China Telecom Helps Unleash the Power of 5G

Carrier actively contributes to open-source and commercial technology pilots.

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5G HAS FINALLY BECOME AVAILABLE. COMPARED TO 4G, 5G CAN DECREASE latency tenfold, increase throughput tenfold, and boost traffic capacity by 100 times. More important than 5G technology itself for telecom carriers and service providers, however, are the wealth of capabilities enabled by 5G.

China Telecom has been investing heavily in 5G networks and related R&D. At the end of 2020, the operator had access to 300,000 5G base stations, five times the number of live stations it had at the end of 2019. Some of these base stations are deployed by China Telecom, and others are part of a 5G network share with China Unicom. Plenty additional base stations are in China Telecom's 5G plans going forward. [1]

The telecom carrier has also made major shifts toward 5G within its CapEx mix. In 2020, 5G grew from an 11.9% share of CapEx to 53%. [1]

At the end of February 2020, China Telecom had over 10 million 5G subscribers [1], a pool that expanded to 86 million at the end of 2020.

Delivering on the Promise of 5G Through Open Source

There is unlimited potential for telecom carriers to leverage 5G, cloud-enabled technologies, and the network telco edge to enhance user experiences and help their enterprise customers improve business outcomes. To truly unleash the power of 5G capabilities and services, telecom carriers need a network architecture that is open and standardized.

The need for more capable, agile, and flexible networks demands a different way of thinking. Network operators must embrace the open source software approach that has transformed the tech industry in recent years and apply it to wireless infrastructure.

At China Telecom, open source participation significantly contributes to delivering on the promise of 5G and advancing innovation. As early as July 2016, the telecom carrier unveiled its CTNet2025 initiative, a plan to make its network simple, open, cloud-based, and agile by 2025. To attain its transformed network architecture, China Telecom is:

- Implementing software-defined networking (SDN) and network functions virtualization (NFV)

- Virtualizing 80% of its infrastructure

- Deploying cloud computing technology

- Using open source software

By using open source software, China Telecom can accelerate the pace of new business and technology adoption. Specifically, open source software helps the telecom carrier:

- Develop customized products flexibly and quickly based on their requirements

- Reduce the software development threshold and risk

- Improve software reliability and security

- Improve software quality with the help of the open source community

MEC and Network Slicing

Most telecom providers know that discussions about promising 5G services eventually lead to the network telco edge.

Gartner estimates that by 2025, 75% of enterprise data will be processed at the network edge, compared to only 10% in 2018. [2] And this is where multi-access edge computing (MEC) becomes important.

MEC enables providers to host content close to the network edge, where their end users are located. MEC uses the telco edge to bring computing closer to the data center, which reduces latency and increases connection speeds. This is the way 5G applications should be delivered.
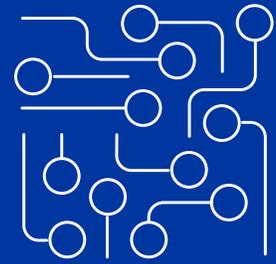
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Another key enabler of 5G architecture is network slicing. A network slice is an end-to-end logical subnet that requires the coordination of a core network, access network, and transport network. Network slices can be based on isolated resources, shared resources, or both. They are deployed in a service-oriented architecture enabling network features configurations in terms of quality of service (QoS), system capacity, and data rate. [3]

As each application and service has different requirements for bandwidth capacity, speed, and latency, the ability for China Telecom to deliver exactly what each service needs is made possible by its ability to slice network capacity across the control, data, and management planes.
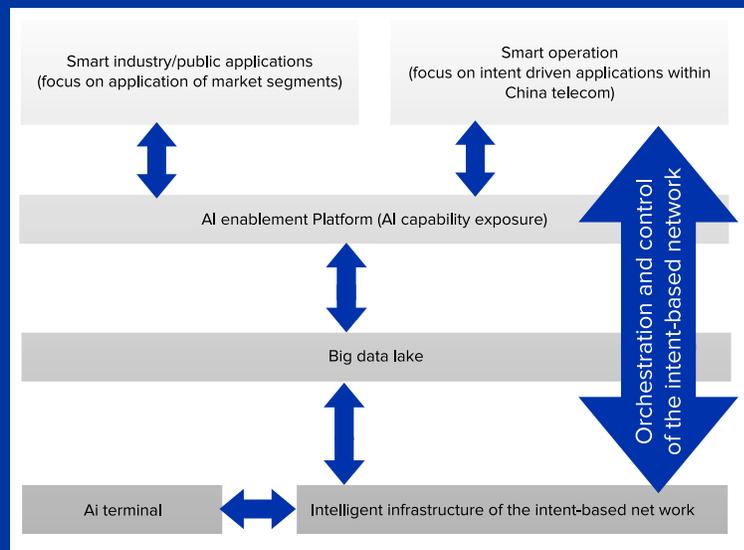
In-network slicing technology, a single physical network can be partitioned into multiple virtual networks, enabling operators to offer optimal support for different types of services, customers, or traffic types. Networks can be provided on an as-a-service basis, which enhances operational efficiency and reduces time-to-market for new services.

