Introduction to free5GC: past, current, and future

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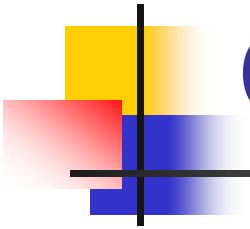
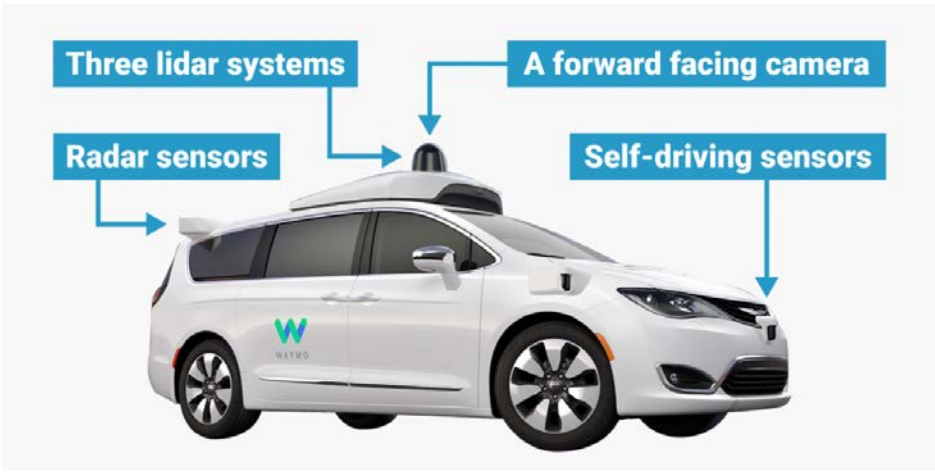
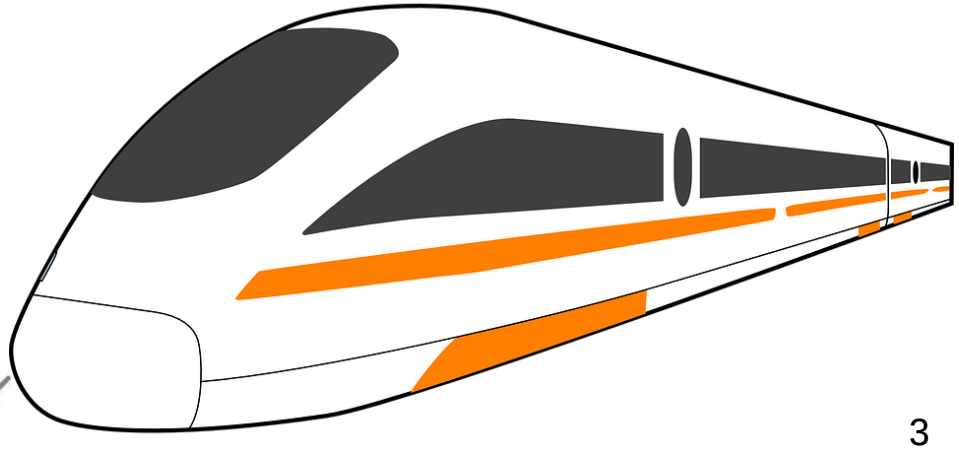


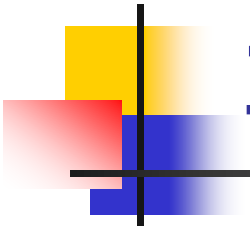
Outline

- Background
- Our open-source testbeds
  - Reconfigurable Core (RECO)
  - Service Level Virtualization (SLV)
  - free5GC

More and more applications

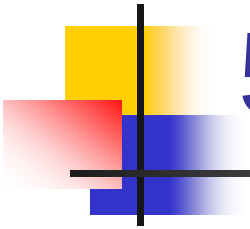






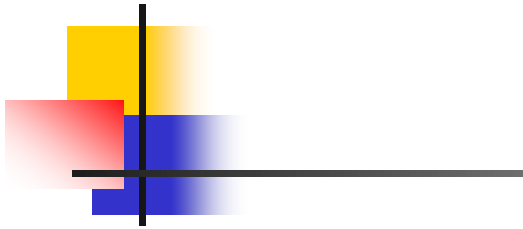
1G to 4G

- Mainly used by human beings
  - 1G and 2G were about voice
  - 3G was about data
  - 4G is about video



