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HUAWEI

ADN Solution White Paper

(Autonomous Driving Network)

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Telecom ADN Exploration and Practice

Opportunities and Challenges in Telecom Network Development

The human race is in constant pursuit of advanced productivity. Each technological revolution throughout human history has been an iteration in productivity and driven society to a new era. Over the past 120 years, the Industrial Revolution, Electricity Revolution, and the information Technology Revolution have been the three breakthroughs in human civilization. Now, a new revolution is emerging, known as the Fourth Industrial Revolution. Driven by artificial intelligence (AI), 5G, and cloud computing, this revolution will create a world where all things are sensing, connected, and intelligent.

Looking ahead to 2025 and the industry development trend, Huawei expects that the requirements for high bandwidth, low latency, and wide connectivity will drive the commercial use of 5G. Huawei Global Industry Vision (GIV) predicts

6.5 million

6.5 million basestations will be deployed

2.8 billion

serving 2.8 billion users

58%

58% of the population using 5G services

The default status of everything and everyone will become "24x7 online real-time". In addition, the intelligent cloud and cloud-edge synergy technologies will become the basic environment for social running.

Enterprise applications developed on the cloud will account for 85%.

Wireless factories will continue to evolve and develop, and intelligent automation will be widely used in construction, manufacturing, healthcare, and other fields.

By 2025, 180 ZB of data will be generated worldwide every year, and as AI algorithms and machine learning continue to improve along with the steady enrichment of industry data.

97% of large-scale enterprises will use AI technologies to enable services and management.

Together with new technologies such as IoT, ICP, GIS, and Big Data, "5G + cloud + AI" build the digital platform and digital capabilities, which form a foundation from which enterprises can implement intelligent upgrade. The telecom industry is an integral part of the intelligent society and committed to promoting its development.

As everything becomes connected and intelligence is converged, the telecom industry faces new challenges, as well as new opportunities, in terms of ICT investment. An analysis by Ovum shows that the telecom industry's revenue growth has never outperformed the OPEX growth over the past decade. As the network scale continues to expand, the OPEX increases rapidly, and the industry structural contradiction becomes increasingly prominent.

Network Complexity

Telecom networks are becoming more and more complex. For example, 2G, 3G, 4G, and 5G form an overlay wireless network, and 10 domains such as CS, PS, IMS, and IoT co-exist in the core network.

Manual operations

Network O&M in this case is dominated by manual operations, which therefore results in high costs. Huawei technical support analyzed more than 1800 typical O&M activities it performed, revealing that manual intervention is required for 95% of the process and job nodes. Taking home broadband as an example: in customer complaint handling process, 15 steps within the process and more than 100 alternate process paths rely on manual analysis and decision-making assisted by isolated auxiliaries, which requires a large operations and maintenance team.

Continued growth in infrastructure construction

As the number of connections increases, the bandwidth grows rapidly, and the construction of telecom infrastructure accelerates. This in turn poses stringent requirements on balancing asset utilization and improving energy efficiency to obtain the optimal TCO. Taking base stations and equipment rooms as an example, a major influence on minimizing TCO is to reduce energy consumption and improve resource utilization.

Poor monetization

Although the business scale and data availability in the telecom industry are extensive, its business monetization capability is poor. The industry lacks differentiated products and customer service capabilities. It also struggles to implement network SLA assurance. Service freezing, intermittent disconnection, and poor quality caused by network congestion frequently occur, and user complaints cannot be handled promptly or accurately.

Slow innovation and introduction of new services

Compared with OTT services, the convergence and innovation of new services is slow. For example, the telecom industry takes more than 12 months on average to roll out a new service. Conversely, AWS launches more than 300 new services per year, averaging 10 new services each week.

Facing these challenges, the telecom industry needs to leverage intelligent technologies to promote the evolution of network architecture and O&M. It also needs to move towards the autonomous driving network (ADN) era of man-machine collaboration, and continuously drive the intelligent upgrade in the industry.

Industry's ADN Exploration and Practice

The telecom industry continuously strives to explore digitalization, automation, and intelligence. When transformation was first considered, the telecom industry started from customer services and product service layers. It then gradually extended to the internal management and operation layer and onward to the network layer. As early as 2011, the telecom industry attempted to improve service and network agility, while reducing costs and complexity, by using SDN, NFV, and cloud technologies.