Core to China Telecom's CTNet2025 evolution is the acceleration of intelligent networks and intelligent operations. See the sidebar for an example of how China Telecom added intelligence in the transport layer through network slice management.

China Telecom: Intelligent Transport Network Slice Management

In the transport network, slices cannot be adjusted in time, resulting in redundancy and wasted resources. To accurately predict traffic conditions, operators can dynamically configure slice resources to achieve intelligent transport network slice management and help ensure service quality.

Figure 1 depicts China Telecom's intelligent transport network slicing system. The Transport Network Slice Manager (TNSM) collects the traffic throughput data of transport network slice instances and sends the data to the Intelligence Module. The Intelligence Module predicts the traffic throughput values and

determines the scaling and bandwidth adjustment policies for transport network slice instances based on the prediction. It then delivers the policies to the TNSM, if necessary. The TNSM reconfigures the port bandwidths to scale up or down depending on traffic conditions.

By using this intelligent policy-based traffic throughput method, prediction precision can be as high as 91.75%. When the alarming rate is acceptable, the resource efficiency of the test set can improve by about 30%.

Source: GSMA, China Telecom Case Study, https://www.gsma.com/futurenetworks/wiki/case-study-china-telecom-2/

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Standalone 5G Network Strategy In addition to the heavy use of MEC and network slicing, China Telecom supports a standalone 5G network strategy. 5G has two network modes: non-standalone access (NSA) and standalone access (SA). NSA still relies on 4G LTE network facilities to provide more speed and higher data bandwidth. In a 5G NSA network, for example, a 5G-enabled smartphone will connect to 4G or 5G, depending on conditions.

On the other hand, a 5G SA network is completely independent of the 4G network. China Telecom favors the 5G SA strategy, whereby all possible use cases can take full advantage of 5G's high throughput, low latency, and other capabilities. Additionally, a standalone network strategy leads to more ubiquitous 5G coverage. [4]

China Telecom's 5G Open Source Contributions

The following are examples of China Telecom's contributions and collaborative efforts in the open source community. It is only a partial representation of the carrier's involvement in helping to advance 5G for telcos and pilot 5G and edge use cases for enterprise businesses in a range of industries. See the sidebar for a complete list of open source organizations that China Telecom participates in.

3rd Generation Partnership Project (3GPP)

3GPP provides its members with a stable environment to produce the reports and specifications that define 3GPP technologies. The project covers cellular telecommunications technologies, including radio access, core network, and service capabilities.

In April 2019, China Telecom submitted a proposal for 5G super uplink technology to 3GPP. It was the first step in making the technology an international standard. Huawei has since joined China Telecom in developing the 5G Super Uplink Joint Technology Innovation. [5]

Formulated around 5G SA, super uplink uses time-division duplex (TDD) and frequency-division duplex (FDD) coordination, time, and frequency domain aggregation to deliver lower latency and higher speeds on the uplink.

In tests, super uplink registered a performance increase of 20% to 60% for uplink traffic on a 5G network. The uplink rate for users at the cell edge increased two to four times, and air interface latency decreased by about 30%. [6]

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In November 2019, it was confirmed that China Telecom would lead the development of a 5G super uplink 3GPP international standard. China Telecom plans to implement the technology in its 5G NR standalone network, which is slated to launch with a cloud-native 5G core in 2021.

Open Network Automation Platform (ONAP)

ONAP, hosted by LF Networking (Linux Foundation), enables telecom, cable, and cloud operators to orchestrate, manage, and automate network and edge computing services. They can use the closed-loop automation platform to build virtual network functions (VNFs) and SDNs end to end. China Telecom, along with several other telecom carriers, conducts tests, proof of concepts (POCs), and trials on ONAP.

In June 2018, ONAP announced the availability of its second software release, called Beijing. As part of the Beijing release, China Telecom helped establish ONAP's first integrated testing project. Referred to as Project Benchmark, it was primarily used to test the scalability, security, stability, and performance (S3P) of ONAP components.

China Telecom's team conducted the S3P test on the ONAP virtual CPE (vCPE) use case. Large-scale concurrent testing was done in real cloud and virtual cloud environments, and functional verification found the vCPE use case to be insufficient. China Telecom submitted multiple test scripts and project amendments to improve the vCPE use case.