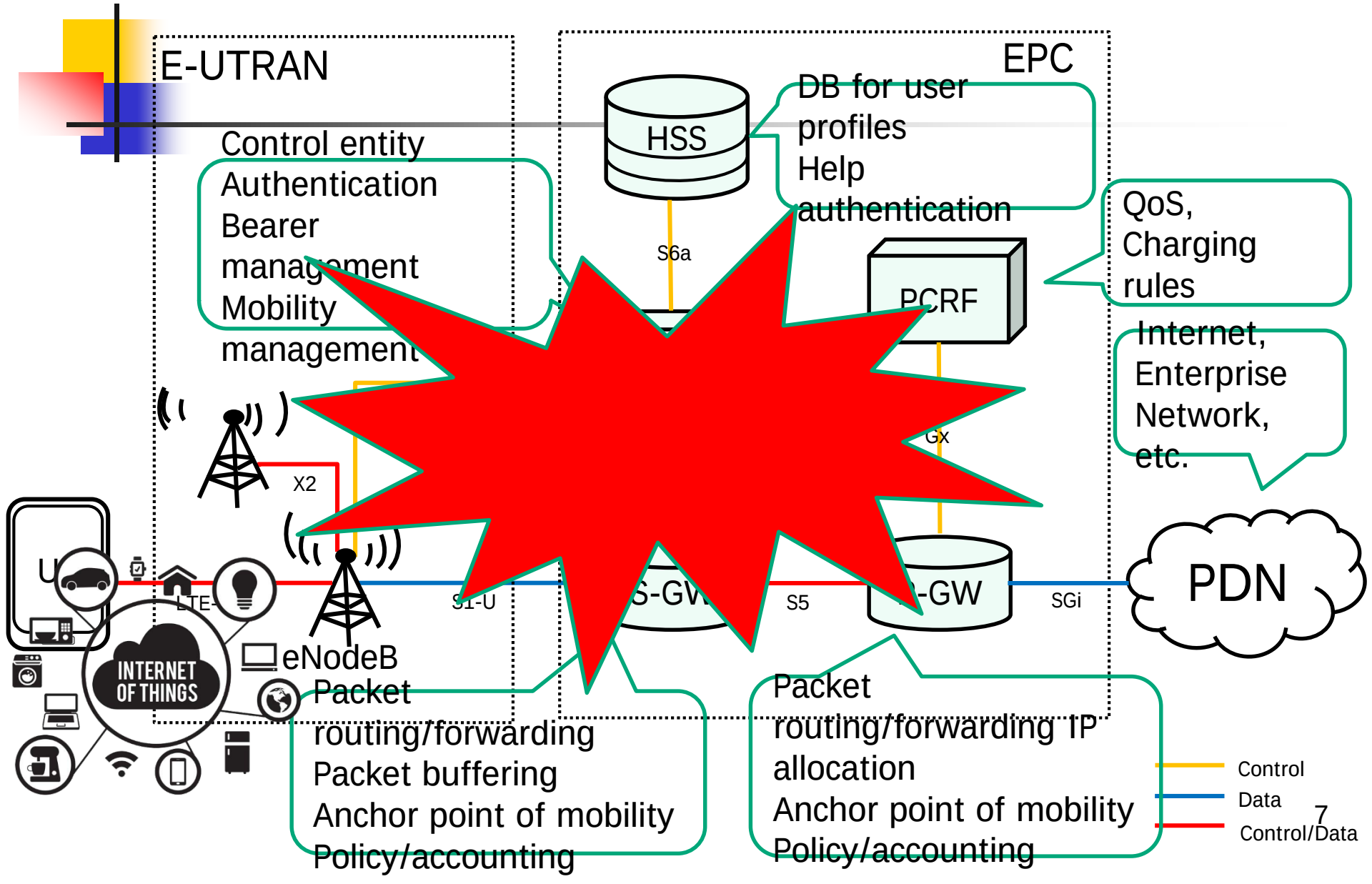
5G

- Human beings
- Machines
  - IoT devices
  - Self-driving cars
  - High-speed trains
  - Smart meters
  - Coffee machines
  - ……



What's wrong with the current 4G core network?

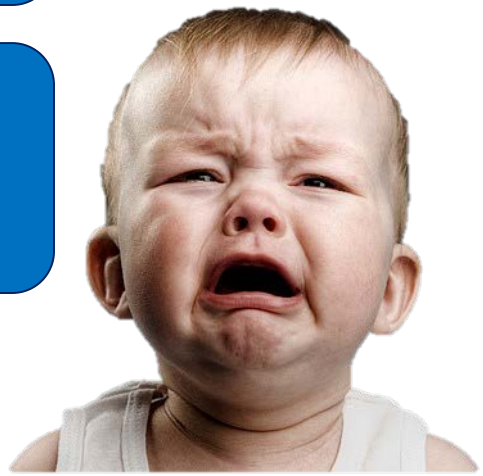
Current 4G Architecture



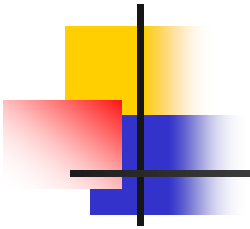
All Propriety Hardware

Specialized Features

Specialized Hardware



Flexi Network Server from Nokia Siemens Networks



High cost

Not flexible

Limit innovation

How to solve?

Softwarization and Virtualization

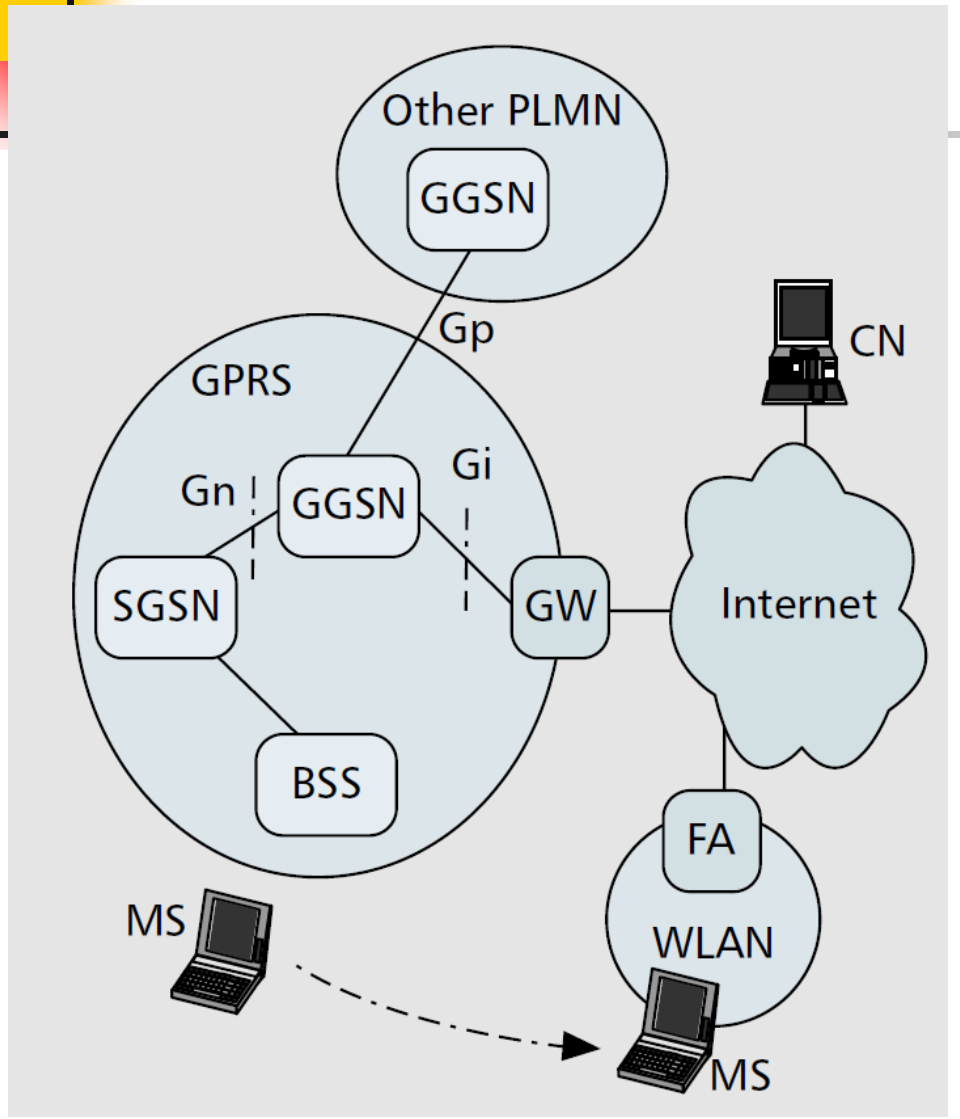
Benefits of Softwarization

- Rapid innovation
  - Innovation at software speed
  - Can do experiments
  - Standards will follow software deployments
  - Open up network innovation to great minds around the world
- Flexibility
  - Deploy services according to geography
  - Deploy services according to user characteristics
  - Dynamically route packets to its particular network slice

Research topics of softwarization

- How to retain the required performance for network entities while it is virtualized?
- How to design and implement the automatic self-management MANO system?
- ……
- **How to implement customized VNFs efficiently for a flexible *OPEN* 5G core network?**

Gateway (GW) Approach

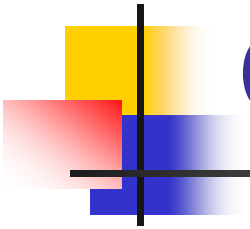


J.-C. Chen and H.-W. Lin, "A gateway approach to mobility integration of GPRS and wireless LANs," *IEEE Wireless Communications*, vol. 12, no. 2, pp. 86-95, Apr. 2005.

