Open-Source Ecosystem Based China Mobile Next-Gen Network Infrastructure

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Imminent Network Transition:

Traditional Network limitation, 5G Commercial Deployment and Edge Computing

中国移动 China Mobile

China Mobile, the largest mobile provider in the world:

2.0 M 4G Base Station

920M Mobile Users

147 M Wireline BB Users

Limitation of Traditional Network

Transition revolving around SDN/NFV

❖ **Slow service agility**: Long life cycle from subscribing to turning on and provisioning services; lack of programmability

❖ **Network Silo** : CT equipment highly specialized , difficult to share

❖ **Complex Network hierarchy** : Multi-layer Network across domains , complicated intra- and inter-domain connectivity, inefficient bandwidth usage

❖ **Weak dynamics**: Lack of the capability to dynamically and flexibly adjust network traffic flow and network element functionalities

5G Architecture and Core technical directions depending on Network Transition

5G System Architecture revolves around 4 main aspects:

- IT-oriented: Low cost with system dynamics; flexible resource management and deployment

- Internet-based, Cloud-native: Agile structure with dynamic configuration and adjustable connection

- Simplicity: High performance, high capacity

- Service-oriented: customized service, adaptable to various vertical industries and use cases
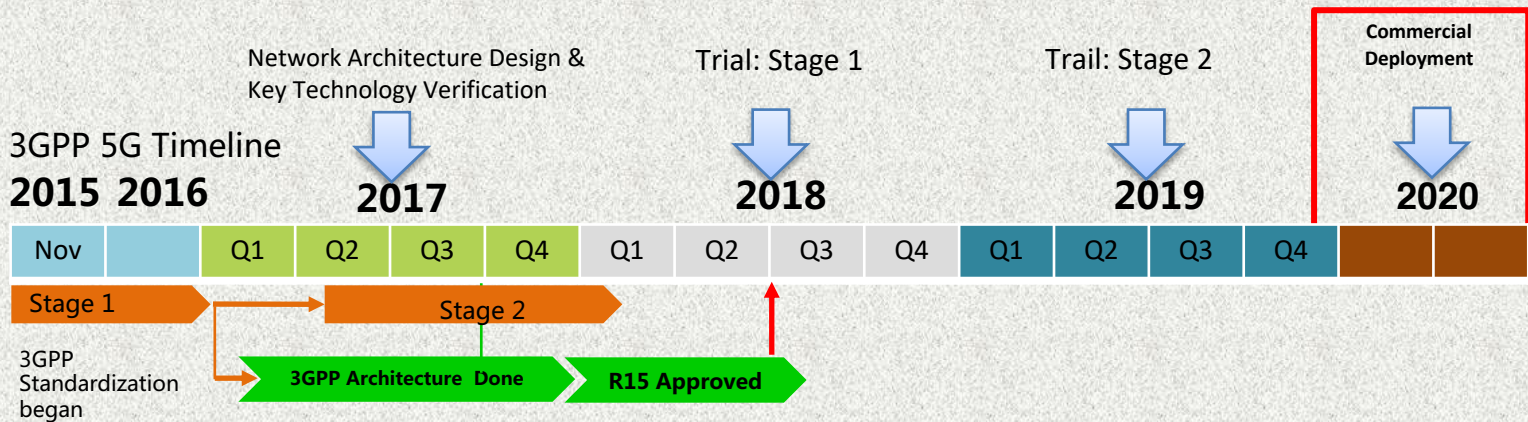
5G Technical directions:

- Software-oriented and Software-defined

- Separation of Control and User planes (CUPS)

- Separation of Compute and Data

- Service-base Architecture (SBA)

- Versatile connectivity
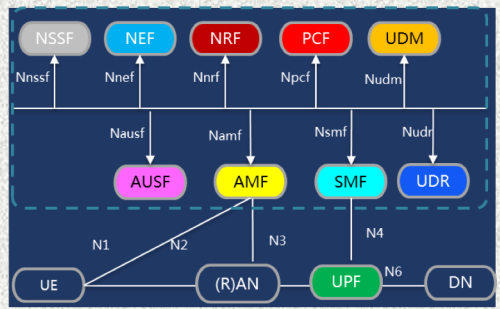
- Network Slicing

- Edge computing

Imminent Network Transition:

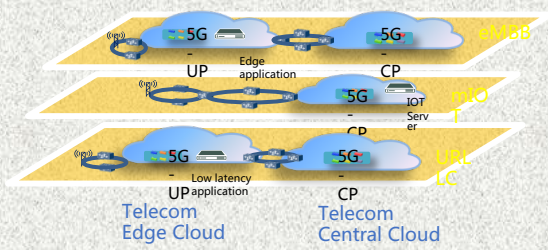## 5G Evolution and Commercial Deployment (Non-SA and SA)

5G Evolution and Commercial deployment

Network Architecture Design & Key Technology Verification

Trial: Stage 1

Trail: Stage 2

Commercial Deployment

3GPP 5G Timeline

2015	2016			2017					2018				2019			2020	
Nov		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4		

Stage 1

Stage 2

3GPP Standardization began

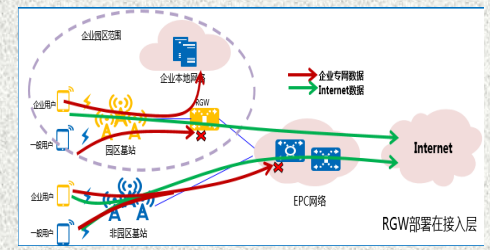**3GPP Architecture Done**

R15 Approved

China Mobile & Prestigious Industrial Vendors collaborate together to promote 5G core technologies

Service-based Architecture

Network Slicing

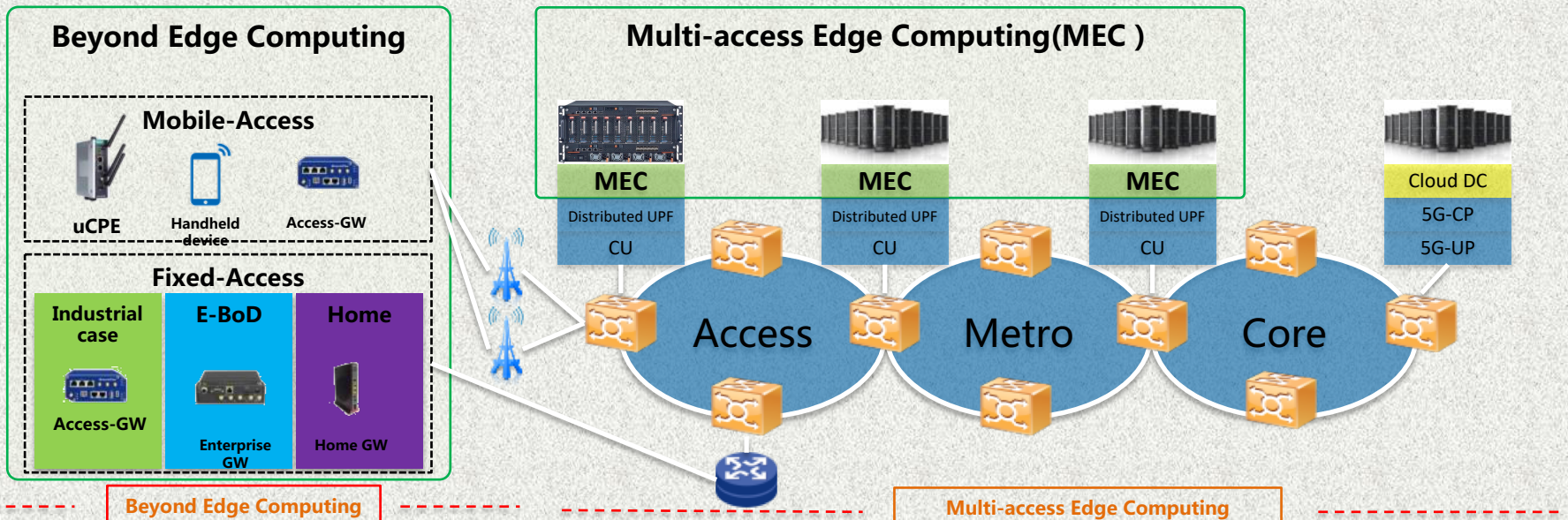Edge Computing

Imminent Network Transition: Edge Computing

Beyond Edge Computing

Mobile-Access

uCPE Handheld device Access-GW

Fixed-Access

Industrial case	E-BoD	Home
Access-GW	Enterprise GW	Home GW

Multi-access Edge Computing(MEC)

