Full-Scenario UPF Deployment

White Paper

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5G Development Trend .1

With 2019 becoming the first year of global 5G commercial launch, 5G is leading and promoting reforms in various industries, changing everyone's life and promoting continuous social progress and innovation.

According to the 5G market survey released by GSA, by mid-September 2020, 101 telcos worldwide had launched 5G commercial networks and 94 telcos had launched mobile 5G services. GSMA predicts that the number of 5G connections will increase from 10 million in 2019 to 145 million by the end of 2020, and reach 1.7 billion in 2025, accounting for 20% of total connections.

According to the GSMA survey, 69% telcos consider that the B2B market is very important for 5G profitability. Most of telcos, vendors and other stakeholders agree that the real value of 5G lies in the vertical industry. More than 80% telcos have provided or plan to provide private networks for enterprises by the end of 2020. 5G has become a new opportunity for telcos to enter the vertical market.

B2B services are implemented through connections. As the bridge connecting the telco and the vertical industry, UPF is the key to expand the B2B market in the 5G era. As an important network function (NF) of the 5G Core Network, UPF processes and routes data traffic. 5G uRLLC and eMBB scenarios have put forward higher requirements for UPF performance such as processing delay, bandwidth, jitter and packet loss rate. With the expansion of 5G edge computing, UPF has gradually moved from the central DC to the access DC. Therefore, telcos collaborate with upstream and downstream enterprises in vertical industries and build various service platforms (such as IoT platforms and enterprise applications) to achieve 5G business model innovation and build a 5G ecosystem covering vertical industries, vendors, telcos and application providers.

Typical UPF Scenarios .2

2.1 UPF Definition

User Plane Function (UPF) is a basic NF in the 5GC architecture defined by 3GPP. It evolves from user-plane function entities SGW-U and PGW-U in the CUPS (Control and User Plane Separation) in the 4G EPC. The position and external interfaces of UPF in the 5G network are as follows:

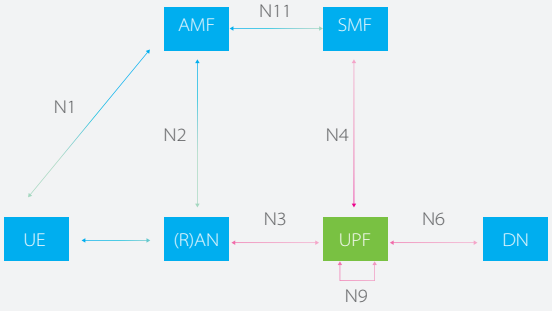


Figure 2-1 Position of UPF in the 5G Network

As a user-plane NF, UPF is controlled and managed by SMF in 5G network, which performs service flow identification (DPI), packet processing (GTP encapsulation / decapsulation, forwarding, caching, and QoS control) and charging (information collection and reporting) in accordance with various policies delivered by SMF.

By deployment independent UPF node in different positions, it can:

- Perform data processing near the network edge to improve bandwidth efficiency, reduce network congestion and delay, and improve user experience.
- Aggregate data streams closer to the center for more centralized resource processing, reducing the number of network egresses, simplifying the network, and saving O&M cost.

In actual deployment, UPF needs to be flexibly deployed in accordance with different service scenarios and latency requirements. Typical deployment locations include campuses, edges, regions, and centers.

2.2 Typical UPF Scenarios

In the 4G era, the user plane mainly bears voice and data services of the public network with simple scenarios and common requirements. However, the user plane deployment scenarios and requirements have been changed during the large-scale commercial launches of 5G networks.

UPF is applicable to the following typical 5G scenarios:

01 Large bandwidth

Video applications, including multi-perspective live broadcast, drone live broadcast, HD video monitoring, AR/VR, and machine vision, require UPF to provide large bandwidth.

02 Low latency

Industrial control, Internet of Vehicles (IoV), rail transit, smart grid, and other applications, require UPF to provide micro-second ultra-low latency forwarding capability.

03 High reliability

Remote surgery, precision manufacturing, and other applications with special requirements for reliability, require UPF to provide multi-level reliability assurance such as dual connectivity and dual tunnels.

The requirements of UPF are diversified in the following aspects:

01 Diversified deployment modes

UPF can be deployed in cloudified mode or dedicated device mode. The cloudified mode maximizes resource reuse, while the dedicated device mode focuses on performance improvement, rapid provisioning, and simplified O&M.

02 Diversified function requirements

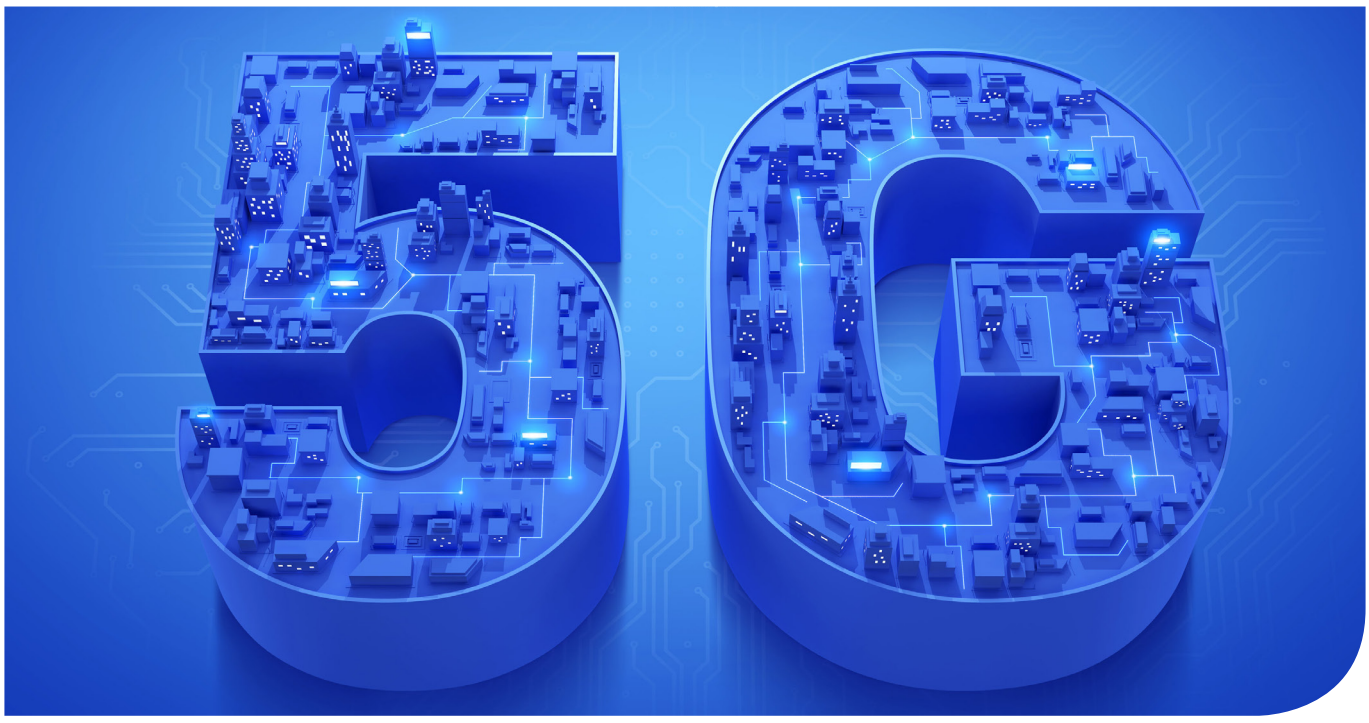
Depending on different application scenarios, UPFs with different function sets are derived, including roles such as PSA UPF, I-UPF, UL CL UPF and Branching Point UPF. Meanwhile, UPF is enhanced in new features of R16 such as 5G LAN, TSN and uRLLC to fully meet the requirements of high reliability and low latency in industrial scenarios.