Node	Model
BTS	Siemens BS20
BSC	Siemens BSC
HLR	Siemens SR8
SGSN	Nokia DX200
GGSN	Nokia GN2500

Doing research in core networks

- The core networks are very expensive, and it’s not easy to access the source code.
- People usually could only conduct mathematical analysis and simulation to verify their ideas.
- With open-source core networks, researchers can implement and test their proposed algorithms in a real testbed.



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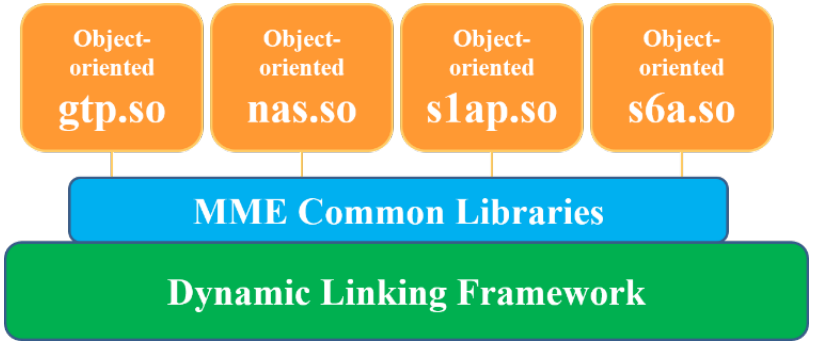
  - free5GC

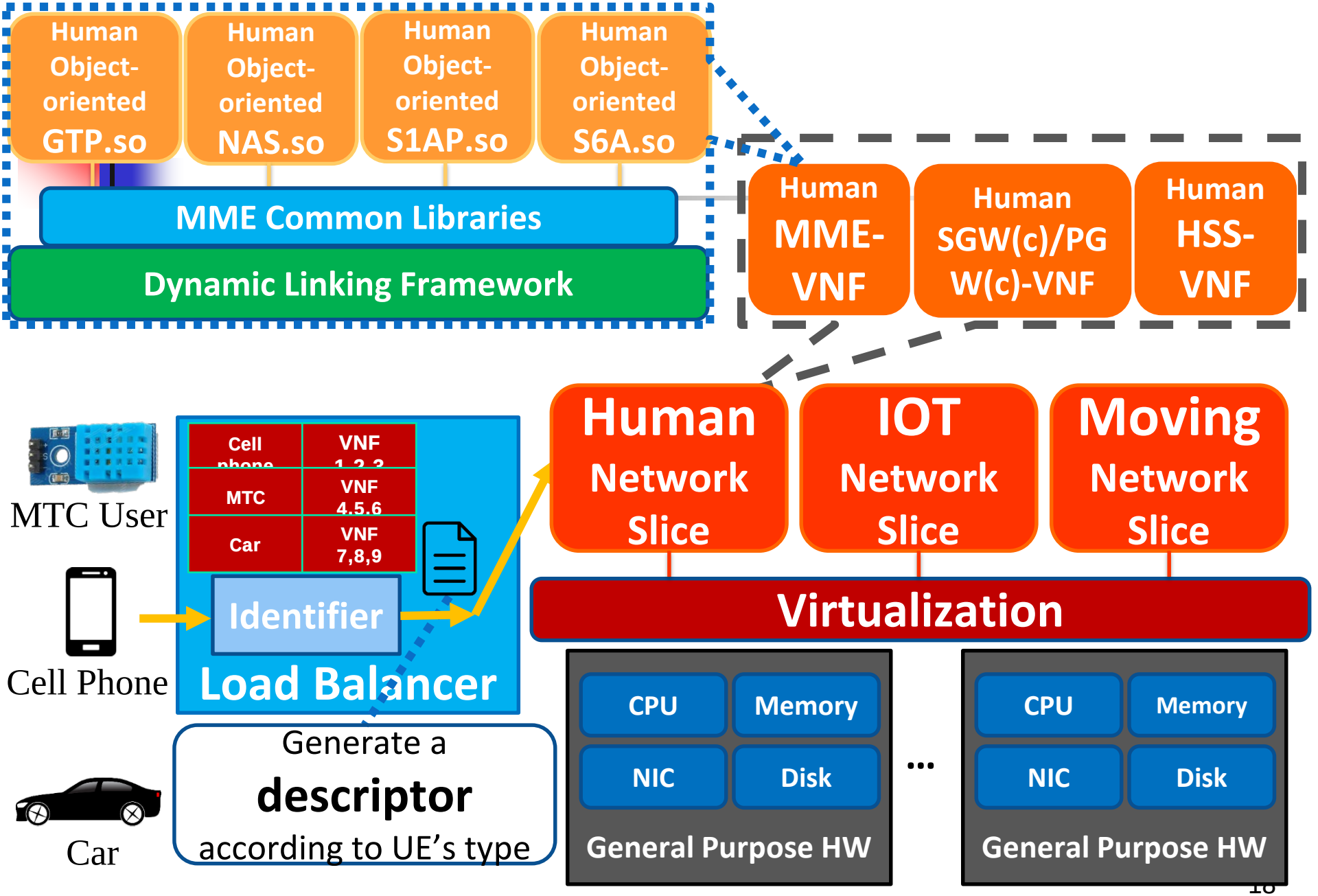
Reconfigurable Core (RECO)

- http://reconet.org/reco/
- C.-H. Wu, W.-J. Chen, and J.-C. Chen, "Poster - RECO: a reconfigurable core network for future 5G communication systems," in *Proc. of ACM International Conference on Mobile Computing and Networking (MobiCom '17),* (Snowbird, UT, USA), pp. 594 - 596, Oct. 2017.

