A Computation Workload Characteristic Study of C-RAN

Yu-Cing Luo
Shih-Chun Huang
Jerry Chou
National Tsing Hua University, Taiwan

SNTA'18 Workshop @ ICDCS 7/2/2018

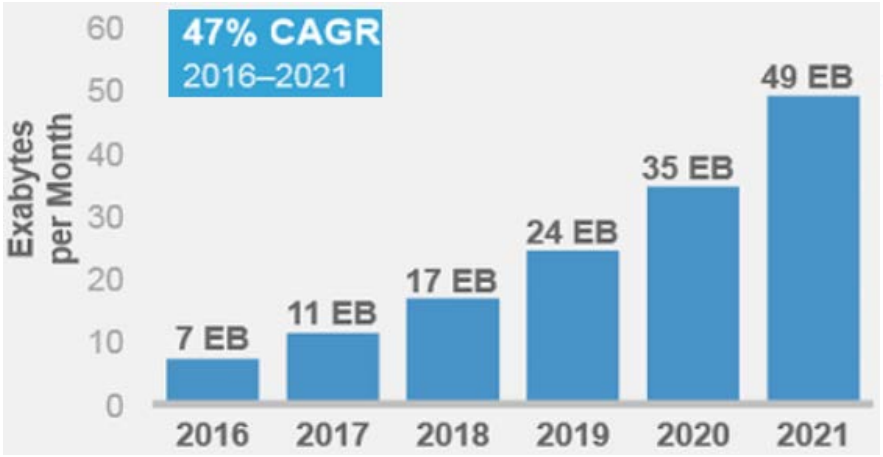
Outline

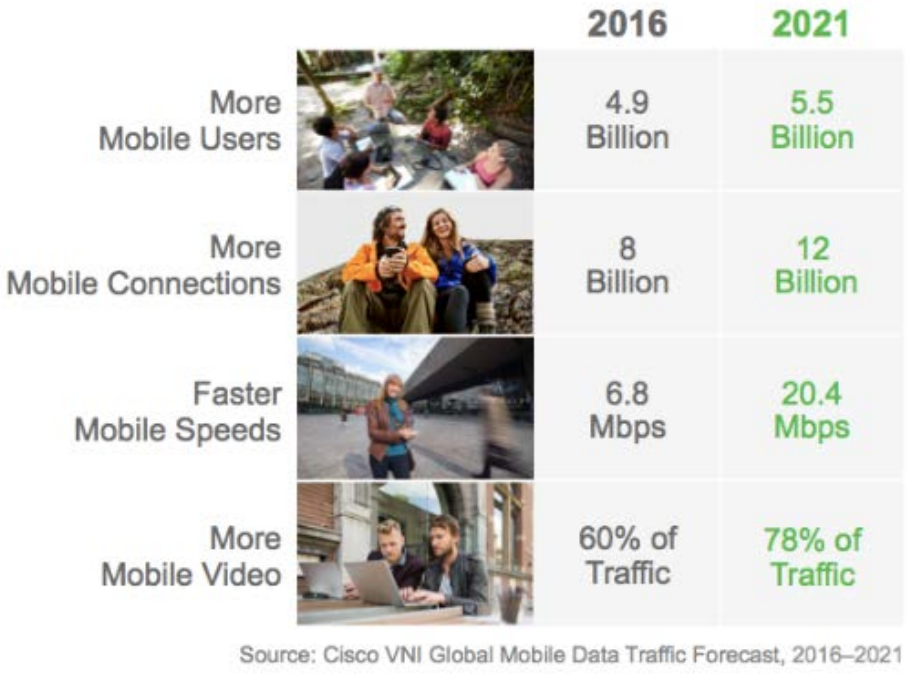
- Background of C-RAN
- C-RAN Testbed Deployment
- Experiments of Workload Study
- Conclusion & Future Work

Growing Mobile Data Traffic

Growing Mobile Data Traffic

- Global mobile data traffic to grow 7-fold from 2016-2021

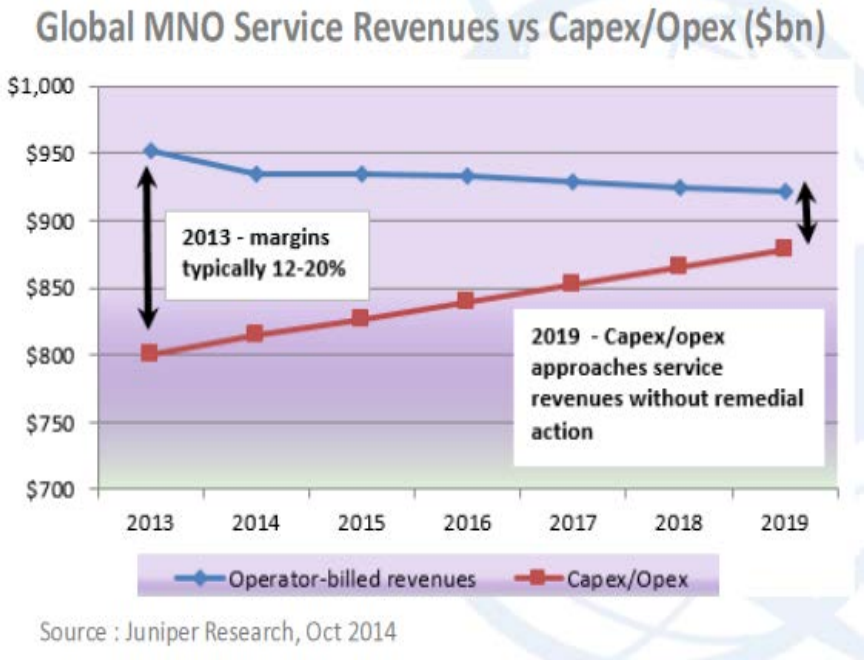




Source: Cisco Visual Networking Index Global Mobile Data Traffic Forecast, 2016-2021

