ZTE Distributed Precise Cloud White Paper

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1 Background

1.1 Trend of Industry Digitalization

From the perspective of global development, digital economy has become the trend of the times. According to the statistics from 47 countries released by the China Academy of Information and Communications Technology (CAICT), the added value of the digital economy reached US $31.8 trillion in 2019, up from US $1.6 trillion in 2018, accounting for 41.5% of GDP. The global industrial digitalization, which accounts for 84.3% of the digital economy, has become a key driving force for the development of the global digital economy.

- Uncertainty becomes the norm

At present, the main challenge of industrial digital transformation is a great deal of uncertainty. As technology iteration accelerates in the global industrial competition, it is shorter for excellent enterprises to take the lead, and the possibility becomes big for the chasers to catch up with the leading roles. With the coexistence of opportunity and challenge, uncertainty will become the norm. On the other hand, due to cross-border replacement under the catalysis of digital information, the opportunity and threat of cross-border business models will be doubled. As opportunity and challenge accelerate at the same time, the uncertainty of development will become the norm.

- Advantages and problems of cloud

Under this uncertain background, the advantages of cloud-based technology gradually become apparent and play a greater role. On the one hand, the cloud computing technology brings higher availability and better elasticity to the infrastructure layer. At the same time, with the introduction of cloud native technologies such as container, Microservice and DevOps, cloud computing improves the response speed and flexible response capability of the service layer development.

The global cloud computing market has grown several times over the past decade. According to the cloud computing development investigation report of the China Academy of Information and Communication Research, the proportion of enterprises

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that have used cloud computing in 2019 reaches 66.1%. In terms of batch access of small and micro customers to public cloud and cloud access by start-up companies, public cloud services are characterized by low thresholds, small initial investment, and quick results, with obvious cost advantages and rapid growth. However, with the growth of an enterprise, cloud requirements become increasingly complicated. Increasingly, an enterprise attaches greater importance to differentiated customization, security, reliability, and manageability. At this time, some weaknesses of public cloud will be exposed. For example, full-stack cloud cannot be tailored to high redundancy costs, and end-to-end SLA cannot be guaranteed, which hampers the development prospects of cloud applications of industrial enterprises.

1.2 A New Cornerstone of Industry Digitalization

As telcos have accumulated years of experience in cloud-based network infrastructure, they have an increasingly deep understanding of cloud development and evolution. In addition to supporting the development of its own communication technologies, dedicated telecom networks are gradually becoming cloud service platforms oriented to thousands of industries. Telecom cloud has its native advantages with respect to network performance and reliability, and continuously integrates new technologies such as AI and big data to build a new high-performance, high-reliability, and intelligent information platform, which can better help the digital and intelligent transformation of industries. It is becoming a new foundation of digital development of industries. At present, the telecom cloud has the following two development trends:

- Distributed architecture

With the rapid development of 5G and edge computing technologies, telecom cloud was evolved into an "edge + cloud" distributed architecture in 2020. This architecture provides a real-time processing capability for massive access data at the network edge, which can greatly reduce network latency, improve user experience, and expose network capabilities to provide service innovation platforms for industry users. The cloud end provides an efficient orchestration of integrated cloud/edge resources, O&M management and operation services for unified management and effective reduction of operation costs

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The telecom cloud with this distributed architecture can be flexibly deployed in industrial parks and supermarkets, easily providing users with ultra-high bandwidth, ultra-low latency, unified access management of massive terminals, and ensuring E2E SLA services. These features create rich application scenarios for applications in different industries, and create new development models.

- Precise deployment

For telcos, flexible network adaptation is another key to build industry cloud capabilities. Telcos need to focus more precisely on application scenarios and provide solutions in a differentiated manner. In addition, because differentiated and customized services involve a large amount of exploration and adaptation, low-cost trial-error modes need to be provided to reduce the startup threshold. Therefore, the precise cloud with lightweight startup and rapid iteration is a more feasible solution.

At present, the industry has the following conclusions on the construction of precise cloud:

a) First, you can make addition on the IaaS layer to increase the selection of service perception, traffic distribution, and access mode of network components, and to increase capabilities such as hardware acceleration and cloud-network collaboration.

b) Secondly, you can make subtraction at the PaaS layer to form different service packages in a way that can be tailored by software, so as to achieve different configurations of PaaS capabilities, meet differentiated requirements of enterprise customers, and provide them with greater customization rights and autonomy.

As a result, "cloud built on demand" and "cloud applied by demand" can be implemented to precisely distinguish between customers and allocate network resources to better display the advantages of telecom networks.

Telcos deeply participate in industry business operation through industry investment. Based on distributed precise cloud, they build a sound ecological cooperation architecture, and jointly innovate high-value services to promote digital transformation and rebuild the value chain of the industry. Driven by technologies and policies, industrial applications will be in full swing to promote the digital development of 5G industry.

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2 Distributed Precise Cloud

2.1 Overview

To sum up, in order to meet the differentiated requirements of the distributed telecom network architecture and diversified vertical industries, building a precisely-deployed telecom cloud is the key for telcos to accelerate the digital transformation of vertical industries. ZTE has proposed the concept of "distributed precise cloud": The network infrastructure TECS Cloud Suite is integrated with key technologies in typical scenarios. Software and hardware can be independently selected as required during deployment, and lightweight initiation and rapid iteration are supported to accelerate agile innovation of industry users.

- Overall architecture

The distributed precise cloud consists of two parts: IaaS layer and PaaS layer. The IaaS layer, which uses series hardware, integrated cloud platform, distributed storage and other products and technologies, constructs a secure, reliable and enhanced resource platform that is deployed on demand and expended flexibly. The PaaS layer, which is based on the cloud-native technical architecture such as Microservice and DevOps, provides a capability deployment platform covering MEC edge computing, database, big data/AI, video, enterprise application and operation management. The capability exposure platform can be flexibly tailored to the needs of industry users to effectively avoid high redundancy costs of the PaaS platform. Through efficient combination of the above two parts, you can precisely meet differentiated requirements of vertical industries by optimizing the price/performance ratio.