Reconfigurable Core (RECO)

- Common modules
  - common MME libraries which different types of users share. E.g., UDP, SCTP, hash table
- Object-oriented customized modules
  - customized modules which differ between different types of users
- Dynamic Linking Framework
  - parse descriptor load and initialize corresponding customized modules




Human Object-oriented GTP.so
Human Object-oriented NAS.so
Human Object-oriented S1AP.so
Human Object-oriented S6A.so
MME Common Libraries
Dynamic Linking Framework
Human MME-VNF
Human SGW(c)/PGW(c)-VNF
Human HSS-VNF
Human Network Slice
IOT Network Slice
Moving Network Slice
Virtualization
MTC User
Cell Phone
Car
Cell phone
VNF 1,2,3
MTC
VNF 4,5,6
Car
VNF 7,8,9
Identifier
Load Balancer
Generate a descriptor according to UE's type
CPU
Memory
NIC
Disk
General Purpose HW
...
CPU
Memory
NIC
Disk
General Purpose HW

Service Level Virtualization (SLV)

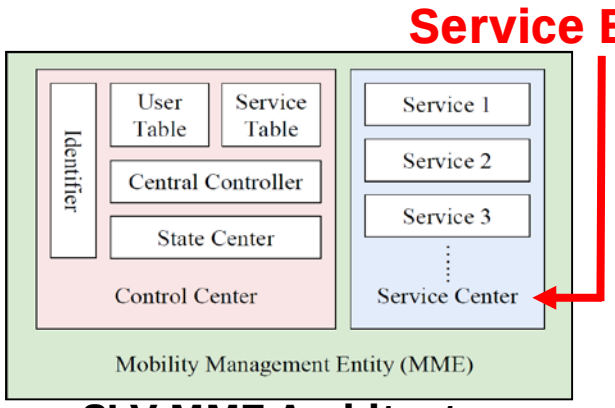
- http://reconet.org/slv/
- B.-J. Qiu, Y.-S. Hsueh, J.-C. Chen, J.-R. Li, Y.-M. Lin, P.-F. Ho, and T.-J. Tan, "Poster: Service Level Virtualization (SLV) - a preliminary implementation of 3GPP Service Based Architecture (SBA)," in *Proc. of ACM International Conference on Mobile Computing and Networking (MobiCom '18)*, (New Delhi, India), pp. 669 - 671, Oct. 2018.

Service Level Virtualization (SLV) for 5GC

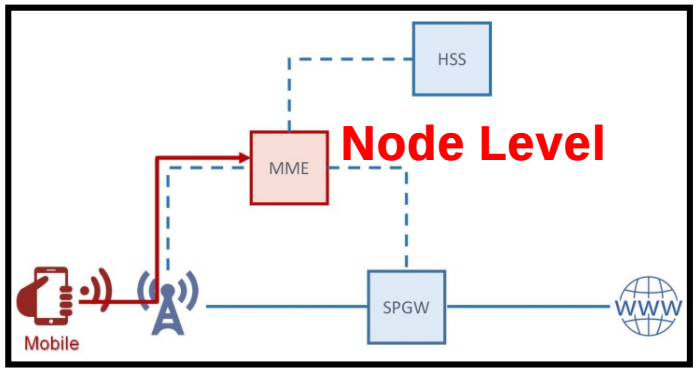
- **SLV: a preliminary implementation of 3GPP R15 Service Based Architecture (SBA)**
  (1) An entity is decomposed into different service blocks to provide different services.
  (2) Tested with commercial handsets and base stations.

Demo at IEEE 5G World Forum, Santa Clara, CA, USA, July 9-11, 2018

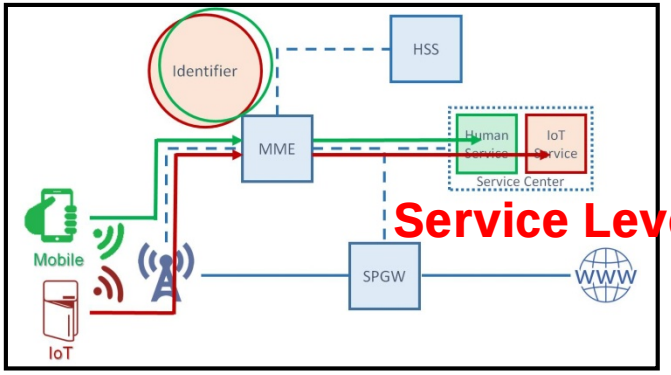
- Virtualize the core network at service level
- Create a new component called **Service Center** to manage customized services