MEC — Distributed UPF — CU
MEC — Distributed UPF — CU
MEC — Distributed UPF — CU
Cloud DC — 5G-CP — 5G-UP

Access Metro Core

Beyond Edge Computing

Multi-access Edge Computing

Vertical Industry/Use Cases

• Heterogenous field access with deterministic latency
• Real-time Data collection, processing, and analytics
• Data Cleaning and desensitization for integrity and privacy
• SmartCity/SmartBuilding/SmartHome
• SD-WAN/LocalFW
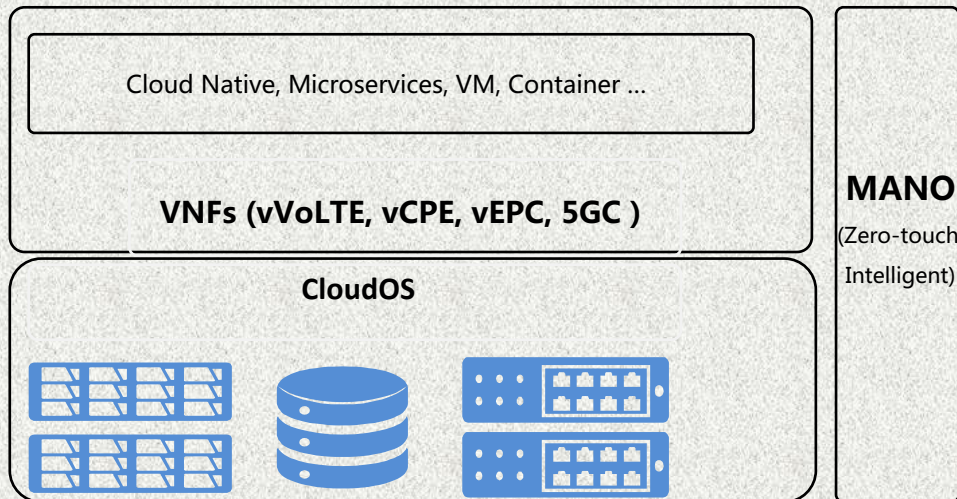• vPLC , human-machine interaction

MEC & Deployment Sites

• Edge-compute nodes close to end users, reduce communication latency and offload core network usage
• End-to-end service collaboration via edge-computing technology for better user experience
• **Access**: Real-time services like location-based Service, AR/VR; Enterprise localized services
• **Metro**: High-bandwidth services like video monitoring; real-time & high-computation services like cloud-gaming
• **Core**: High-computation/high-storage Services like mobile CDN

Next-Gen Network: 3-layer Decoupling Architecture

Cloud-based Infrastructure : Customized white-label HW with CloudOS for effective resource sharing
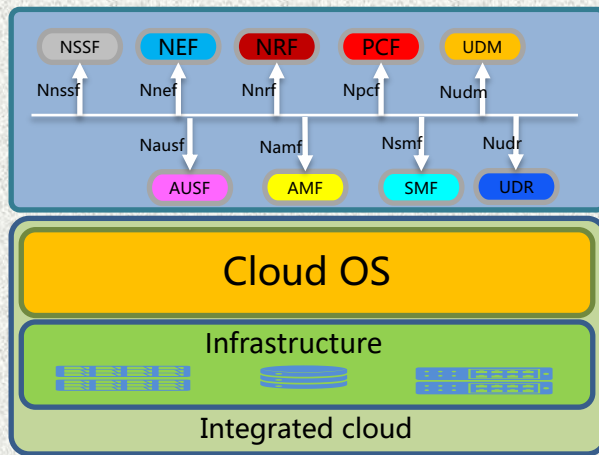
SW-defined Network & Functions : Network elements and connectivity via SW implementation

Intelligent Operations : Automatic (or zero-touch) end-to-end network management, control and orchestration

Cloud Native, Microservices, VM, Container ...

VNFs (vVoLTE, vCPE, vEPC, 5GC)

CloudOS

Infrastructure: Compute, Network, Storage

MANO

(Zero-touch, Intelligent)

China Mobile Trial Case:
- An integrated platform with 3-layer decoupling architecture
- 5GC success deployment
- Multi-vendor integrated solution over 3rd-party platform

NSSF	NEF	NRF	PCF	UDM
Nnssf	Nnef	Nnrf	Npcf	Nudm
	Nausf	Namf	Nsmf	Nudr
	AUSF	AMF	SMF	UDR

Cloud OS

Infrastructure

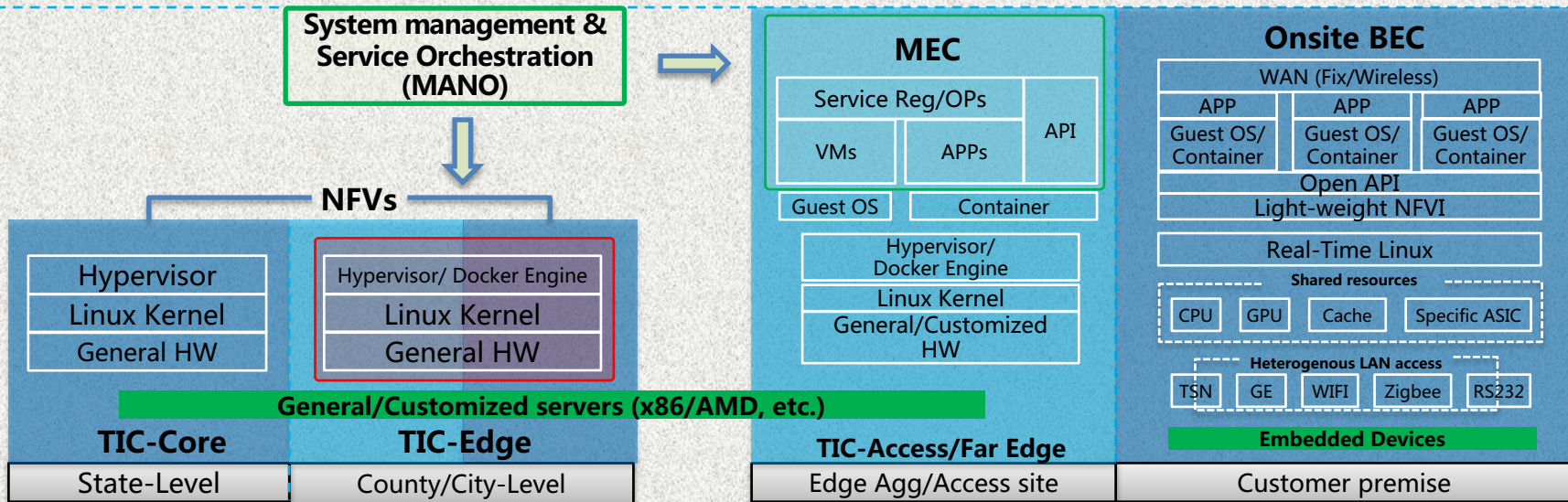Integrated cloud

ZTE中兴
HUAWEI
大唐移动 DTmobile
ERICSSON
H3C 新IT解决方案领导者
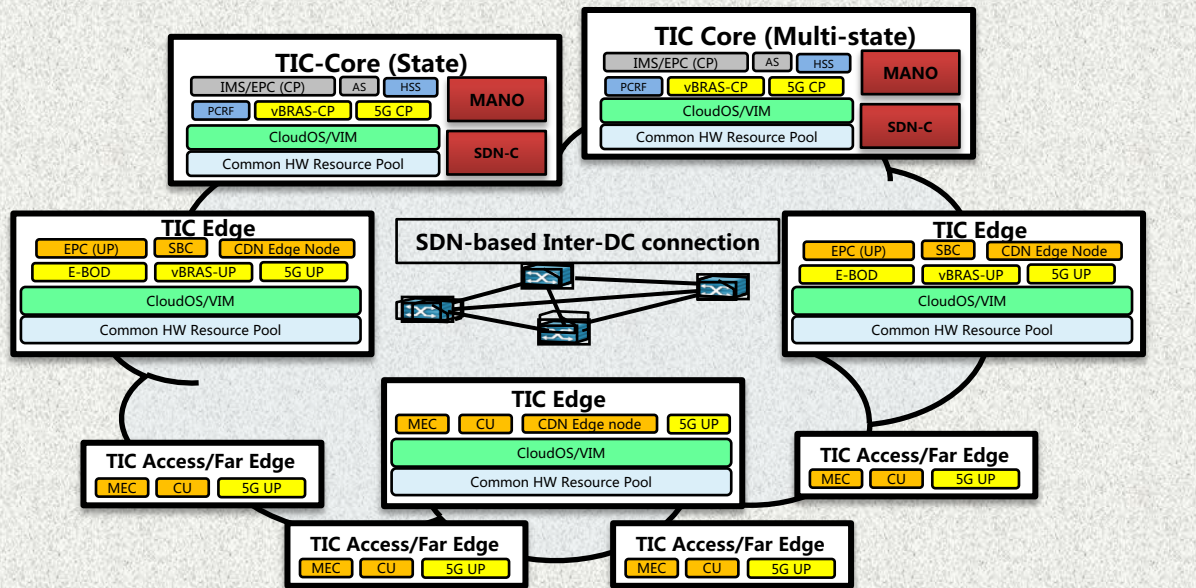WIND RIVER