03 Diversified product specifications

To adapt to equipment room environment and O&M conditions in different deployment locations of the center, region, edge, and campus, UPF needs diversified product specifications. It can be deployed in enterprise campuses as multi-rack server, single-rack multi-server, or single-server, even compact hardware.

04 Diversified industry environment

To meet diversified deployment requirements of the B2B market and match different industry admission specifications, including explosion-proof, dust-proof, moisture-proof and high-temperature-resistant, UPF needs to be able to be directly deployed on the site to provide one-stop ultra-high bandwidth and ultra-low latency 5G service experience for industry applications.



Full-Scenario UPF Deployment Solution .3

3.1 Overview

To meet differentiated SLA requirements for latency, bandwidth and reliability, UPF needs to be deployed at different positions including central DC, regional DC, edge DC and campus DC. Therefore, it needs a full-scenario deployment solution.

Full-scenario UPF has the following requirements of function, form, throughput, etc.

Location	Performance Throughput (bps)	E2E Latency	Function Set	Scenario	Product Form
Central UPF	>200G	>50ms	Full function set	B2B & B2C	Dedicated UPF
					Cloudified UPF
Regional UPF	100~200G	>30ms	Full function set	B2B & B2C	Dedicated UPF
					Cloudified UPF
Edge UPF	<100G	10~30ms	Edge offloading Capability exposure 5G-LAN	B2B & B2C	Dedicated UPF
					Cloudified UPF
Campus UPF	50G	<15ms	Function simplification Customized function enhancement Industrial environment requirements (security and explosion-proof)	B2B	Lightweight UPF
					Public cloud

Table 3-1 Deployment Requirements of Full-Scenario UPF

Terms

Dedicated UPF

The UPF that is provided by the vendor with dedicated hardware and software, E2E integrated delivery, and same deployment and O&M as traditional equipment.

Cloudified UPF

The UPF that is based on the NFV cloud resource pool architecture and has cloudified features such as software and hardware decoupling and elastic scalability.

Lightweight UPF

The edge UPF, which meets various requirements of vertical industries such as network specialization, lightweight equipment, and flexible deployment.

3.2 Central UPF

The central UPF is applicable to services that are latency-insensitive, and high throughput, such as common Internet access service, VoLTE and NB-IoT. Therefore, the central UPF should have the following features:

01 It should meet the requirements for 2G/3G/4G/5G/Fixed full access, packet identification and content charging of telcos' B2C networks. With the development of 3GPP standards, the wireless technology evolves from GERAN/UTRAN and E-UTRAN to 5G NR. In the actual network deployment of the operator, there will be coexistence of multiple access networks within a certain period of time. The UPF needs to support multiple types of radio access such as GERAN, UTRAN, E-UTRAN and NR at the same time to meet the requirements for fully converged access. As an IP anchor point, the convergent UPF ensures that the same session IP address remains unchanged when the user moves across assess networks, thus ensuring service continuity.

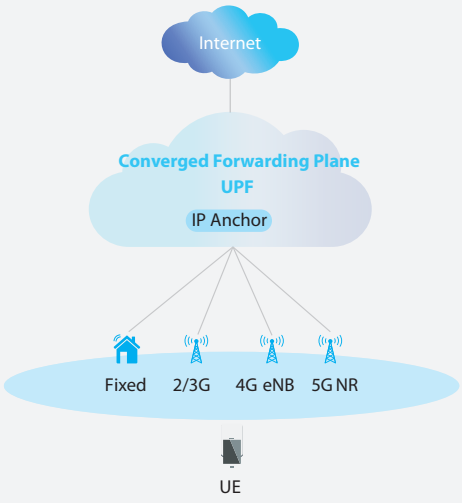


Figure 3-1 2G/3G/4G/5G/Fixed Fully-Converged Forwarding Plane

02 It should have the network sharing capability of the virtual operator. Through network sharing technologies such as network slicing and GWCN, it supports multiple logical UPF instances, multiple tenants, right-based and domain-based O&M, to meet differentiated service requirements of different virtual operators.

03

To meet the high bandwidth forwarding capability requirement brought about by centralized construction, it can expand computing resource scale and apply SR-IOV + vector forwarding technology to improve the forwarding efficiency, or use SmartNIC-based heterogeneous hardware to greatly improve the forwarding capability. On the basis of SR-IOV, the vector forwarding technology improves the forwarding process capability. It introduces the intelligent self-learning function, so as to learn traffic flow rules intelligently and implement vector forwarding for the traffic flow. In addition, it merges multiple individual stream of traffic to form concurrent streams, thus improving the forwarding efficiency and reducing the bottleneck of system forwarding.

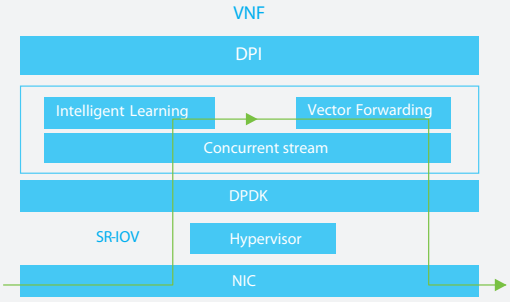


Figure 3-2 SRIOV + Vector Forwarding Technology Improve Forwarding Capability

SmartNIC acceleration solutions include virtual-layer OVS offloading and application-layer GTPU offloading. OVS offloading provides a high-throughput virtualization solution, and provides a set of communication framework and programming interfaces between upper-layer applications and each Hypervisor virtualization device (KVM, Xen, VMware, etc.), thus reducing cross-platform compatibility problems. GTP-U offloading is oriented service acceleration. The SmartNIC identifies the DPI of GTP packets, identifies the service flow and defines follow-up actions, and then implements fast forwarding for subsequent packets, obviously reducing the occupation of CPU resources, greatly improving forwarding performance and reducing latency.