SLV MME Architecture



LTE Architecture

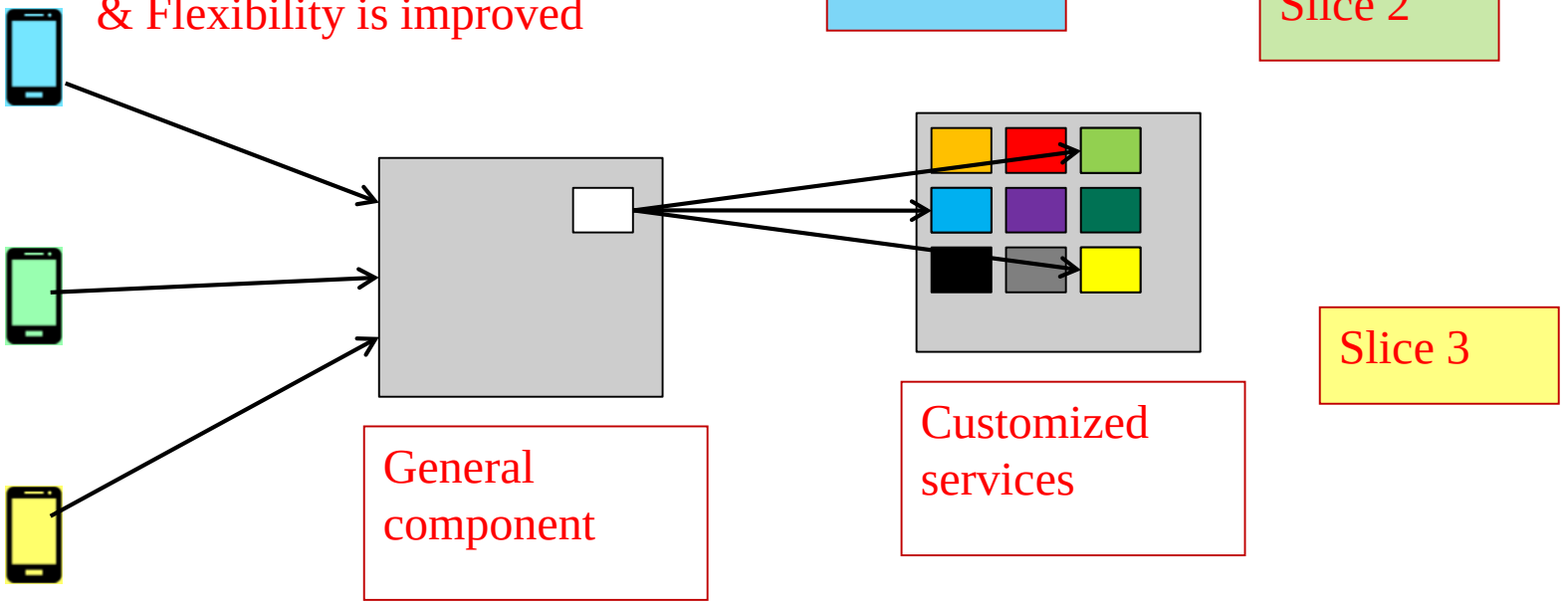


SLV Architecture

SLV – Service Level Virtualization

- Each function runs as a process on different hardware
- Resources are saved

  & Flexibility is improved



https://www.free5gc.org/

MOST 科技部
Ministry of Science and Technology

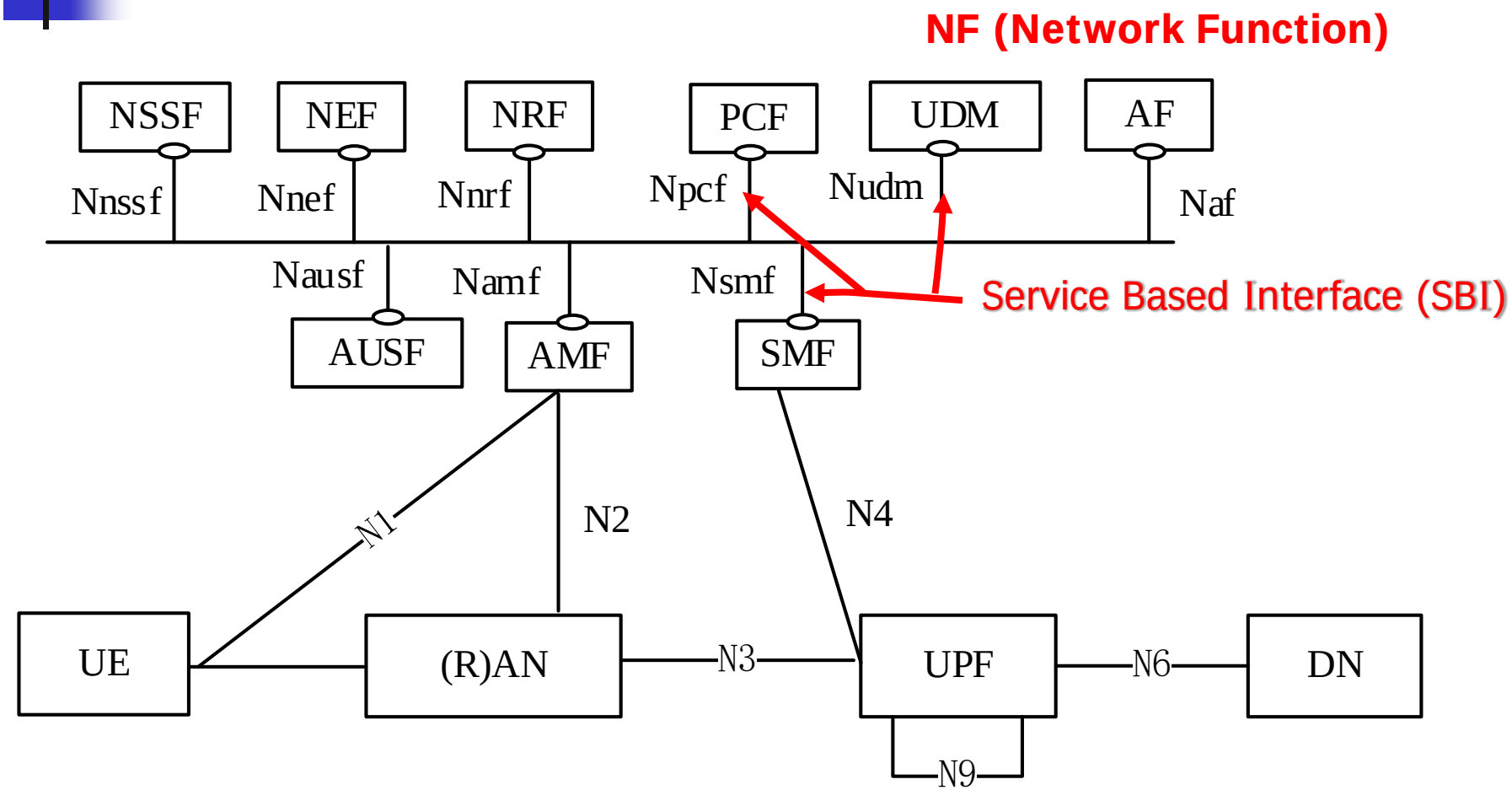
中華民國經濟部
Ministry of Economic Affairs, R.O.C.

