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

China Mobile, the largest mobile provider in the world:

- **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 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

#### 3GPP 5G Timeline

<table>
<thead>
<tr>
<th>Year</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
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<tr>
<td>2015</td>
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<td>Q1</td>
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<td>Q4</td>
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- **Stage 1**
- **Stage 2**
- **3GPP Architecture Done**
- **R15 Approved**

#### Key Technology Verification

- **Trial: Stage 1**
- **Trial: Stage 2**

China Mobile & Prestigious Industrial Vendors collaborate together to promote 5G core technologies
Imminent Network Transition: 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

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

Infrastrucure: Compute, Network, Storage

Integrated cloud
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
TIC Overview: Hierarchical Structure & Interconnection

**TIC Core (State)**
- IMS/EP (CP)
- EPC
- BSS/DBS
- MANO
- SDN-C
- CloudOS/VIM
- Common HW Resource Pool

**TIC Core (Multi-state)**
- IMS/EP (CP)
- EPC
- BSS/DBS
- MANO
- SDN-C
- CloudOS/VIM
- Common HW Resource Pool

**TIC Edge**
- EPC (UP)
- SDN Edge Node
- BRAS-CP
- SG UP
- CloudOS/VIM
- Common HW Resource Pool

**SDN-based Inter-DC connection**
- SDN-GW
- ToR
- SDN-controller

**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

**DC-Interconnection**
- CR
- SDN-GW
- Public Net
- CMNet

**TIC Edge**
- VSW
- sCPE Server
- vIMS/vEPC Server
- V M
- SR-IOV Server

**ToR**
- SDN-ToR

**VSW**
- vIMS/vEPC Server
- V M
- SR-IOV Server

**SDN-GW**
- ToR
- SDN-controller
**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

[Diagram of TIC Core and TIC Edge/Far Edge with components labeled.]
Open-source Ecosystem for China Mobile TIC

- **ONAP**
- **OPNFV (Edge Cloud project)**
- **OpenStack**
- **CNCF (Cloud Native, Container, etc.)**
- **ONF**:
  - Transport: SPTN, SOTN, SPN
  - DataCenter, OpenFlow MFT
  - Open-source SW: CORD
- **SDN (SDN-controller)**
- **Customized switch; VNF (vIMS, vEPC, E-BoD)**
- **OTII (open-HW initiative)**

Traditional Network Challenge/5G/Edge Computing
**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

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018.6</td>
<td>WMC (Shanghai) OTII (prototype) server released</td>
</tr>
<tr>
<td>2018.10</td>
<td>(Beijing) ODCC/OTII Summit OTII server tech-spec published; Prototype Testing started</td>
</tr>
<tr>
<td>2019</td>
<td>OTII HW/Motherboard design start officially</td>
</tr>
<tr>
<td>2020</td>
<td>5G Commercial Deployment OTII servers commercial deployment for 5G services</td>
</tr>
</tbody>
</table>

Customized OTII Edge Servers (Prototype)

Tech Spec

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

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

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.

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

**CMCC SDN APP**

- **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)**

- **Data Plane**
  - Legacy Switch/Router
  - OVS/Virtual Switch
  - OpenFlow/White-label Switches
  - NFV

**SDN-Controller**

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

**OpenStack**

- SDN Controller (Aero)
- VNFM2
- VNFM1

**SDN-O**

- Openflow, ovsdb, netconf, rest...

**Data Plane**

- China Mobile
- Multi-Vendors
- Standard

**SDN Controller (Aero)**

- CMCC SDN APP
- REST API
- Service Abstraction Layer (SAL)
- Data Plane

**CMCC SDN APP**

- SNMP
- OVSDB
- OPENFLOW
- NETCONF YANG

**SDN Controller (Aero)**

- Openflow, ovsdb, netconf, rest...

**Data Plane**

- China Mobile
- Multi-Vendors
- Standard

**CMCC SDN APP**

- SNMP
- OVSDB
- OPENFLOW
- NETCONF YANG

**Service Abstraction Layer (SAL)**

- 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

<table>
<thead>
<tr>
<th>Customized Switch Model</th>
<th>Supported Functions</th>
<th>Port#</th>
<th>Application Domains</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Traditional L2/L3</td>
<td>48x10G+4x40G</td>
<td>Underlay</td>
</tr>
<tr>
<td>2.0</td>
<td>Traditional L2/L3 VTEP</td>
<td>48x10G + 6x40G</td>
<td>Underlay+ Overlay</td>
</tr>
<tr>
<td>3.0</td>
<td>Traditional L2/L3 VTEP, OF w/ multiple-flow tables</td>
<td>48x10G + 6x40G</td>
<td>Underlay+ Overlay</td>
</tr>
</tbody>
</table>

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

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

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
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.

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

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 planned and shall be built, deployed (led by the local team).

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!