Pressure on Mobile Network Operator

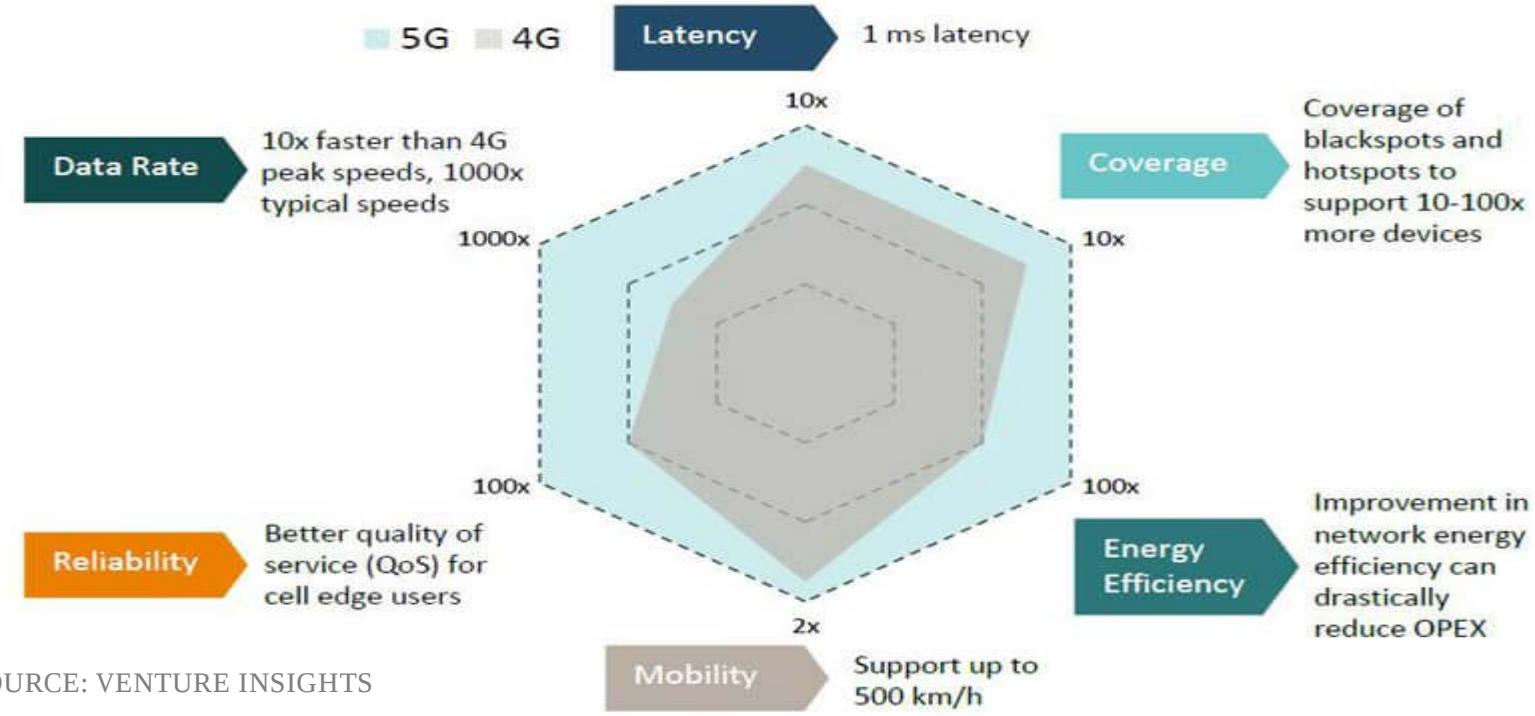
- Between 2008 to 2013, data traffic grew 46-times , while revenue from data only grew 3-times
- Complex and heterogeneous transport network must co-exist
  - 2G voice oriented: TDM/SDH
  - 3G hybrid: IP/MPLS, ATM
  - 4G LTE: Ethernet-based



CAPEX: Capital expenditures
OPEX: Operating expenses

5G: Next Generation Wireless Communication

- Require a fundamental shift in the way we **construct and manage mobile network infrastructure**



SOURCE: VENTURE INSIGHTS

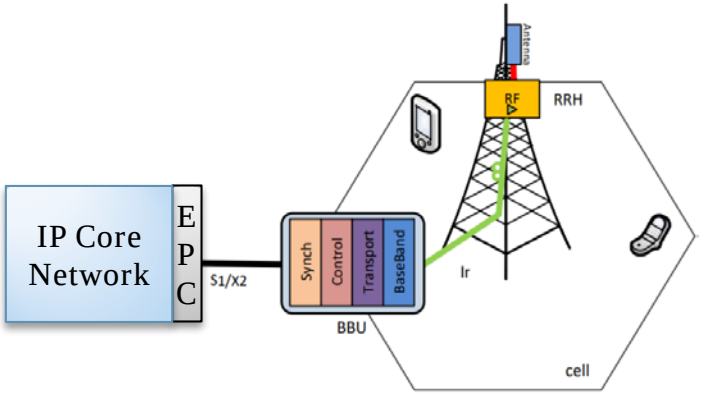
5G Platform: A Cloud Native Software-Defined Networking

- Borrow principles of the more **scalable**, **flexible** networks that deliver **cloud-based services** from **IT** companies

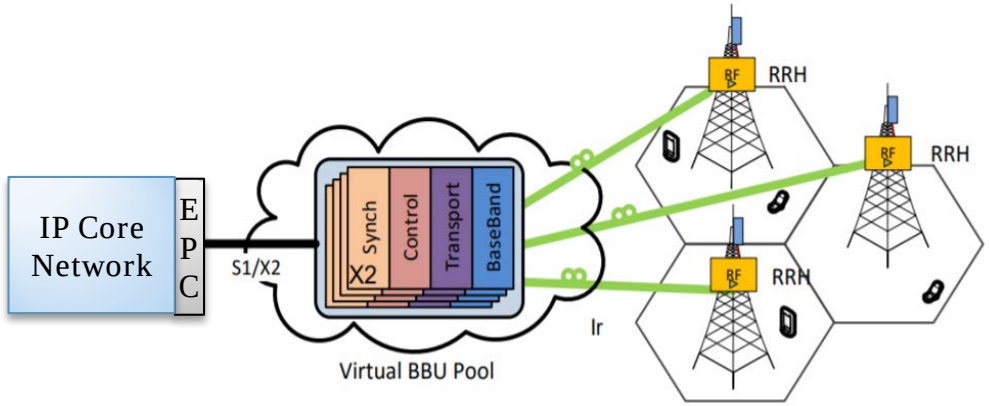
- Toward a **centralized** and **virtualized** networking platform
  - **Software-Defined Networking** (SDN)
  - **Network Function Virtualization** (NFV)

C-RAN: A Cloudified Radio Access Network

- Proposed by China Mobile in 2010
  - "C" refers to Cloud or Centralized
- A centralized and virtualied Radio Access Networks (RAN)
  - RRHs(RF signal transceiving) connect to a centralized BBU(baseband processing) hosted on a resource pool
  - BBU is virtualized on scalable commodity hardware



Base station with RRH
(Traditional Mobile Network Arch.)