SDN

A series of explorations were conducted on SDN in terms of data center automation, WAN optimization, and SD-WAN. The driving force for carriers to deploy SDN has been their desire to implement network automation.

NFV

NFV improves resource utilization through solutions such as vIMS, vEPC, and vCPE, and promotes efficient product development through the DevOps process and CI/CD toolchain.

However, SDN/NFV-based network automation will not be able to completely resolve the problems caused by the large-scale deployment of different applications and the introduction and expansion of new network technologies in the future. The industry is still facing the challenge of how it can improve efficiency E2E on a large scale and continuously introduce new technologies and services.

Against this backdrop, ADN is emerging. It attempts to drive the telecom industry from digitalization to intelligence by applying multiple intelligent technologies and leveraging the advantages delivered by convergence. This will have a profound impact on the production and operational modes, as well as the skills and thought processes of personnel, across the entire telecom industry.

> Gartner points out that a major catalyst for automation and empowered human capabilities is AI technology.
>
> 
>
> Gartner

AI is evolving from perceptual intelligence to cognitive intelligence. In the next 10 years, technologies such as neural networks, knowledge graph, and domain migration will make it possible to achieve system autonomy in telecom networks. Combining AI with other technologies can significantly improve O&M efficiency. It can replace manual operations that were once required to solve large numbers of repeated and complex computing tasks in the telecom field. It can also improve telecom network prevention and forecast capabilities based on big data volumes. These data volumes provide insight into better understanding customers and drive differentiated product services, enabling highly automated and intelligent telecom network operations.

In May 2019, the TM Forum, together with Huawei, China Mobile, Orange, BT, Telstra, and Ericsson, jointly released the industry's first ADN white paper.

This white paper proposes a three-layer framework and four closed-loop for single-domain autonomy and cross-domain collaboration, as shown in Figure 1-1. The paper also delivers an architectural blueprint for carriers' digital transformation, providing top-level architectural references for practices and cooperation of all parties in the telecom industry. Carriers can build a path to a network that can provide highly customizable on-demand communication services for today's and tomorrow's agile enterprises.

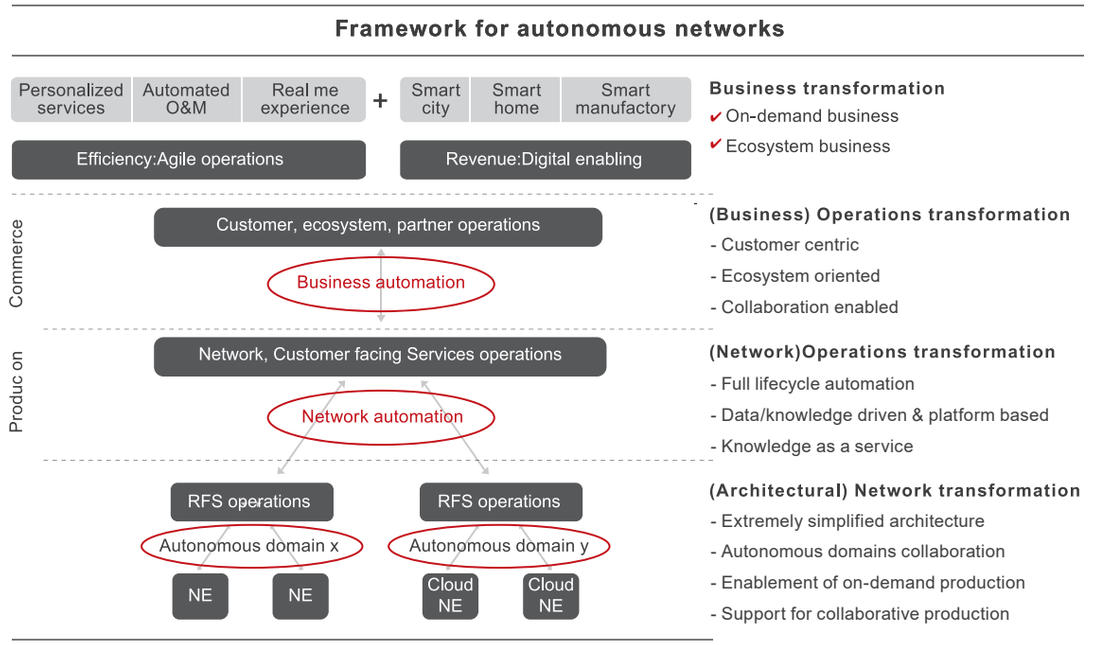


Figure 1-1 Target architecture of TMF ADN

The white paper further defines the conceptual criteria of ADN L1 to L5, and provides a set of high-level references for progressive evolution, as shown in Figure 1-2.