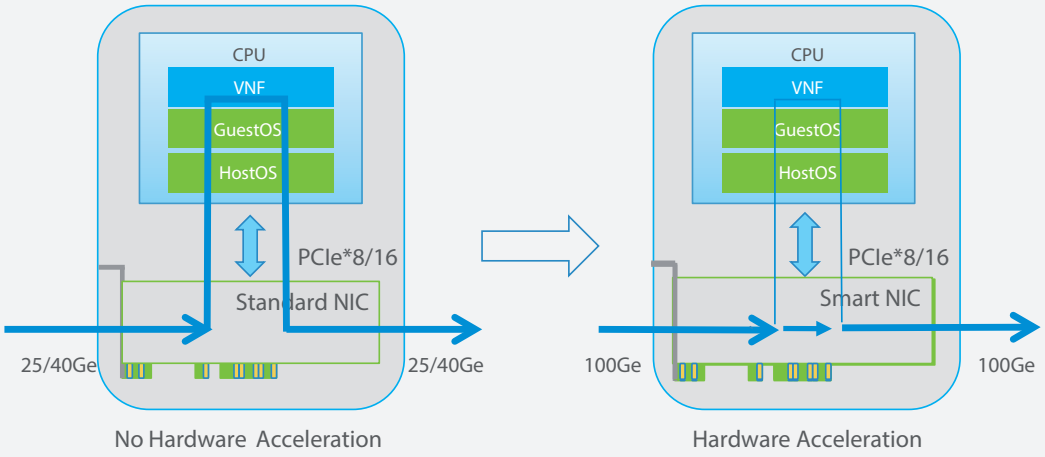


Figure 3-3 SmartNIC-based Hardware Acceleration Improves Forwarding Capability

The software acceleration solution is applicable to the cloudified UPF. Since there is no standard GTP-U acceleration algorithm, the UPF and the acceleration NIC cannot be decoupled in the early stage. The deployment of the UPF should be based on the dedicated equipment with integrated software and hardware. In the future, the NIC and the acceleration algorithm can be decoupled step by step according to the following evolution process.

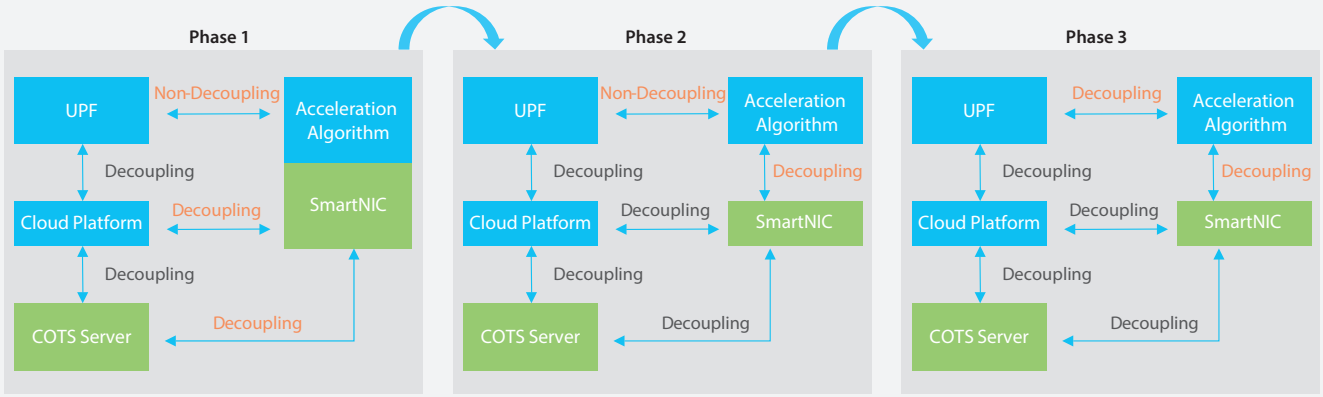


Figure 3-4 Evolution Process of Software and Hardware Acceleration Solution Decoupling

04 It should provide security protection and address NAT function for N6/Gi/SGi traffic. External hardware firewalls, virtualized firewalls and UPF built-in firewalls can be used for deployment. In scenarios with high throughput, hardware firewalls are preferred. In scenarios with high integration requirements, UPF built-in firewalls can be deployed. Firewalls and NAT can be implemented as service components of the UPF, improving UPF integration and reducing deployment costs.

3.3 Regional UPF

The regional UPF is deployed to carry user-plane services within city area, including Internet access, audio and video, and local enterprise services.

The regional UPF is distributed deployment at the city DC, which helps reduce the transmission pressure of data traffic backhaul on the transport network. In addition, it performs local data service offloading, reducing service latency. The typical application scenario is big video service. To improve user experience of video services, regional UPF needs to be deployed in each city to access service ends of local video service providers. Moreover, the transmission path of video access can be shortened by deploying UPF and CDN/Cache nodes together in the regional data center.

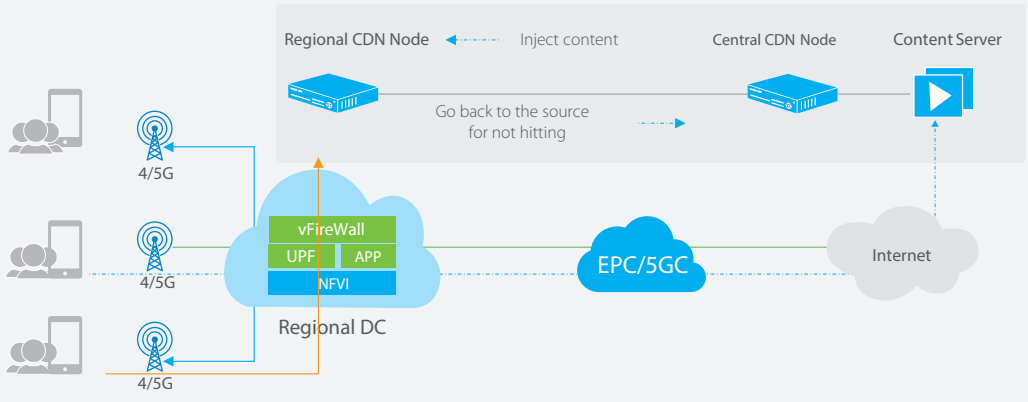


Figure 3-5 Regional UPF Local Offloading Solution

Compared with the central UPF, regional UPFs bring the challenge for the centralized O&M. The centralized FCAPS data reporting and distribution of regional UPFs can be processed by remote EMS access or by expanding the N4/Sx interface. Considering the decoupling requirement for the N4/Sx interface in the future, the former mode is preferred in the industry.

3.4 Edge UPF

With the extensive use of intelligent terminals and the development of large-bandwidth, low-latency and multi-connection service applications such as live webcast, network games, and VR/AR, the communication network is facing great challenges:

- A large amount of high-bandwidth data is aggregated from NR to the data center, which seriously consumes the transmission bandwidth of the backbone network. It is an urgent need to directly process high-bandwidth services at the edge, thus saving the bandwidth consumption of the backbone network.
- For latency-sensitive services (such as Internet of Vehicles and industrial control), they need to be deployed at the edge of a network to be close to users.
- Some industry applications (such as hospitals and airports) have high data confidentiality and need to be restricted to specific edge areas. It needs to reduce the risk of network data leakage and protect user data security and privacy.