MINISTRY OF EDUCATION 教育部

5G Architecture – R15

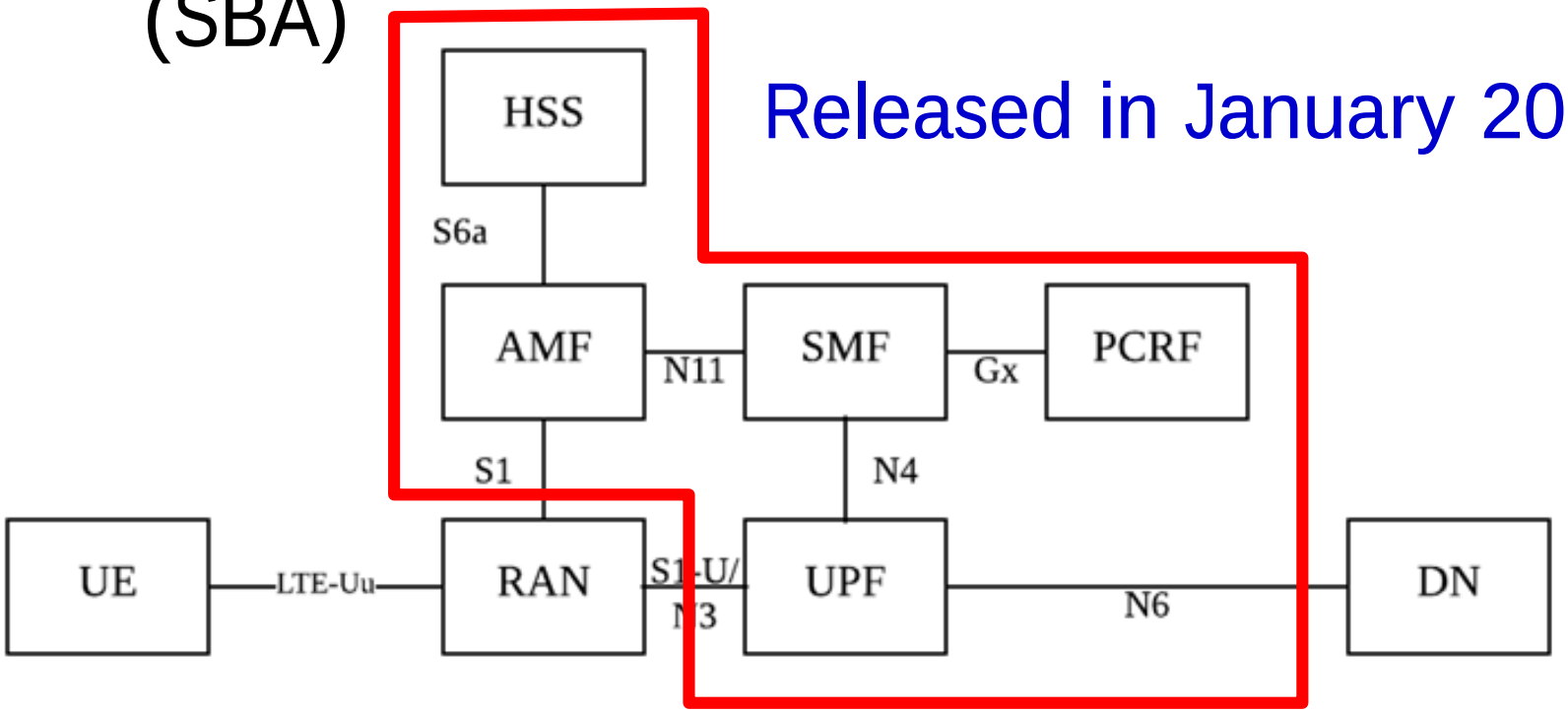
- Non-Standalone (NSA)
  - Use 4G EPC as the core network
- Standalone (SA)
  - 5G Core (5GC) network
  - Service Based Architecture (SBA)

3GPP R15 Architecture (5GC)



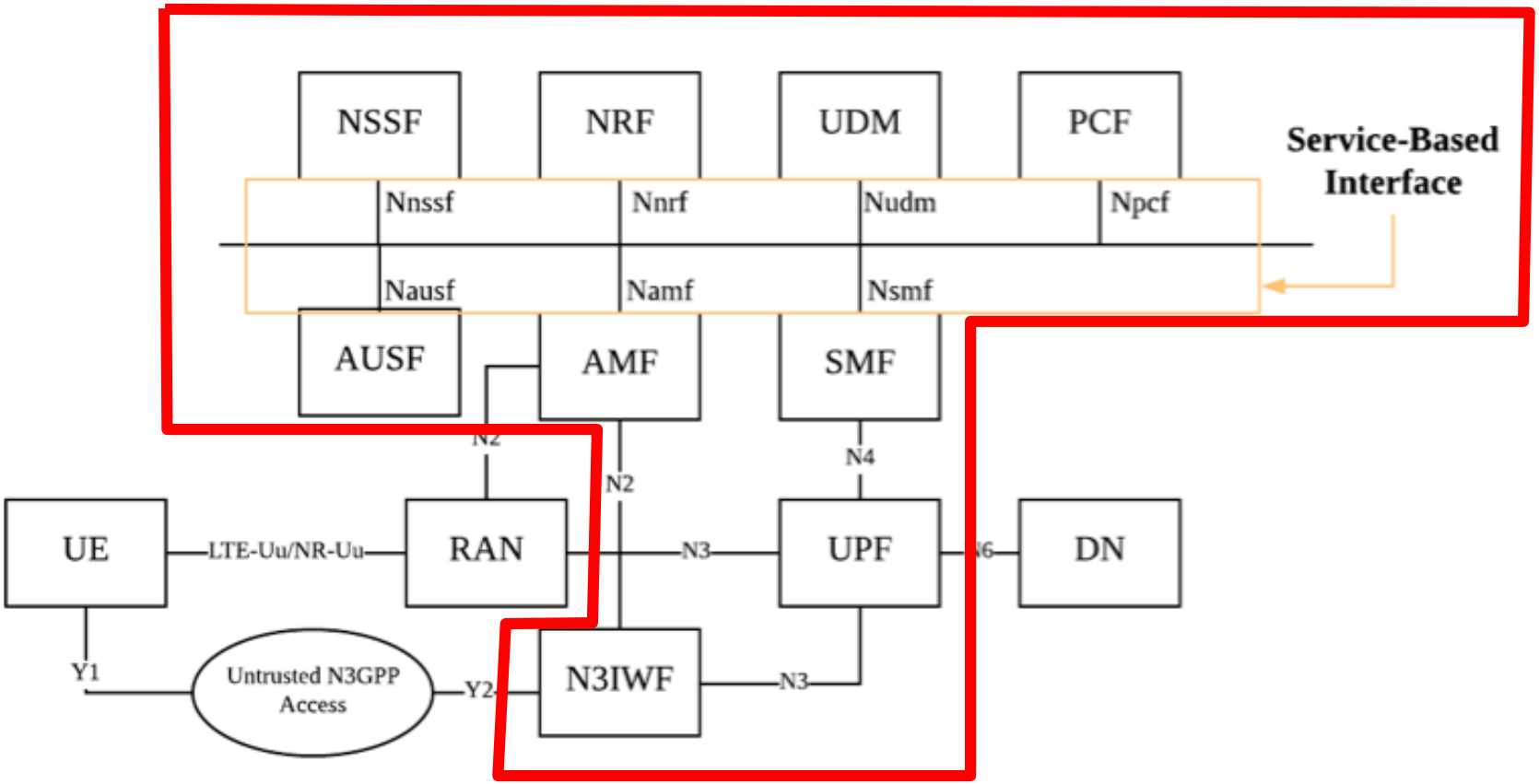
Stage 1: migrated 4G EPC into 5GC SBA

- Migratrd 4G Evolved Packet Core (EPC) into 5GC Service-Based Architecture (SBA)



Released in January 2019

Stage 2: implementing standalone 5GC features



Released in October 2019

Stage 3: a full operational 5GC

- IPTV is supported in this stage.
- Added features: Operation, Administration and Management (OAM) of 5GC, 5G Orchestrator, and Network Slicing.

