

Huawei Core Network Autonomous Driving Network White Paper

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01

Industry Development and Challenges

1.1 5G Core Network Is the Key to Enabling a Wide Range of Industries

According to GSMA's prediction, global carriers will invest as much as US\$ 1 trillion in 5G network construction from 2018 to 2025. The global 5G network construction will be on the fast track. Compared with the 4G technology, 5G introduces key capabilities such as high bandwidth, ultra-low latency, and massive connections, providing a brand-new key infrastructure for the digital economy and further expanding the digital economy in various industries. The 5G core network is the key to enabling a wide range of industries. On an end-to-end 5G network, the core network schedules and manages global resources and manages the global network topology, all access information, all user data, and all industry requirements. The 5G core network uses dynamic intelligent network slicing to ensure that users in each industry have their own private channels on the public network. The MEC technology is used to meet the low latency requirements of the industry market to the maximum extent, ensuring data security, network security, and network quality.

1.2 Automation Is Key to Service Agility for 5G Core Network

As telecom networks are undergoing NFV cloudification transformation, technologies such as slicing and service-oriented architecture are integrated, and applications and requirements of vertical industries are diversified, telecom network O&M will face unprecedented challenges in the 5G era. Automation has become a key element for 5G core networks.

1.2.1 New Service Development Requirements

- » In the 5G era, 2B (To Business) services in vertical industries become a competitive market for carriers. To meet diversified requirements of the industrial Internet, Internet of Vehicles (IOV), and smart healthcare, carriers use the slicing technology to provide virtual networks to ensure network quality. The quick slice deployment and the DIY slice provisioning by tenants will help carriers seize the opportunity in competition. Carriers need to implement service agility and shorten the time to market (TTM) of new service deployment by using the automatic slice deployment capability.

Industry Development and Challenges

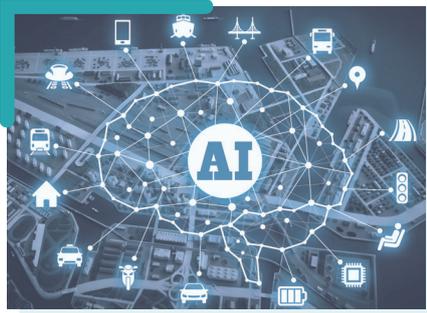
- » 2B key services in vertical industries, such as ports, factories, mines, and self-driving cars, require high network quality assurance, efficient fault location, and short network recovery time. Carriers need to improve fault locating efficiency and implement network self-healing by using the automatic O&M capability of the AI technology to meet the network quality requirements of vertical industries.
- » Diversified and flexible 5G services require various third-party tenant apps to be deployed at edge sites. Carriers need to meet tenants' requirements for frequent app deployment, upgrade, and service rollout. App management at massive MEC sites complicates carriers' management. The automatic app life cycle management capability is required to improve the operation and management efficiency.

1.2.2 Network Architecture Requirements

- » 2B services in vertical industries pose higher requirements on the network delay, which requires a significant evolution of the core network architecture. Carriers need to deploy user plane network functions at the network edge, and deploy a large number of edge sites at the network edge to meet service requirements, 100x to 1000x edge sites are widely distributed in campuses, factories, mines, and ports. Multiple site visits for installation, deployment, and O&M of massive edge sites will cause dramatic increase of labor and time costs for carriers. Therefore, the automation capability is required to improve deployment and O&M efficiency and reduce labor costs.
- » The NFV telecom cloud has operation breakpoints between planning, construction, maintenance, optimization, and operation, and requires continuous manual intervention to connect "islands of automation". Carriers need the E2E automation tool chain to build a fully automated network, providing on-demand, real-time, and agile network services for end users.

1.2.3 Requirements for New Technologies

- » The introduction of NFV, slicing, and microservices complicates the core network, increases the number of managed objects, and causes change operations. Carriers conduct hundreds to thousands of change operations every year on average. 70% of network accidents are caused by misoperations during the change process, burdening carriers heavily. Carriers need to use the automatic O&M capability based on the AI technology to reduce manual operations during the change process and implement automatic check, monitoring, and recovery.



02

Huawei Core Network Autonomous Driving Network Solution

Huawei is among the first vendors to propose the concept of Autonomous Driving Network and grading standards in the industry. The Autonomous Driving Network grading standards are defined in terms of customer experience, labor saving, and network environment complexity.