China Telecom also performed the S3P tests for ONAP's subsequent software releases, Casablanca (released in December 2018) and Dublin (released in June 2019). These releases included blueprints for new 5G and cross-carrier virtual private network (CCVPN) functionality.

Use Case: CCVPN-Based Service Function Chaining China Telecom led the completion of service function chaining based on CCVPN, combining a software-defined optical transport network and SD-WAN network as a service orchestrated by ONAP. [8]

An offshoot of the CCVPN project, group members further improved the system architecture and submitted an intent-based network 5G slicing use case to ONAP for review.

Use Case: End-to-End Network Slicing End-to-end network slicing enables telecom carriers and service providers to tailor QoS and QoE to the customer's needs. Slicing can be done according

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to performance requirements such as latency, throughput, and availability, as well as characteristics such as mobility, security, and resource sharing.

Further slice functionality enables network automation, and it can play an important role in accelerating service rollouts and adhering to service assurance and service-level agreements. [9]

In December 2020, ONAP announced its seventh software release called Guilin. New features in Guilin focus on 5G wireless networks and open RAN. For this release, China Telecom participated in additional 5G network slicing use cases, including the capability to orchestrate network slices in RAN, transport, and core domains.

OpenDaylight Foundation

A Linux Foundation project, OpenDaylight is a platform for SDN and NFV. Through OpenDaylight, organizations can acquire a complete network stack.

China Telecom uses OpenDaylight in its SDN controller, IP SDN and NFV on WAN, and unified control and management for the cloud and WAN. [10]

China Telecom's OpenDaylight efforts concentrate on the northbound service plugin and the Yang model. The carrier would like northbound to be more abstracted and the Yang model to be standardized and more mature in OpenDaylight.

OpenStack Foundation (OSF)

OSF is a programmable infrastructure for virtual machines, containers, and bare metal. It helps open source communities, all size businesses, telecom carriers, and other service providers build the tools they need for data center clouds, 5G, the network edge, and more.

China Telecom builds its public and private clouds with OpenStack. The telecom carrier collaborates on developing use cases for SDN, NFV, containers, and big data, and sharing best practices with OSF members.

As an OSF Gold Member, China Telecom supports OpenStack's development in the growing Chinese and Asia-Pacific markets.

Open-Radio Access Network (O-RAN) Alliance

The O-RAN alliance supports its members in testing and integrating their O-RAN implementations. O-RAN hosts worldwide plugfests to demonstrate the functionality and multivendor interoperability of open radio access network equipment.

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China Telecom joined the O-RAN alliance in June 2018 and became a director company. It provides in-depth, systematic integrity innovation results for indoor coverage scenarios.

Use Case: 5G White-Box Small Base Station As a member in O-RAN, China Telecom has done a lot of work on white-box small base stations with great results. In February 2019 at Mobile World Congress, the joint partners showed the first 5G white-box small base station prototype based on the O-RAN concept at Mobile World Congress.

In October 2019, China Telecom launched the first commercial pilot of white-box small cell based on SA mode in Guangdong Province. It successfully connected the 5G white-box small cell and the 5GC core network of main equipment manufacturers. In March 2020, the baseband field-programmable gate array (FPGA) acceleration card solution independently controlled by China Telecom was written as a reference design to O-RAN Working Group 7 for the FR1 indoor small base station hardware reference design standard.

XGVela

XGVela is a 5G cloud-native, open source platform as a service (PaaS) for telecom providers. Telco-related services and network functions are designed and developed using PaaS. The XGVela framework helps providers focus on seizing new business opportunities without getting mired in the complex telecom infrastructure.

As part of China Telecom's commitment to accelerating cloudification, it supports the XGVela initiative, working with other telecom carriers to accelerate cloud adoption and cultivate services innovation in the 5G era.

XGVela PaaS helps telecom operators:

- Align with the fast-changing requirements around building 5G networks driven by cloud-native backhaul

- Develop microservices-driven and container-based network functions (CNFs)

- Reduce network construction costs through participation in open technology ecosystems and eliminate barriers to delivering end-to-end 5G telecom networks

- Simplify the design and innovation of 5G network functions

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by enabling developers to focus on application development through service logic instead of dealing with underlying complex infrastructure. XGVela provides standard APIs to integrate many internal projects. [11]

Notable Commercial 5G Deployments

In addition to China Telecom's ongoing technology contributions in the open-source arena, the carrier participates in a variety of commercial and public sector 5G projects. For example, in 2020, China Telecom worked with GSMA and the China Academy of Information and Communications Technology (CAICT) to be among a selected group of mobile operators and vendors featured in the report, 5G Use Cases for Verticals China. [7] Following are cases from the report.