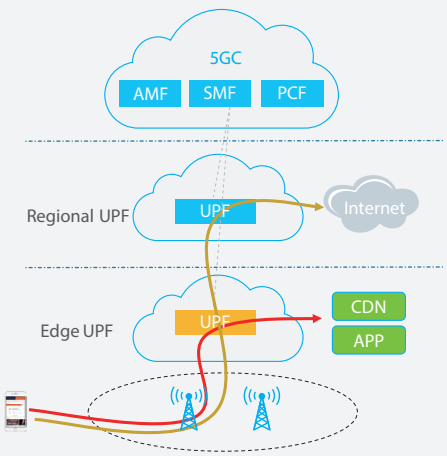


Figure 3-6 Edge Service Offloading Scenario

To cope with such challenges, the UPF is moved to the mobile edge node. It identifies users based on DNN/IP address, and offloads user traffic according to traffic offloading policy. It performs local forwarding and routing for data traffic requiring local processing, thus avoiding detour, reducing data forwarding latency, improving user rate and user experience.

The offloading policy includes:

01 Network-level offloading

Different PLMN or NSSAI are configured to distinguish users and traffic in private networks or different slices, thus implementing network-level traffic offloading.

02 NF-level offloading

In the same network/slice, SMF selects different UPF based on service area, load, DNN and DNAI to perform offloading. In addition, LADN traffic offloading is adopted to serve specific areas.

03 Session-level offloading

In the same session, UL CL/Multi-homing offloading is performed on the data forwarding path according to different anchor points and offloading policies.

In terms of deployment, the edge UPF can be deployed in cloudification or Dedicated UPF mode. In comparison, the Dedicated UPF can improve device forwarding performance by combining software and hardware, thus reducing device power consumption and costs.

In terms of O&M, there are a large number of edge UPFs. It features pre-installation of software and hardware, automatic management, and automatic configuration and delivery to achieve plug-and-play. In normal O&M, centralized configuration delivery and O&M management can be implemented through the EMS.

In addition, as the edge UPF interconnects with the SMF of the central DC through the N4 interface, it needs to consider the security of the N4 interface. Generally, security policy enhancement is implemented by considering the N4 interface as an independent network plane or deploying firewall/IPSEC.

3.5 Campus UPF

With the development of industrial 4.0 and digital transformation of enterprises in depth, more and more enterprises want to deploy Campus UPF in the campus, to improve the efficiency and automation level of industrial control through ultra-low latency and ultra-high reliability connections. Therefore, the industrial robot and unmanned transmission system under centralized control can run simply, efficiently and securely, so that the production parts can run fast and efficiently on the assembly line. Through ultra-high bandwidth connection, machine vision or AR ultra-HD video backhaul can be used to improve product quality detection efficiency. At the same time, production data can be terminated in the campus and isolated from the public network to ensure production security and reliability. Network provisioning and deployment are automatically completed, and the O&M mode supports unified maintenance of telcos or simple maintenance of local enterprises.

Industry applications and industrial environments are greatly different from public networks. In addition to basic traffic forwarding and local traffic offloading, Campus UPF needs to meet the following requirements.

01 Private network access and management are performed based on 5G LAN. Through the intra-UPF Local Switch and inter-UPF N19 tunnel encapsulation technology, it constructs the enterprise's exclusive wide "LAN" for large-scale conferences, events, disaster relief and remote office. In industrial scenarios, it supports point-to-point and point-to-multipoint networking, meeting flexible networking requirements of industrial applications. In addition, the 5G private line is interconnected with traditional private lines such as IPRAN, MPLS VPN and OTN to meet the requirements of enterprise accessing the cloud or remote interconnection of large layer 2 networking.

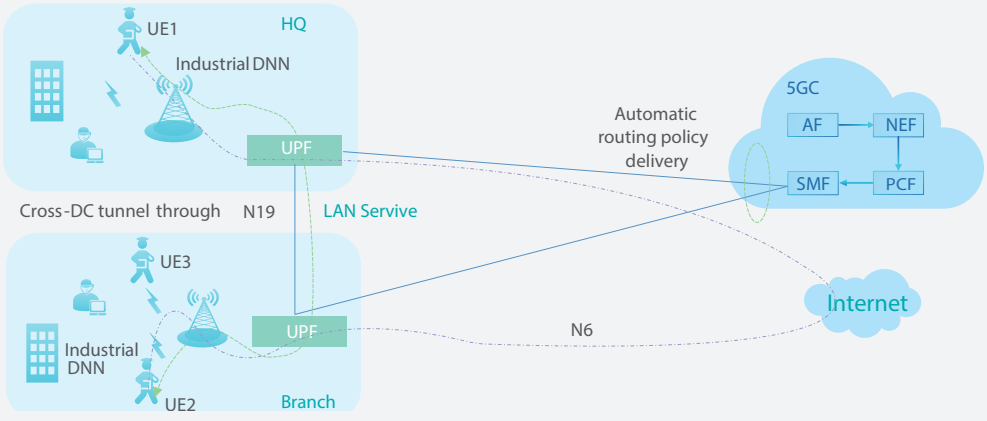


Figure 3-7 5G LAN Enterprise Cross-Branch Communication

02 Based on the TSN technology, the deterministic network is implemented by controlling the transmission delay and jitter. For the TSN scenario, the UPF is enhanced to support high-precision clock and packet queuing and scheduling mechanism under high-precision clock management. In addition, the UPF is deployed at the enterprise site to eliminate interruption factors such as transport network, thus achieving nanosecond-level timing precision, millisecond-level end-to-end delay and 99.9999% reliability. High-precision clock and precise jitter control rely on dedicated hardware.

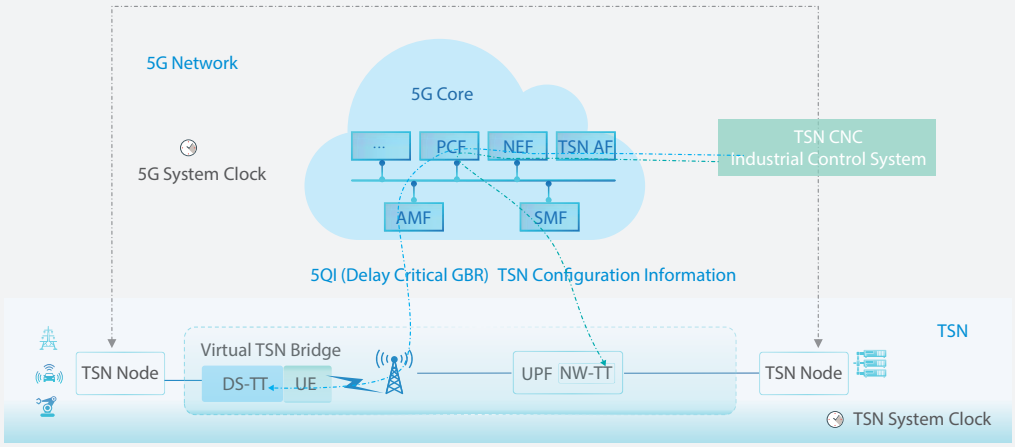


Figure 3-8 5G + TSN Network Integration

03 Ultra-high transmission reliability is provided based on the uRLLC technology. Dual GTP-U tunnels are established on the N3/N9 interface to implement redundant transmission on the user plane. Even if the reliability at the NR cannot be guaranteed, an end-to-end dual PDU sessions can be established to transmit the same packet between two sessions. In addition, two PDU sessions start from different NFs of the NR. Only the UE and DN are co-located. Through end-to-end redundant connection, it ensures connection reliability.