- » **L0 manual O&M:** The system delivers assisted monitoring capabilities, which means all dynamic tasks have to be executed manually.
- » **L1 assisted O&M:** The system executes a certain repetitive sub-task based on pre-configured rules to increase execution efficiency.
- » **L2 partial autonomous network.** The system enables closed-loop O&M for certain units under certain external environments, lowering the bar for personnel experience and skills.
- » **L3 conditional autonomous network.** Building on L2 capabilities, the system with awareness can sense real-time environmental changes, and in certain network domains, optimize and adjust itself to the external environment to enable intent-based closed-loop management.
- » **L4 highly autonomous network.** Building on L3 capabilities, the system enables, in a more complicated cross-domain environment, analyze and make decision based on predictive or active closed-loop management of service and customer experience-driven networks. Carriers can then resolve network faults prior to customer complaints, reduce service outages, and ultimately, improve customer satisfaction.
- » **L5 fully autonomous network,** This level is the ultimate goal for telecom network evolution. The system possesses closed-loop automation capabilities across multiple services, multiple domains, and the entire life cycle, achieving autonomous networks

Huawei's autonomous driving network hierarchy provides a measurable and practical guide for carriers to evolve their existing networks to autonomous driving networks. The practice of key scenarios should follow the gradual evolution strategy from point and line to plane. The focus should be shifted from the NE-oriented automatic equipment management to the all-scenario automation. In this way, the goal of E2E autonomy of the core network can be achieved.

2.1 Huawei Core Network Autonomous Driving Network Solution Concept

As a world-leading 5G commercial solution provider, Huawei has launched the iMaster series of intelligent O&M products and solutions for autonomous driving networks. With a view to providing the shortest TTM/TTR in the industry and best customer experience, Huawei iMaster MAE-CN, an intelligent O&M solution of core network autonomous driving network, is deeply integrated with AI, data native, and automation technologies in the communications field based on its technical advantages in the 5G core network and in-depth understanding of O&M services.

As an innovative solution integrated with multiple products and professional service tools in the core network management domain of Huawei, it enables visibility, manageability, and traceability of network-wide data assets, introduces artificial intelligence (AI) technologies such as intelligent analysis, model training, AI inference, and intent insight. On the basis of the automation capabilities of the orchestratable workflow, an E2E autonomous core network is constructed, helping carriers construct the autonomous driving 5G core network.

With an open, cooperative, and win-win mind, Huawei actively participates in and promotes the formulation of ADN-related standards and regulations, and contributes to open source technologies. This facilitates the booming development of the 5G industry, helping customers usher in a new intelligent era of connectivity of everything.

2.2 Huawei Core Network Autonomous Driving Network Solution Concept

In the 5G era, differentiated network service requirements and experience assurance are not only the core competencies of carriers but also the main trend of 5G core network autonomy. iMaster MAE-CN, Huawei's intelligent O&M solution of core network autonomous driving network, is dedicated to minimizing TTM and TTR in the industry and providing best customer experience.



- **Intelligent O&M management**

To cope with complex issues such as co-existence and coordination of various 5G network standards, NFV cross-layer fault locating, and differentiated SLA requirements for industry applications, the AI-based intelligent O&M helps operators establish a timely preventive and proactive O&M mechanism to improve the network service quality and experience while maintaining the overall OPEX smooth.

- **Agile service provisioning**

Fast rollout and provisioning of diversified services (such as high-bandwidth, large-scale connections, ultra-high reliability, and low-latency applications) are supported. For example, fast network slice release and rapid rollout of edge computing nodes.

- **Visible and manageable assets**

At any stage of communications network evolution, even at a completely autonomous level, people must have the highest emergency intervention permission on a network, and the capability of unified O&M management of assets (such as network services, VNF/VNC, virtual resources, physical resources, and SDN resources) over the entire network.

- **Optimal resource efficiency**

On-demand and dynamic allocation of network virtualization resources and optimal scheduling of resources from a holistic perspective are supported.

- **Evolving AI applications**

AI applications in communications networks are gradually developed and evolved. A systematic AI framework that supports evolution is required to adapt to continuous self-learning and evolution capabilities of AI and finally help achieve ubiquitous network intelligence.

2.3 Huawei Core Network Autonomous Driving Network Solution Architecture

To address the O&M challenges brought by 5G networks, Huawei has launched the industry's first intelligent O&M solution of 5G core network autonomous driving network, iMaster MAE-CN, that features cloud-edge collaboration, hierarchical autonomy, and integrated management and control. It is developed based on key technologies such as automation, data native, and AI, helping carriers build agile, intelligent, and simplified 5G core networks.