China Mobile Telecom Integrated Cloud (TIC)

Challenges in traditional networks, 5G evolution and its imminent commercial deployment as well as the ubiquitous edge-computing initiatives together promote the network transition to the cloud-based infrastructure. The cloud-based architecture helps extend networking services closer to end customers and accordingly can significantly improve user experience.

This brought the birth of the **China Mobile** next-gen network, the **Telecom Integrated Cloud** or **TIC**.
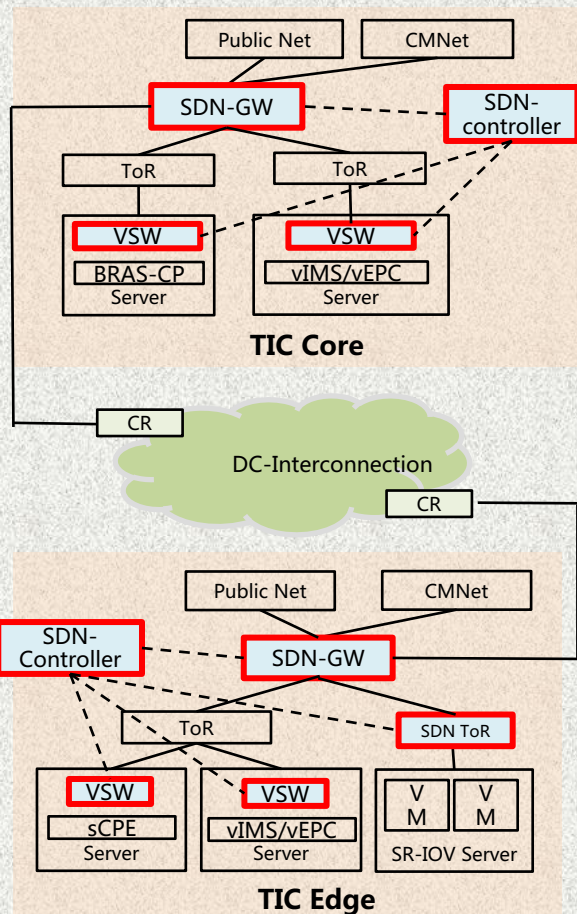- ➢ HW versatility: both general and customized devices
- ➢ NFVI heterogeneity: Interoperable CloudOS, VM/Container/Bare metal, lightweight design on edge
- ➢ Multi-vendor, multi-ecosystem VIM/VNF supports
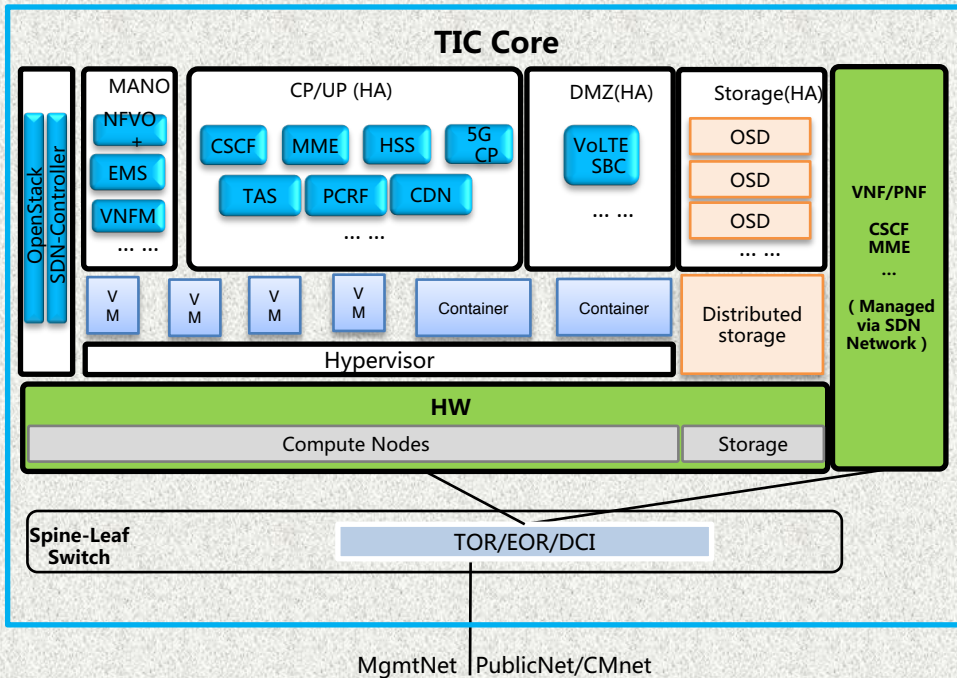- ➢ Integrated system management and orchestration

System management & Service Orchestration (MANO)

NFVs

Hypervisor
Linux Kernel
General HW

Hypervisor/ Docker Engine
Linux Kernel
General HW

General/Customized servers (x86/AMD, etc.)

TIC-Core	**TIC-Edge**
State-Level	County/City-Level

MEC

Service Reg/OPs
VMs | APPs | API
Guest OS | Container

Hypervisor/ Docker Engine
Linux Kernel
General/Customized HW

TIC-Access/Far Edge
Edge Agg/Access site

Onsite BEC

WAN (Fix/Wireless)

| APP | APP | APP |
| Guest OS/ Container | Guest OS/ Container | Guest OS/ Container |

Open API
Light-weight NFVI

Real-Time Linux

Shared resources
CPU | GPU | Cache | Specific ASIC

Heterogenous LAN access
TSN | GE | WIFI | Zigbee | RS232

Embedded Devices

Customer premise

TIC Overview: Hierarchical Structure & Interconnection

TIC-Core (State)
- IMS/EPC (CP) AS HSS
- PCRF vBRAS-CP 5G CP
- CloudOS/VIM
- Common HW Resource Pool
- MANO
- SDN-C

TIC Core (Multi-state)
- IMS/EPC (CP) AS HSS
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- Common HW Resource Pool
- MANO
- SDN-C

TIC Edge
- EPC (UP) SBC CDN Edge Node
- E-BOD vBRAS-UP 5G UP
- CloudOS/VIM
- Common HW Resource Pool

SDN-based Inter-DC connection

TIC Edge
- EPC (UP) SBC CDN Edge Node
- E-BOD vBRAS-UP 5G UP
- CloudOS/VIM
- Common HW Resource Pool

TIC Edge
- MEC CU CDN Edge node 5G UP
- CloudOS/VIM
- Common HW Resource Pool

TIC Access/Far Edge
- MEC CU 5G UP

TIC Access/Far Edge
- MEC CU 5G UP

TIC Access/Far Edge
- MEC CU 5G UP

TIC Access/Far Edge
- MEC CU 5G UP

TIC Core:
- Large-size resource pool (1000s+ servers)
- Homogeneous TIC structure
- Control Plane & MANO deployed

TIC Edge:
- Medium-size resource pool (100s+ servers)
- TIC structure similar to TIC Core
- Data Plane

TIC Access/Far Edge:
- Relative small-size resource pool (10s+ servers)
- Heterogeneous TIC internal structure
- Service agility; edge-computing use cases deployed

TIC Core

- Public Net CMNet
- SDN-GW
- SDN-controller
- ToR ToR
- VSW VSW
- BRAS-CP Server
- vIMS/vEPC Server
- CR