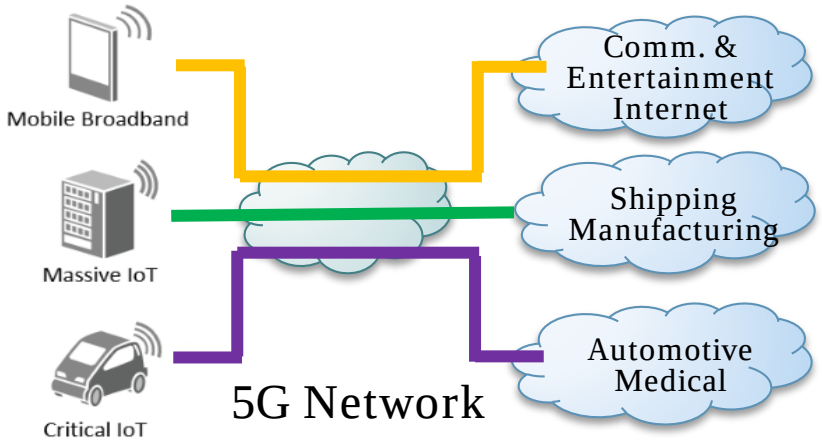


BBU Pool with RRH (C-RAN)

Source: Cloud Radio Access Network architecture. Towards 5G mobile networks

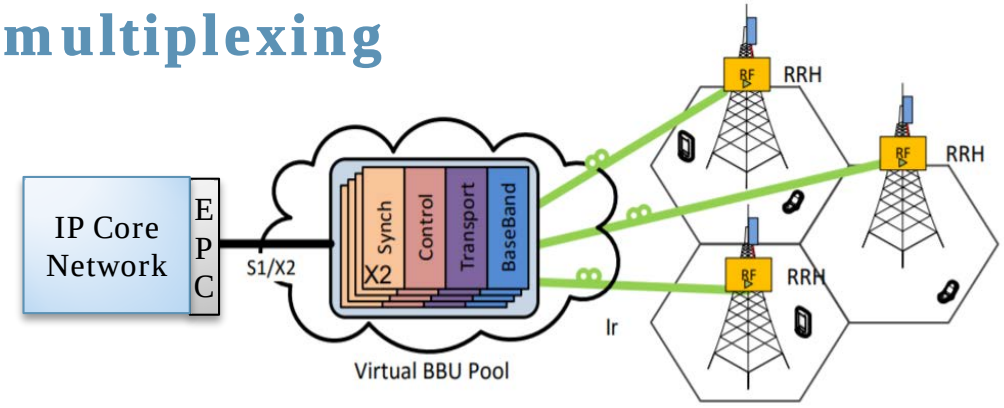
C-RAN: A Cloudified Radio Access Network

- Advantages
  - Running on general purpose processors
  - Collaborative radio protocol
  - Network slicing
  - **Resource statistical multiplexing**



Lower energy & cost

Higher efficiency & resource utilization



BBU Pool with RRH (C-RAN)

Our Work

How to orchestrate & mange the **BBU resource pool for C-RAN**?

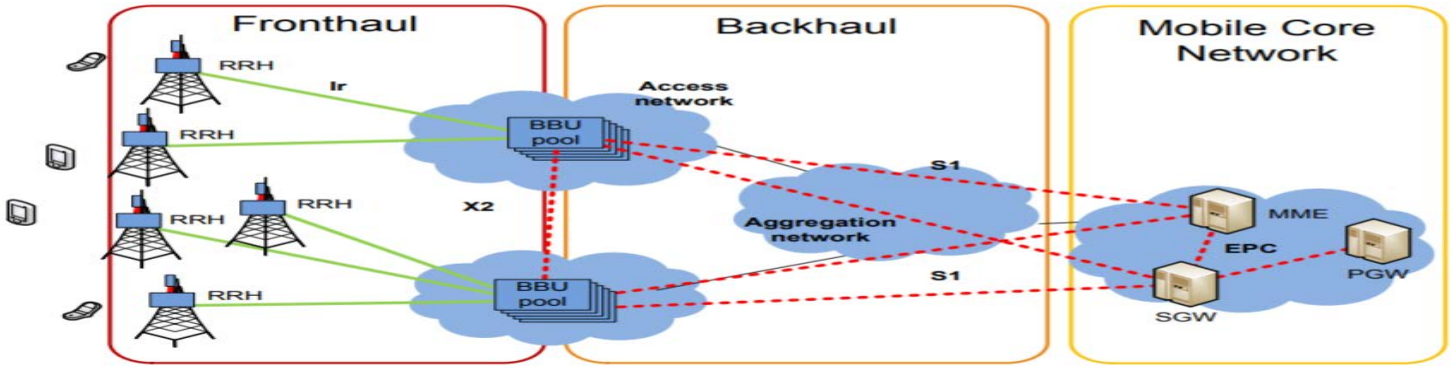
1. Built a C-RAN cloud platform by deploying OpenAirInterface (OAI) on OpenStack
2. Analyze the computing resource demand and performance bottleneck of virtualized BBUs
3. Follow the NFV concept to achieve functional split of BBU modules

Outline

- Background of C-RAN
- C-RAN Testbed Deployment
- Experiments of Workload Study
- Conclusion & Future Work