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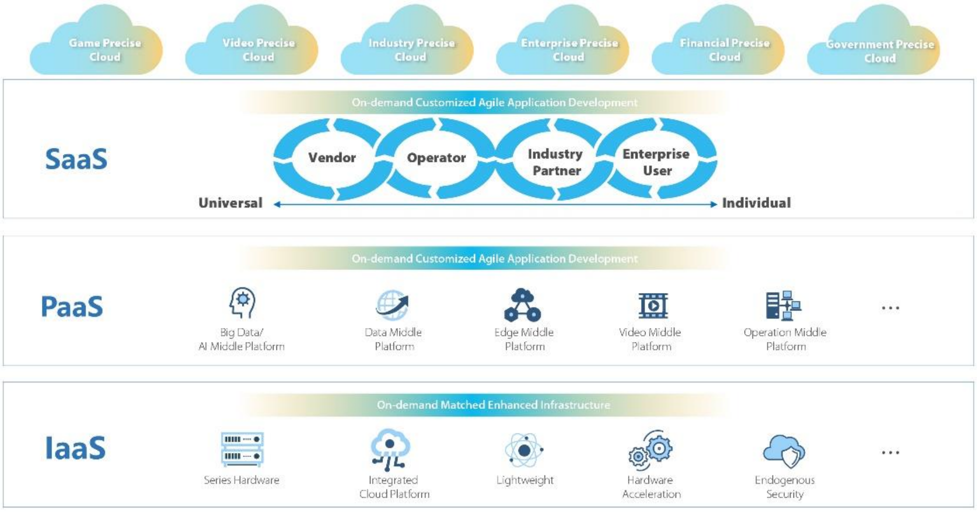

Figure 2-1 Distributed Precise Cloud Overall Architecture

- Deployment mode

The "distributed precise cloud" can flexibly adapt to the requirements of different scenarios from the edge to the center in accordance with the separated architecture of the telecom network, and implement on-demand deployment of resources and services. Core cloud is generally deployed in the regional centralized equipment rooms with sufficient environment conditions. The general servers can be used in terms of hardware. The software focuses on large-scale deployment, diversified middle platform, and automatic intelligent O&M capabilities. Edge cloud is generally deployed in site equipment rooms with limited environment conditions. Embedded devices and integrated hardware can be flexibly used. Convenient and lightweight deployment and O&M modes are required with respect to software. In addition, the "distributed precise cloud" needs to provide centralized resource management and orchestration capabilities, implement cross-cloud resource scheduling, and provide the underground support for application migration and coordination between clouds. The following figure shows the deployment mode of the "distributed precise cloud".

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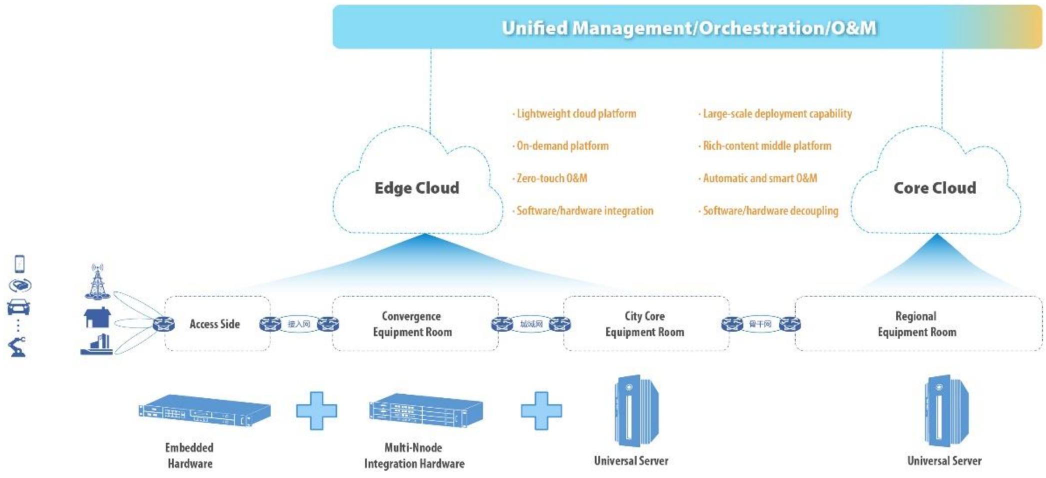

Figure 2-2 Distributed Precise Cloud Full-Scenario Deployment

- Main characteristics

1. The hardware is fully compatible: Various types of hardware such as general servers, embedded devices, integrated devices and acceleration cards exist in the telecom network. On the TECS Cloud Suite, hardware differences must be shielded to implement on-demand hardware selection in all scenarios. Enterprise applications only need to determine the requirements for computing power and throughput, so that they can operate on various types of hardware without modification.

2. Multiple resources are selected at random: With the development and evolution of telecom cloud, the resources in the network infrastructure are diversified in form, including VMs (virtual machines), containers, BMs (bare metals) and accelerated resources. The TECS Cloud Suite needs to coexist with and manage multiple resources. During deployment, an enterprise application can specify a resource type or be automatically matched by the cloud base in accordance with the deployment environment and service requirements for performance.

3. Low-cost test error: To encourage innovative exploration, a low-cost test error environment should be provided. Especially the network edge, where terminals, industrial applications, and networks interact closely, is becoming an innovation hotspot. For the TECS Cloud Suite, the most effective cost-reduction method is to

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reduce the investment in hardware devices. Lightweight deployment can be implemented through bare containers and hyper-convergence, minimizing resource usage and reducing hardware requirements. For example, embedded devices provide MEC computing power by supporting general computing boards without any additional devices.

4. Successful and fast replication: The TECS Cloud Suite is based on the Microservice system. The entire software system is a unified cloud native technology stack, which can be coded for one time and deployed as required. Service innovation in any place can achieve rapid replication of the entire network, and support senseless scaling and migration.

2.2 Key Technologies

2.2.1 Series Hardware

The distributed precise cloud provides various types of hardware products for full scenarios of the on-site side, access edge, convergence edge, and core side. It can be deployed in compact hardware forms such as embedded devices, single-server, and single-rack, multi-rack, and multi-server, flexibly adapting to the environment and service requirements.

1. On the site side, you can use ultra-lightweight embedded equipment and bare container services to provide computing power for industrial production lines and on-board computing.

2. On the access side, you can integrate wireless and wired access equipment and deploy the MEC products with IT BBU and OLT to provide lightweight cloud computing services. It is applicable to the deployment of small and medium-sized integrated access equipment rooms with small MEC service traffic.

3. You can provide medium/high-level computing power cloud services through AIO (all-in-one) cloud system products at the convergence node. It is applicable to Internet of Vehicles and large park scenarios.

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4. The cloud is located in the central equipment room of the province and the city. The equipment room environment is good and the requirement for equipment capacity is relatively high. Therefore, the general servers with strong expandability are often used to form a cloud resource pool.

- Computing power resources are integrated for access devices in a single-frame 5G private network

By deploying base stations and MECs in access devices at the same time, you can make full use of access device resources, integrate computing power resources, and provide built-in switching and single-shelf networking. After arriving at the site, the pre-installed 5G devices are interconnected with the base station and can be used immediately after being powered on. They can be used in small and medium-sized access equipment rooms to meet the requirements of one-stop 5G deployment in limited space environments, and can also be installed in emergency communication vehicles and exhibition vehicles for emergency relief and live broadcast scenarios to meet the requirements of emergency communication.

- Computing power is integrated with the network in edge servers for the one-stop MEC solution

The edge AIO system integrates UPF/MEP/APP software functions, virtualization layer, hardware and networking security equipment. One frame can be configured with devices for a set of edge computing platform. The AIO device has small footprint, high integration, low equipment room requirements, and strong environmental adaptability. It completes hardware integration and software pre-deployment before delivery. On the delivery site, you can power on the devices and quickly import the on-site configurations to enable services and meet the requirements of out-of-the-box.

