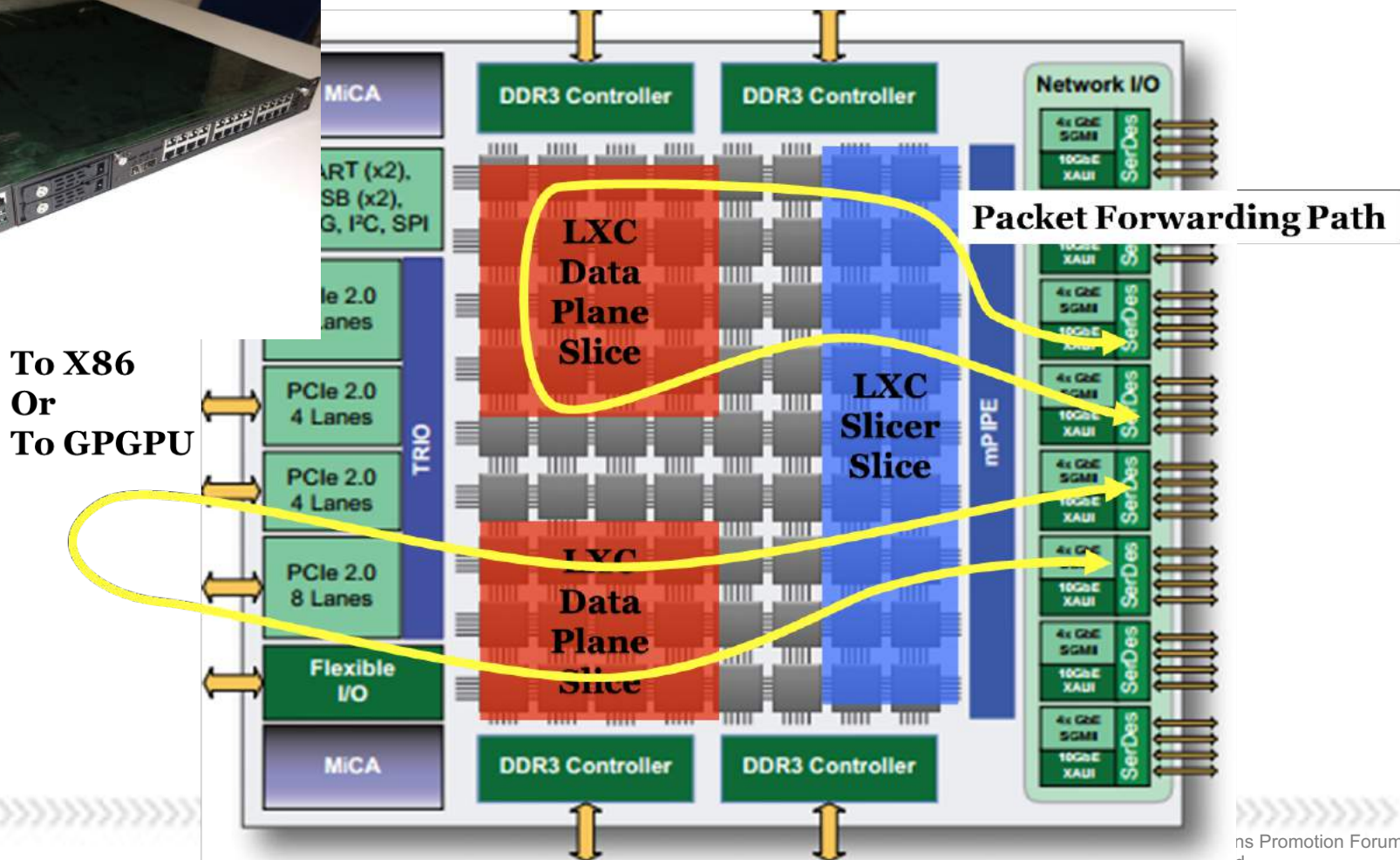


## ◆ *FLARE Platform will be enhanced towards 5G Slicing*

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)**

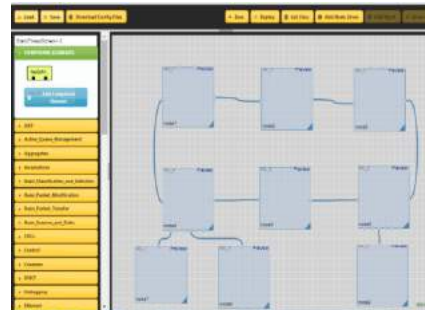


## ◆ Open Source based Network Softwarization Platform

**Click!** Open Source  
**Click!** Optimization

**TILERA** SDK

**Network Functions  
Software Defined  
Data Plane**



**Toy-Block  
Networking GUI**

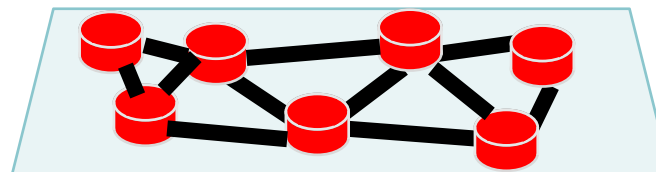
**FLARE Project** **FLARE Central** edit primary info