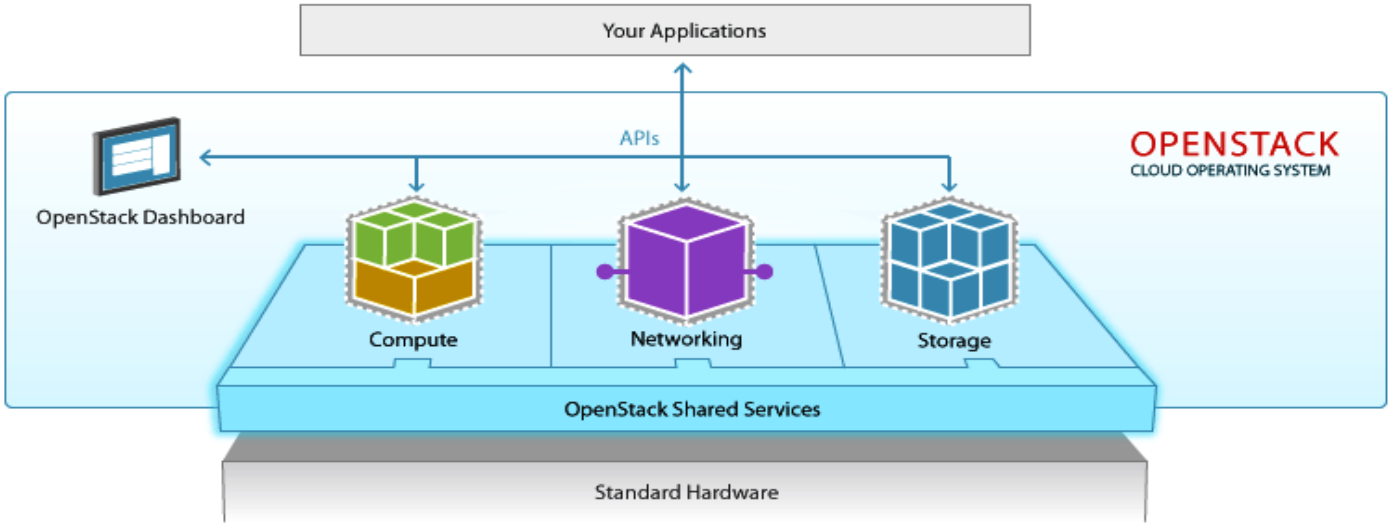
OAI: OpenAirInterface

- An EURECOM software project to advance wireless innovation of 3GPP cellular networks for the future 5G wireless network design
- An open source software implementation of 3GPP standard
  - Core network (**EPC**)
  - Access network (**eNodeB**/BBU pool)
  - User equipment (UE)

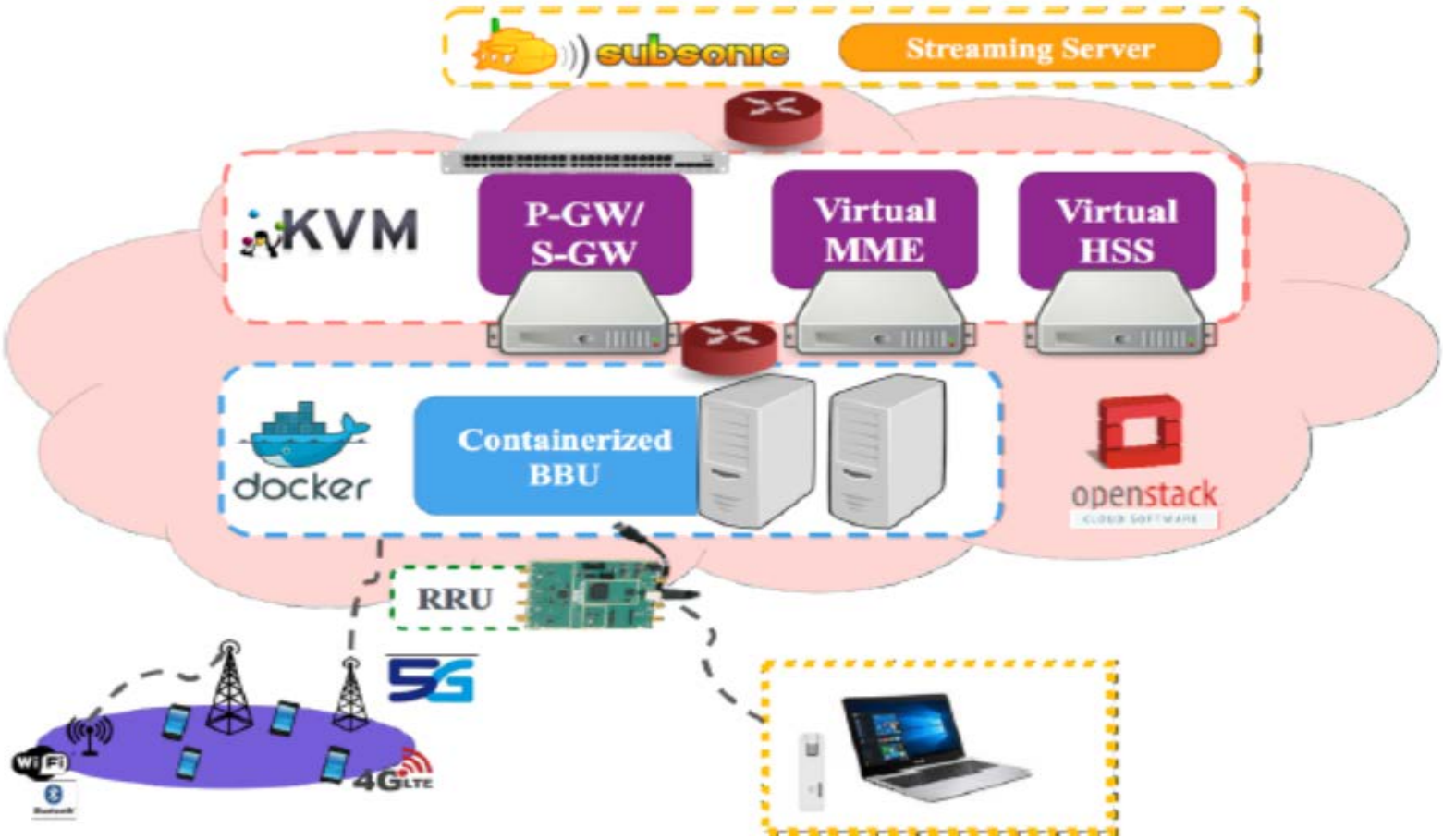


OpenStack

- An open-source software platform for cloud computing, mostly deployed as infrastructure-as-a-service (IaaS)
- Widely used to deploy private clouds and public clouds (e.g., Rackspace)