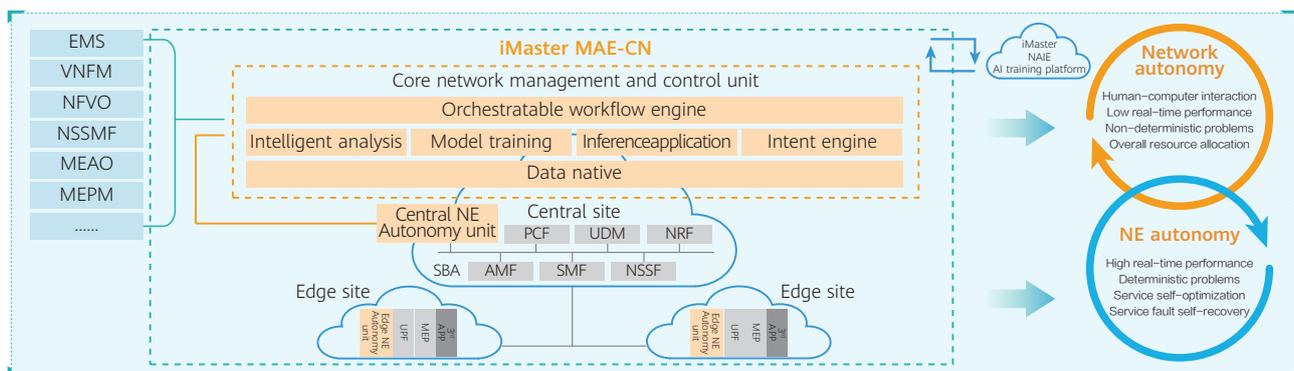


Figure 2-1 iMaster MAE-CN overall framework

The 5G core network adopts a service-oriented distributed cloud architecture. iMaster MAE-CN integrates NE management and service control capabilities and deploys functions from the center to the edge on demand, implementing hierarchical autonomy of cloud-edge collaboration.

- » **Integrated management and control:** The management domain modules (EMS, VNFM, and VIM) and the orchestration domain module (NFVO) in the cloud-based network are integrated, and the service self-discovery and VNFC topology management capabilities provided by the NRF are introduced, thereby enhancing an execution unit in a closed-loop control process. The network can dynamically and flexibly adjust network services, configuration parameters, and virtual resources according to business intentions or intelligent policies.
- » **Cloud-edge collaboration:** The central or edge NE autonomy unit and the core network management and control unit work in a hierarchical and collaborative manner to jointly implement E2E closed-loop control based on the generation, optimization, and execution of policies.
- » **Network autonomy:** The core network management and control unit is located at the top layer of the network. It provides functions such as user intention insight, centralized training and reasoning of global policies, and network closed-loop control, implementing low real-time network autonomy.
- » **NE autonomy:** The closed-loop autonomous system in the central or edge NE autonomy unit analyzes the collected network data in real time, and quickly performs NE-level closed-loop control (such as resource scheduling and parameter adjustment) based on a pre-set policy, thereby implementing high real-time NE autonomy.

iMaster MAE-CN enhances capabilities in three aspects (data native, orchestratable workflow engine, and AI engine), combines the two-layer closed-loop autonomous system of the 5G core network, and introduces corresponding automation and intelligence capabilities at different network layers to implement E2E autonomy of the 5G core network.

- **Data Native**

Data native is fundamental to AI applications and automation. It is required to be able to sense, obtain, unify, aggregate, and associate network status, service process, and user behaviors on the entire network to form shared and unified network data assets, supporting AI model training and closed-loop policy triggering. In addition, the data asset topology of the entire network can be displayed horizontally (cross-service) and vertically (cross-layer), helping operators observe and monitor the service running of the entire network.

- **Orchestratable workflow engine**

The orchestratable workflow engine aims to realize more automatic and less human-intervened operations. The workflow mechanism can be used to schedule and orchestrate atomic processes and quickly implement automatic closed-loop management in different scenarios (such as NE upgrade and configuration optimization) during network O&M. The AI-based orchestratable workflow engine, on the basis of network O&M experts' experience library, provides optimal network O&M policies through network self-learning, to ensure continuous process optimization.