- Standard servers are configured for the IT/CT convergence cloud in core regions

With the maturity of virtualization technologies, accelerated hardware resources such as FPGA and GPU can be provided through virtualization, and the security isolation technology can also meet the security requirements between different domains in the same resource pool. The regional CT cloud can be expanded to provide unified computing, storage, network, and acceleration hardware resources for telecom NFV and

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IT dedicated cloud scenarios under the prerequisite of security and isolation, so as to improve resource utilization and management efficiency.

- Multiple deployment forms are flexibly adaptable to resource requirements

The deployment modes vary with hardware forms and scenarios. There are two deployment modes: AIO mode and cloud mode. The AIO mode improves performance through the combination of software and hardware, and can also implement plug-and-play and rapid commissioning of devices through hardware pre-integration and software pre-installation, thus simplifying operation and maintenance. The cloud mode refers to constructing cloud resource pools through multiple servers, with the software and hardware decoupling and scalability features.

The distributed precise cloud integrates diversified hardware devices and various resource pools, fully adapts and shields hardware differences, integrates heterogeneous computing power, and provides unified computing power services.

2.2.2 Integrated Cloud Platform

The virtualization technologies of the cloud platform include VMs and containers. Due to the rapid development and wide application of technologies, VMs have matured at present. As a new-generation virtualization technology, containers are attracting more and more attention due to their lightweight, fast, and flexible deployment. At the same time, some key services have high performance requirements and require a secure and reliable operating environment. In this case, more BM servers are selected. Therefore, there are various resource pools in the cloud environment, which can be flexibly matched in accordance with service requirements. The VM resource pool and the bare machine resource pool generally adopt the mainstream open source project OpenStack. The Docker container engine technology is the core at this stage. The open source project Kubernetes, with its complete functions and mature ecosystem, has become the actual standard of the container cluster management system, providing users with virtualized container solutions. The integrated cloud platform combines the two elements to make up for their advantages and disadvantages (OpenStack is good at resource management, Kubernetes is partial to resource orchestration). Compared with simple stacked layers (virtual layer + container layer), the integrated cloud platform makes use

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of resources more efficient, makes management more convenient and makes service deployment easier. The following figure shows the architecture of the integrated cloud platform.

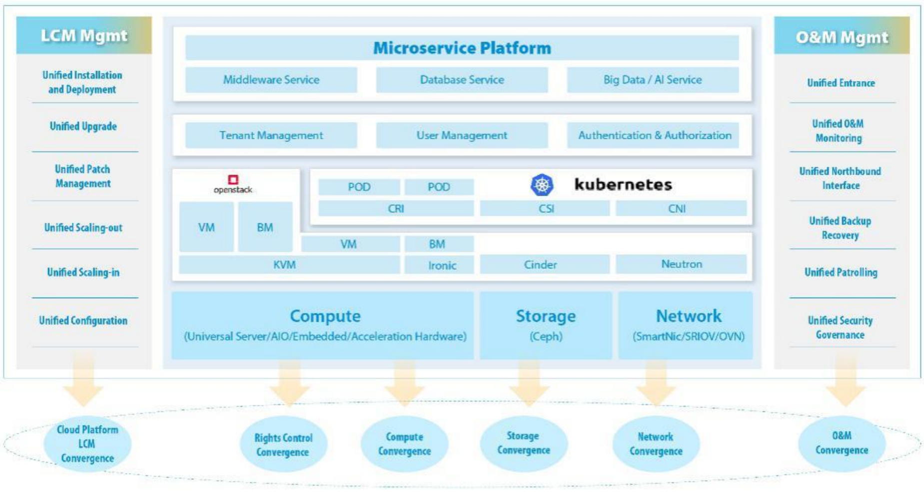

Figure 2-3 Integrated Cloud Platform Overall Architecture

The integrated cloud platform has the following major features:

- Unified lifecycle management

The unified lifecycle management tool is used to provide the installation and deployment, configuration management, version upgrade, patch management, security hardening, scale-in/scale-out, and other functions of the virtual layer and the container layer.

- Unified computing

The virtual layer manages resources in a unified manner, and provides computing resources such as VMs, BMs, VM container nodes, BM container nodes, and accelerated resources for the dual-engine cloud platform.

- Unified storage

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The unified storage management module provides unified block storage, file storage, and object storage for the virtual layer and container layer. In addition, the back-end storage device only needs to be interconnected with the unified storage management module to facilitate the management and adaptation of the back-end storage device.

- Unified network

You can use a unified network management module to perform unified lifecycle management on network objects, and automate network orchestration and provisioning.

- Unified tenant/user management

Both the virtual layer and the container layer manage tenants and users in a unified manner, including quota management and rights management. Unified authentication and authorization are made at the same time, so that you can apply for resources on the same page and use them as required.

- Unified O&M

You can manage the virtual layer and the container layer in a unified and centralized manner, including resource lifecycle management, performance statistics, alarms, and logs.

With the extreme requirements for resource utilization and performance, virtualization is deployed to the hardware, and BM virtualization is becoming increasingly popular. The integrated cloud platform also needs to support virtualization of BMs, including virtualization of management, computing, storage, and network, and deploy them to the edge so that users can obtain excellent performance and security experience.

2.2.3 Bare Metal Virtualization

BM virtualization means that virtualization software is installed directly on the hardware, and then operating systems and applications are installed, which are managed through the virtual layer kernel and server console. With the development of hardware acceleration technology and virtualization technology, virtualization software is deployed on the hardware, so that the hypervisor is lightweight and super-strong performance is achieved through software-hardware collaboration and virtualization.

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BM virtualization has the following advantages:

- As there is no management consumption, the virtualization damage is next to nothing

The virtualization software implements full unloading, ultra-lightweight of hypervisor, and zero resource loss. The software operates stably, and the jitter is close to zero.

- Hardware acceleration promotes the performance

The computing virtualization, storage virtualization, and network virtualization functions are all uninstalled to the acceleration hardware, breaking the bottleneck of storage and network virtualization performance, and providing the performance that matches with what physical machine can provide.

- High security assurance

The cloud management is deployed to the edge and controlled in one way, and the VMs cannot penetrate the management system. The hypervisor is separated, and the minimized host system on the host is used to reduce the leakage of vulnerabilities. The network and storage data can be encrypted and decrypted at the hardware level without affecting the performance. The hardware-level security isolation, exclusive resource occupation, and highly trusted security isolation domain are provided.

- Zero-difference services of VMs and BMs

The distributed precise cloud can provide the same BM cloud services as VMs, flexibly distribute BM services, and support high-performance network, storage, and security capabilities.

2.2.4 Multi-Cloud Collaboration

With the development of edge computing, data centers form the "cloud -> edge -> end" system. Compared with the scenario where cloud computing is transmitted to the cloud, edge computing has higher efficiency in nearest resolution by sending the result to the path of a terminal. However, as a new solution, edge computing focuses on the "small data" computing problems close to users, and cannot replace cloud computing.

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Edge computing and cloud computing are mutually coordinated, just as if one element serves the central mainstream backbone hub while the other element handles the hub-side branches. Two services cooperate with each other, and each service user needs to adapt to its own products and capabilities.