Use Case: 5G+Cloud-Enabled Smart Factory In 2019, China Telecom partnered with the Haier Washing Machine Factory to develop a pilot 5G innovation facility focused on smart manufacturing. One of Haier's interconnected factories, the facility integrates technologies such as 5G, AI, and cloud computing into its production and field operations to enable a variety of new applications. [7]

Among China Telecom's smart factory contributions:

- It provides 5G coverage across different areas of the facility, both indoor and outdoor.

- It uses 5G end-to-end network slicing to support production scenarios with different network requirements. Network slicing enables different QoS levels to be applied within the same core network and adjusted as needed.

- It offers CT's eCloud as a platform for aggregating the factory's business data, along with relevant information from 5G applications. The platform also supports centralized monitoring of the factory floor; system reliability is checked with open source technologies such as SSH and Spring.

The smart factory applications include:

- AR remote instruction for frontline workers to resolve technical issues

- Computer vision inspections of raw materials at every production line checkpoint

- Unmanned forklifts for transporting finished products

- Unmanned patrol cars and drones for security management and coordination at the factory site

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Use Case: 5G MEC-Enabled Automated Guided Vehicle (AGV) In 2019, SANY Heavy Industry with China Telecom jointly developed and tested a 5G, smart-connected, cloud-based AGV. In smart manufacturing, AGVs are critical for providing flexible logistics in production environments and factories.

They used 5G, MEC, and AI technologies to migrate the AGV's laser-based navigation to machine vision, taking advantage of 5G's large uplink bandwidth. They also moved deep learning algorithms to the 5G edge computing MEC platform integrated with GPUs, which reduces local computing requirements and significantly reduces the complexity and cost of the AGV while boosting its intelligence and standardization. [7]

The low latency requirement is maintained with the help of MEC technology and network slicing.

Use Case: 5G Cloud Virtual Reality Education In 2019, China Telecom, Nokia, and Baidu launched a six-month pilot to deliver a VR education solution at Shanghai Changning Yuyuan Road No. 1 Elementary School. Today, the project is in commercial operation, and the school can host VR natural science courses for more than 40 classes. [7]

China Telecom supports the VR solution with its cloud computing resources and 5G network coverage.

- VR panoramic video streams and 3D audio demand the high bandwidth and low latency of 5G.
- MEC technology enables content to be deployed closer to the end-users.
- AI is used for dynamic bandwidth and encoding optimization, improving the quality of experience (QoE).

The VR solution is sustainable and scalable, providing:

- Simple hardware maintenance and high availability. The VR cloud platform is set up with hardware redundancy.
- Wireless connection for enhanced user experience. VR headsets run contents from the cloud over the 5G network.
- Hardware and software resource sharing. The VR platform can allocate resources based on the number of teaching sites and class frequency without impacting curriculums.
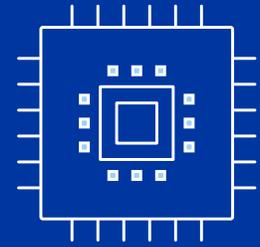
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Use Case: 5G-Empowered Hospital Network Architecture Standard
This standard divides a hospital 5G network into three parts: 5G radio access network, edge computing, and 5G medical modules. [7]

China Telecom participates in developing applications that use network slicing, edge computing, or both to advance innovations in healthcare.

The standard 5G radio access network has already been adopted by more than 30 hospitals.

Conclusion

5G networks are being built with cloud-native software and open standards, making 5G and open source a hot combination in the telecom industry. China Telecom actively contributes to several open source organizations and projects, along with a variety of commercial and public sector 5G use cases.

For 5G development, the carrier prefers the standalone architecture approach rather than the non-standalone that relies on the 4G LTE network in addition to 5G.

Cloud-network convergence is the foundation of China Telecom's digital transformation, along with its network transformation and commitment to accelerating intelligent networks and operations. In addition to 5G SA development, China Telecom takes advantage of cloud-enabled technologies and edge computing to create and test an array of innovative new services. [12]

The carrier works diligently with industry partners to build an ecosystem-based on 5G+cloud+network convergence. Its open source and commercial efforts are benefiting not only China Telecom's business and customers, but also promoting new 5G services in a wide range of industries including smart factories, manufacturing, transportation, healthcare, and education, among others.

China Telecom actively participates in the following open source organizations and initiatives.

3GPP

5GAA

IMT-2020 5G Promotion Group

LF Networking
(Linux Foundation)

ONAP

OpenBRAS

OpenDaylight

OpenStack

OPNFV

O-RAN

XGVela

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