shu@flare.tokyo.ac.jp

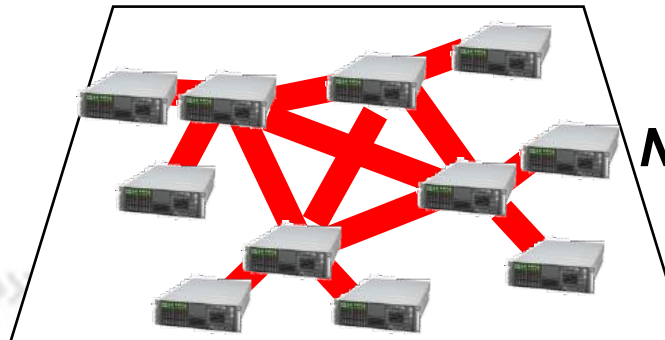
Nodes on site FLARE Central

| Node | Host                             | IP            | Role       | Type       |
|------|----------------------------------|---------------|------------|------------|
| 13   | flare-ws1-johannes.tokyo.ac.jp   | 192.168.1.13  | FireSwitch | FireSwitch |
| 14   | flare-ws2-johannes.tokyo.ac.jp   | 192.168.1.14  | FireSwitch | FireSwitch |
| 15   | flare-ws3-johannes.tokyo.ac.jp   | 192.168.1.15  | FireSwitch | FireSwitch |
| 16   | flare-ws4-johannes.tokyo.ac.jp   | 192.168.1.16  | FireSwitch | FireSwitch |
| 17   | flare-ws5-johannes.tokyo.ac.jp   | 192.168.1.17  | FireSwitch | FireSwitch |
| 18   | flare-ws6-johannes.tokyo.ac.jp   | 192.168.1.18  | FireSwitch | FireSwitch |
| 19   | flare-ws7-johannes.tokyo.ac.jp   | 192.168.1.19  | FireSwitch | FireSwitch |
| 20   | flare-ws8-johannes.tokyo.ac.jp   | 192.168.1.20  | FireSwitch | FireSwitch |
| 21   | flare-ws9-johannes.tokyo.ac.jp   | 192.168.1.21  | FireSwitch | FireSwitch |
| 22   | flare-ws10-johannes.tokyo.ac.jp  | 192.168.1.22  | FireSwitch | FireSwitch |
| 23   | flare-ws11-johannes.tokyo.ac.jp  | 192.168.1.23  | FireSwitch | FireSwitch |
| 24   | flare-ws12-johannes.tokyo.ac.jp  | 192.168.1.24  | FireSwitch | FireSwitch |
| 25   | flare-ws13-johannes.tokyo.ac.jp  | 192.168.1.25  | FireSwitch | FireSwitch |
| 26   | flare-ws14-johannes.tokyo.ac.jp  | 192.168.1.26  | FireSwitch | FireSwitch |
| 27   | flare-ws15-johannes.tokyo.ac.jp  | 192.168.1.27  | FireSwitch | FireSwitch |
| 28   | flare-ws16-johannes.tokyo.ac.jp  | 192.168.1.28  | FireSwitch | FireSwitch |
| 29   | flare-ws17-johannes.tokyo.ac.jp  | 192.168.1.29  | FireSwitch | FireSwitch |
| 30   | flare-ws18-johannes.tokyo.ac.jp  | 192.168.1.30  | FireSwitch | FireSwitch |
| 31   | flare-ws19-johannes.tokyo.ac.jp  | 192.168.1.31  | FireSwitch | FireSwitch |
| 32   | flare-ws20-johannes.tokyo.ac.jp  | 192.168.1.32  | FireSwitch | FireSwitch |
| 33   | flare-ws21-johannes.tokyo.ac.jp  | 192.168.1.33  | FireSwitch | FireSwitch |
| 34   | flare-ws22-johannes.tokyo.ac.jp  | 192.168.1.34  | FireSwitch | FireSwitch |
| 35   | flare-ws23-johannes.tokyo.ac.jp  | 192.168.1.35  | FireSwitch | FireSwitch |
| 36   | flare-ws24-johannes.tokyo.ac.jp  | 192.168.1.36  | FireSwitch | FireSwitch |
| 37   | flare-ws25-johannes.tokyo.ac.jp  | 192.168.1.37  | FireSwitch | FireSwitch |
| 38   | flare-ws26-johannes.tokyo.ac.jp  | 192.168.1.38  | FireSwitch | FireSwitch |
| 39   | flare-ws27-johannes.tokyo.ac.jp  | 192.168.1.39  | FireSwitch | FireSwitch |
| 40   | flare-ws28-johannes.tokyo.ac.jp  | 192.168.1.40  | FireSwitch | FireSwitch |
| 41   | flare-ws29-johannes.tokyo.ac.jp  | 192.168.1.41  | FireSwitch | FireSwitch |