Autonomous networks levels

Level Definition	L0: Manual Operation & Maintenance	L1: Assisted Operation & Maintenance	L2: Partial Autonomous Network	L3: Conditional Autonomous Network	L4: High Autonomous Network	L5: Full Autonomous Network
Execution	P	P/S	S	S	S	S
Awareness	P	P	P/S	S	S	S
Analysis	P	P	P	P/S	S	S
Decision	P	P	P	P/S	S	S
Intent/ Experience	P	P	P	P	P/S	S
Applicability	N/A	Select scenarios				All scenarios

P: Personnel, **S:** Systems

Figure 1-2 Five-level definition of TMF ADN

- **Level 0-manual management:** The system delivers assisted monitoring capabilities, which means all dynamic tasks have to be executed manually.
- **Level 1-assisted management:** The system executes a certain repetitive sub-task based on preconfigured to increase execution eciency.
- **Level 2-partial autonomous network:** The system enables closed-loop O&M for certain units based on AI model under certain external environments.
- **Level 3-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.
- **Level 4-high 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.
- **Level 5-full 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 lifecycle, achieving autonomous networks.

In October 2019, GSMA and its partners, such as China Mobile, China Telecom, and China Unicom, and Huawei, jointly released the Intelligent Autonomous Network Case White Paper. This white paper focuses on how to introduce AI on demand and gradually promote ubiquitous intelligence of networks. It further describes the application characteristics and key points of AI technologies in the three-layer architecture. It also presents practices and cases of applying AI technologies to mobile network solution, maintenance, optimization, service assurance, energy saving and efficiency improvement, security protection, and network operation services. AI technologies are gradually becoming mature.

Tractica/Ovum predicts that, by 2025, the telecom industry worldwide will invest US$36.7 billion in AI software, hardware, and services.

The overall market value of AI use case software in the telecom industry will increase from US$315.7 million to US$11.3 billion in 2025, with a compound annual growth rate of 48.8%, quickly propelling the industry to become the world's largest AI application industry.

It is expected that 2021 will be a turning point of network automation, driven by the large-scale deployment of SDN, NFV, and 5G. According to IDC statistics, 63.5% of telecom organizations are investing in AI to improve their infrastructure construction. This investment focuses on the following AI application scenarios:


network and IT operation monitoring and management


intelligent CRM system


customer service and marketing VDAs


customer experience management improvement


cyber security analysis

Of these five scenarios, network and IT operation monitoring and management will become the largest, accounting for 61% of the telecom industry's expenditure in AI from 2016 to 2025.

In summary, ADN has become a common area of focus for all players in the telecom industry to explore and practice. It has a wide range of applications and business values, and with all players working together to achieve a common goal, ADN will transform from a vision to a reality.

Huawei's ADN Exploration and Practice

2012 — **Established the future network lab**

Huawei established a network lab in 2012 to research and innovate future network architecture and continuously carry out joint innovation and practices with global customers.

2013 — **Released the SoftCOM strategy**

Derived from the research on the impact of SDN/NFV and cloud to future network architecture, Huawei established "All Cloud" strategy based on SoftCom (Software defined network + Telecom) concept. This value-driven strategy aims to use new technologies to put devices, networks, services, and operations to the cloud. It aims to help carriers implement digital transformation, agile services, and efficient O&M, and achieve data center-centric networks.

2014 — **Launched NFV solutions**

The following year, Huawei launched the SoftCOM-based CloudCore and Cloud-Edge NFV solutions.

2015 — **Released the SDN controller**

Then in 2015, Huawei launched the Agile Controller3.0 for SDN. Huawei is actively advocating and leading cloudification in a new direction. To date, Huawei's All Cloud solutions and products have been deployed commercially for carriers in more 100 countries, 680 NFV sites, 1000 data center networks, and 200 SD-WAN networks.

2016 — **Released the All Cloud strategy**

As AI technologies become mature, Huawei has conducted research and exploration of the impact AI has on the network architecture since 2016.