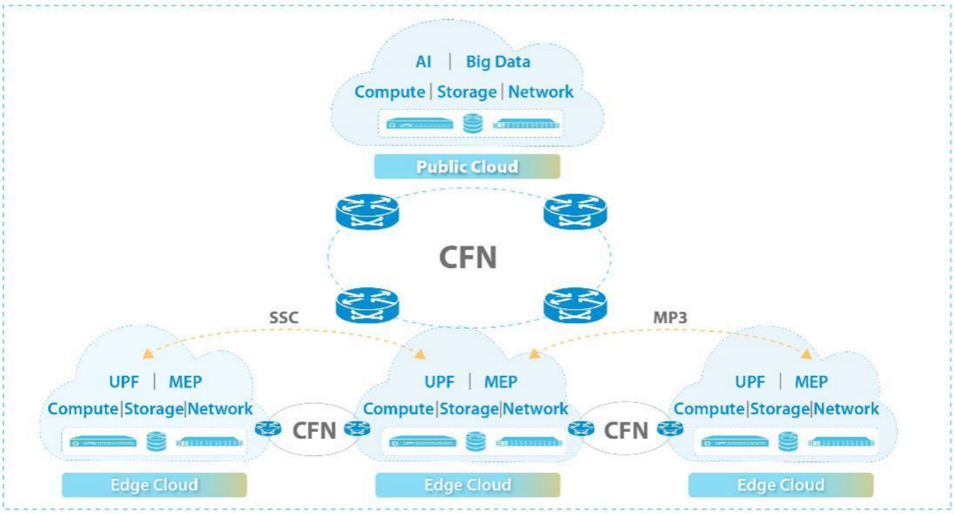

Figure 2-4 Multi-Cloud Collaboration Overall Architecture

Multi-cloud collaboration is mainly displayed in the following three aspects:

- Connection collaboration

The biggest improvement of 5G network over 4G network is that the user plane is completely separated from the control plane. As the only user-plane NE, the UPF can be flexibly deployed in accordance with service requirements. The UPF can act as a service anchor point for regional central deployment to meet the basic Internet requirements for wide coverage. The UPF can also act as a local service anchor point for edge deployment to meet the service requirements in local low-latency and high-reliability scenarios.

To solve the session and service continuity problems caused by 5G UPF distributed edge deployment and service application localization, 3GPP provides three session and service continuity management modes.

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- Platform collaboration

In addition to connecting to the system, for the platform part of edge cloud computing, it is also necessary to support the mutual collaboration between different platforms. The MEC platform should be able to discover other MEC platforms that may belong to different MEC systems. The MEC platform should be able to exchange information with other MEC platforms that may belong to different MEC systems in a secure way. An MEC application should be able to exchange information securely with other MEC applications that may belong to different MEC systems.

- Computing power/network collaboration

In edge computing and even ubiquitous computing scenarios, due to the limited computing resources of a single site, multi-site collaboration is required. The existing architecture is managed and scheduled through a centralized orchestration layer, and has the problems of poor scalability and scheduling performance. The existing service application layer is decoupled from the network, so the application layer cannot precisely master network performance in real time. The comprehensive performance of the addressing result based on the application layer may not be optimal or even poor, resulting in poor service experience. In addition, the current assumption of the Internet is that static server plus mobile client. Traditional DNS-based IP addressing, and TCP/TLS session establishment network mode cannot give full play to the advantages of dynamic, Microservice and ubiquitous computing, and cannot ensure maximum computing efficiency. The future network architecture should be able to support different computing applications. According to different service requirements, the real-time network status, and the real-time computing resource status, the computing task can be dynamically routed to the computing node at a distance from client.

2.2.5 Rich Middle Platform Capabilities

The distributed precise cloud must be oriented to the applications of thousands of industries, and must have rich middle platform capabilities and provide abundant capabilities for various industrial applications, so that applications can focus on their own business logic and do not need to focus on general services. In addition, the system can be combined and tailored in accordance with the actual service requirements, and can be rapidly deployed to meet service requirements.

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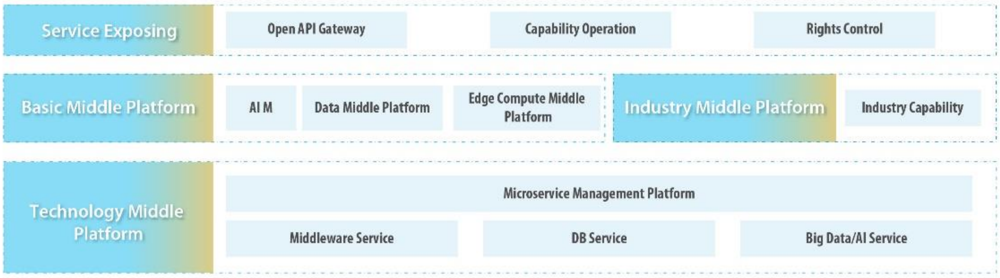

Figure 2-5 Middle Platform Overall Architecture

The following figure shows the overall architecture of the middle platform, including the technical middle platform, basic middle platform, industrial middle platform, and service exposing platform.

- Technical middle platform: The technical middle platform is the foundation of the whole middle platform. It needs to provide overall framework and basic middleware services, including Microservice bus, database service, general big data platform service, general AI platform service and basic middleware platform service (Kafka, ES).

- Basic middle platform: It includes network edge middle platform, data middle platform and AI middle platform.

- Network edge middle platform: It provides edge network capabilities, including network pipeline capability and wireless optimization capability such as distribution, positioning, TCPO and edge gateway. The user's applications can provide the reliable edge computing capability and acceleration capability to the customers through the network edge middle platform.

- Data middle platform: It provides general service capabilities with data as objects, including data collection, data storage, data development, data governance, data exposing, algorithm learning, knowledge atlas and data label. Through the data middle platform, applications can easily process general data.

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- AI middle platform: It provides universal AI capabilities, including universal AI capability exposure services (image recognition, machine translation), AI training services (machine learning, in-depth learning.), AI reasoning services (big data reasoning, real-time reasoning), AI model development services (data marking, model compilation) and technical services of framework components (deep learning framework, machine learning framework)

- Industry middle platform: It mainly includes general industry capabilities strongly related to services, such as IoT industry capabilities (IoT gateway capability, IoT access capability) and video industry capabilities (video acceleration, codec acceleration).

- Capability exposing platform: It provides a unified entrance for the middle platform services. It provides an open API gateway to facilitate users to invoke the service capability API, provide permission control, and isolate service access security. In addition, the platform can perform capability operation and implement unified measurement of capability invocation.

After the technical middle platform is deployed as the basis of the middle platform, other middle platforms can be deployed as required in accordance with different scenarios and applications to achieve accurate adaptation of the industry and applications. For example, in edge computing scenarios, in addition to the technical middle platform, the network edge middle platform, capability exposure platform, and industry middle platform need to be deployed to meet the requirements for deploying service applications to the edge.

2.2.6 Agile Development DevOps

DevOps is designed to facilitate communication, collaboration and integration between development, technical operation and quality assurance links. It completes software lifecycle management through automatic process and automatic tool collaboration and communication, so as to make software construction, testing and release more quickly, frequently and reliably, thus delivering more stable software faster and more frequently.