| 42   | flare-ws30-johannes.tokyo.ac.jp  | 192.168.1.42  | FireSwitch | FireSwitch |
| 43   | flare-ws31-johannes.tokyo.ac.jp  | 192.168.1.43  | FireSwitch | FireSwitch |
| 44   | flare-ws32-johannes.tokyo.ac.jp  | 192.168.1.44  | FireSwitch | FireSwitch |
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| 79   | flare-ws67-johannes.tokyo.ac.jp  | 192.168.1.79  | FireSwitch | FireSwitch |
| 80   | flare-ws68-johannes.tokyo.ac.jp  | 192.168.1.80  | FireSwitch | FireSwitch |
| 81   | flare-ws69-johannes.tokyo.ac.jp  | 192.168.1.81  | FireSwitch | FireSwitch |
| 82   | flare-ws70-johannes.tokyo.ac.jp  | 192.168.1.82  | FireSwitch | FireSwitch |
| 83   | flare-ws71-johannes.tokyo.ac.jp  | 192.168.1.83  | FireSwitch | FireSwitch |
| 84   | flare-ws72-johannes.tokyo.ac.jp  | 192.168.1.84  | FireSwitch | FireSwitch |
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| 89   | flare-ws77-johannes.tokyo.ac.jp  | 192.168.1.89  | FireSwitch | FireSwitch |
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| 91   | flare-ws79-johannes.tokyo.ac.jp  | 192.168.1.91  | FireSwitch | FireSwitch |
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| 93   | flare-ws81-johannes.tokyo.ac.jp  | 192.168.1.93  | FireSwitch | FireSwitch |
| 94   | flare-ws82-johannes.tokyo.ac.jp  | 192.168.1.94  | FireSwitch | FireSwitch |
| 95   | flare-ws83-johannes.tokyo.ac.jp  | 192.168.1.95  | FireSwitch | FireSwitch |
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| 97   | flare-ws85-johannes.tokyo.ac.jp  | 192.168.1.97  | FireSwitch | FireSwitch |
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| 99   | flare-ws87-johannes.tokyo.ac.jp  | 192.168.1.99  | FireSwitch | FireSwitch |
| 100  | flare-ws88-johannes.tokyo.ac.jp  | 192.168.1.100 | FireSwitch | FireSwitch |
| 101  | flare-ws89-johannes.tokyo.ac.jp  | 192.168.1.101 | FireSwitch | FireSwitch |
| 102  | flare-ws90-johannes.tokyo.ac.jp  | 192.168.1.102 | FireSwitch | FireSwitch |
| 103  | flare-ws91-johannes.tokyo.ac.jp  | 192.168.1.103 | FireSwitch | FireSwitch |
| 104  | flare-ws92-johannes.tokyo.ac.jp  | 192.168.1.104 | FireSwitch | FireSwitch |
| 105  | flare-ws93-johannes.tokyo.ac.jp  | 192.168.1.105 | FireSwitch | FireSwitch |
| 106  | flare-ws94-johannes.tokyo.ac.jp  | 192.168.1.106 | FireSwitch | FireSwitch |
| 107  | flare-ws95-johannes.tokyo.ac.jp  | 192.168.1.107 | FireSwitch | FireSwitch |
| 108  | flare-ws96-johannes.tokyo.ac.jp  | 192.168.1.108 | FireSwitch | FireSwitch |
| 109  | flare-ws97-johannes.tokyo.ac.jp  | 192.168.1.109 | FireSwitch | FireSwitch |
| 110  | flare-ws98-johannes.tokyo.ac.jp  | 192.168.1.110 | FireSwitch | FireSwitch |
| 111  | flare-ws99-johannes.tokyo.ac.jp  | 192.168.1.111 | FireSwitch | FireSwitch |
| 112  | flare-ws100-johannes.tokyo.ac.jp | 192.168.1.112 | FireSwitch | FireSwitch |