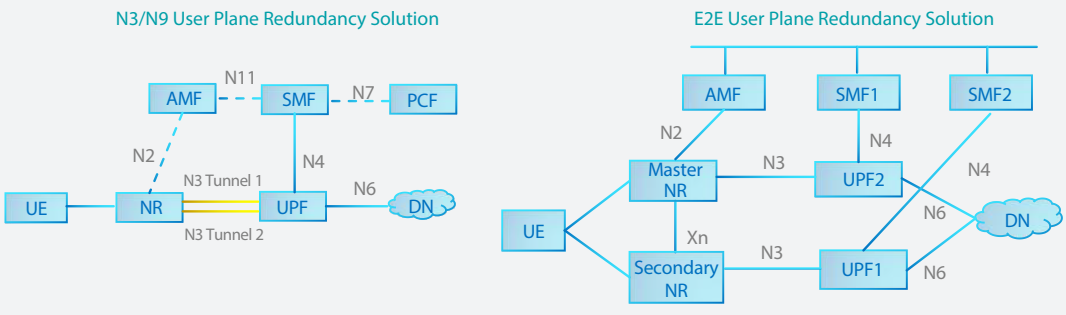


Figure 3-9 uRLLC Multipath Ultra-High Reliability Transmission

04 In some management or non-production scenarios, Campus UPF needs to solve high startup costs, complicated device functions, and high deployment and O&M difficulties of edge UPF. The number of servers and switches needs to be reduced to the minimum to control costs. At the same time, functions can be flexibly tailored and combined in accordance with scenario requirements. The product should be pre-installed and out-of-the-box, and support local O&M and remote O&M. The market needs to introduce a lightweight Lightweight UPF solution, focusing on access and campus scenarios, to further improve space and cost competitiveness and meet diversified requirements of industry customers.

05 Usually, Campus UPF is deployed outside the operator network. Dual security needs to be considered for the operator network and enterprise network. It needs to provide security filtering, two-way digital authentication, data encryption, anti-malicious attack and other capabilities.

3.6 ZTE Full-Scenario UPF Deployment Solution

ZTE's full-scenario UPF deployment solution covers all the scenarios of current UPF construction, including central UPF, regional UPF, edge UPF and campus UPF. It provides series of UPF products to meet full-scenario UPF deployment requirements from B2C to B2B, from center to campus.

The following figure shows the ZTE UPF hardware platform.

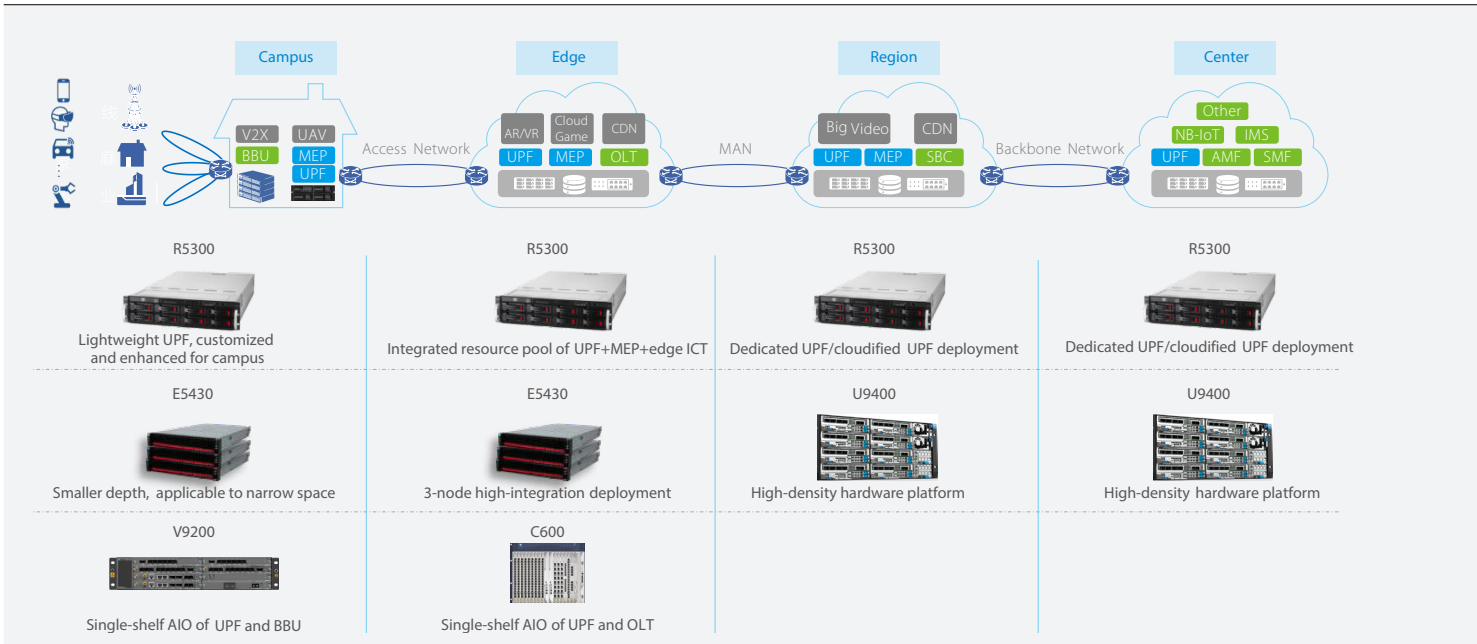


Figure 3-10 Full-Scenario UPF Hardware Platform Forms

ZTE UPF hardware platform has three forms:

01 COTS server

such as R5300 and R5430, can be widely deployed at the center, region, edge, and campus. At the edge, the UPF can be integrated with the MEP. At the campus, the lightweight UPF can be deployed on a single server.

02 High-density dedicated hardware

U9400, is a single 4U server with 8 nodes and built-in switch, highly-integrated, meeting the deployment requirements of central and regional large-bandwidth UPFs.

03 Hyper-integrated single shelf

such as V9200 and C600. It provides integrated deployment of UPF and BBU or OLT, and satisfies the converged access of wireless and wired networks in the compact form of single shelf.

ZTE full-scenario UPF deployment solution has the following highlights.

Fully-converged UPF supports 2G/3G/4G/5G/Fixed full-stack access

As a forwarding highway connecting terminals, wireless networks, industrial applications, and the Internet, the UPF has a converged access capability that directly affects service experience.

The common UPF in the industry only supports 4G/5G converged access. ZTE UPF has considered protocol downward compatibility since its design. It can support various access technologies such as 2G/3G/4G/5G/NB-IoT, and support NSA/SA converged networking to fully meet differentiated access requirements of global telcos. With the deployment of the fully-converged UPF, users can access the network anytime and anywhere, and perform seamless handover crossing various systems to enjoy the ultimate experience brought by network convergence.

The software and hardware acceleration technology meets 5G ultra-high bandwidth requirements.

Enhanced software acceleration technology: Based on SR-IOV, ZTE UPF improves the upper layer traffic forwarding flow. It introduces the intelligent self-learning function to intelligently learn traffic flow rules and implements vector forwarding. Conventional single-channel streams are optimized and enhanced to form multiple concurrent streams, thus improving forwarding efficiency and reducing the bottleneck of system forwarding.