As the telecom network architecture is deployed in distributed mode gradually, and industry applications need to be rapidly innovated. DevOps ensures frequent and stable

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version delivery and rapid deployment through the agile collaboration and communication mechanism and tool environment.

Generally speaking, the DevOps tool environment has the following basic features:

1. Automation---E2E delivery: The version-level R&D process is aggregated by drilling down and integrating the data of requirements, code and product information, to reflect DevOps E2E delivery. In addition, data-driven improvement is made by means of organization measurement, project measurement, product panoramic view and personal portrait.

2. Visualization---tool chain value presentation: The DevOps tool provides a visual interface that can be orchestrated to solve the easy-of-use issues, and supports customized tasks including plug-in definition, multiple triggering modes and serial and parallel execution modes.

3. Ultimate---one-stop user experience: It includes one-click commissioning, unified entrance and one-stop resource application.

- Arbitrary access, cloud end development integration

In the era of multi-industry ecological collaboration based on distributed cloud-network integration in telco networks, because partners are distributed everywhere, the traditional centralized R&D mode is no longer applicable. The "arbitrary access, cloud development integration" mode of DevOps is particularly important. This mode can help telcos and enterprises establish a cloud-end development integration environment, and connect devices, technologies, services, and developers. Enabling developers to access operation and development, and integrate automatic execution, process visualization, and experience perfection can help users solve problems with respect to development, deployment, and O&M.

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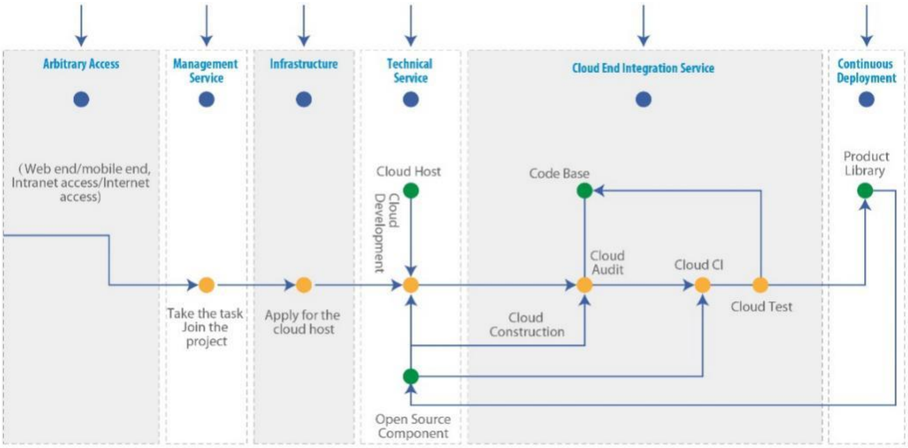

Figure 2-6　DevOps Cloud End Development Integration Flow

- One-aspect innovation, multi-site copy and deployment

In an edge computing scenario, because edge computing sites are distributed on multiple sites, zero O&M requirements at the edge are required to reduce manpower investment. Therefore, after centralized R&D, testing, and version release, edge computing applications are copied and deployed remotely and rapidly on edge computing sites, which is the competition force key for the system to meet the agile innovation.

The operation center provides capability integration, and the entire-process application incubation environment and application store for application development and test deployment. It collaborates with MEP to achieve remote replication and deployment to edge cloud after agile and rapid innovation of central cloud applications. This model provides a good platform environment for agile innovation of edge computing applications.

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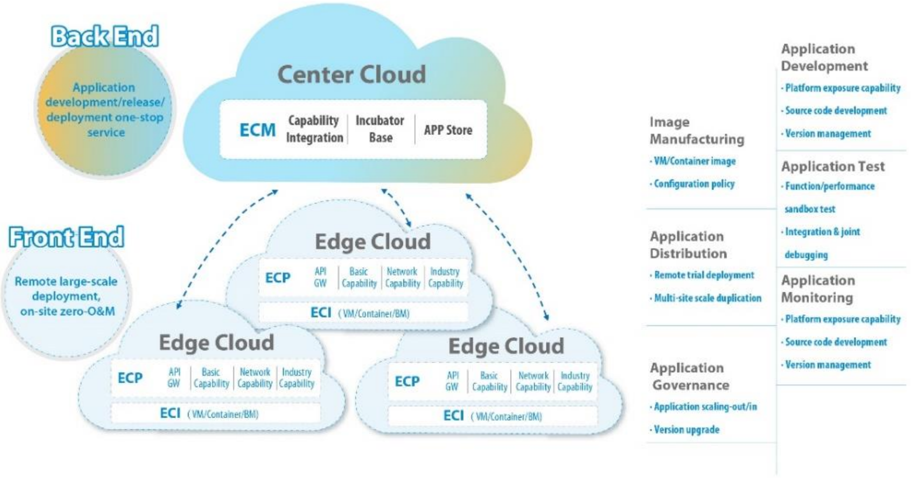

Figure 2-7 DevOps Multi-Site Copy & Deployment Flow

2.2.7 Endogenous Security

With the rapid construction of information infrastructure such as 5G, IoT, and industrial Internet, distributed cloud becomes an important choice in the industry. The multi-cloud architecture complicates the technical environment and the situations of attack-defense confrontation, which requires the interconnection and interaction between products, technologies, services, and management, thus providing continuous security capabilities.

Network security is often mentioned as a leakage of personal privacy, while 5G security does not solve communication security problems in a conventional way. It mainly solves security problems in different industry scenarios after the application of new technologies. Security risks focus on application scenarios and access devices, which are particularly important in industries, cities, and infrastructure construction.

Endogenous security is a new concept in the field of network security. The traditional cyber security defense is like seeing a doctor. It is to fix vulnerabilities after a virus attack. The idea of endogenous security is prevention. The defense mechanism is implanted at the beginning of the system design, which is equivalent to enhancing the "immunity" of network.

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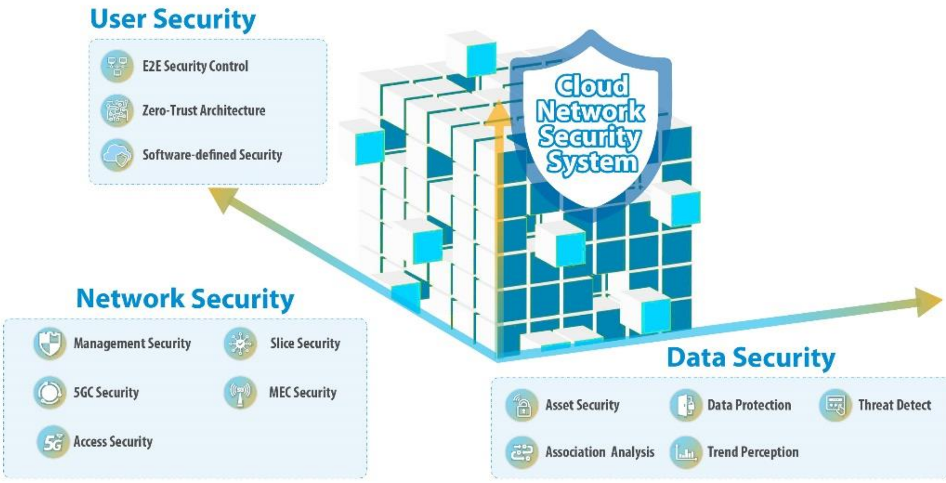

Figure 2-8 Endogenous Security 3D Diagram

Endogenous security, which is applicable to digital transformation information systems such as 5G, cloud, and big data, is suitable to these systems at the beginning of the top-level information-based design and plan. In the 5G era, more cloud/edge collaborations make computing marginalized, and data that arrives at the edge becomes more dispersed, but more logically unified.