- **AI Engine**

The AI engine introduces the AI technology represented by machine learning, and constructs an independent AI training platform (Cloud AI) outside the existing network for data lake services, training services, and related tests, and for AI model outputting. The core network management and control unit constructs a local network AI engine (Network AI) to control network behaviors based on models and policies. The result data of network behaviors is collected again for local model re-training, model optimization, policy update, and local inference, implementing network-level closed-loop control. In addition, the core network central or edge NE autonomy unit constructs an AI inference unit (Site AI), and implements high real-time NE-level closed-loop control based on the specified model or policy delivered by the Network AI.



iMaster MAE-CN always attaches importance to enhancement of intelligence and automation capabilities. It enables networks to be dynamically and flexibly adjusted based on carriers' business intentions or injection policies. Network challenges (such as network faults, SLA exceptions, and performance deterioration) can be detected in real time and closed-loop control is driven through policies to autonomize networks.

Typical Usage Scenarios



03

Typical Usage Scenarios

3.1 5G Slices

Huawei's core network autonomous driving network solution provides E2E automation capabilities for 5G slices, helping carriers implement automated slicing management, facilitate fast service provisioning for industry tenants, offer template-based slice design and orchestration, one-click slice deployment, and automatic SLA monitoring and assurance, thus managing the entire life cycle of slices.

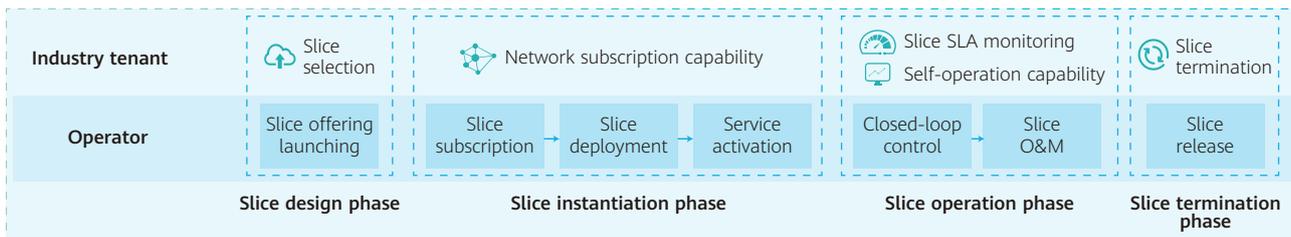


Figure 23 Automatic Network Slice Management

- » **Slice design:** 5G slicing is oriented to massive vertical industries. Requirements vary in different industries for network functions and SLA levels. Therefore, it is important to customize 5G slices for each industry in the design phase.
- **Coping with differentiated requirements of various industries:** Based on Huawei's deep understanding and insight of entire industry chain, three fundamental 3GPP-defined network slice types are used to design 10-plus slicing templates that can closely meet the typical communications service requirements of various industries. These templates reflect the common requirements of a specific industry and offer differentiated options that might concern. Operators can use these templates directly to design slice products for different industries or perform differentiated design based on these templates.
- **Graphical online design in drag-and-drop mode:** Capabilities of slicing template customization in the flexible and efficient way are provided to improve operation efficiency through simple graphical user interfaces (GUIs). Carriers can customize some differentiated functions based on the basic template to quickly design a new template. They can also customize a slice template based on the abundant atomic capabilities of network connection provided by Huawei and specific requirements of various industries.

- >> **Slice provisioning:** Agile response to market requirements is the core competitive edge of various industries. The core value of slicing is the ability to provision or change slicing services in days or even hours. Huawei's core network autonomous-driving network solution builds models of self learning for slicing services and fully automates the whole process from slice subscription to provisioning, achieving quick TTM of new services in various industries.
- **Deployment upon subscription:** After an SLA from an industry customer is received, the required slice network topology, slice resource model, service configuration model, and slice network link model are generated through automatic online orchestration. Based on these models, slice network instances and slice service instances can be deployed and enabled automatically.
- **Provisioning upon deployment:** After slice instances are deployed, the online tool platform automatically completes slice functions and SLA acceptance tests, implementing slice service deployment and provisioning.
- >> **Slice O&M:** Compared with traditional networks, objects and complexity of slice O&M vary greatly, posing higher requirements on O&M personnel. To make O&M efficient, automatic and intelligent slice monitoring and automatic SLA closed-loop are a must.
- **Automated and intelligent of slice SLA monitoring:** Based on Huawei's global network O&M cases, a model of mapping between slice experience and network KPIs is constructed. In addition, live network data is used to continuously improve the accuracy and predictability in abnormal scenarios, implement early intelligent prevention and identification of slice SLA exceptions and degradation, and automatically push exception reports.
- **Automatic close-loop of slice SLA deterioration:** Based on intelligent monitoring of user-level or session-level experience, SLA degradation items and root causes can be accurately identified; Automatic scaling of slices can allocate dynamic slice resources properly and provide real-time response to resource requirements in seconds; As the SLA assurance center based on self-learning policies, the cross-domain SLA optimization process can be triggered by the policy to implement the slice E2E optimization measures.