April 2018 — **Proposed AI-powered autonomous network**

In April 2018, Huawei first proposed the concept of "AI-enabled autonomous network", introduced AI technologies based on the All Cloud network architecture, and released the SoftCOM AI solution architecture. Huawei strives to build an autonomous network that is automated, self-optimized, self-healing, and "always healthy".

October 2018 — **Took the lead in launching intent-driven network (IDN) solution**

In the Ultra-Broadband-Forum (UBBF), Huawei first claimed that in the era of intelligent everything, the telecom network has to become an autonomous driving network. Huawei took the lead in launching intent-driven network (IDN) solution in the fixed network domain covering broadband access, IP, optical, data center, and enterprise private line networks. This helps carriers and enterprises implement service experience-centric digital network transformation.

November 2018 — **Released the Autonomous Driving Mobile Network White Paper**

At the Global Mobile Broadband Forum in November 2018, Huawei released the ADN White Paper, which recommends that network automation be implemented in seven sub-scenarios, such as base station deployment and network energy saving. The release of this white paper clearly demonstrated that Huawei is the first to innovate and implement the ADN strategy in multiple fields including the fixed network and mobile network.

April 2019

Released the Telecom ADN Communications Intelligence White Paper

In April of the following year, Huawei started to provide a one-stop AI development platform and commercial trial for carriers to accelerate the application of AI technologies in telecom networks. This platform is designed to help telecom developers overcome difficulties throughout the entire AI development process, including data preparation, model training, model release, and deployment verification. At the same time, Huawei released the Telecom ADN Communications Intelligence White Paper, which describes the AI application scenarios and pace at the infrastructure layer, network device layer, and service bearer layer. In addition, Huawei announced its exploration and planning of a 5G + AI combination. Huawei will apply AI throughout 5G network life-cycle: planning, construction, optimization, and maintenance to achieve intelligent 5G.

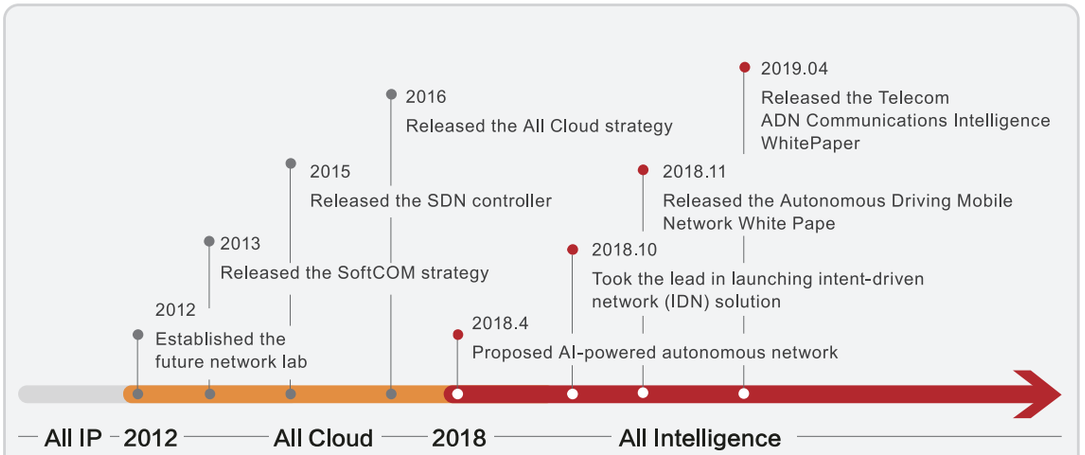


Figure 1-3 Huawei's ADN exploration process

From the All Cloud strategy to the ADN strategy, Huawei continues to explore new network architectures, O&M modes, and business models. It is committed to becoming an explorer, innovator, and leader of future networks and promoting intelligent upgrades and intergenerational evolution of the telecom industry.

Huawei's ADN Strategy and Architecture

Huawei's ADN Strategy

Huawei's ADN strategy (ADN) is a 10-year strategy following Huawei's All Cloud strategy. It aims to research the impact of AI technologies on future network architectures, O&M modes, and business models by integrating multiple intelligent technologies, such as: SDN, NFV, cloud, big data, AI, and the knowledge graph. Huawei will conduct architectural innovation to solve the structural TCO problems of telecom networks and drive the intelligent upgrade of the telecom industry. Huawei will also proactively participate in, promote the development of, and share the dividends of, service innovation in the intelligent society. The strategy will revitalize the telecom industry, attract new talent to the industry, and promote healthy and sustainable development of the industry.

short–term and mid–term

Huawei ADN will focus on valued scenarios and iteratively launch a series of scenario-based solutions to improve resource utilization, energy consumption, O&M efficiency, and transform NE-centric O&M to user-experience-oriented O&M, helping carriers seize the opportunities of 5G and industry intelligence to achieve business success. In addition, the open and programmable design capability enables O&M personnel to have certain development capabilities. Technical means are used to break the traditional O&M efficiency curve, making the network more secure and reliable.