ZTE is the first to launch iNIC, the hardware-based SmartNIC acceleration technology in the industry. Through FPGA (Field Programmable Gate Array), it assists the CPU in processing network load, extracts user plane traffic through intelligent analysis, generates the flow table and distributes it to the iNIC. Then the iNIC implement high-speed hardware forwarding, greatly reducing the occupation of CPU resources, significantly improving performance and reducing latency. For video streams, iNIC offloading shows more obvious effect.

Enhanced industrial Internet meets 5G industry private network requirements

ZTE UPF provides powerful support capabilities for industrial market and environment.

ZTE UPF provides dedicated private networks and corresponding management capabilities for industry customers through 5G LAN. Industry customers can customize private networks, create and manage sub-clusters in the private network, and specify transmission and security policies for cluster users. In addition, industry customers can observe the operational statuses of clusters in the private network in real-time, and can obtain problem alarms detected by the UPF system in time.

In an industrial scenario, the customer network needs the Ethernet access capability. ZTE UPF takes the lead in launching the enhanced Ethernet access solution to meet the urgent requirement of industrial scenarios. This solution can provide mobile private line services and mobile LAN services instead of WiFi coverage, thus greatly reducing the network construction cost and O&M cost of industry customers.

In order to further meet the strict requirements for latency, jitter and transmission reliability in specific industrial scenarios, ZTE UPF provides a highly reliable solution through uRLLC mechanism with dual N3 tunnels or dual PDU sessions to address the industrial environment. Evolving to 3GPP R16/R17 TSN standards, ZTE UPF is deployed with dedicated hardware and forwards key service data streams preferentially to ensure real-time service processing and accurate packet scheduling, meeting the deterministic network requirements for low latency and jitter.

Simplified O&M provides fast provisioning and O&M capabilities for large-scale edge UPF deployment

ZTE UPF provides a series of simplified O&M methods, such as out-of-the-box, automatic configuration, automatic dialing test, fault self-healing and parameter self-optimization, to help telcos and industry customers to perform rapid provisioning and efficient O&M, improving efficiency and saving costs.

ZTE UPF simplified O&M is shown in the following figure.

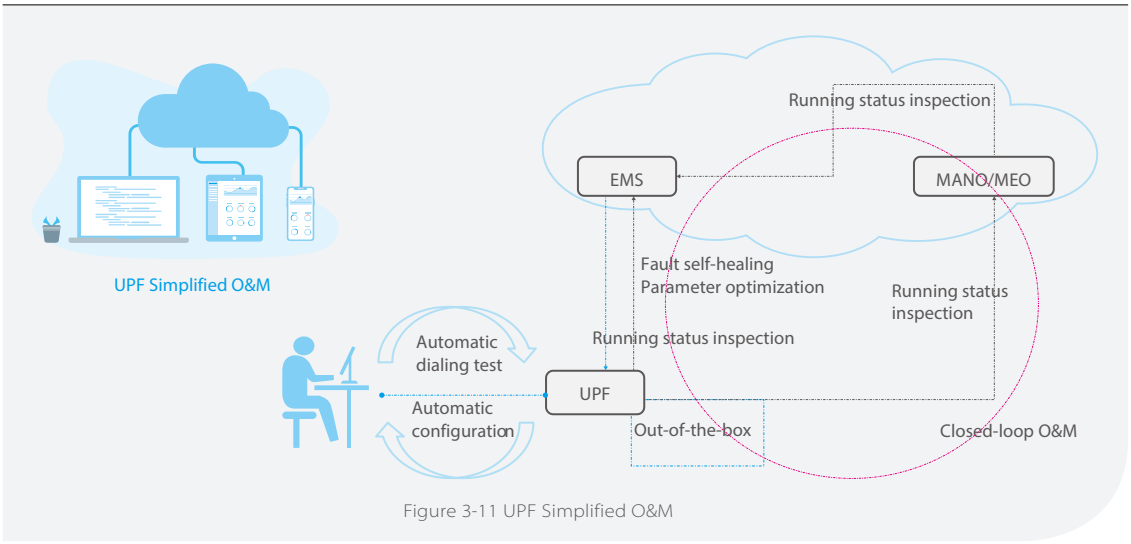


Figure 3-11 UPF Simplified O&M

UPF, MANO/MEO and EMS together form a small closed-loop O&M system. With this system, the fault handling and system parameter optimization of the UPF can be implemented automatically, and manual intervention is not required or is rarely required. In this way, it achieves unattended O&M.

Multidimensional UPF security assurance

ZTE UPF has the following endogenous security features, ensuring the security of the all-scenario UPF.

- Trusted

  Multiple trusted technologies are provided to ensure UPF security. The UPF with endogenous security shares threat information with the Exogenous Security Center in B2C carrier-grade applications and scenarios, and cooperates against the invasion threat. In B2B edge application scenarios, it can guarantee the security access of third-party applications.

- Reliable

  Multiple technologies are provided to ensure data security. The UPF supports both lightweight encryption and heavy encryption to ensure data application security for IoT access or enterprise access.

- Manageable

  It is capable of discovering threats. The UPF has the built-in firewall function. In addition to the traditional DoS attack resistance, it also has the function of associating with the control plane to discover/intercept unknown threat traffic, so as to ensure the availability of services.

Build an open decoupling and cooperative win-win OpenUPF

ZTE has been committed to building an open UPF ecosystem. As a bridge between the 5G network and B2B industry, the UPF plays an important role in enabling thousands of 5G industries. ZTE UPF provides open capabilities at different layers including the interface layer, edge layer and resource layer to fully embrace the arrival of the 5G era.

- Interface exposure

  The N4 interface complies with telco interface specifications and is decoupled from the SMF.

- Edge exposure

  It delivers various policies through the service-based interface, including offloading, to support MEC applications.

- Resource exposure

  The unified IaaS and PaaS resource platform is provided for the deployment of third-party APPs.

Cases .4

ZTE has launched the full-scenario UPF deployment solution, and carried out in-depth cooperation and practice with telcos and industry partners in many fields, focusing on application scenarios, technical features, and future development opportunities of the industry market. With an open, cooperative, and innovative attitude, ZTE continues to explore to accelerate digital transformation and business model innovation in the industry.

4.1 Full-Scenario UPF Fuels China Mobile's 5G New Infrastructure

Guided by the "5G New Infrastructure," China Mobile's 5G SA commercial process and scale are leading in the world. To meet the requirements of distributed network construction and intensive O&M, its 5G Core adopts the regional construction solution. Due to the great difference in industrial maturity, network functions and market applications of B2C and B2B networks, the two networks are built independently. Naturally, UPFs are also built separately. To meet service differentiation and industry fragmentation requirements, distributed multi-level UPF deployment mode is adopted. Therefore, China Mobile selects ZTE full-scenario UPF solution to build the distributed network.