3.2 MEC

Huawei's core network ADN solution supports plug-and-play of MEC edge devices and fast rollout of third-party apps. With centralized management and O&M capabilities, this solution enables fast site deployment, as well as single-site innovation and network-wide replication.

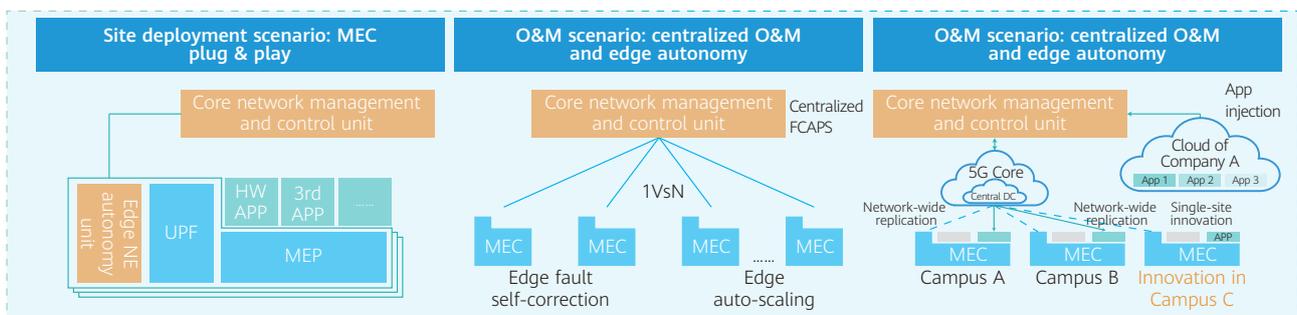


Figure 3-2 MEC applicable scenario

Typical Usage Scenarios

- **Automatic MEC site deployment**

Network connections are established, edge NEs are managed, and site service configuration, testing, and rollout are completed automatically. Devices are plug-and-play, reducing installation and deployment costs. Services can be provisioned during one-time site visit, shortening the site rollout duration from weeks to days.

- **Centralized O&M and edge autonomy**

The core network management and control unit centrally manages edge sites, monitors all MEC devices globally, and supports remote upgrade and policy delivery in batches, reducing O&M costs caused by frequent local site visits. In addition, edge sites can be scaled automatically (quick response to service adjustment requirements) and perform self-recovery based on user-defined policies (for example, when edge sites are not managed, some faults can be quickly self-recovered).

- **Flexible app rollout**

During app upgrade and deployment, apps can be quickly deployed in navigation mode by app providers, which greatly lowers the learning costs and skill requirements of operating personnel. After an app is deployed, the app software, traffic distribution rules, and policies are managed in a centralized manner. Apps can be manually specified and copied to other sites with one click. Apps can also be automatically copied to other sites based on user-defined deployment policies, achieving “Single-site Innovation, and Network-wide Replication”.

3.3 Workflow Orchestration

Huawei’s core network ADN solution introduces a powerful engine which enables workflow orchestration based on atomic operations under different scenarios during the live network operation process to form flexible workflows and implement them automatically. This greatly improves the work efficiency and shortens the service TTM.