**Resource  
Management  
Center**

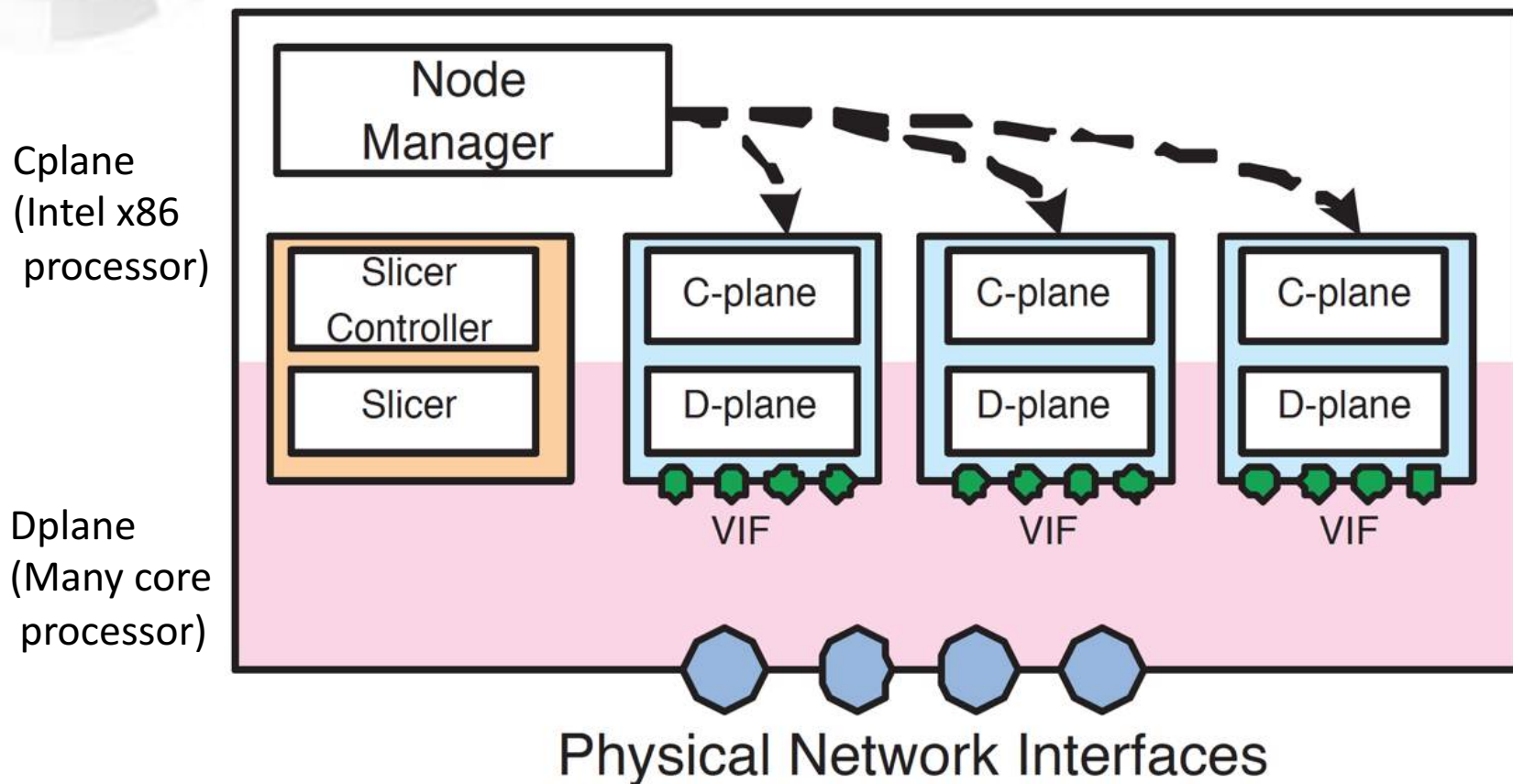


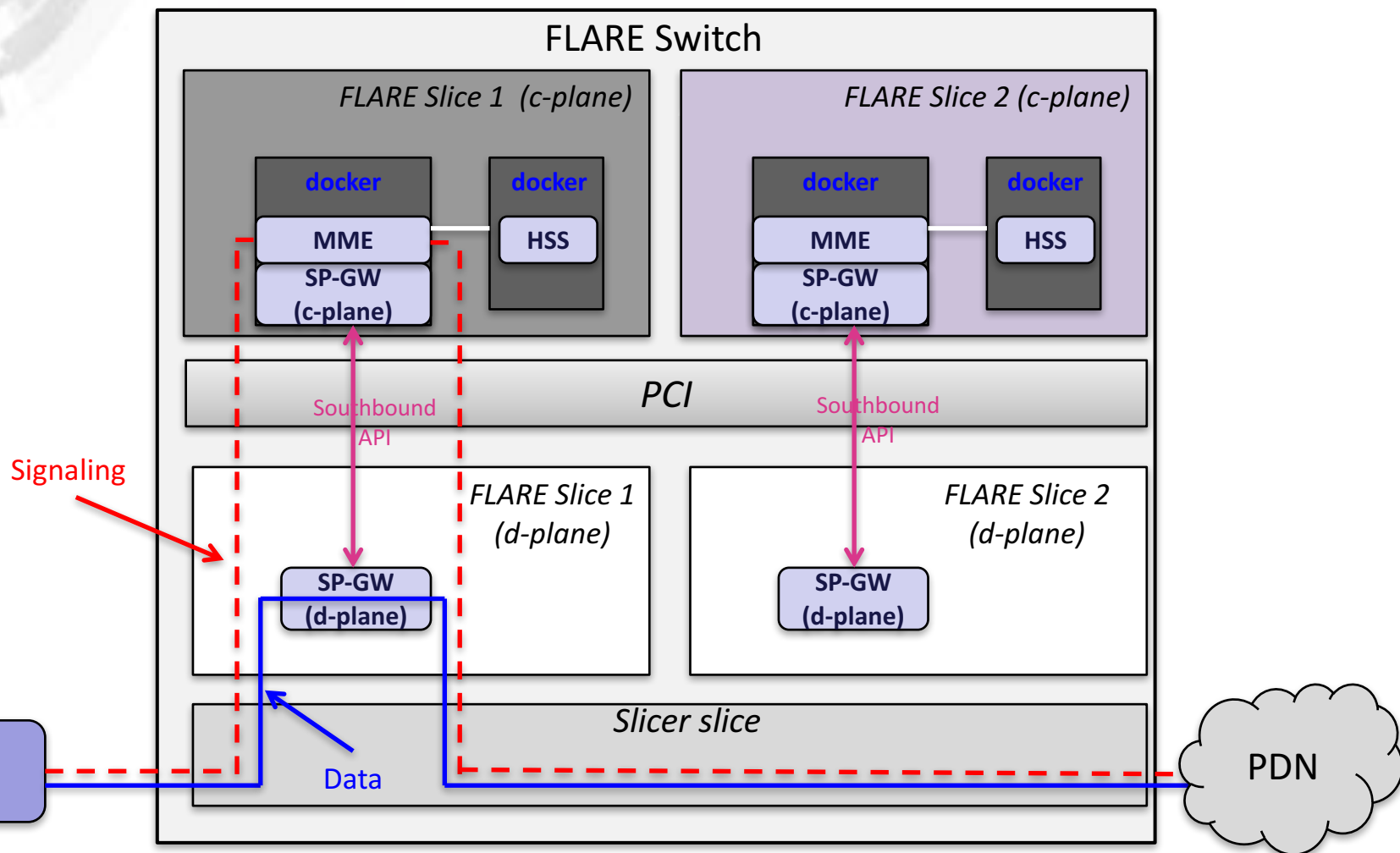
**Slice  
(Logical NW View)**



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

# FLARE Node Architecture

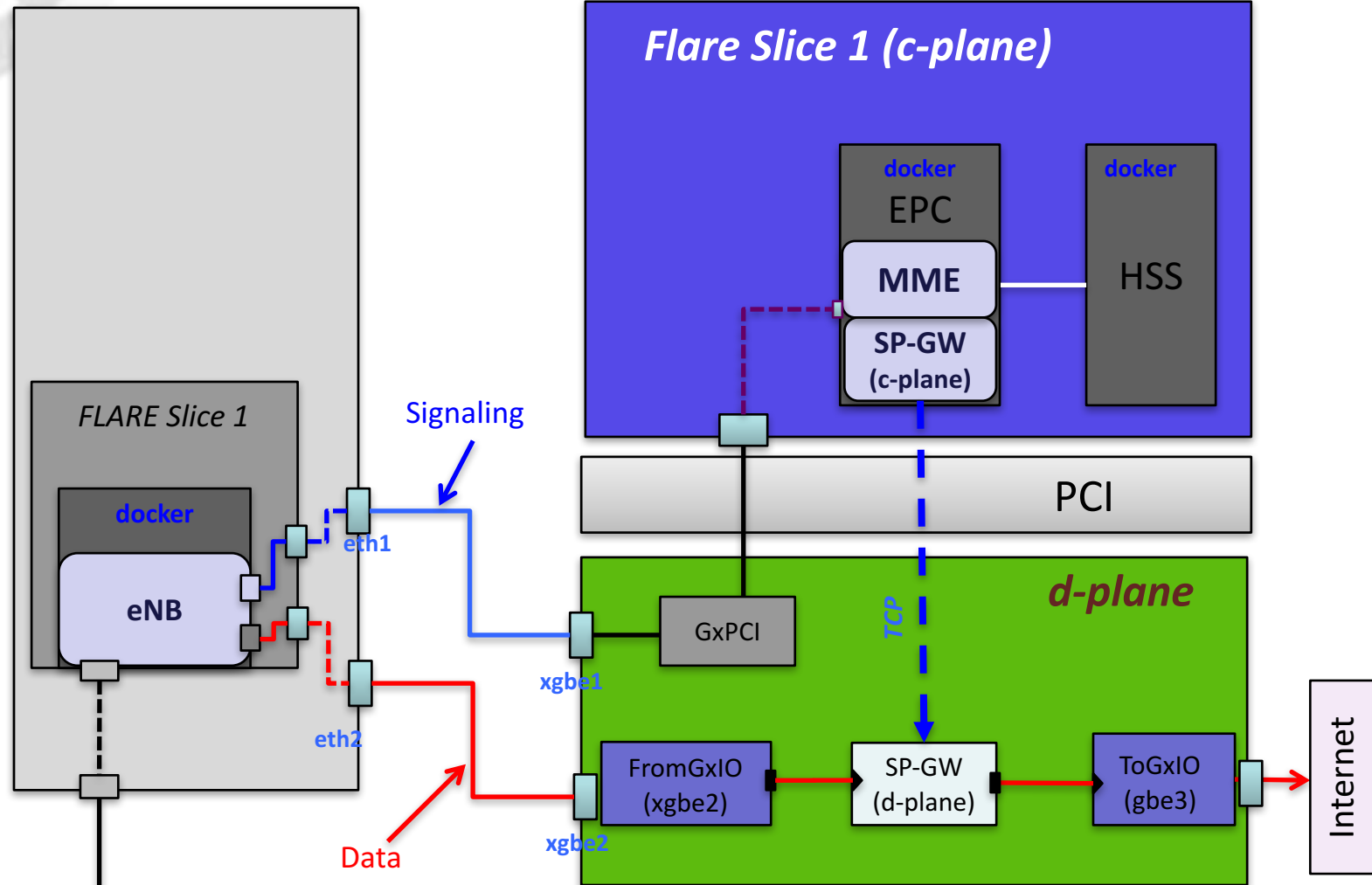




# Architecture in Demo

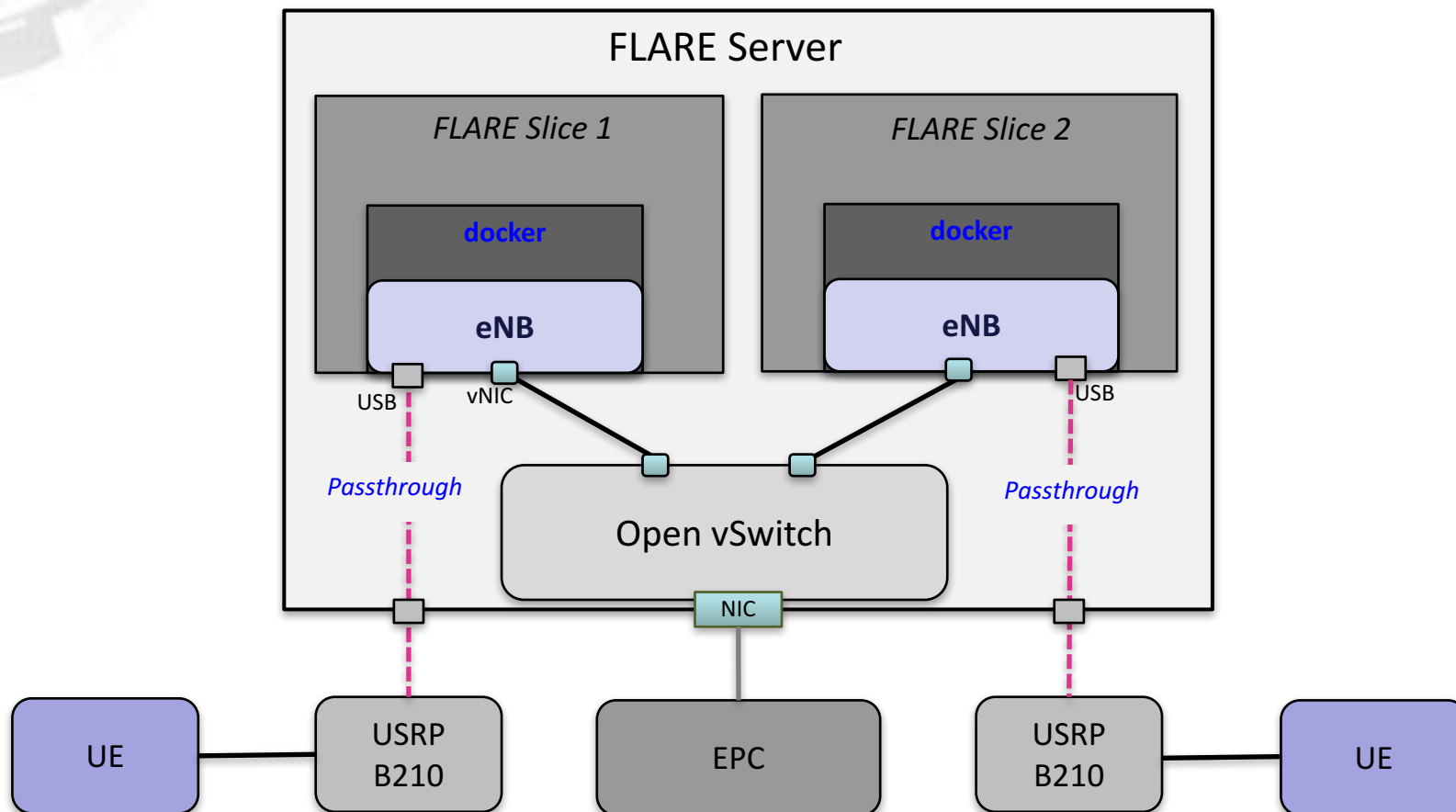
FLARE Server

FLARE2 Switch



USRP  
B210

# OAI eNB Integration in FLARE Node **OKI**



# LTE in A Slice in Operation

OKI

eNB docker instance

```
File Edit