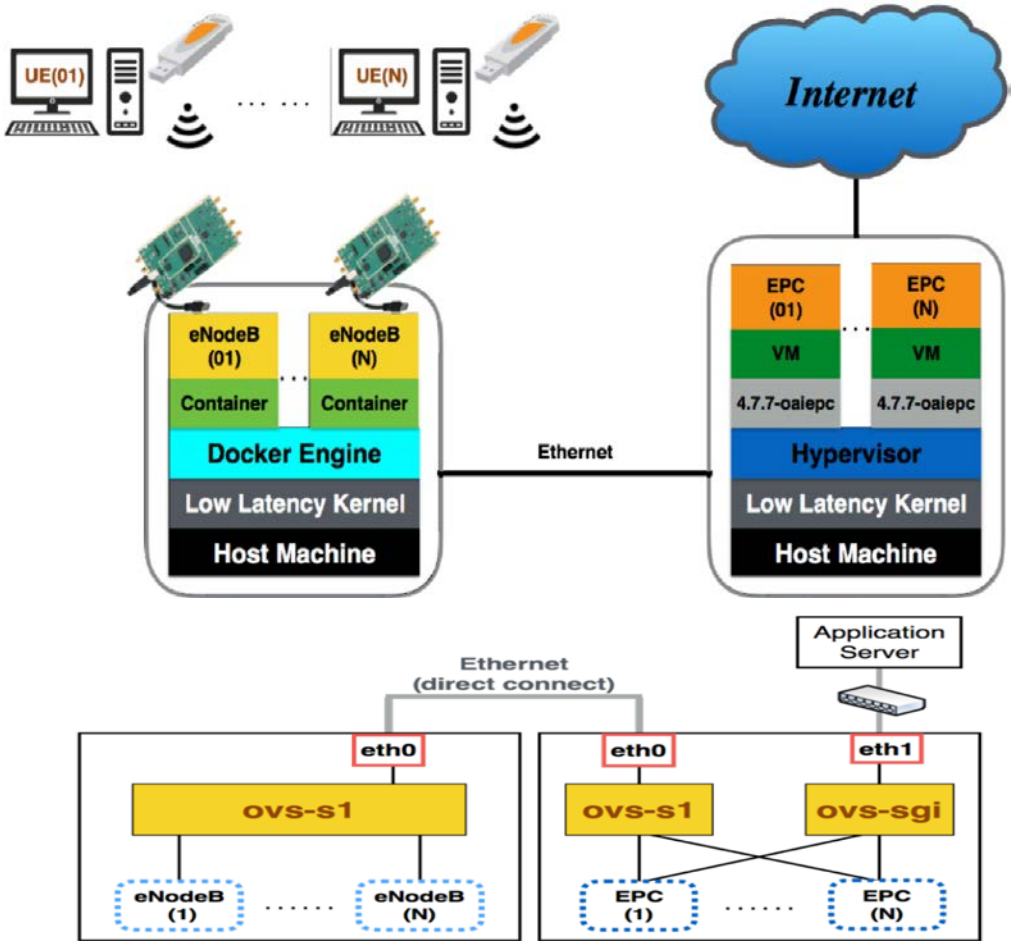


C-RAN Testbed



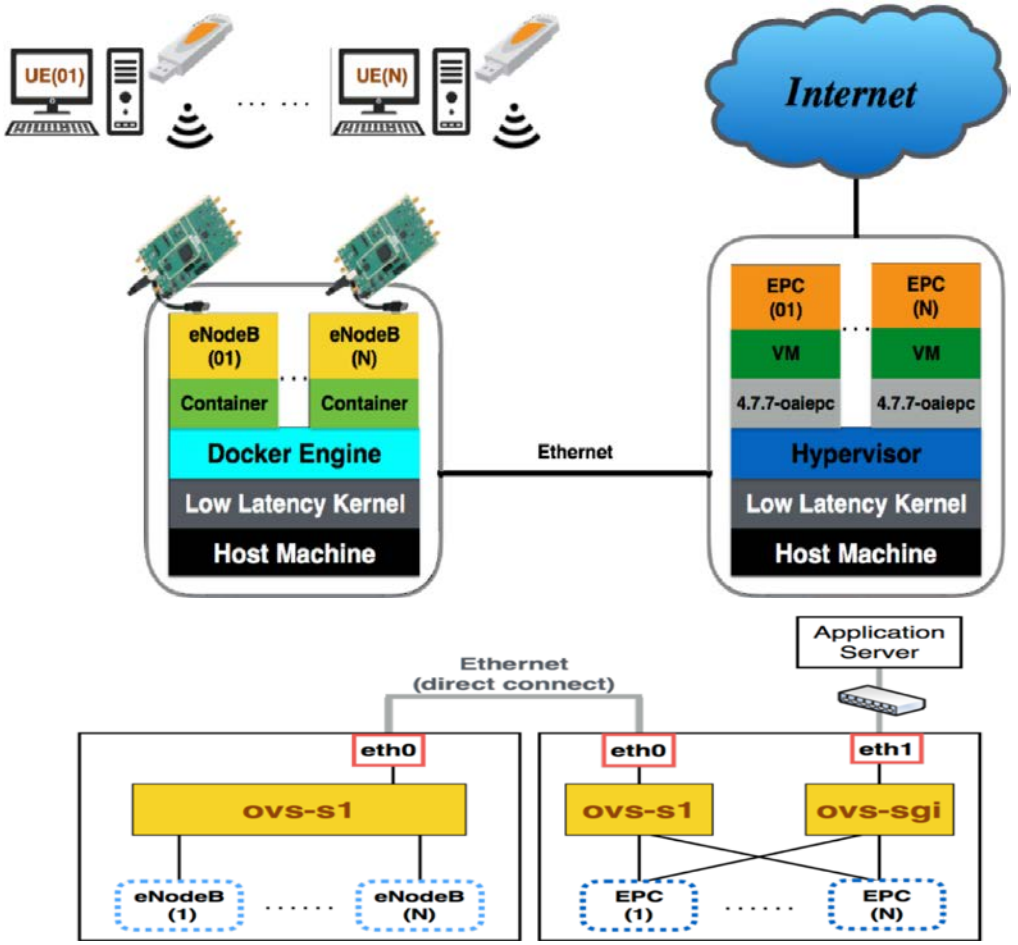
Deployment and Integration

- **BBU pool** (eNodeB) are hosted on **Docker containers** for better network performance
- **Core network services** (EPC) are hosted on **Virtual Machine** b.c. kernel modules are required
- Host with low latency kernel (Ubuntu 14.04.1 LTS OS)
- **Open vSwitch**(OVS) for enabling **multi-tenant network virtualization** and **SDN**