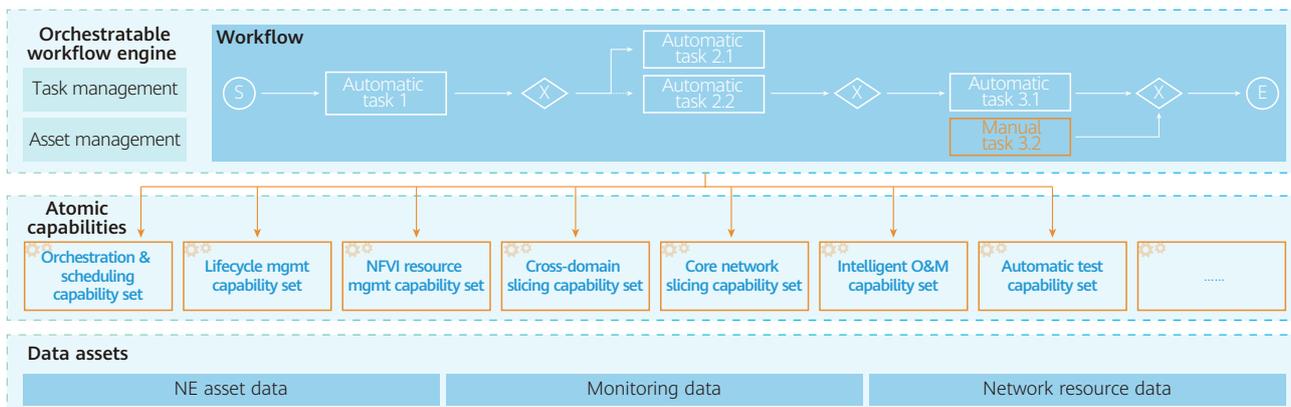


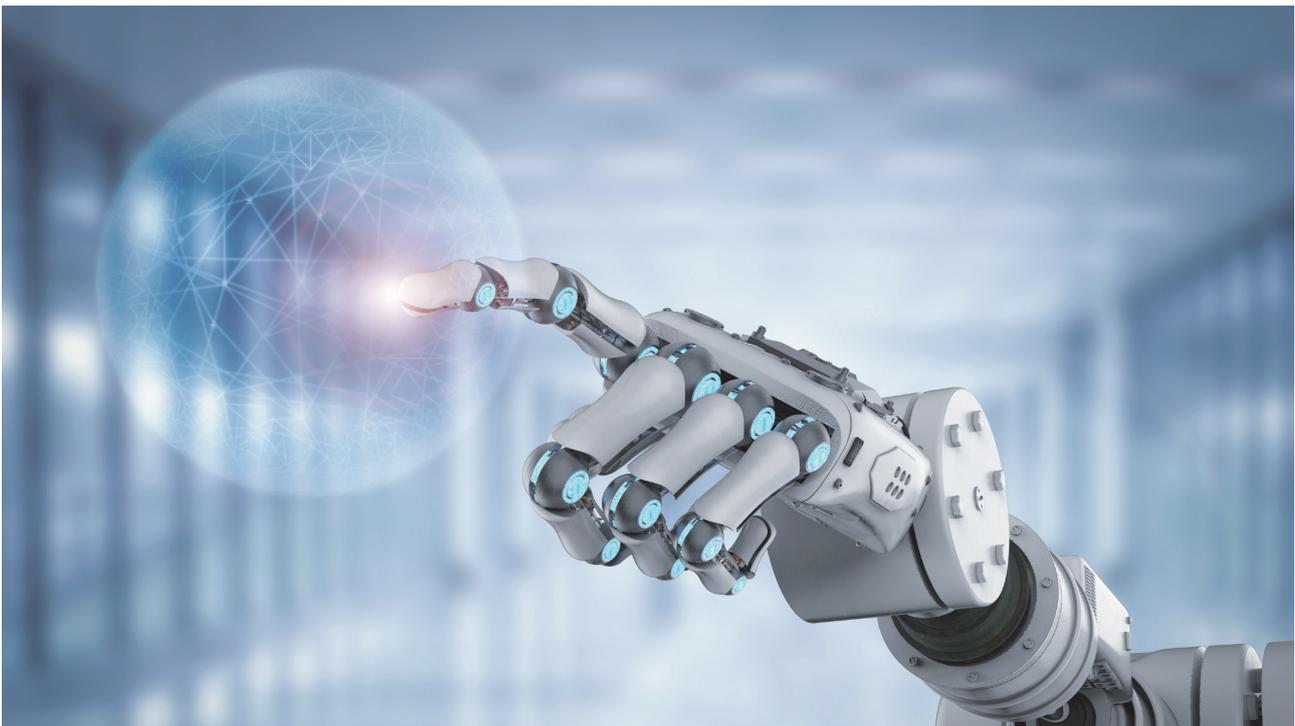
Figure 3-3 Atomic capability-based orchestration workflow

- **Abundant atomic capabilities:** Various atomic capabilities are provided including the atomic capabilities of components in the management domain (such as NFVO, VNFM, EMS, VIM, MEAO, NSMF, and NSSMF) and those of professional tools (such as intelligent O&M and automatic test), facilitating flexible orchestration and supporting workflow automation in various complex scenarios.
- **Orchestrated workflow:** A user-friendly workflow design GUI allows users to quickly create customized workflows by the drag-and-drop gesture, helping customers customize processes rapidly. The workflow execution process is visible. Customers can view the procedure and status of the work flow so that abnormal operations can be easily detected and located.
- **Automation test:** As one of the most important atomic capabilities, automation test is key to improve the work efficiency of carriers. It supports multi-location and multi-point automatic service path traversal tests based on actual environment and service simulation, 24/7 service SLA evaluation, automatic collection and analysis of test results, and test report generation.