DC-Interconnection

CR

TIC Edge

- Public Net CMNet
- SDN-Controller
- SDN-GW
- ToR
- SDN ToR
- VSW VSW VM VM
- sCPE Server
- vIMS/vEPC Server
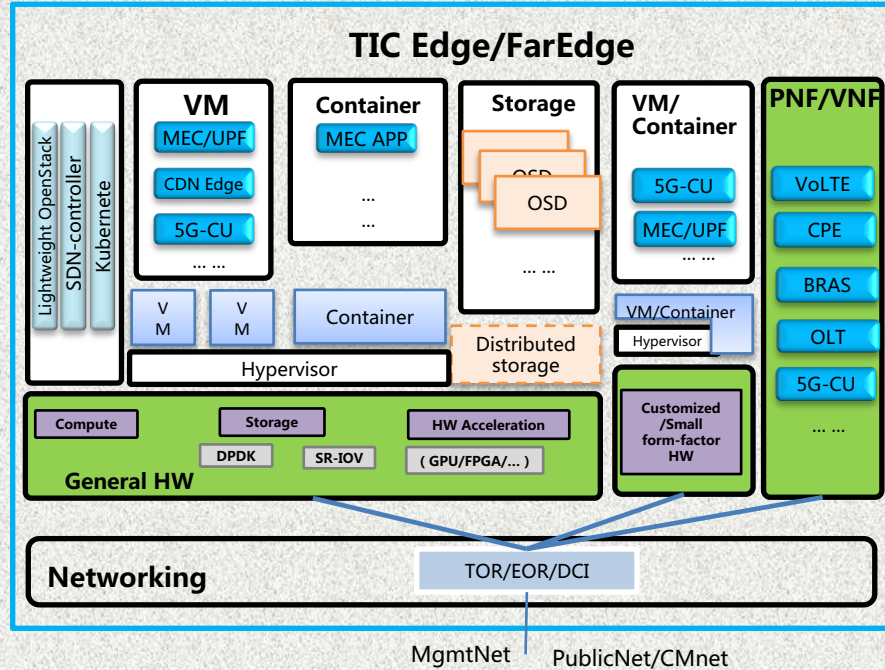- SR-IOV Server

# TIC Detailed Design: Core & Edge

TIC Core:
- 3-layer decoupling, CP-focus, easy-to-migrate architecture
- HW commonality: Compute/Storage/Switch
- Virtualization technology (VM/Container), SDN
- Multi-vendor solutions: VIM, Networking
- Unified MANO (NFVO/VNFM/EMS)

TIC Edge/Far Edge:
- 3-layer decoupling, UP/Data Forwarding
- HW heterogeneity: COTS and customized
- Virtualization technology (VM/Container), SDN
- Multi-vendor solutions: VIM, Networking
- Lightweight CloudOS; Effective OPs

Open-source Ecosystem for China Mobile TIC
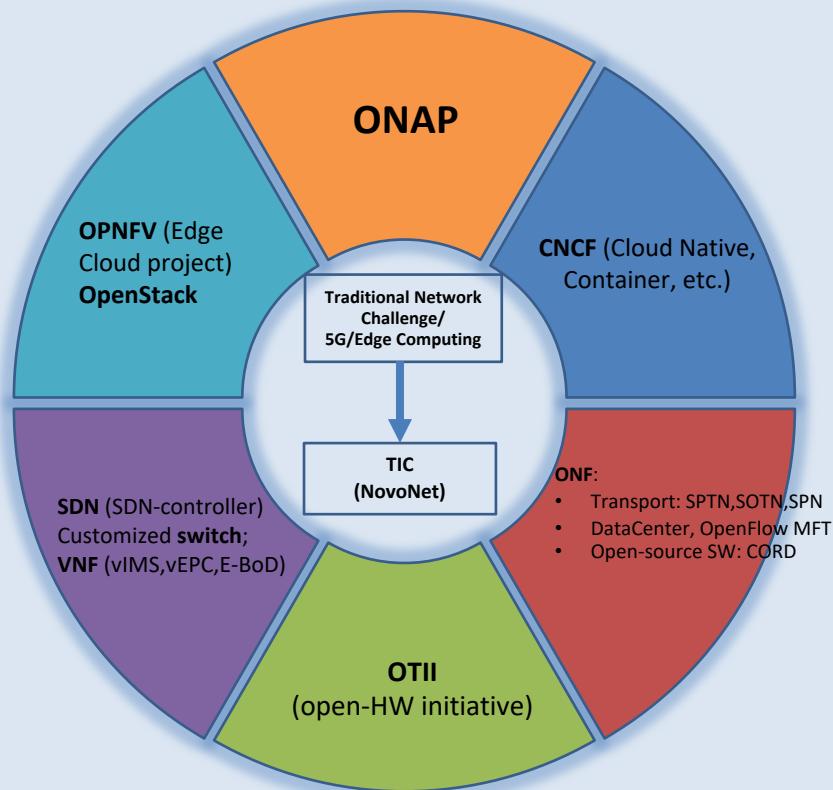
OTII (Open Telecom IT Infrastructure)

Challenges for Servers in TIC (Carrier-grade cloud):

- **Performance** - reduce traffic forwarding latency, improve real-time response and performance stability
- **Enhanced features** - Effective management, feature offloading, clock precision, etc.
- **Interoperability, Operation and maintenance**
  - Compatibility challenges over multi-vendor, multi-server, multi-VIM, multi-VNF services
  - HW performance/power consumption of different hardware design, component selection and BIOS parameters are different
  - Difference within server management interfaces bring a large number of adaptation problems to VIM/PIM and other management software
  - Different server hardware, panel and port layout need different data center spaces, complicated operation and management problems

Initiative & Solutions

- **OTII Initiatives** –
  - Open IT infrastructure for Telecommunication Applications
  - Deep customization, open standards, unified and standardized server technology solutions and prototype products for Telecom Applications
- **Design Objectives**
  - User dominated depth customization, highly scalable, manageable server motherboard scheme
  - NFV-focused; and also targeting for private cloud / public cloud and other IT services.
  - Forwarding-looking: performance can be extended or accelerated, such as 25GE/100GE network card, network acceleration technology, etc.
  - Improve performance stability to simplify application deployment, such as NUMA-Balanced design
  - Unified selection of core components (like NICs, Raid, Memory, SSD, etc.)
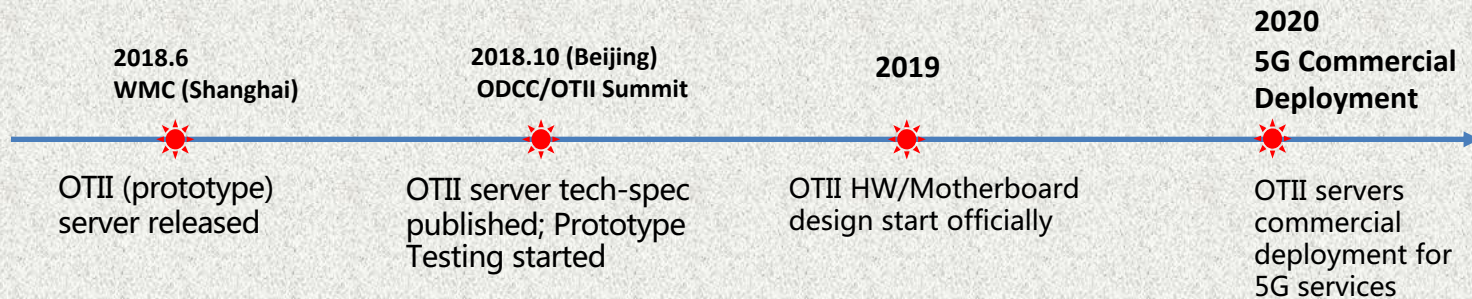 - Unified BIOS, BMC, Firmware, and device management interfaces

OTII Sponsors

OTII Members

OTII Progress (Now & Future)

OTII Roadmap

2018.6
WMC (Shanghai)

OTII (prototype) server released

2018.10 (Beijing)
ODCC/OTII Summit

OTII server tech-spec published; Prototype Testing started

2019

OTII HW/Motherboard design start officially

2020
5G Commercial Deployment

OTII servers commercial deployment for 5G services

Customized OTII Edge Servers (Prototype)

	General Rack-mount server	**OTII** server (prototype)
Depth	> 700mm	< 470mm
Power Consumption	~ 300W	~ 200W
Ops/Maintenance	Front-back	Front-only (excluding FAN,Power)
FAN location	Chassis Middle	Back-side, Hot OIR
Temperature	10℃ ~ 35℃	(normal) 5℃ ~ 40℃ (short-term) -5℃ ~ 45℃

Tech Spec
- 18-core Intel Xeon-D CPU
- 8 DIMM slots (up-to 512G/slot)
- 8 x2.5-inch HD slots
- 3 PCIe slots

ONF (Open Networking Foundation)

ONF (Open Networking Foundation) was founded in 2011. It is a nonprofit organization funded by Tier-1 providers as well as top OTT companies, aiming at promoting SDN and standardizing the OpenFlow protocol and related technologies.