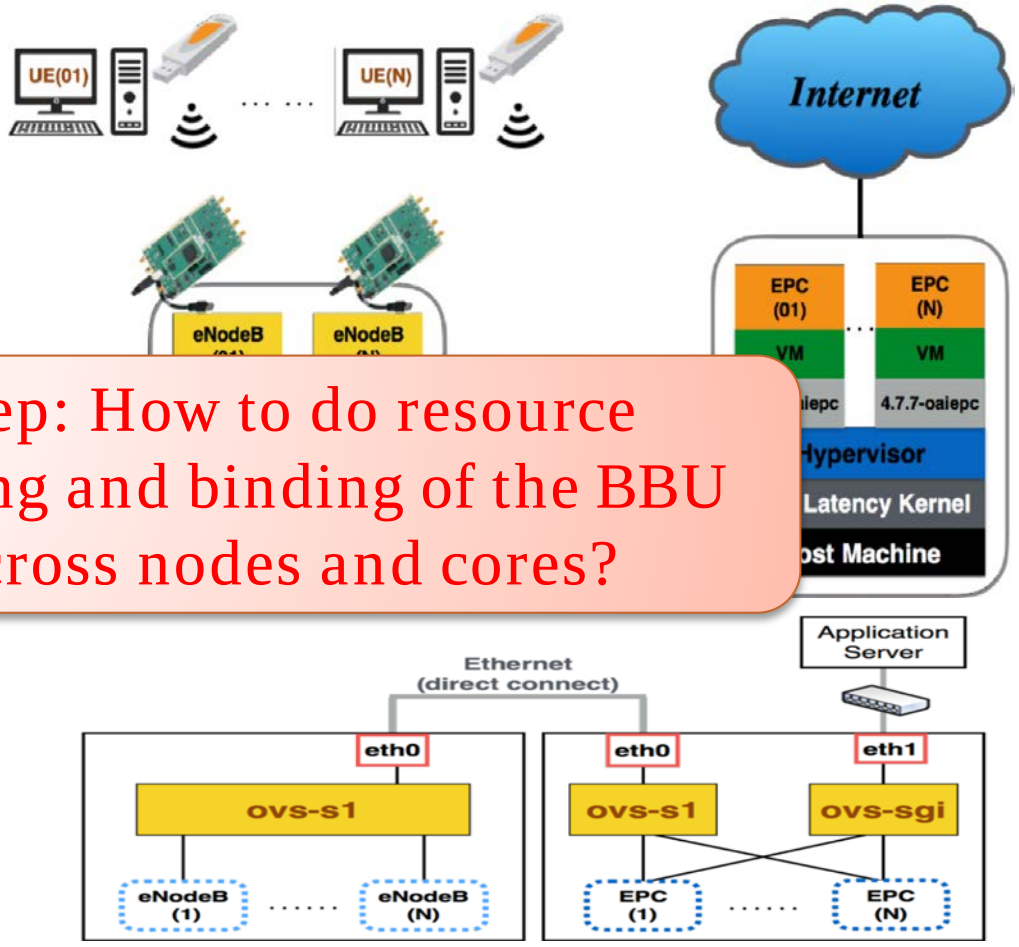
Deployment and Integration

- Enabling features:
  - Network slicing from eNodeB to EPC
  - On-demand network **service deployment**
  - **Shared resource** for multiplexing
  - Real-time resource **monitoring** and service **fail recovery**



Deployment and Integration

- Enabling features:
  - Network slicing from eNodeB to EPC
  - On-demand network **service c**
  - **Shared r** multiplex
  - Real-time resource **monitoring** and service **fail recovery**



Next step: How to do resource provisioning and binding of the BBU pool across nodes and cores?