Reconstruct the product system architecture, and explore to make breakthroughs in full-lifecycle closed-loop autonomy of telecom networks. Continuously remove obstacles in AI development in the telecom industry to allow practitioners to explore the value of big data with ease, and promote skill improvement and continuous career development. Based on the differences between regions and between customers' network development stages, Huawei will use intelligent technologies to continuously develop and share best practices, promote the capability improvement of the telecom industry, and foster the healthy development of the entire industry.

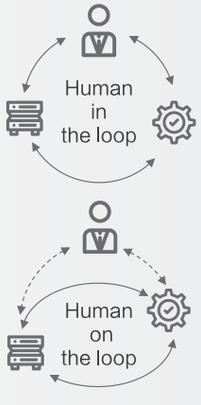
mid–term and long–term

The ultimate goal of Huawei ADN is to achieve network automation, self-healing, self-optimization, and autonomy based on data and knowledge. More specifically, new services can be enabled with optimal customer experience and automatic O&M, resource and energy utilizations are maximized, and network self-evolution towards autonomy is achieved based on automation, self-optimization, and self-healing.

In the future, ADN will transform the existing network architecture and O&M mode with the following profound changes:

Change 1 From manual operation to automatic execution

Traditional inefficient and repetitive operations (configuration delivery, dialing test, change, and upgrade) will be replaced with ADN's automated processes. O&M personnel's operation model will change from "In the Loop" (manual intervention in a process) to "On the Loop" (designing and managing a process, using rules, policies, and procedures). This will greatly improve work efficiency in addressing the heavy maintenance workload, caused by massive connections and large scale networks. Furthermore, the time required for network construction and service provision will be significantly reduced.



Change 2 Maintenance transition from reactive maintenance driven by complaints to proactive maintenance before issues occur

Passive O&M, which is triggered by customer complaints and performs trouble-shooting within days, will transform to proactive O&M completed in minutes. In proactive O&M mode, predictive maintenance is conducted through an in-depth analysis of large volumes of historical data. O&M personnel can proactively identify, locate, resolve, and, if required, notify customers of problems. This O&M mode drastically enhances network exception identification and analysis capabilities, and continuously improves network running quality and service experience.

Change 3 Manual decision–making to machine–based decision–making

Traditional O&M that relies on expert experience will be altered. Under certain conditions (specified networking, underlying bearer technologies, and security authorization), ADN will be driven by data and leverage AI machine learning and make decisions under human supervision. This enhances the system's capability to cope with complex and uncertain issues, greatly improving the response speed, and resource and energy efficiency of network services.

Change 4 Open-loop management to data-driven, closed-loop autonomy of assured service experience

Traditionally, network planning, construction, maintenance, and optimization are independent of each other. Upstream and downstream data is transferred between processes and manual operations, without full-process data sharing and intelligence to ensure full-lifecycle experience. In the future, L4 and L5 capabilities will streamline the data flow across the entire process and implement closed-loop autonomy. The network SLA is specified in the network planning phase, including, but not limited to, the network QoS, time to provision, and time to repair. The construction, maintenance, and optimization phases will be automatically driven according to this SLA for autonomy. This enables the network and service experience to be assured and enables business innovation of differentiated network services.

Huawei's Target ADN Architecture

Long-term exploration and collaboration is required to achieve L5 ADN on telecom networks for the ultimate goal of self-evolution and self-optimization. The achievement of the ultimate goal depends on a series of theoretical and technical breakthroughs, such as network self-cognition and knowledge and experience extraction. In consideration of the maturity of current technologies and commercial uncertainties, it is recommended that L4 ADN become the phased target of future ADN architectures, and that newly matured technologies, tools, and methods, such as AI and knowledge graph, be introduced to reconstruct and optimize network devices, O&M systems, and business operations in an all-round manner.