Original SDN → **Carrier-grade SDN**

Original SDN

➢ Led by IT companies
➢ Targeting for data-center and small enterprise networks
➢ Lack of large-scale network Ops & maintenance scheme (like OAM, QoS)

Carrier-grade SDN

➢ Led by Carriers
➢ Targeting for large-scale, multi-vendor, inter-provider domain, complicated carrier networks;
➢ Multi-hierarchy SDN architecture for dynamically-provisioned end-to-end services
➢ Efficient Ops & supports across carriers' networks.

➢ Carrier-SDN addresses the challenges in carrier network domain, like the proprietary of equipment, the lack of automation, etc., and then solves the SDN application problems in carrier networks.

➢ **SPTN** (Software defined Packet Transport network), as contributed by **China Mobile**, is one of the typical carrier-grade SDN use cases as published in **ONF TR-538**.
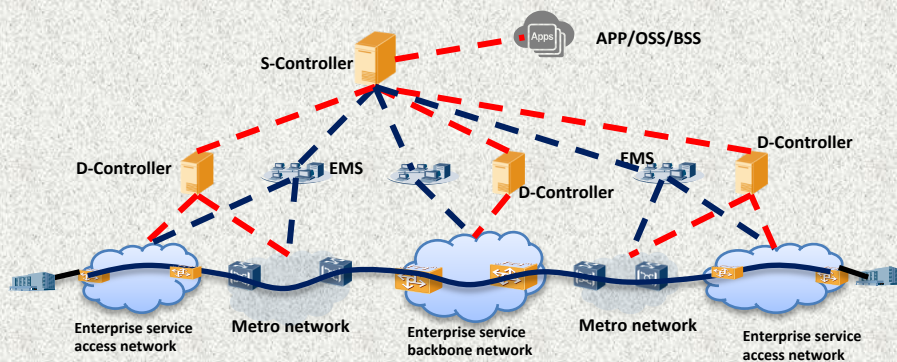
China Mobile in ONF – SPTN

中国移动 China Mobile

End-to-End SPTN Network Architecture
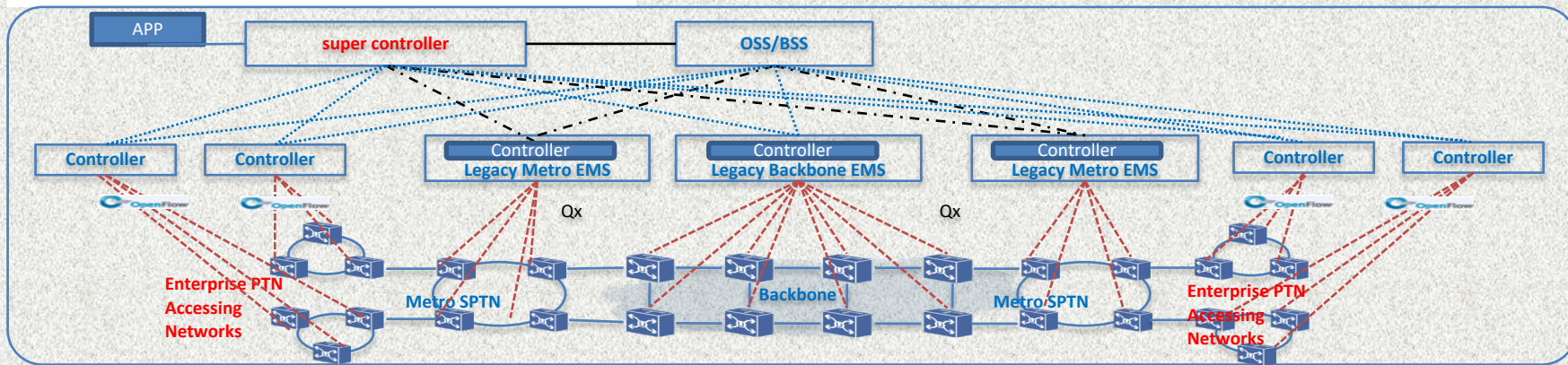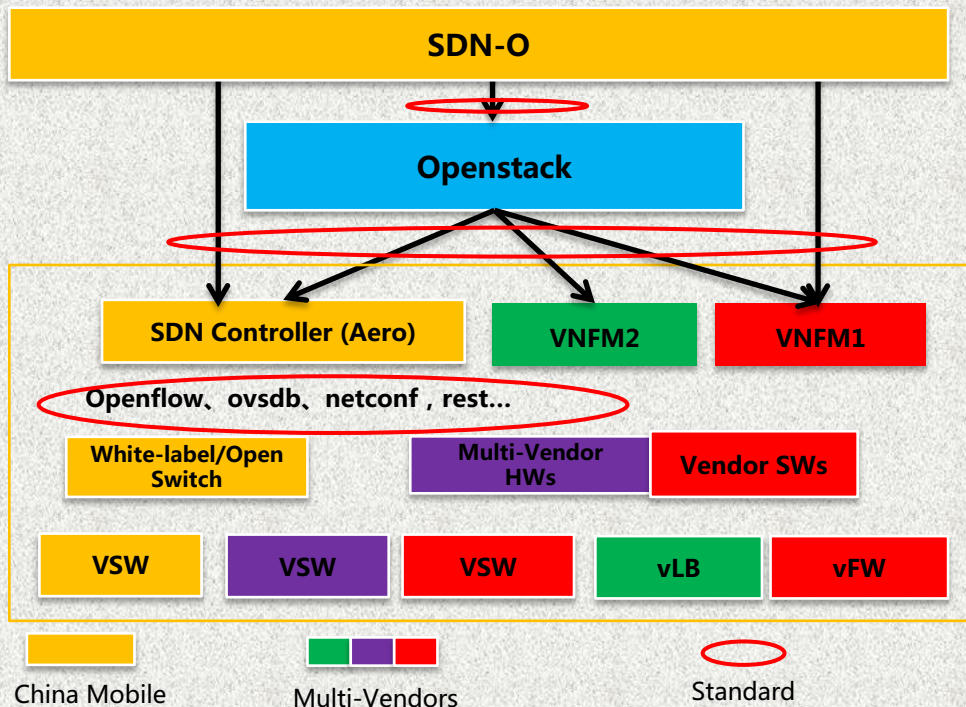

SPTN for LTE Backhaul in China Mobile
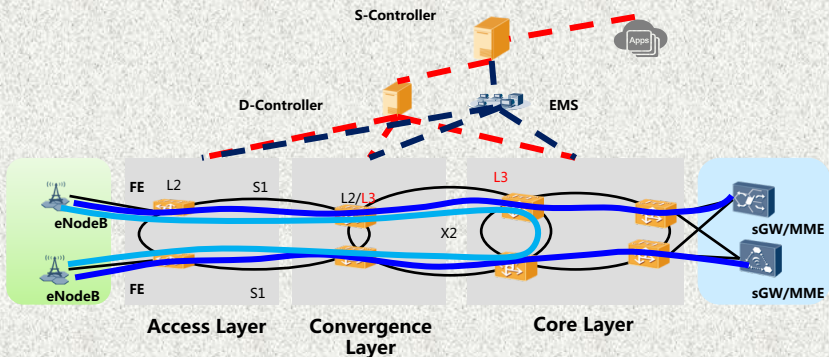
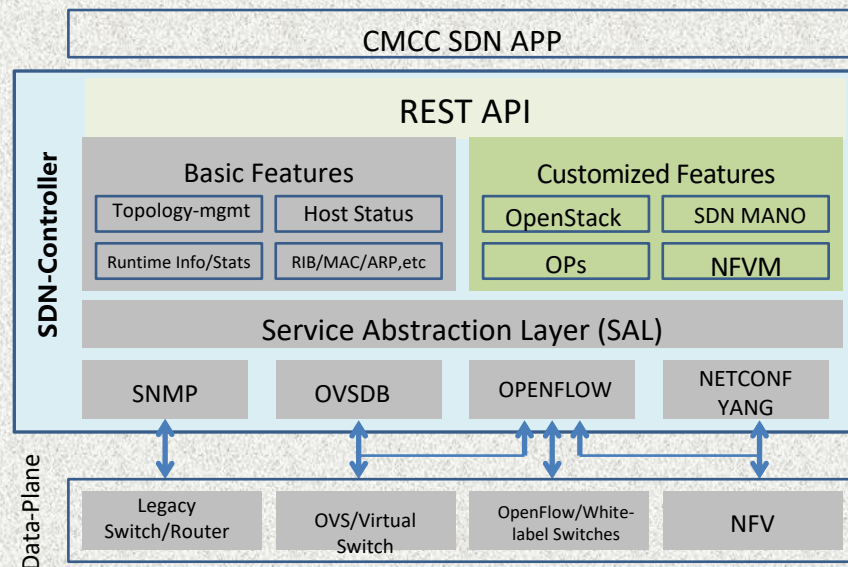## SPTN for Enterprise customer in China Mobile