[RRR][I][FROM 20150][ENB][MAC 00][RRR] Received on DCCH 1
RRR DCCH DATA IND
[SCTP][I][sctp send data] Successfully sent 64 bytes on stream 1
for assoc_id 80946
[SCTP][I][sctp_enb_flush sockets] Found data for descriptor 46
[SCTP][I][sctp_enb_read_from_socket] Received notification for s
4 46, type 32777
LLLLLLLLLLLL[MAC][I][schedule_ue_spec] [eNB 0][DLSCH] Frame 196
Generate header for UE id 0 on CC id 0: sdu length total 56, num
sdus 1, sdu_lengths[0] 56, sdu_lcids[0] 3 => payload offset 3,t
iming advance value : -2, padding 0,post padding 0,(mcs 7, TBS 5
9, nb rb 4),header dcch 0, header dtch 1
LLLLLULULLLLLL[MAC][I][schedule_ue_spec] [eNB 0][DLSCH] Frame 7
94 Generate header for UE id 0 on CC id 0: sdu length total 962,
num sdus 1, sdu_lengths[0] 962, sdu_lcids[0] 3 => payload offse
t 5,timing advance value : -1, padding 2,post padding 0,(mcs 16,
TBS 967, nb rb 25),header dcch 0, header dtch 1
LLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLL
LLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLL
```