From a technical perspective, the L4 ADN architecture will have the following basic features:

Feature 1: The expert knowledge of networks and services is digitalized, transforming from passive manual O&M to predictive intelligent O&M.

Most carrier networks are manually operated and maintained by experts. If a network problem occurs, experts, primarily driven by customer complaints, use OSSs, EMSs, or auxiliaries to perform manual analysis, decision-making, and closed-loop management. In the future, this will no longer be viable because of the numerous connections, increasing network scale, and on-demand cloud service provisioning. The following capabilities need to be improved:

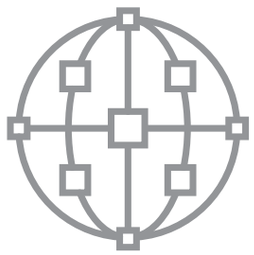
Predictive network problem awareness: Based on in-depth analysis of large volumes of network data, O&M personnel should proactively analyze network status, predict network faults and problems, and promptly provide RCA results. This helps resolve problems before customers complain.

Autonomous network decision-making: Under certain conditions, for example, under the supervision of O&M personnel, the network should make decisions independently for specific networking and service scenarios. This will greatly speed up the network's response to complex and uncertain problems and improve network efficiency.

Automated network execution: Automated processes should replace inefficient and repetitive manual operations. O&M personnel operations will change from "In the Loop" to "On the Loop", and will focus more on process and rule management and design.

Network and expert knowledge digitalization is a key prerequisite for improving the preceding capabilities.

First, network digitalization is a prerequisite to automated networks. It provides network data for network status awareness, analysis, and AI training and inference activities, including network resources, service data, and dynamic real-time data such as running status, faults, and logs. Telecom network resources and services have been gradually digitalized over the past three decades. With the evolution of 5G networks and introduction of AI, the original network digitalization model needs to be further expanded and revised to suit new network services and scenarios. Spatial/temporal attributes need to be added to enhance description of the network history, status, and future state. In addition, extensive real-time data is required for perception and decision-making at the service, network, and device layers.



Second, expert knowledge has been digitalized. After years of network O&M, carriers and network device providers have summarized numerous management rules, troubleshooting methods, and additional expert knowledge and experience, which are available in various forms, including device O&M manuals, network O&M specifications, and other intellectual assets. In automatic closed-loop network management, the scattered knowledge that humans understand needs to be injected into computers to form a knowledge base that machines can understand and use. With AI technologies, computers can quickly make better use of this knowledge and experience to play a key role in automated network analysis, decision-making, and closed-loop management. Some methods and technologies, such as knowledge graphs, have already been successfully applied to telecom networks to form network knowledge bases for scenarios like intelligent network fault identification and closed-loop processing.

The maturity and commercial use of AI technologies require long-term efforts. AI in telecom networks is still in its initial phase, and is mainly used to enhance the network's intelligent perception capability, or improve the efficiency and quality of manual decision-making through intelligent recommendations (L2 or L3). We believe that with continuous advancements in basic theories and technologies, such as network cognition and knowledge extraction, AI will be further used for self-optimization and adjustment in specific network domains to implement conditional closed-loop autonomy (L3), and then to achieve predictive and proactive closed-loop autonomy in multiple networks (L4). Efficient autonomous decision-making will replace more and more manual decision-making over time.

Feature 2: Simplified network infrastructure and intelligent NEs are emerging.

Networking and devices are simplified covering equipment, implementation, protocol, and architecture.

Lightweight equipment: Devices are integrated, blade-based, high-density, and modular.

Elastic implementation: Involves site cloudification, automatic deployment, pre-connection and pre-installation, and heterogeneous compatibility.

Normalized protocol: Protocols are simplified and gradually unified.

Agile architecture: Involves architectural decoupling, flattening, network convergence, and resource pooling.

Conversely, NEs are added with intelligent and digital capabilities. More sensing components are introduced, and the capability of sensing resources, services, and surrounding environments are increasingly stronger. Multi-dimensional real-time sensing is provided, covering service flows, resources, topology status, O&M events, and power consumption. In addition, NE built-in AI operators and AI inference units are introduced to achieve AI inference, making NEs smarter. A single NE has some degree of intelligent autosensing, decision-making, and closed-loop management.

Feature 3: Hierarchical single-domain autonomy and cross-domain collaboration drive the network to real-time closed-loop management.