Edge computing generates a large amount of end data, which has a large real-time data throughput and is easily tampered and stolen. Due to the disappearance of traditional borders, the security protection logic is transformed into closer to protected business entities and to the data itself. Endogenous security is an identity-based concept, which has great changes with the traditional security system. From the three dimensions of basic network security, data security and user security, endogenous security has different security measures in different fields:

	Big Video	Internet of Industry	Power Industry	Internet of Vehicles	E-business
Infrastructure Security	1. Slice security 2.Security authentication	1.Slice security 2.Security authentication 3.Internal NE authentication 4.Network isolation	1.Slice security 2.Security authentication 3.Internal NE authentication 4.Network isolation	1.Slice security 2.Security authentication	1.Slice security 2.Security authentication
Data Security	1.MEC security	1.MEC security	1.MEC security	1.MEC security	1.MEC security

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		2.Private data security 3.E2E data transmission security	2.Private data security 3.E2E data transmission security	2.Private data security 3.Private transmission security	2.Private data security 3.Private data transmission security
App Security	1.Service level SLA guarantee 2.Low-cost security solution	1.Private data security guarantee	1.Private data security guarantee 2.Service level SLA guarantee	1.Service level SLA guarantee 2.Personalized security customization	1.Low-cost security solution

2.2.8 Intelligent O&M

In distributed cloud scenarios, the central cloud has a large number of hardware nodes, while the edge cloud has a small number of hardware nodes but has a large number of sites. In addition, there are many software products in the distributed cloud, especially the Microservice architecture. Each Microservice has its independent O&M requirements. Manual O&M is used for large-scale software and hardware O&M objects in a distributed cloud. Intelligent O&M will be an inevitable requirement for distributed cloud O&M.

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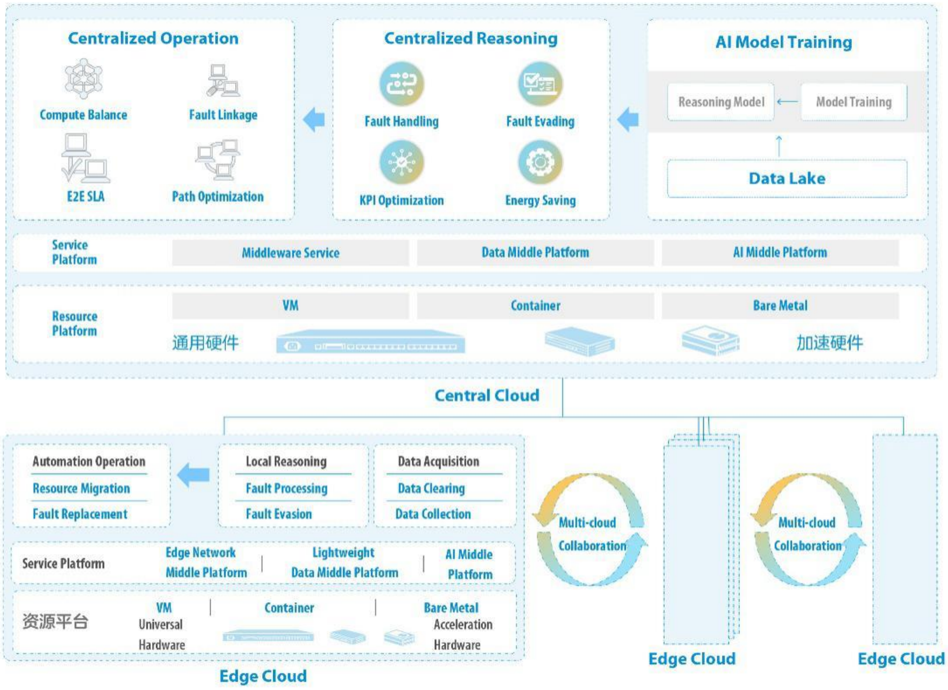

Figure 2-9 Intelligent O&M Overall Architecture

The distributed cloud intelligent O&M architecture is shown in the previous figure, which has two major features:

- Distributed smart system

In a distributed cloud, due to the limited computing resources of edge offices, a complete set of intelligent O&M products cannot be deployed. For the distributed cloud, intelligent O&M products also need to be distributed. Data collection in the intelligent O&M system and lightweight reasoning and operations can be deployed on edge nodes. AI model training (including data lake and reasoning model training), which consumes huge computing power resources, is usually deployed on the central cloud, and the trained reasoning model is pushed to the local reasoning module of edge cloud on demand.

- Hierarchical intelligence

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Troubleshooting and KPI optimization are two most important tasks in cloud O&M. In a distributed cloud system, faults and KPIs may be intra-cloud or cross-cloud. Edge intelligent O&M and central intelligent O&M are generated.

Edge intelligence: For example, troubleshooting, avoidance, and KPI optimization inside edge cloud are usually processed by the local intelligent O&M part of edge cloud to meet the fast and real-time response of edge cloud O&M.

Central intelligence: Cross-cloud faults and KPI optimization can only be handled by the central cloud. Multi-cloud collaboration is a major task of center intelligence. The center intelligence optimizes the KPIs through the KPIs of the large data analysis edge cloud and the factors that affect the KPIs, and optimizes the KPIs through such technical means as computing power balance, service route adjustment and QoS processing. Cross-cloud faults, for example, packet loss on cross-cloud links can be solved by analyzing the fault information of all cloud links and their associated nodes to locate the location of packet loss, so that cross-cloud linkage can be implemented.

3 Typical Industry Applications

The following describes how to use the distributed precise cloud in three typical scenarios: Private networks (industry/campus), big video, and office cloud.

3.1 Private Network (Industry/Campus)

A private network is a secure and reliable professional network, which is dedicated to providing services for specific departments or groups (such as government and vertical industries). The private network needs to be independent of the public network to ensure secure isolation and reliability of data. A private network usually uses private network addresses, and multiple distributed private networks are connected in tunnel mode. With the development of 5G and MEC technologies, the combination of traditional private network technologies, 5G and MEC technologies can further meet the mobility, service continuity, low latency, and low cost requirements of private network users. As a support cloud layer of private network services (CT/IT cloud), it needs to meet the distributed characteristics of the private network and the accurate support

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services of different branches of networks in the private network. The following figure shows a private network solution based on the distributed precise cloud.