3.4 Intelligent O&M Scenario

As 5G services and NFV/SDN technologies are used, the core network becomes more complex, featuring more frequent services change and potential faults. On average, carriers perform hundreds of to thousands of change operations every year. 70% of accidents are caused by changes, which brings great challenges to carriers.

To address the challenges facing the telecom industry, traditional O&M is far from enough. Huawei's core network ADN solution introduces AI to the telecom network, creating the value of predictability. O&M is performed from passively to proactively so loss can be prevented in time before the fault impact increases.



Typical Usage Scenarios

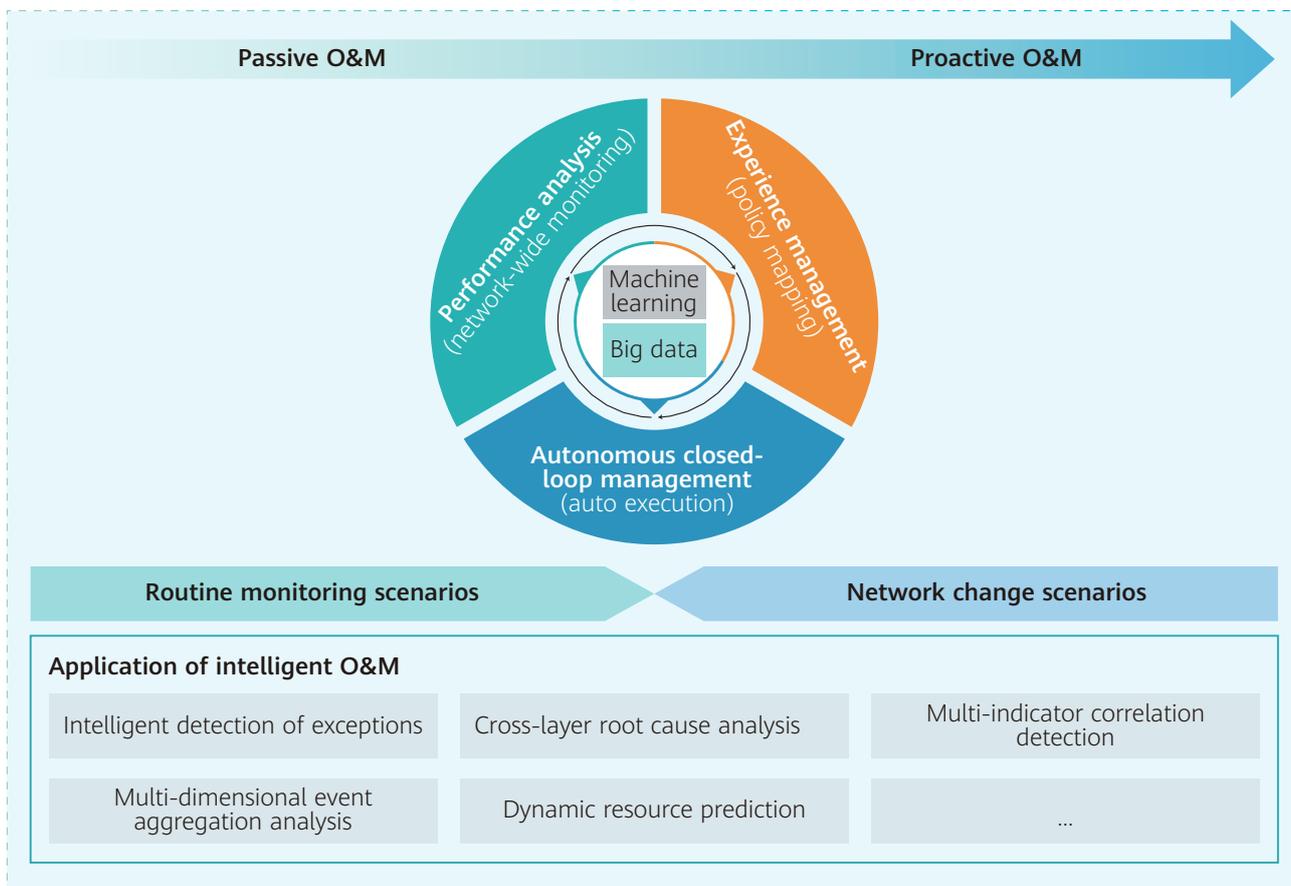


Figure 3-4 Intelligent O&M capabilities

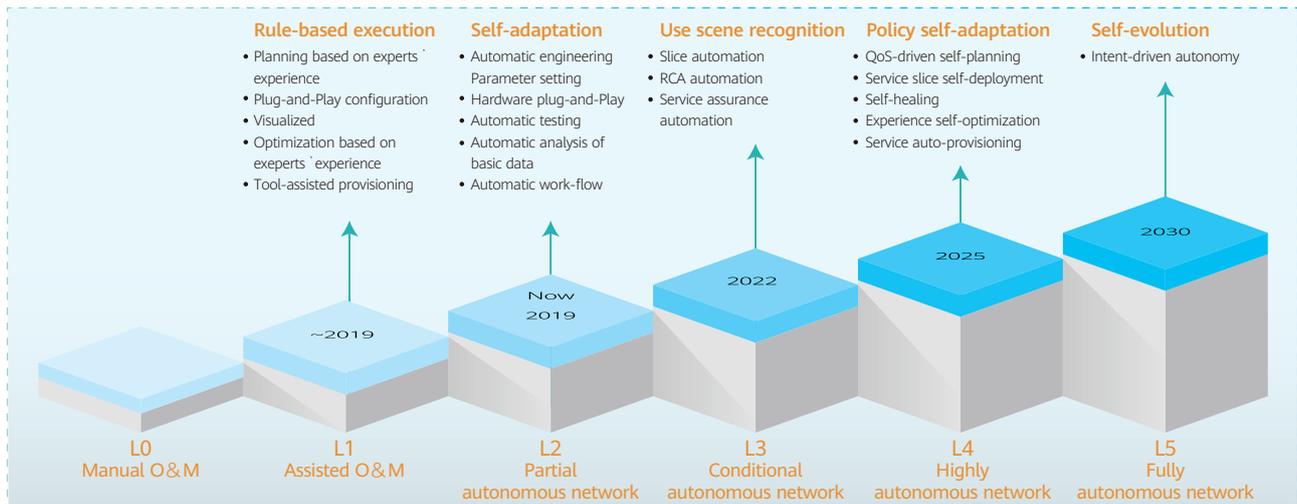
- » **Daily Monitoring:** Traditional O&M and fault identification methods are insufficient. Faults can be located only after VNF alarms are triggered by KPI deterioration or user complaints are caused, which is inefficient, time-consuming, and error-prone. The Huawei core network autonomous driving solution continuously learns historical KPI data, sets and maintains massive dynamic KPI thresholds, reduces labor costs, improves detection accuracy, and identifies exceptions in the sub-optimal health state before faults occur. In addition, the incident-based multi-dimensional event correlation detection and analysis allows users to quickly implement fault demarcation and root cause analysis based on the time and space correlation.
- » **Network change:** In the 5G era, versions are released more and more frequently, and a large number of changes (such as upgrade, cutover, and configuration change) are involved. As a result, fault risks are greatly increased. The Huawei core network autonomous driving solution offers "three lines of defense" before, during, and after a change so that it can detect and prevent problems caused by 40% changes in advance. The online health