Released in April 2020


Microsoft
Windows


hp 250 G6

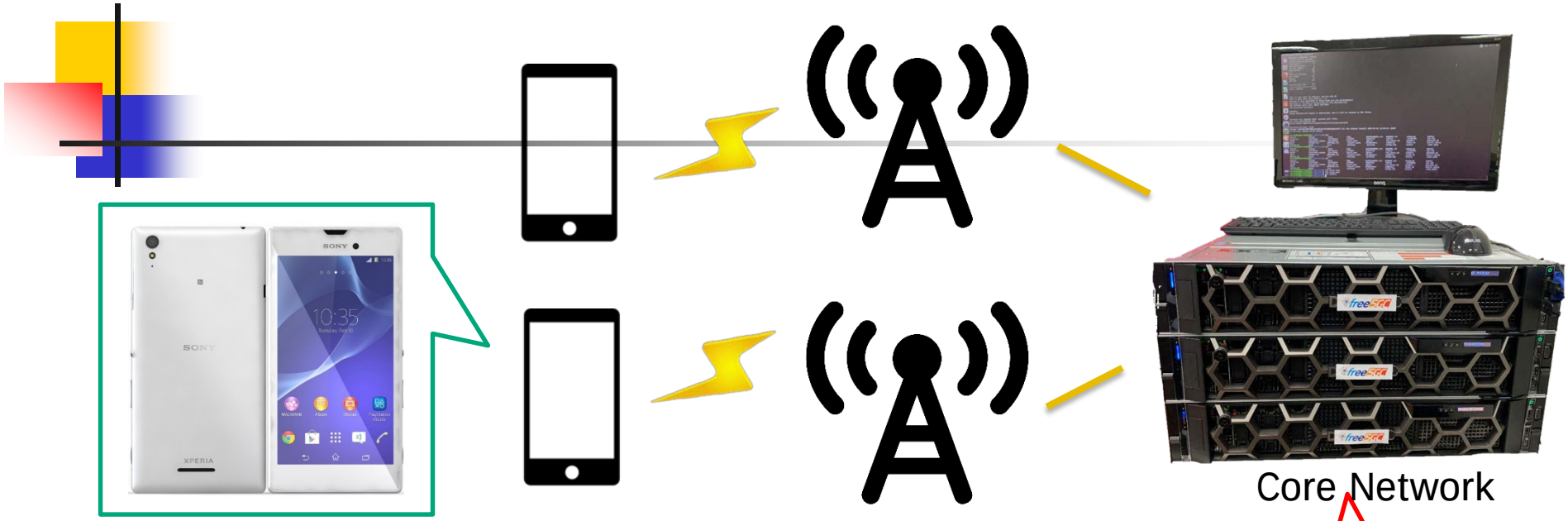

DELL


Linux


ASUS

Free the cellular core network

Demo



Commercial phones

Commercial base stations

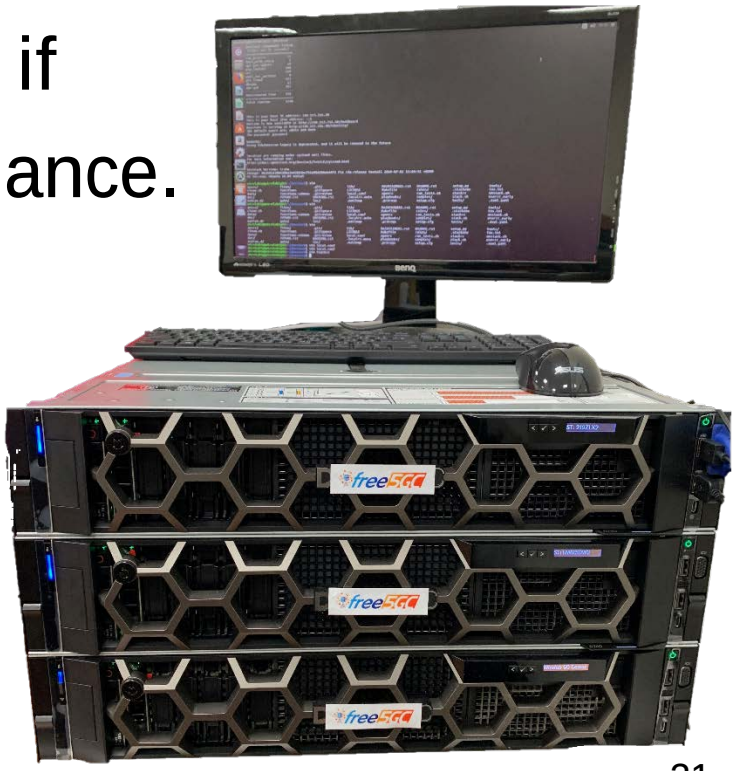
Core Network

SIM card made by us

Equipment: Core Network

- Dell PowerEdge R740xd: Ubuntu 18.04.02, Intel Xeon Gold 6316, 128G RAM, 5840G HDD
- Any laptop/desk should work if you don't care about performance.
- For minimum requirements, please refer to:

  https://www.free5gc.org/installation



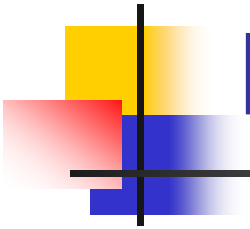
How do we test? (1/2)

- Commercial base stations
  - free5GC stage 1:
    - 4G eNB: WNC, D-Link, GemTek, Foxconn, ...
    - UE: commercial smartphones
  - free5GC stage 2 & 3:
    - 5G standalone (SA) gNB: Lions (UE: CPE w/ qcom x55 chip), ITRI (UE: SAMSUNG S20), Alpha (UE: SAMSUNG S20, Quanta dongle)
    - Huawei P40 5G UE and Amarisoft gNodeB

      Reported from: https://forum.free5gc.org/t/running-free5gc-stage3-with-amarisoft-gnodeb-ue/532
    - More local companies in Taiwan will provide us 5G SA gNB

How do we test? (2/2)

- Spirent Landslide
  - https://www.spirent.com/products/core-network-test-5g-lte-ims-wifi-diameter-landslide
  - Emulate both 5G SA UE and gNB



Performance

external version / internal version

- Control plane
  - 5 / 20 attachments per second
  - 100 / 1,000 simultaneously active users
  - 500 / 5,000 registered users
- User plane
  - 800 Mbps / 10 Gbps
  - Highly depends on hardware