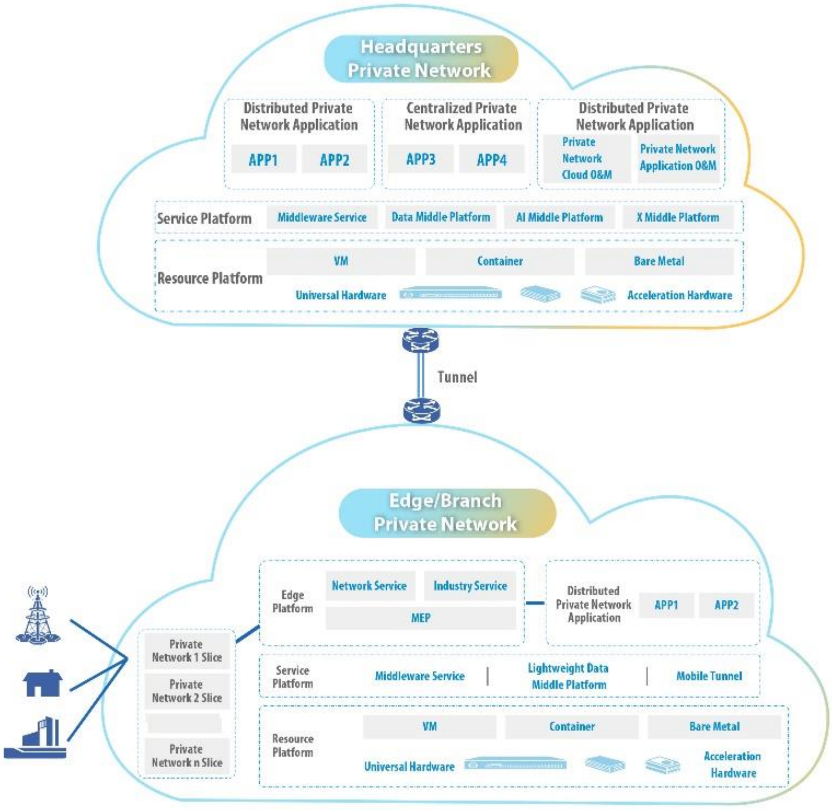

Figure 3-1 Distributed Precise Cloud Based Private Network Solution

A private network consists of an edge/branch private network and a headquarters private network, and both of them are connected through tunnels.

The headquarters private network is responsible for centralized processing and management of private network services and data. The headquarters private network is usually deployed on the IT private cloud. The private network of the headquarters is usually large in scale and provides abundant services. The private cloud of the private network needs to provide rich resource platforms and various service platforms to meet the deployment of various service applications and management applications in the private network.

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The edge/branch private network meets the mobile access requirements of private network users and the requirements of private network applications. It includes private network mobile access and private network applications. Private network applications are deployed on dedicated MEC edge cloud. The MEC edge cloud features ICT convergence cloud, and accurately meets the requirements of the edge/distributed private network in three aspects:

1. Lightweight resource platform: It is a simplified service platform, which adapts to resource limitation in case of edge deployment

2. Edge platform: It provides network services such as edge traffic distribution and specific industry services for private network applications.

3. Cross-domain 5G network tunnel: It is used to build a LAN of private network

5G network is the main network for private network users to implement mobile access. To meet the requirements of the industrial/campus private network, the 5G private network solution based on the slicing technology is usually used to achieve the isolation of services, data and QoS requirements of the industrial/campus private network, thus achieving the goal of cloud-network collaboration. The following figure shows the 5G private network solution, which usually includes three implementation modes: soft slicing, soft/hard slicing and hard slicing.

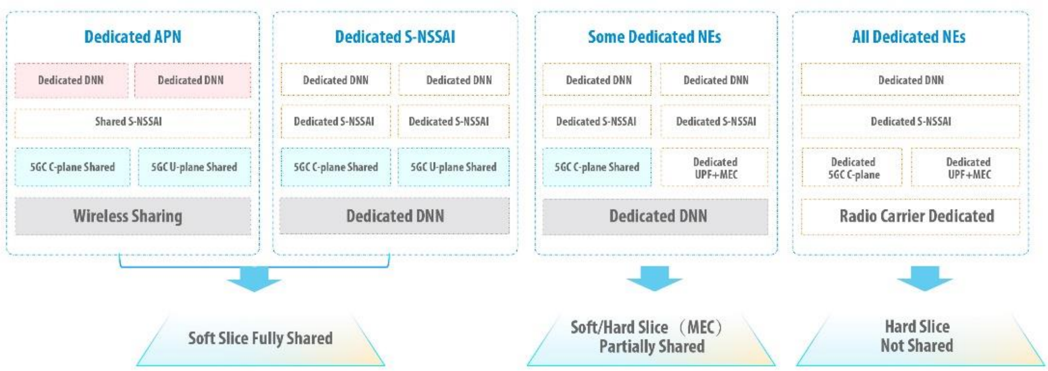

Figure 3-2 5G Private Network Solution

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3.2 Big Video

The big video service includes 4K/8K live/on-demand, VR live/on-demand, VR game, AR, and video surveillance. Video service traffic accounts for more than 60% of mobile network traffic, but will still increase in the future. This puts forward the challenges of high bandwidth (corresponding to high costs) and low latency for mobile networks. With the maturity of the MEC technology, the video service uses the edge to build a distributed video service system and balance the power of the video service. The following figure shows a typical solution for the big video service.