Central/Regional UPF		Edge/Campus UPF	
B2C UPF	B2B Centralized UPF	B2B Edge UPF	B2B Edge Enhanced UPF+MEP
Provincial capital center/cities	Provincial capital center	City/County/Campus	City/County/Campus
Dedicated UPF	Dedicated UPF	Dedicated UPF	Dedicated UPF
50G/100G/200G	50G/100G/200G	5G/10G/50G/100G	5G/10G/50G/100G

Figure 4-1 China Mobile Full-Scenario UPF Introduction

B2C UPF – Center/Region

The B2C UPF includes Central UPF (capital center) and regional UPF (cities), to balance service latency and transmission cost, meeting requirements of large bandwidth and low latency. In terms of cost and long-term evolution, the B2C UPF uses 100G SmartNIC for acceleration and one-step-to-target configuration, fully addressing 5G long-term service development.

B2B UPF – Center/Region/Edge/Campus

China Mobile considered the following aspects for B2B UPF selection.

Deployment location

B2B UPF is divided into three levels according to the deployment location, including centralized UPF, edge UPF and edge enhanced UPF+MEP.

Equipment room location

In addition to hardware parameters such as equipment room space, air-conditioner cooling, and power supply limitation, security, delay, coverage, and remote disaster recovery should also be considered for the edge equipment room.

Capacity requirement

The UPF has five levels of models: 5G/10G/50G/100G/200G. The B2B network generally has a small user scale, and the industry can flexibly select according to its own needs, thus saving network construction costs and improving resource utilization.

Service requirements

Industry applications have many customized demands, and need local data processing and storage, high security isolation and low-cost network construction. ZTE provides lightweight UPF with simplified and customized functions to meet such requirements.

China Mobile provides a full-scenario UPF to meet differentiated service requirements of B2C and B2B industries, assisting the whole industry achieving digital transformation.

4.2 Regional/Edge UPF Helps Austria H3A Lead the 5G Era

Aiming at the digital transformation of the whole network, Austria H3A 5GC project has made a ten-year network development plan, which adopts two-level DC deployment at the center and edge to meet service requirements of B2C and B2B respectively.

The target network capacity will serve 4.5 million subscribers and provide 2.4Tbps throughput. The regional DC under construction is deployed in a centralized manner through the cloudified UPF, to provide basic 5G SA service capabilities. At edge DCs, the Cloudified UPF / Dedicated UPF+MEP are deployed to achieve dedicated wireless access coverage, local user traffic offloading and third-party local application deployment. Based on network slicing and MEC technologies, the network can meet 5G service requirements of vertical industries such as low latency and large bandwidth.

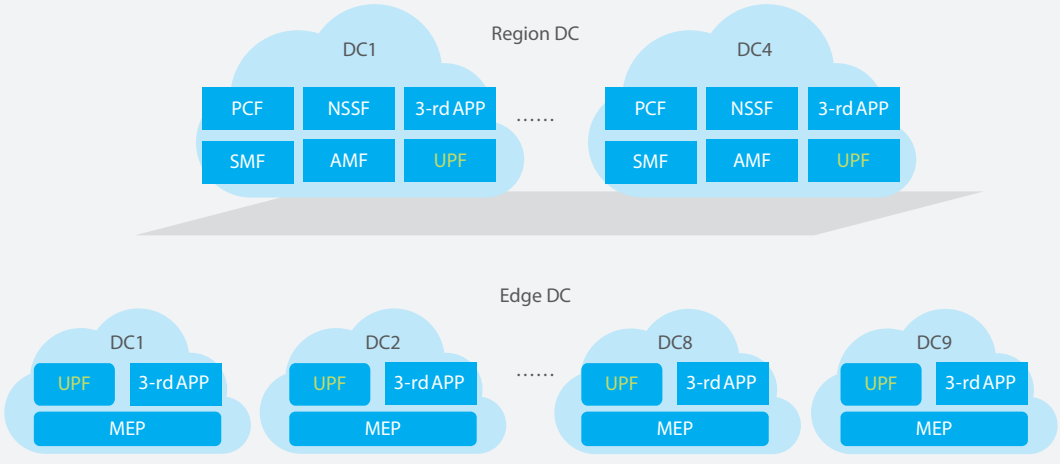


Figure 4-2 Deployment Architecture of Austria H3A 5GC

4.3 Edge UPF Enables Intelligent Steel Industry Interconnection

As the strategic basic industry, the steel industry is driving the global industrialization development. Baosteel Zhanjiang is the latest and most competitive production base of Baosteel. Based on advanced production equipment and management levels, Baosteel Zhanjiang vigorously promotes 5G and intelligent innovation technologies, and leads the whole country with 1,800 tons of steel produced per year per capita.

In January 2019, Baosteel Zhanjiang and Guangdong Unicom signed a 5G strategic cooperation agreement, together with Shanghai Baosight and ZTE, being committed to assisting Baosteel Zhanjiang in building a world-class smart steel factory through advanced 5G technologies. The world's first 5G industrial private network in the steel industry has been built and put into commercial use at an area of 12.58 square kilometers, with one set of 5G SA Core, 72 NRs and more than 100000 users. The 5G private network in the factory campus is physically isolated from the public network. Subsequently, the 5G private network will be integrated with network slicing technology to isolate the network for different industrial scenarios in the campus, and the control and data will not leave the campus at all, achieving the highest-level security assurance.

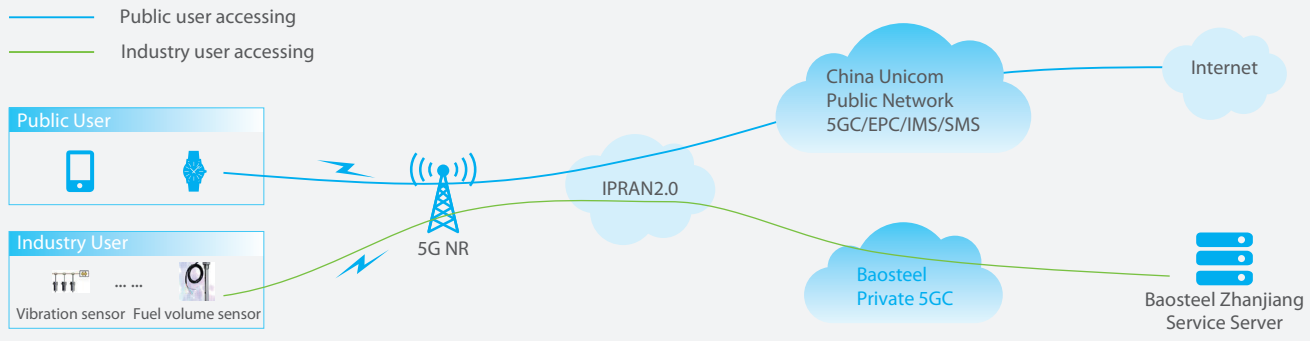


Figure 4-3 5G Network Architecture of Baosteel Zhanjiang

An entire 5G Core network is deployed in the factory campus. The Campus UPF implements local offloading to achieve high data rate, while greatly shortening network transmission delay. 5G applications such as online fan monitoring, high-risk construction video monitoring, AR helmet smart patrol, and robotic arm remote operation have been put into commercial use. This solution improved the efficiency by 48%, and optimized personnel more than 500 times, saving annual cost of about 200 million yuan.