SDN/NFV: Complete Decoupling for End-to-End Solution

- 3-layer decoupling: HW/Infrastructure/VNFs
- China Mobile invested and developed SDN-O, SDN-C, Customized Switches & NOS, etc.

SDN-O

**Openstack**

SDN Controller (Aero)   **VNFM2**   **VNFM1**

Openflow、ovsdb、netconf , rest...

White-label/Open Switch   **Multi-Vendor HWs**   **Vendor SWs**

VSW   **VSW**   **VSW**   **vLB**   **vFW**

China Mobile   Multi-Vendors   Standard

China Mobile SDN-Controller (**AERO**) based on ODL

AERO   OPEN DAYLIGHT

CMCC SDN APP

SDN-Controller

REST API

Basic Features

Topology-mgmt | Host Status

Runtime Info/Stats | RIB/MAC/ARP,etc

Customized Features

OpenStack | SDN MANO

OPs | NFVM

Service Abstraction Layer (SAL)

SNMP | OVSDB | OPENFLOW | NETCONF YANG

Data-Plane

Legacy Switch/Router | OVS/Virtual Switch | OpenFlow/White-label Switches | NFV

SDN/NFV: Customized Switch

Customized Switch = HW (white-label switch) + Customized NOS (based on ICOS)

- Suitable for IDC networking, underlay and overlay SDN-based TOR

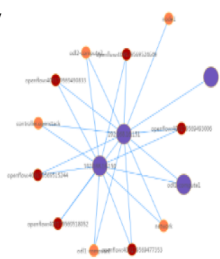| Customized Switch Model	Supported Functions	Port#	Application Domains
1.0	Traditional L2/L3	48x10G+4x40G	Underlay
2.0	Traditional L2/L3 、VTEP	48x10G + 6x40G	Underlay+ Overlay
3.0	Traditional L2/L3 、VTEP、OF w/ multiple-flow tables	48x10G + 6x40G	Underlay+ Overlay
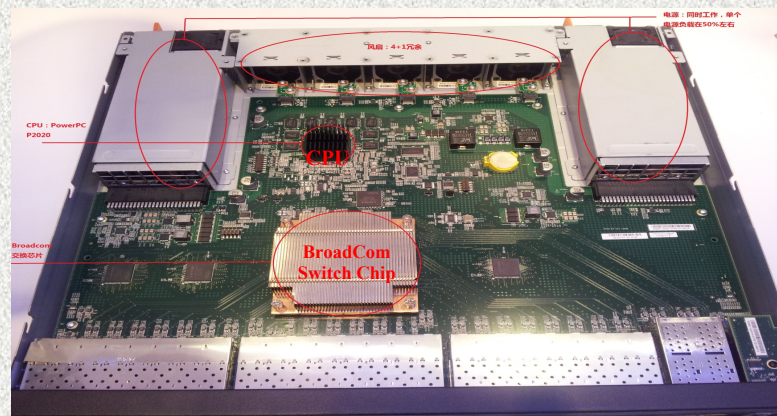
Switch Vision - Web-based Switch MIS to monitor device info and stats (CPU, Memory, Storage; network topology, traffic stats, MAC/ARP/RIB, Power/Fan/Temp, etc.

CPU

5.8122%

Topology

Ports

SDN/NFV: Field Trial – SDN-based Cloud DC (*province-level*)

OpenStack

SDN APP

Neutron NB

Restful API

SDN-Controller
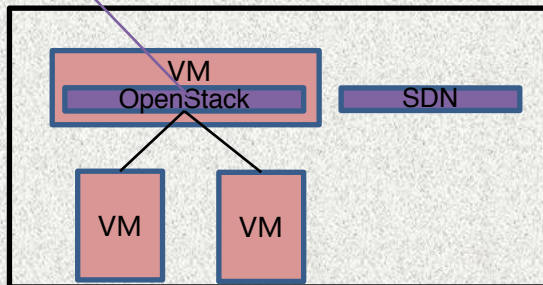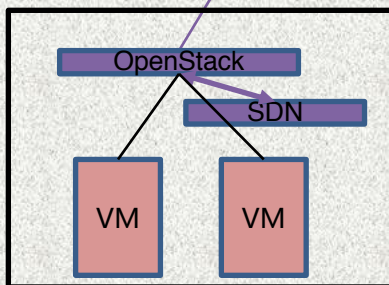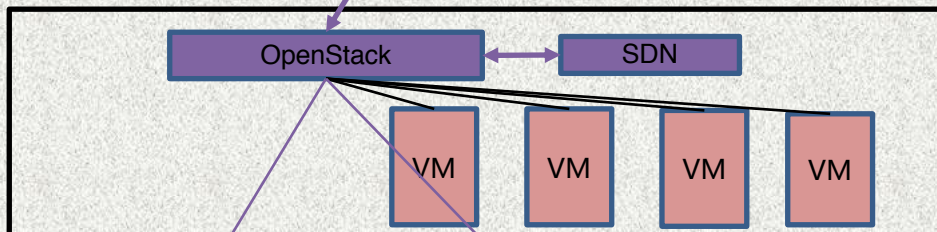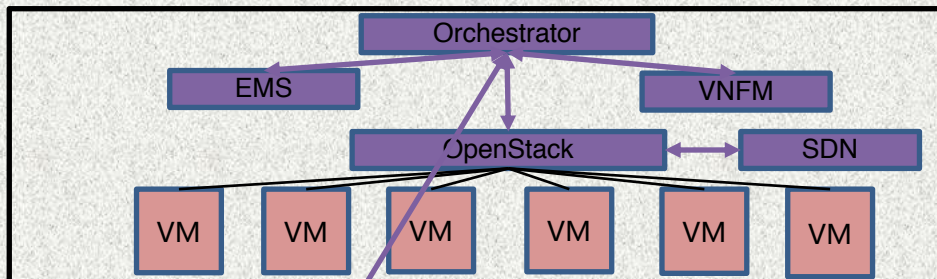(China Mobile **AERO**)
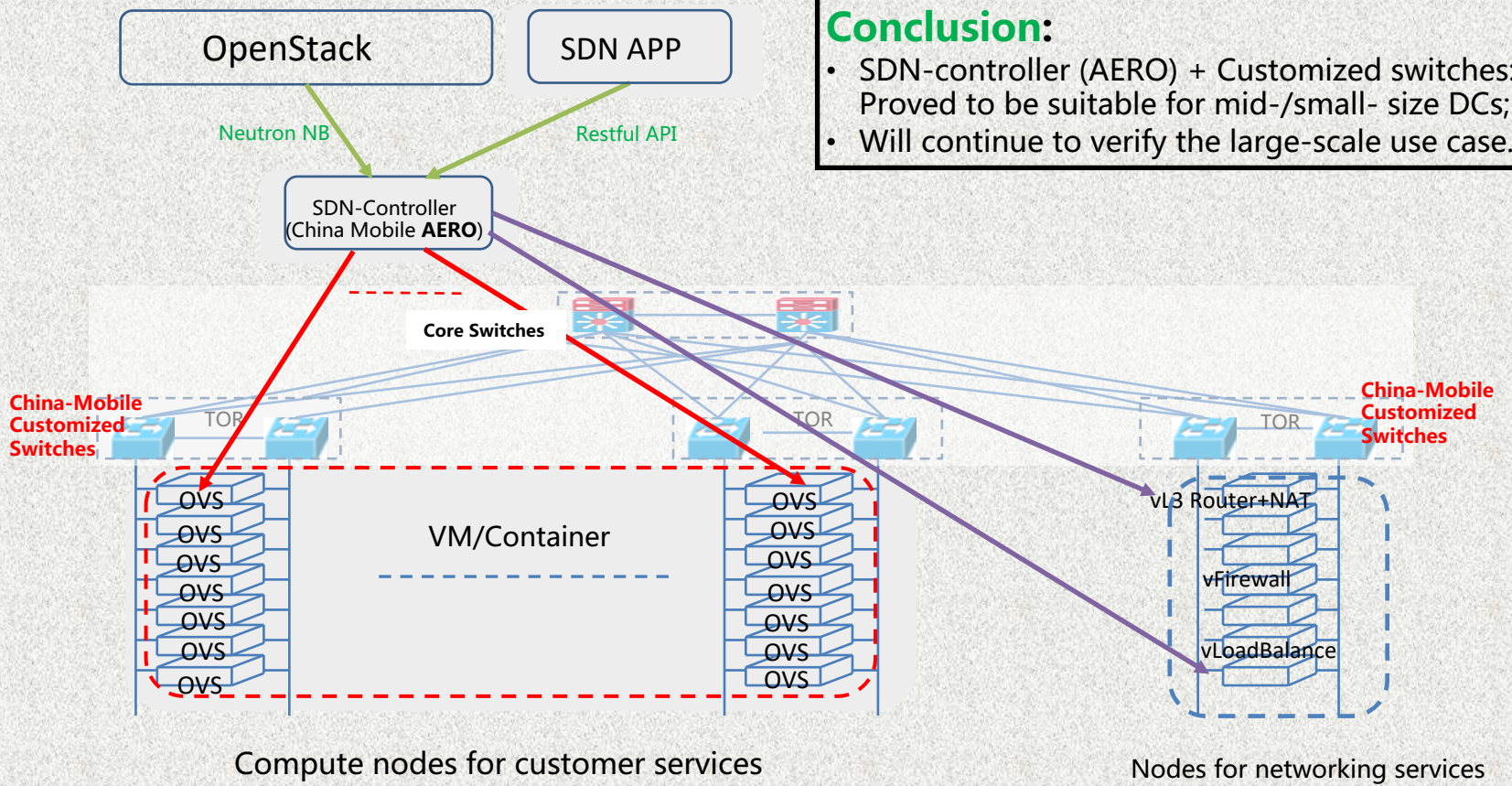
Conclusion:
- SDN-controller (AERO) + Customized switches: Proved to be suitable for mid-/small- size DCs;
- Will continue to verify the large-scale use case.