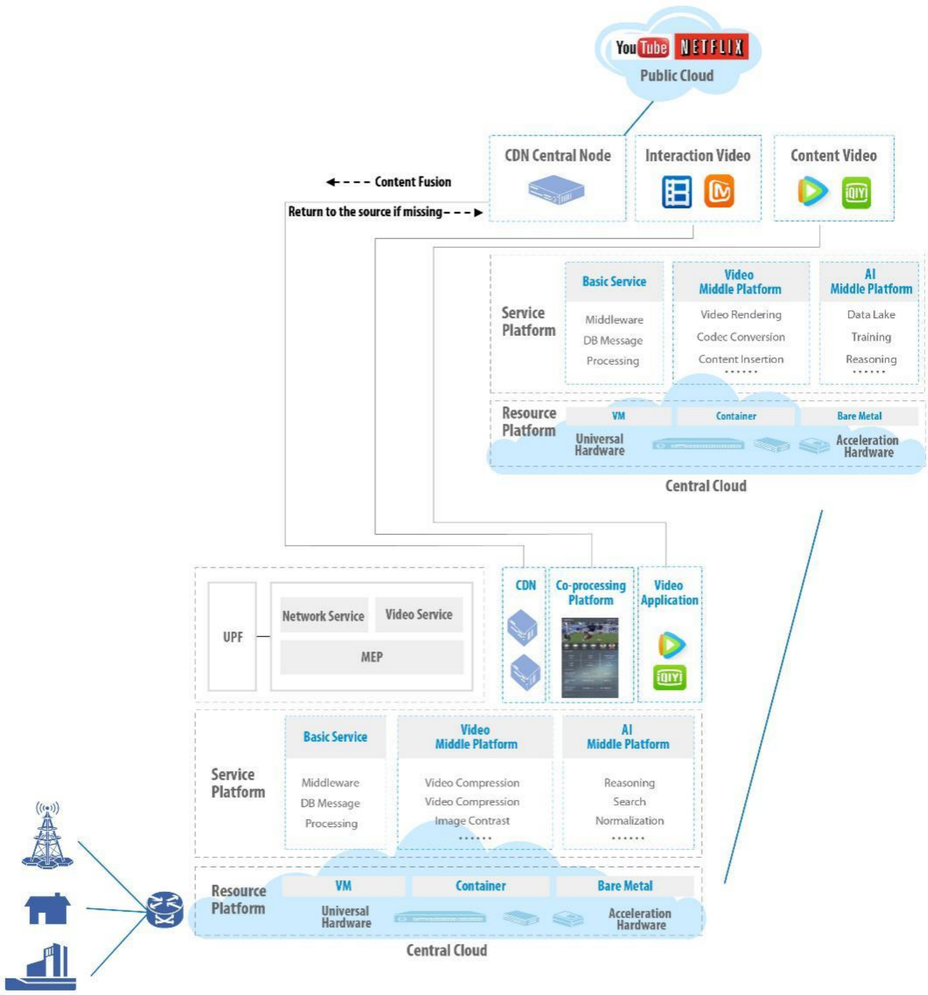

Figure 3-3 Distributed Big Video Service Solution

For content video services, CDNs and services are moved to the edge to save backbone and convergence network traffic, reduce the transmission latency of video

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services, and improve the user experience of video on-demand services. For interactive, monitoring, and live video services, the uplink service traffic is heavy, which occupies the backbone network bandwidth and increases the service processing latency. The uplink stream of these video services needs to be processed on the edge cloud, such as video compression and local proxy processing of video services.

On the edge cloud, the distributed precise cloud provides the following capabilities:

1. Video middle platform with a tailored version, such as image contrast, video stream compression, and front-end video rendering

2. AI middle platform with a simplified version, mainly providing AI reasoning capability.

3. CDN, co-processing platform for interactive/monitoring/live broadcast video services

On the central cloud, the distributed precise cloud provides the following capabilities:

1. Complete video middle platform, containing capabilities such as video codec conversion, content injection, background video rendering

2. AI middle platform with the complete version, containing capabilities such as data lake, training and reasoning.

3.3 Office Cloud

In 2020, due to the COVID-19 outbreak, many enterprises let employees stay at home and handle their work through the online platform, making "cloud office" become popular. Behind the cloud office is the way the office cloud supports. "Cloud office" is only a scenario for the office cloud. In addition to the cloud office, the emergence of the office cloud mainly solves the problems of complicated management, high costs, low security and reliability, and high energy consumption in the original office mode.

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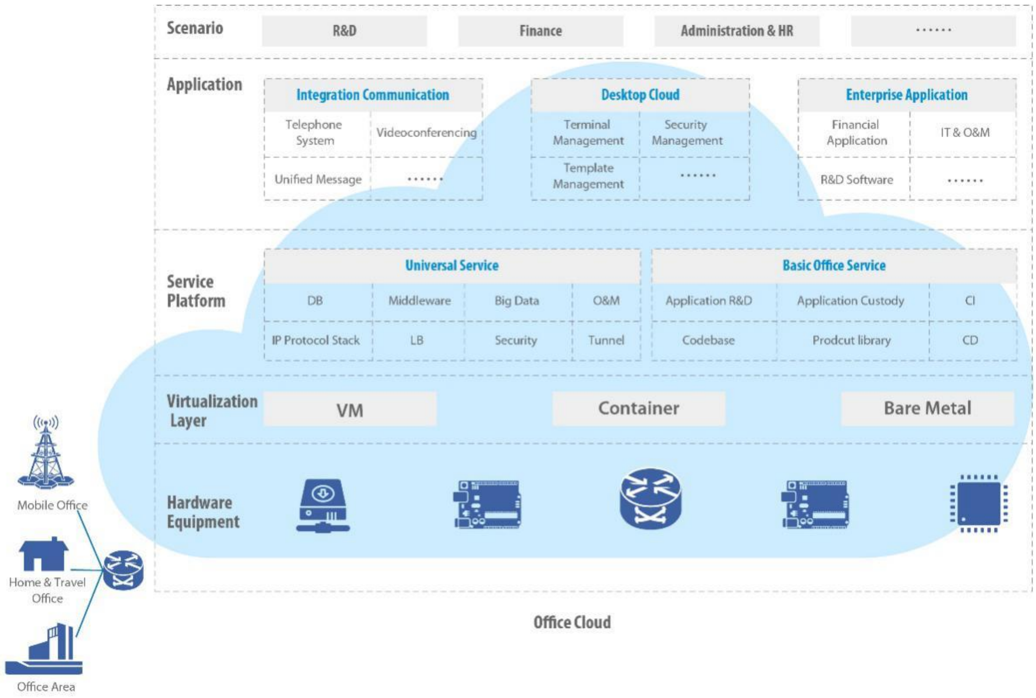

Figure 3-4 Distributed Cloud Based Office Cloud Solution

The office cloud features cloud computing first. The "cloud layer" of the office cloud, which is usually based on general servers, provides computing resources such as VMs, containers, and bare machines.

The service platform of the office cloud is tailored on the basis of the big PaaS platform. The basic general services, such as database, middleware and IP protocol stack, are kept. Some basic office services are also kept according to the characteristics of the enterprise.

The office cloud usually has some native applications, such as integrated communications applications and desktop cloud applications, and integrates some third-party applications, such as finance, IT, and R&D software, as required.

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4 Conclusion

To sum up, on the one hand, the distributed precise cloud focuses on the separated structure of telecom networks, and provides adaptive IaaS resource services based on the service features and environmental conditions in different network locations. Finally, the integrated supply, O&M, and operation of network-wide "edge", “management”, and "cloud" resources should be achieved, to make on-demand resource scheduling, efficient utilization, and quality assurance. On the other hand, it focuses on key requirements of industry scenarios. With a unified architecture, a universal industry, and service-based PaaS technology stacks, the system can quickly select and deploy services by scenario, and build customized self-service platforms for industry users to better meet the transformation and innovation requirements of different industries.

In the future, with the further in-depth integration of cloud computing and network technologies, foreseeable technical hotspots will be around the edge-to-edge collaboration and cloud-to-edge collaboration to achieve the integrated deployment of public cloud, private cloud, and edge cloud. In addition, the telecom cloud will enter the precise operation stage from the precise deployment stage: According to the multi-dimensional network characteristics (traffic, rate, latency, service level and slice type), you can further subdivide the industry customers to provide differentiated network experience and achieve precise operation.

With the rapid commercial use of 5G, the "distributed precise cloud" will surely become the binder, propellant, and catalyst of the joint development of telcos, industry users, and equipment vendors.

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5 Abbreviation

Table 5-1 Abbreviations

Abbreviation	Full Spelling
AI	Artificial Intelligence
DevOps	Combination of Development and Operations
IaaS	Infrastructure as a Service
PaaS	Platform as a Service
SaaS	Software as a Service
SLA	Service-Level Agreement
MEC	Mobile Edge Computing

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