Field trial at NYCU

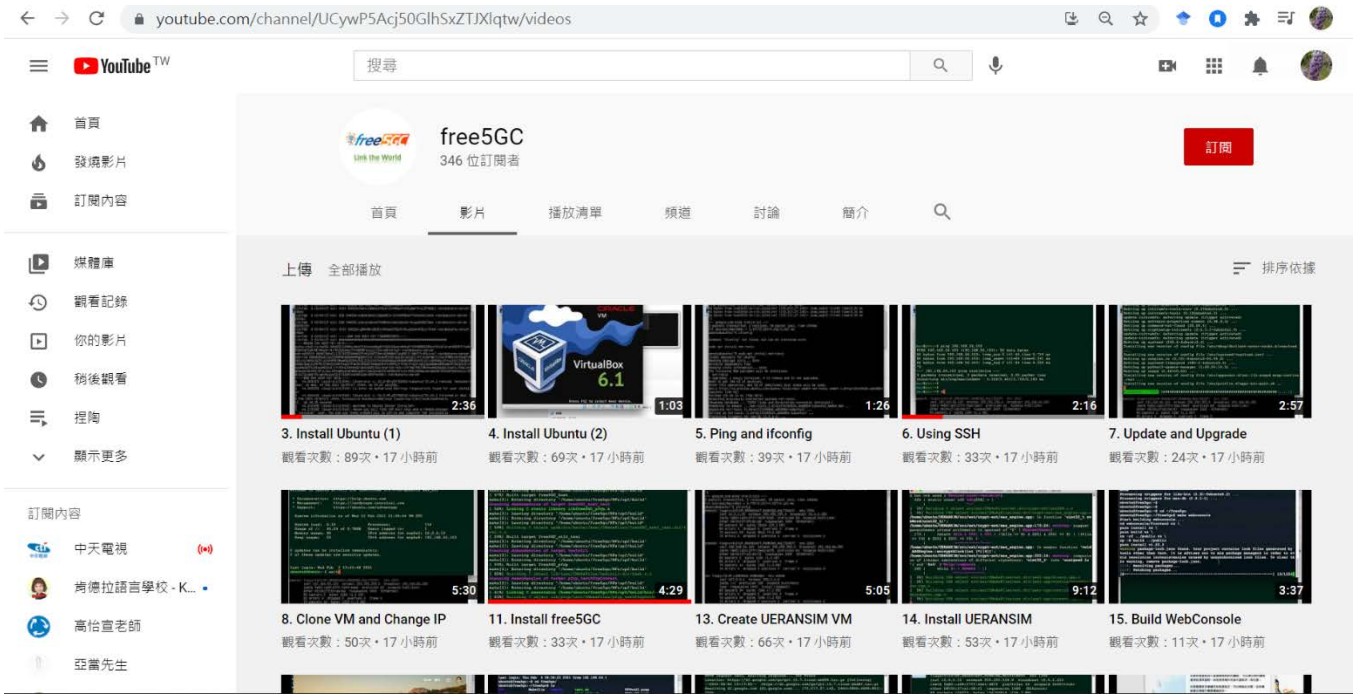
- SA 5GC: free5GC
- SA gNB
  - In Taiwan: 4.8 ~ 4.9 GHz for private 5G networks
- SA UE

Open for academics for research and educational purposes

Sponsored by Ministry of Education 教育部

YouTube free5GC courses

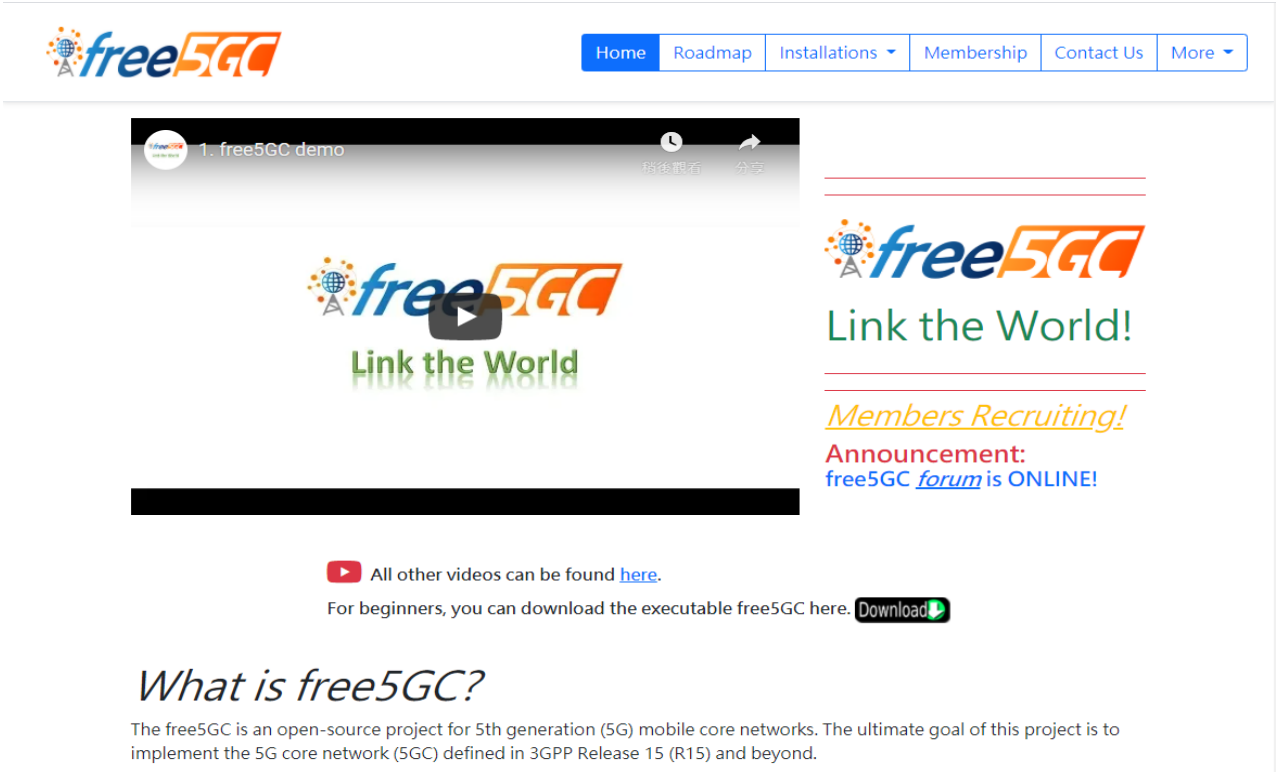
- 48 Chinese/English training videos



free5GC - Link the World

https://www.free5gc.org/

- Please visit free5GC website for more resources



Communication Service/Software Laboratory (CS Lab)

The main purpose of the CS Lab is to advance the research and development of mobile communication networks, and to cooperate with professors and industrial experts in related fields to develop cutting-edge technologies for mobile communication networks. We also develop open-source software and provide professional services to the communities.

https://cslab.nctu.edu.tw/

Please use it, give us feedbacks, and even join us to develop the first comprehensive, free, and open-source 5G core network.


Thank You