Core Switches

China-Mobile Customized Switches

TOR

TOR

TOR

China-Mobile Customized Switches

OVS
OVS
OVS
OVS
OVS
OVS
OVS

VM/Container

OVS
OVS
OVS
OVS
OVS
OVS
OVS

vL3 Router+NAT

vFirewall

vLoadBalance

Compute nodes for customer services

Nodes for networking services

OPNFV Edge-Cloud

❖ A new edge-focused project to cover those uncovered requirements for edge.
  ➢ Focusing on the NFV Platform integration for Telco Edge cloud.
  ➢ Platform for edge, which is homogeneous with core in orchestration, so that unified orchestration and operation mechanism can be used
  ➢ Better trimmed platform to meet the specific need for edge services
  ➢ Project working group led by **China Mobile**
❖ Upstream collaboration – with related communities (ONAP, OpenStack Akraino etc.) for requirement analysis and scenario design
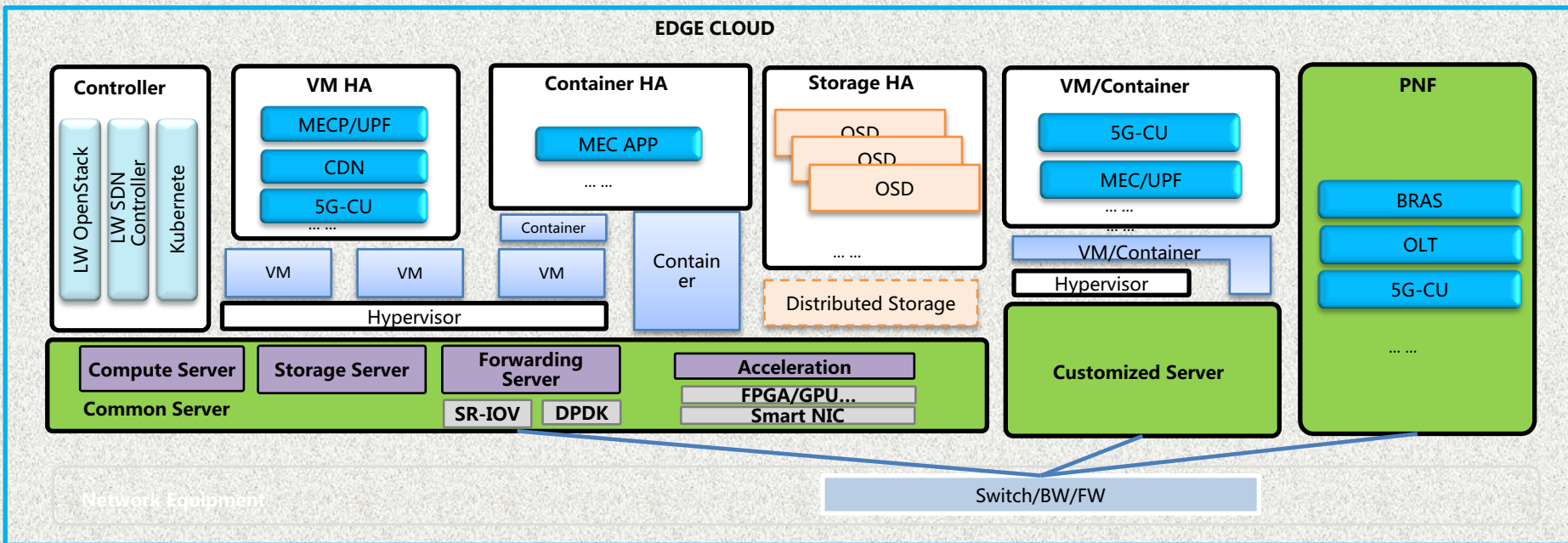
OPNFV: Edge-Cloud Architecture

Orchestrator

EMS

VNFM

OpenStack

SDN

VM VM VM VM VM VM

OpenStack

SDN

VM VM VM VM

OpenStack

SDN

VM VM

VM
OpenStack

SDN

VM VM

Architecture is different among core, edge and far-edge clouds. Space and power are fairly restrained in the edge clouds that are in remote areas (i.e., the far-edge clouds), which leads to the constraints on deployed devices.

❖ Lightweight control, Resource heterogeneity, Remote provisioning, Hardware/Software acceleration
❖ Multi region and lightweight OpenStack are the main solutions for edge cloud
❖ Match with our **TIC** initiative and practice

Core cloud
- Scale: ~ 1000+
- With fully deployment of MANO
- Cloud resources are managed with one or several OpenStack cloud