check is performed before the change, and preparation and operation are carried out according to specifications. For exceptions during the change and attendance, multi-dimensional event aggregation analysis together with root cause analysis is used to quickly demarcate faults and prevent problems that may be caused by the change in advance, and implement intelligent online machine attendance.



04

Evolving to Be Mature and Autonomous

Autonomous driving with communications networks is a long-term process of gradual evolution. Following the technical development trend in the industry, Huawei has drawn up the blueprint for the 5G core network autonomous driving network in the long term.



- » **2019 to 2022:** Focus on building L3 conditional autonomous networks. With the AI technology as the core, key capabilities such as one-click network planning and design, integrated deployment, acceptance test, automatic and flexible deployment, and automatic service rollout are integrated to achieve conditional autonomous networks core networks.
- » **2022 to 2025:** Focus on building L4 highly autonomous networks. Building on L3 automation capabilities, the network enables self-decision-making in all scenarios and accurate predication of network capacity. During optimization and maintenance, the network can perform self-monitoring, fault self-discovery, self-diagnosis, and self-recovery. Manual intervention is only an auxiliary method.
- » **2025 to 2030:** Gradual evolution to L5 full autonomous networks. Based on L3 and L4 technologies and tested by the carrier market, the network will gradually evolve to be the intent-driven core network of full automation.

With an open mind for win-win cooperation, Huawei is willing to work with global carriers and partners to promote the development of 5G core network autonomous driving networks, achieve the intent-driven network of full autonomy, and contribute to the booming 5G industry.





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