At the Third Bloom Cup 5G Application Competition held in September 2020, the Zhanjiang Iron and Steel Project won the first prize. In the future, China Unicom, Zhanjiang Iron and Steel, and ZTE will be committed to using the world's first steel production technology to drive the intelligent manufacturing reform of Chinese iron and steel and boost the Chinese iron and steel industry.

4.4 Campus UPF Fully Accelerates the Digitalization of Smart Mine

Smart mine plays an important role in developing 5G new infrastructure. Smart mines are usually far away from cities, and some are even remote mountainous areas with poor network coverage. It is difficult to build networks by themselves, which seriously restricts the construction and development of smart mines.

ZTE together with partners, jointly built the 5G smart mine campus project. In the mine environment, this project achieves four major innovations:

(1) A complete set of 5G network is deployed underground, including terminal, NR, standby Dedicated 5GC (including Lightweight UPF) and MEC equipment.

(2) The underground 5GC and UPF adopt a simplified architecture with compact design, meeting requirements of small space and low power consumption to reduce costs.

(3) The underground UPF and 5GC should be packaged in explosion-proof boxes to meet the explosion-proof requirement of the mine.

(4) All the underground equipment is loaded in 7*24 hours mobile trolleys, and moves with the coal rack in real time to achieve full coverage of 5G network at key sections.

A set of lightweight 5GC is deployed aboveground for centralized control. When the underground and aboveground link is interrupted, the underground standby lightweight 5GC takes over 5G services, ensuring that services at key sections are not interrupted for eight hours and providing ultra-high reliability. 5G SA private network is used to ensure data security.

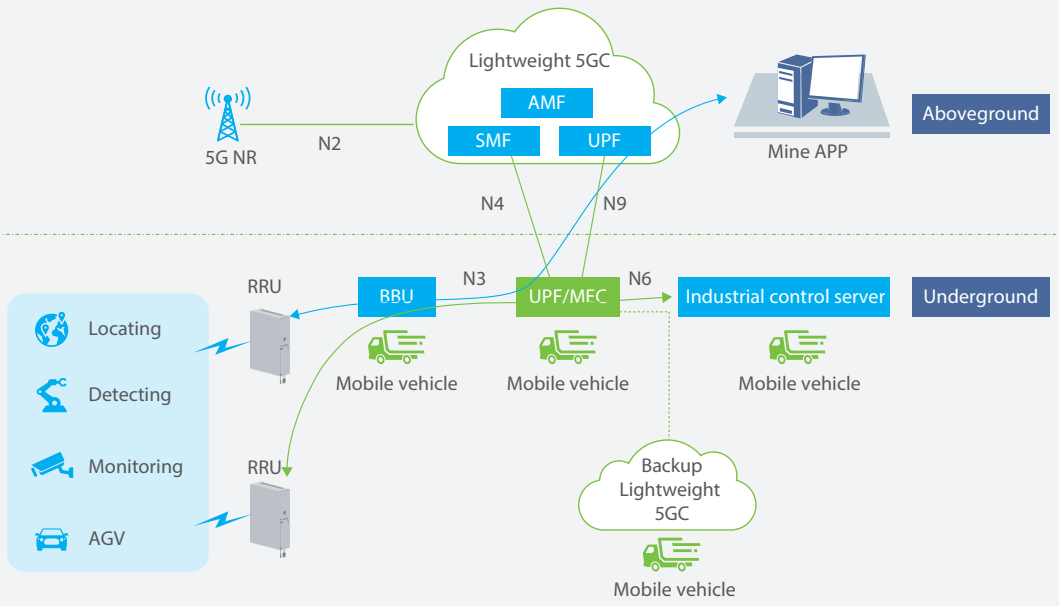


Figure 4-4 5G Network Architecture of Smart Mine

In order to improve the accuracy and stability of unmanned mining, the underground UPF implements local offloading, communicates with the control server directly and analyzes services in real time, to provide 10ms ultra-low latency for automatic operating control. The aboveground and underground UPFs implement multi-channel HD video backhaul (100Mbps) through the N9 interface. The aboveground staff monitor the underground operation remotely to improve automatic operation level, reduce cost and increase efficiency.

5G technologies empower coal mining and reshape industry production models. Through the application of 5G technologies, it promotes the intelligent upgrade of coal mines and accelerates the digital transformation of smart mines.

5 Summary and Outlook

5G provides telcos, end-users, and industries with brand-new experience and business models. As an important carrier for 5G traffic, UPF provides key network functions of high bandwidth and low latency, and is a master for 5G network connecting thousands of industries. Its high performance, flexibility, openness, and serviceability are the cornerstone of 5G enabling the Internet of Everything.

Facing the uncertain era and uncertain technological changes, ZTE has been committed to exploring and researching the 5G user plane to provide customers with deterministic network experience. ZTE takes the lead in launching the SmartNIC technology based on hardware acceleration in the industry, breaking the bottleneck of software performance forwarding. ZTE provides the most flexible and open series of UPFs to meet the converged deployment requirement in different access scenarios. ZTE provides the Lightweight UPFs with the smallest dimensions and ultra-low power consumption, to directly get close to the production site and meet the requirements of specific industries. By way of deep collaboration with standards and the industry chain, this solution accurately meets industrial interconnection requirements. ZTE UPF is ready for large-scale 5G commercial deployment.

In the future, the world is embarking on a new era of Internet of Everything (IoE) based on 5G new infrastructure. ZTE is willing to work with telcos and industry partners to jointly promote the maturity of the industry chain, jointly lead the development of 5G user plane technologies, and jointly explore the innovation of new business models.

Abbreviations .6

Abbreviation	Description
5GC	5G Core
BBU	Baseband Unit
CDN	Content Delivery Network
CUPS	Control and User Plane Separation
DC	Data Center
DNAI	DN Access Identifier
DNN	Data Network Name
DPI	Deep Packet Inspection
eMBB	Enhanced Mobile Broadband
EMS	Element Management System
EPC	Evolved Packet Core
GWCN	Gateway Core Network
IaaS	Infrastructure as a Service
I-UPF	Intermediate UPF
iNIC	intelligent Network Interface Card
LAN	Local Access Network
LADN	Local Area Data Network

Abbreviation	Description
MANO	Management and Orchestration
MEC	Multi-Access Edge Computing
MEP	MEC Platform
MEO	Mobile Edge Orchestrator
mMTC	Massive Machine Type Communication
NF	Network Function
NPN	Non-Public Network
NSSAI	Network Slice Selection Assistance Information
OLT	Optical Line Terminal
PaaS	Platform as a Service
PCF	Policy Control Function
PSA UPF	PDU Session Anchor UPF
RAN	Radio Access Network
RRU	Remote Radio Unit
SaaS	Software as a Service
SLA	Service Level Agreement
SMF	Session Management Function
SR-IOV	Single Root I/O Virtualization
B2B	To Business
B2C	To Customer
TSN	Time Sensitive Network
UPF	User Plane Function
UL CL UPF	Uplink Classifier UPF
uRLLC	Ultra Reliable Low Latency Communication
VNF	Virtualized Network Function

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