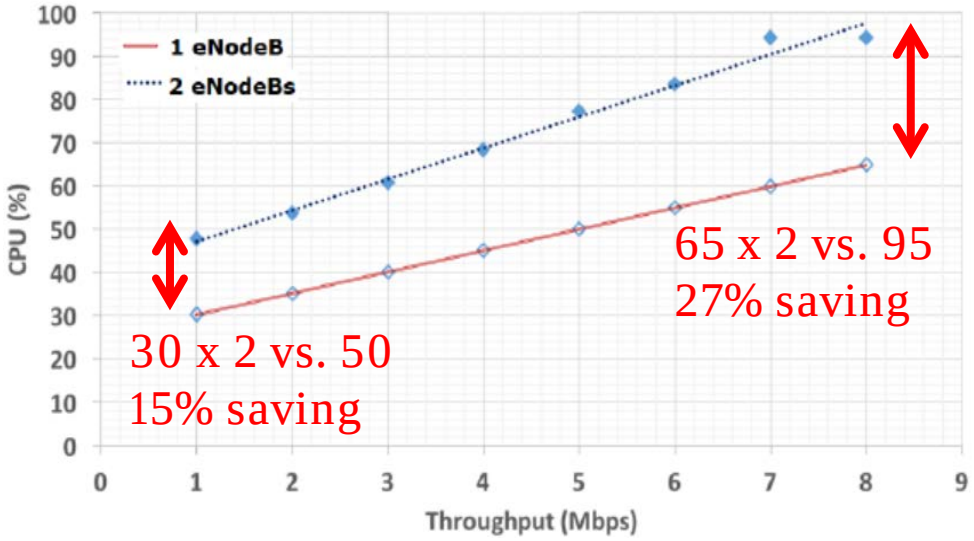
Outline

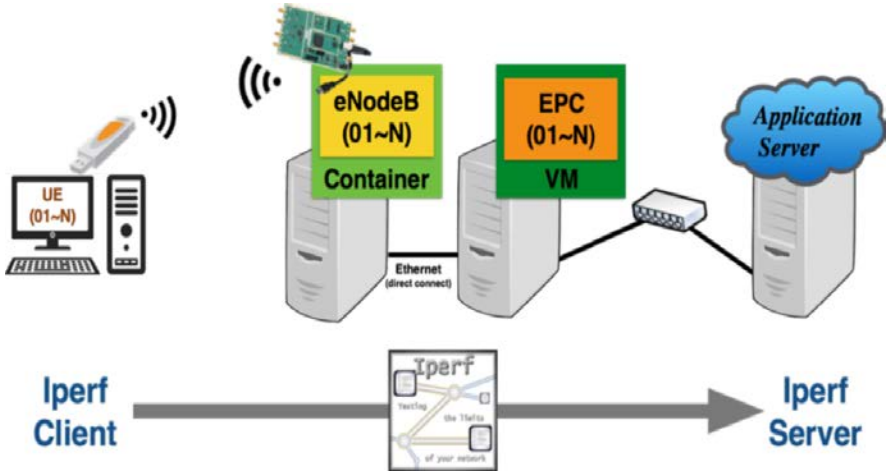
- Background of C-RAN
- C-RAN Testbed Deployment
- Experiments of Workload Study
- Conclusion & Future Work

Workload Characteristic Study

- eNodeB CPU usage is proportional to the traffic throughput
- Consolidate multi-eNodeB on a single core can reduce total CPU usage

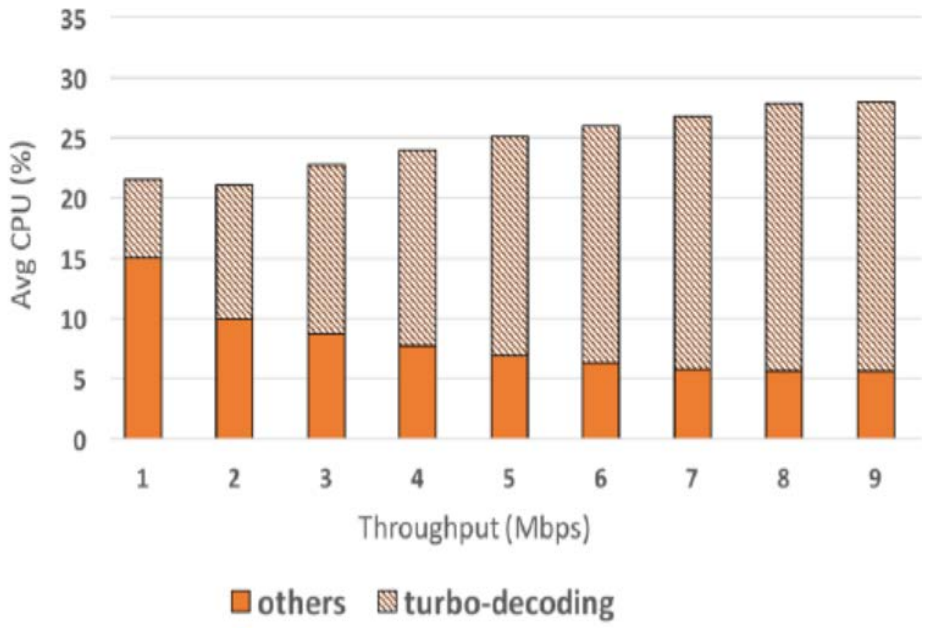
➔eNodeB placement is a **bin-packing problem**





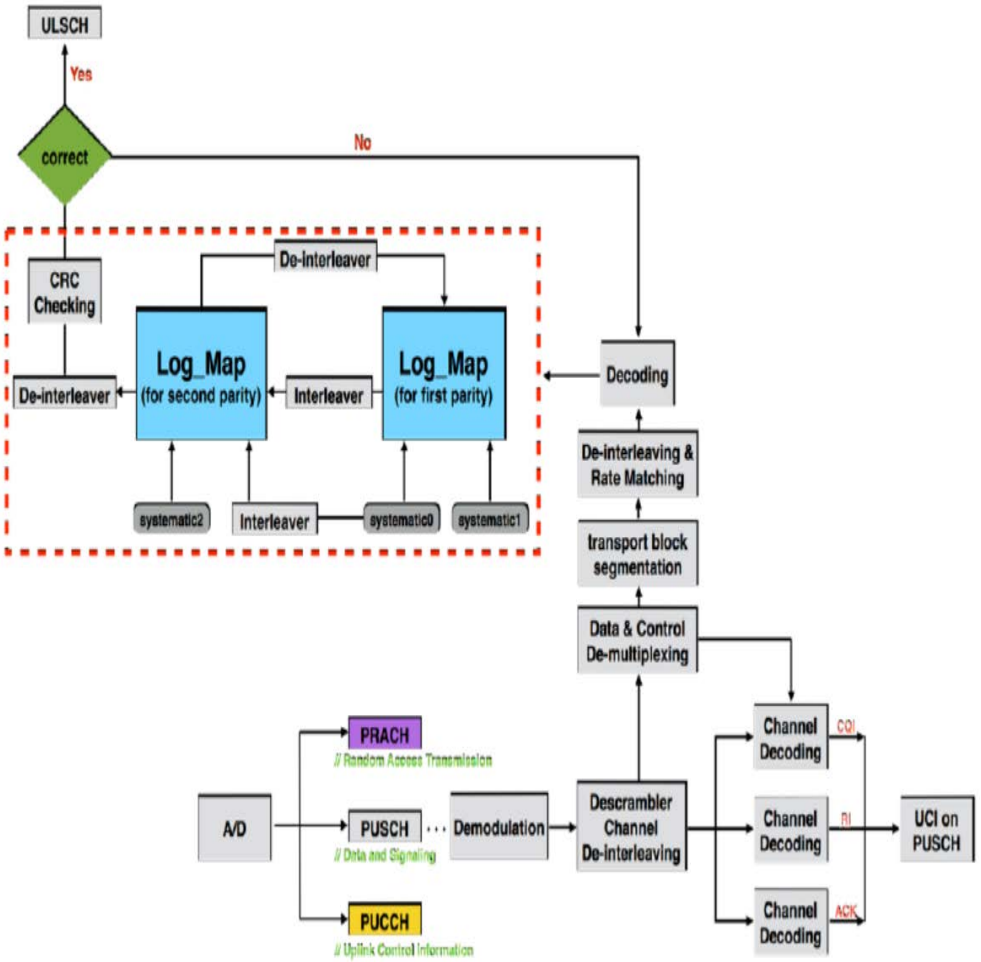
Workload Profiling Study

- Top 4 CPU usage functions come from the implementation of **turbo-coded decoding, especially under high throughput traffic**