EPC D-plane docker instance

```
root@testnode218:~
Configuring fg_gtpu (FromGxIO: xgbe2): tid:2(0x1ffe
g:17, cpu:5
Configuring fg_pcl (FromGxIO: gxpci): tid:4(0x1ffe8
:19, cpu:11
Configuring tg_outer (ToGxIO: gbe3): tid:0(0x1fff7f
2
Configuring tg_pcl (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: gbe1): tid:3(0x1ffe8
:18, cpu:10
Flushing table
Adding rule: 192.188.2.2 3396329693
Updating rule: 192.188.2.2 3396329693
```

UE



HSS docker instance

```
File Edit
root@HSS: ~
root@HSS: ~
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)
```

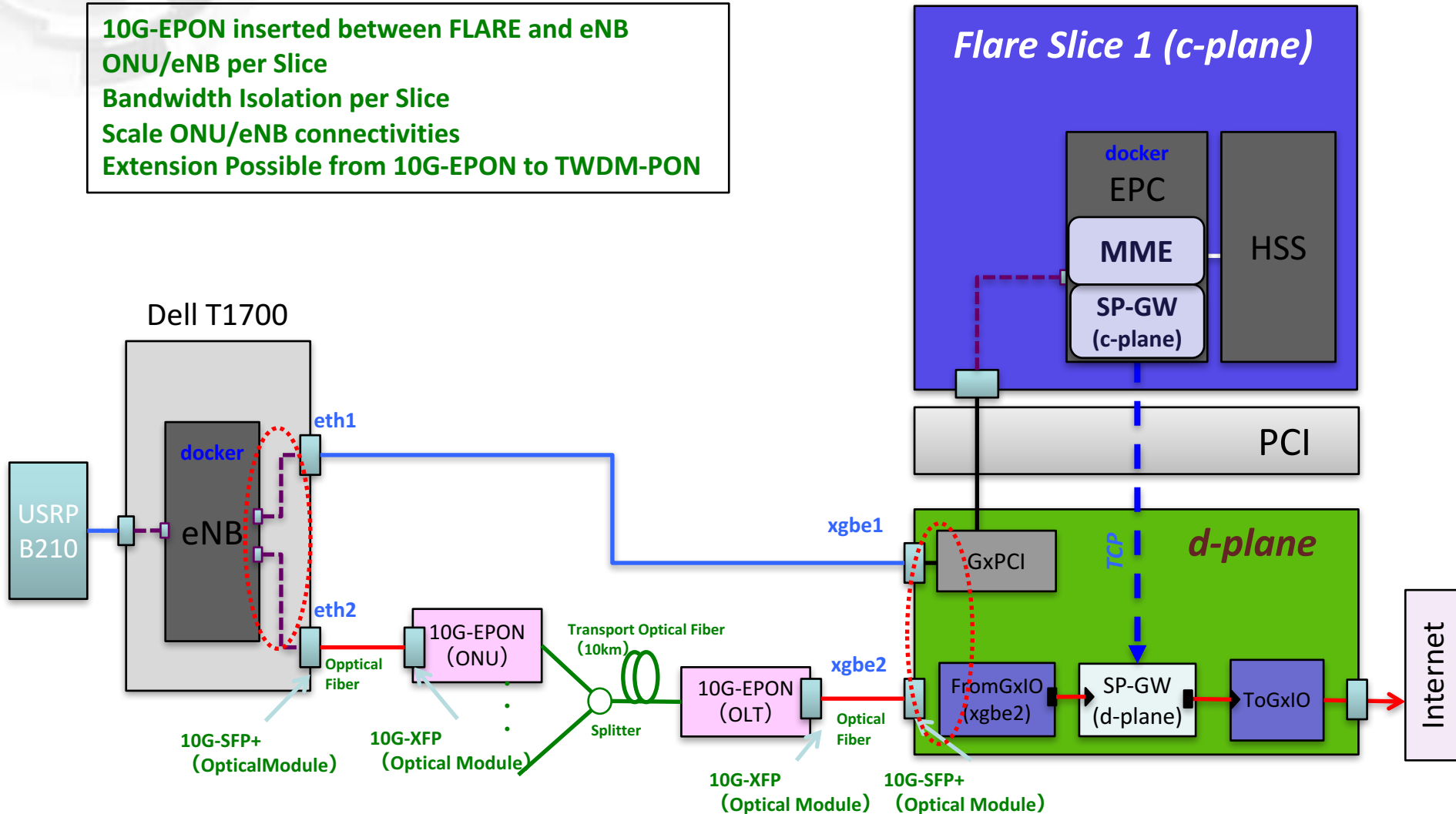
EPC C-plane docker instance

```
001637 00510:942529 7F3D41169700 DEBUG MME-AP SRC/M
istics,c:0037 | Global | Since last d
001658 00510:942539 7F3D41169700 DEBUG MME-AP SRC/M
istics,c:0038 UE | 1 |
001659 00510:942541 7F3D41169700 DEBUG MME-AP SRC/M
istics,c:0039 Bearers | 1 |
001660 00520:942520 7F3D41169700 DEBUG MME-AP SRC/M
istics,c:0036 ***** Statistics *****
001661 00520:942538 7F3D41169700 DEBUG MME-AP SRC/M
istics,c:0037 | Global | Since last d
001662 00520:942540 7F3D41169700 DEBUG MME-AP SRC/M
istics,c:0038 UE | 1 |
001663 00520:942541 7F3D41169700 DEBUG MME-AP SRC/M
istics,c:0039 Bearers | 1 |
```