Edge (city-level) Cloud
- Scale: ~ 100+
- Only CloudOS(like OpenStack) deployed , no Orchestrator/VNFM/EMS
- Remotely managing County and access level OpenStack with shared Keystone and Horizon
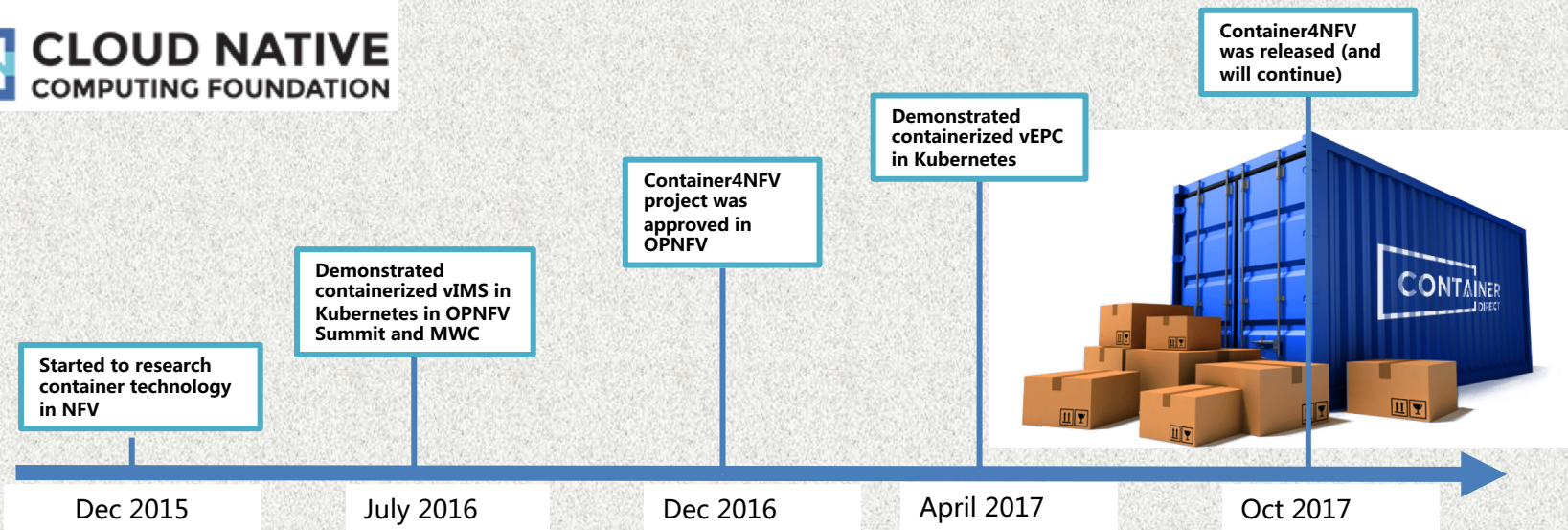
Far Edge (access-level) cloud
- Scale : 20-100 nodes
- Remotely controlled by city level OpenStack

Far Edge (customer-premises-Level) cloud
- Scale : <20 nodes
- Light weight OpenStack with few virtual resources

CNCF: Container in China Mobile

- Container in China Mobile TIC
- Container4NFV: a Project in OPNFV, led by China Mobile
- Container support in ONAP (Beijing Release)
- 5G Service-based architecture ('cloudified') – more suitable to Cloud-Native technologies
- Service Deployment: Containerized vEPC and vIMS have been demonstrated in China Mobile

Container4NFV was released (and will continue)

Demonstrated containerized vEPC in Kubernetes

Container4NFV project was approved in OPNFV

Demonstrated containerized vIMS in Kubernetes in OPNFV Summit and MWC

Started to research container technology in NFV

| Dec 2015 | July 2016 | Dec 2016 | April 2017 | Oct 2017 |

ONAP: Open Networking Automation Platform

- An initiative created by the merge of the ECOMP and Open-O. It brings the capabilities for designing, creating, orchestrating and handling of the full lifecycle management of VNFs, SDNs, and the services that all of these things entail.
- ONAP: The 'brain' of SDN/NFV, the core of MANO.
- ONAP community: There are 100[+] members worldwide covering 65[+]% of global customers.

Service Design
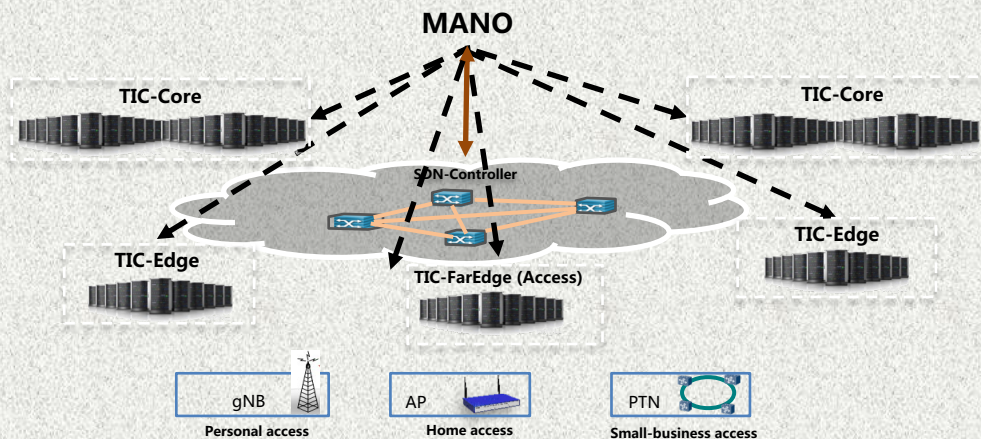
Service Orchestration

Onboarding

Policy & Runtine

China Mobile Practices:
- Taking on some major roles in ONAP community: LFN Board, TSC vice-chair, etc.
- Use case: ONAP as the MANO in China Mobile TIC

MANO

TIC-Core

TIC-Core

SDN-Controller

TIC-Edge

TIC-Edge

TIC-FarEdge (Access)

gNB

AP

PTN

Personal access

Home access

Small-business access

TIC Overview:
- Design cloud-based architecture
- SDN/NFV 3-layer decoupling
- ONAP Field trial (Province-level) started in 2018Q3

Production Services in TIC:
- CCVPN: cross-provider-domain, cross-layer(OTN/SD-WAN), with SDN/NFV technologies, using ONAP; commercial deployment in 2018Q4
- E-BoD dynamic provisioning trial via ONAP; commercial deployment in 2019H1

China Mobile TIC (NovoNet) Global Trial Practice

TIC Field Trial (global scope):
- TIC trial nodes have been deployed in 4 different locations in mainland China.
- A new TIC node has been planed and shall be built, deployed (led by the local team).

A new TIC Trial Node to be built (Internal Diagram)

Open-source Ecosystem for China Mobile TIC
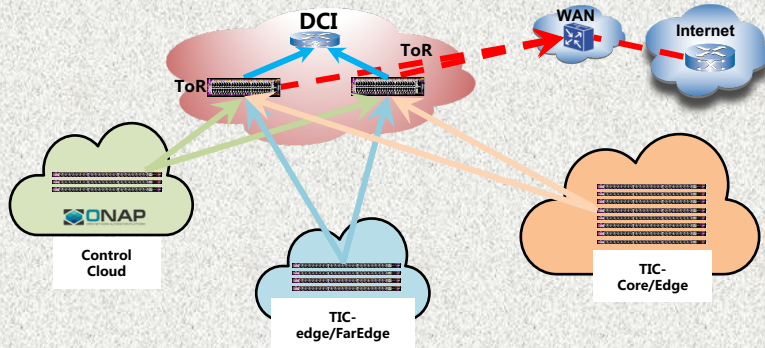
Key facts in the (to-be-built) new trial TIC node:
- **Architecture (cloud-based)**: Core/Edge/FarEdge
- **Open-Ecosystem HW**: OCP/OTII/Misc
- **SDN/NFV**: SDN-C/CMCC Customized Switch
- SPTN (**ONF** CMCC use case)
- **Edge Computing**: **OPNFV** Edge cloud, lightweight **OpenStack**, OpenStack multi-region
- **ONAP** as the MANO
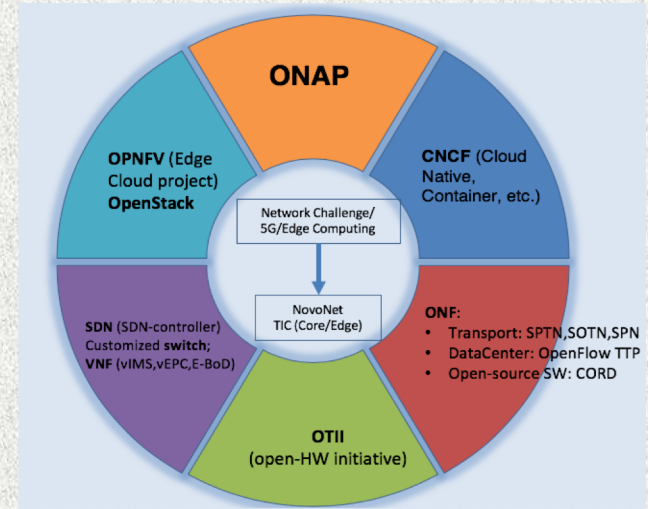
Call for Actions:
- HW pre-integration for effective reproduction, delivery and on-site deployment
- Seamless integration across various open ecosystems (e.g., open-HW, SDN/NFV, CloudOS, Edge cloud, Cloud native, MANO, etc.)
- Automation of system deployment across multi-vendor, multi-SW/FW
- Efficient OPs & Maintenance across versatile systems

Thank You !