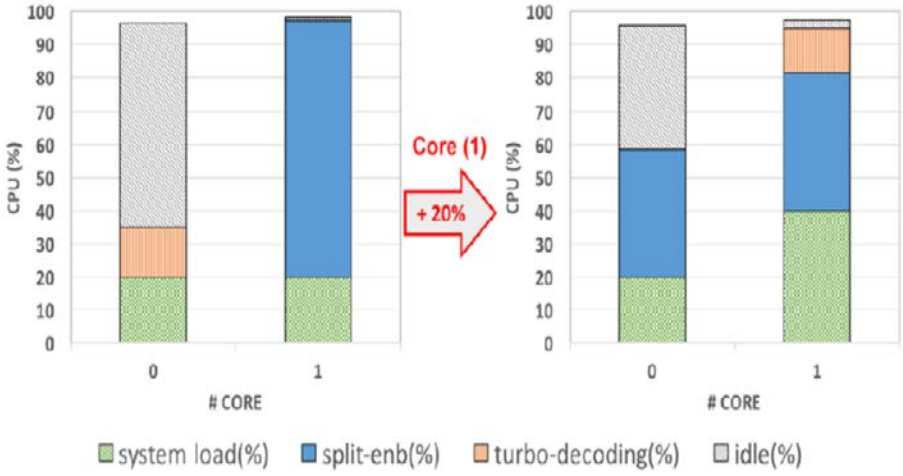
Functional Split of eNodeB

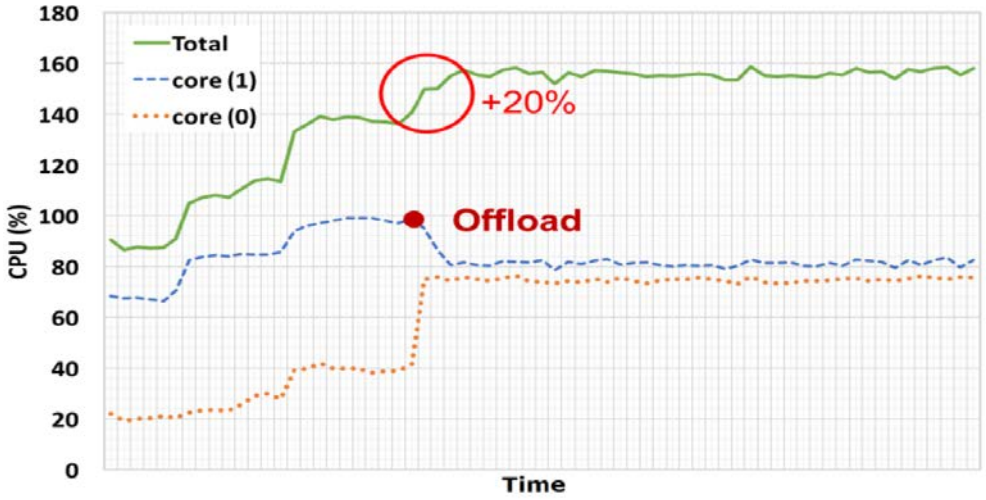
- Goal:
  - Decompose eNodeB to reduce CPU demand
  - Offload computations across containers/cores
- Implementation:
  - Pass function argument by **shared memory**
  - Coordinate processes by **signal**
  - Select **proper cutting point** to reduce communication overhead



Functional Split of eNodeB

- Running two eNodeBs on 2 cores
- Increase throughput by 20% on one of the eNodeB
- Runtime migrate turbo-decoding function to improve resource utilization





Outline

- Background of C-RAN
- C-RAN Testbed Deployment
- Experiments of Workload Study
- Conclusion & Future Work

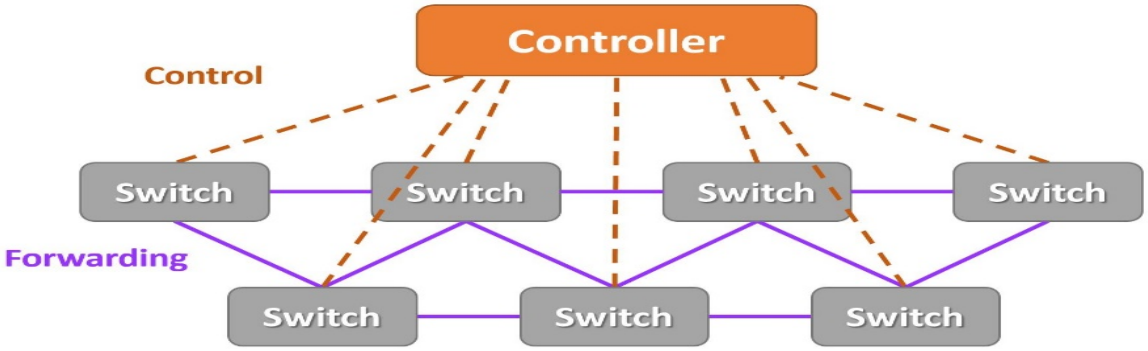
Conclusions & Future work

- We have built a C-RAN testbed for exploring future 5G wireless communication technologies
  - Network Slicing
  - Mobile Edge Computing
  - Software Defined Radio
- We have done preliminary workload characteristic study
  - It will be used to model resource usage and design workload aware resource provisioning strategy
- We have shown the benefits of functional split eNodeB modules
  - More efforts are required to build a NFV infrastructure for future 5G access network for less latency delay and higher throughput performance

Q & A

Software Defined Networking

- Separate the **control plane** from **data plane**
- **Centralized control for routing planning** with **global view of the network**
- Switches simply follow the **routing labels** to forward packets
- Isolated routing and QoS of each **network tenant**



Network Function Virtualization

- Virtualize the traditional networking hardware equipment functions by software implementation
- Replace specialized HW by **general purpose processors**
  - Reduce capital cost
- Virtualized network function can be **deployed on-demand**
  - Reduce operating cost