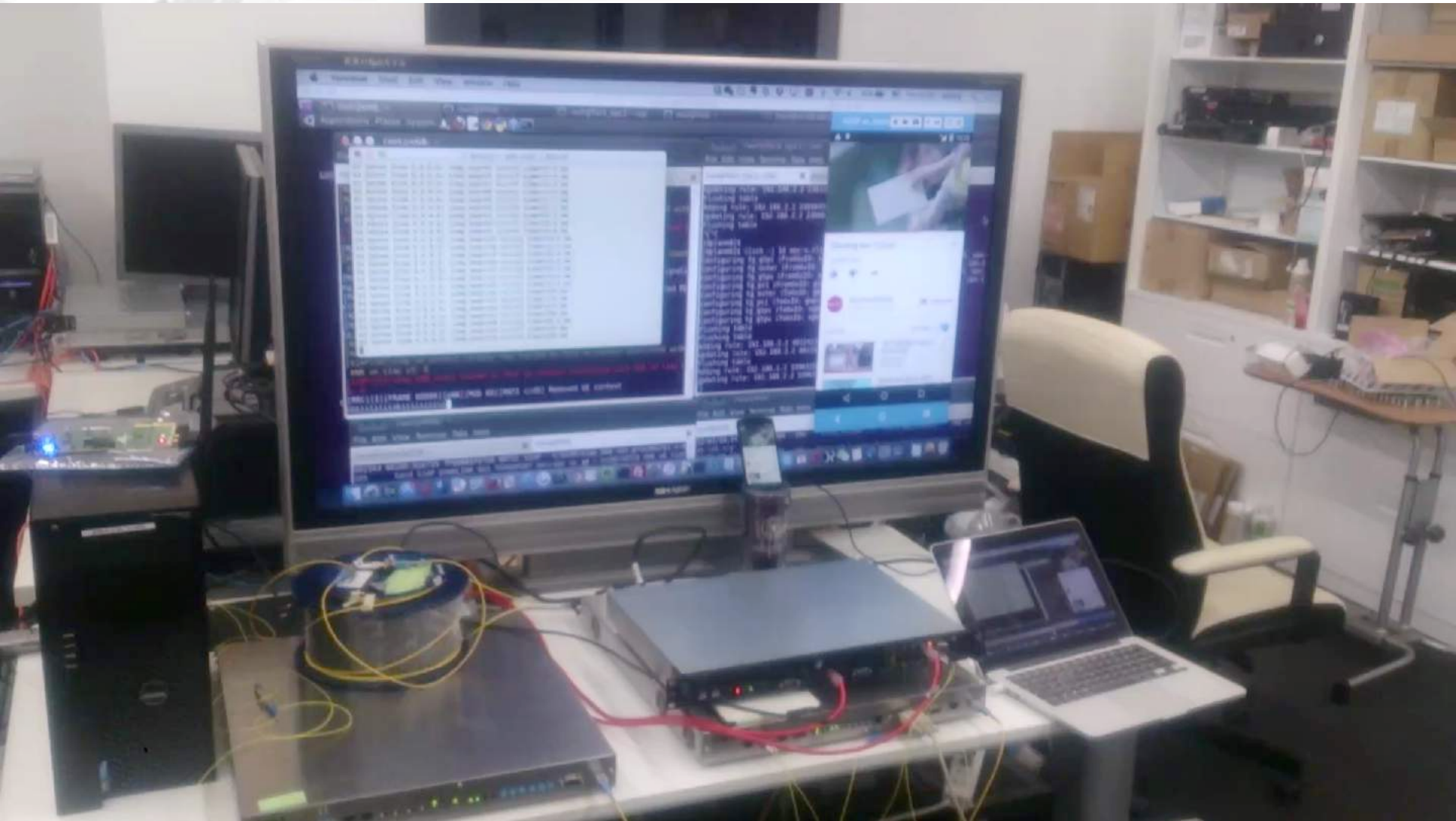
# OKI's BH Slicing Inserted

10G-EPON inserted between FLARE and eNB  
ONU/eNB per Slice  
Bandwidth Isolation per Slice  
Scale ONU/eNB connectivities  
Extension Possible from 10G-EPON to TWDM-PON

FLARE 2



# FLARE EPC Slicing + BH Slicing



# Conclusion

- Network Softwarization / Network Slicing is key technology for 5G mobile applications
- End-to-end slicing including Transport, Core, FH/BH and RAN is just around the corner