With the evolution of telecom networks, an increasing number of parameters need to be configured on new devices, and service scenarios are becoming more complex. Multiple vendors, technologies, as well as software and hardware versions coexist, with a complex and dispersed network architecture. This increases the complexity and cost of network O&M significantly, and creates two network O&M challenges that need to be addressed:

Challenge 1

Complex networks are split into multiple autonomous systems (ASs), while single-domain autonomy and cross-domain orchestration are required to implement autonomous closed-loop management of ultra-large complex networks.

An AS is a group of intelligent network infrastructures combined with a network management and control system. ASs are divided by carriers based on their service characteristics, network technologies, and maintenance modes. They can independently complete closed-loop data collection, analysis, control, and optimization, as well as provide intent APIs to simplify network operations and shield internal implementation and differences.

single-domain autonomy

- In short, a single-AS network runs as a system with increasing autonomy. It senses its own status and intelligently recommends possible networking options, configuration models, and policies based on the dynamic changes of external users, applications, O&M processes, and environments. This enables proactive or preventive optimization to be conducted, and the network progresses towards online real-time closed-loop management.

Challenge 2

A flexible design and orchestration platform is required for carriers' service production and O&M processes to transform traditional passive and manual operations into data-driven intelligent AIOps.

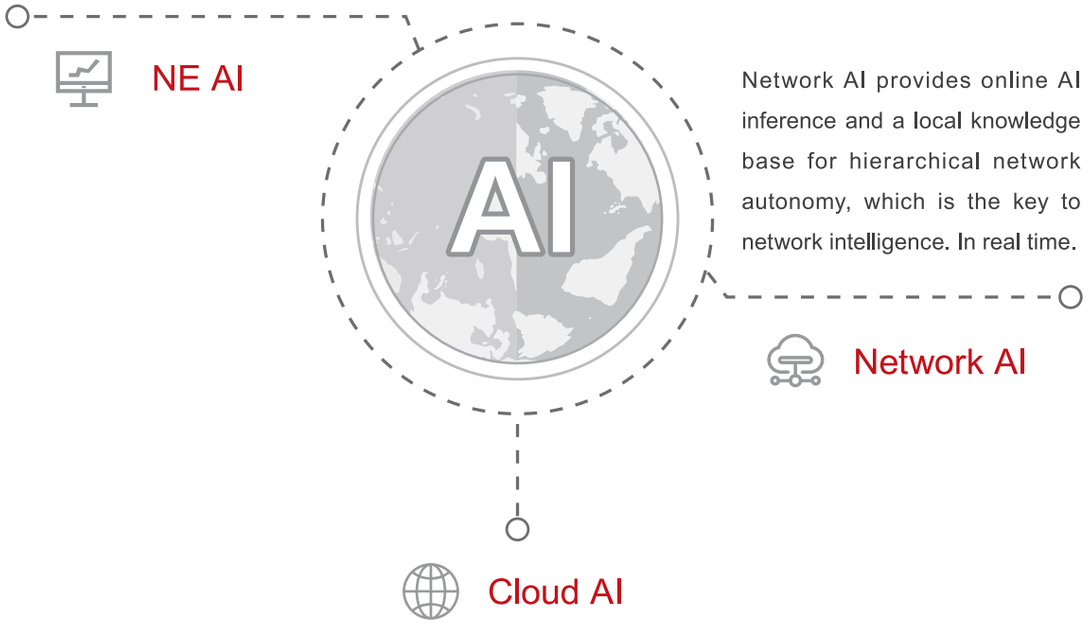
cross-domain orchestration

- First, based on openness and programmability, network ASs focus on abstract network technologies and provide scenario-specific intent APIs to decouple services from network resources. They allow flexible definition, global orchestration, and data training for service scenarios, networking solutions, O&M processes, and knowledge, as well as continuously reconstruct and optimize O&M processes.
- Second, after years of network O&M, carriers and network device providers have summarized numerous management rules, troubleshooting methods, and other expert knowledge, which are available in various forms, such as maintenance manuals, specifications, and other intellectual assets. During transformation, scattered knowledge that humans can understand needs to be injected into computers to form a knowledge base that machines can understand. Meanwhile, O&M engineers will play a greater role with machine assistance as new O&M positions emerge in the future, such as network strategists, orchestration engineers, and data analysts.
- In addition, people will continue to play an important role in intent design, exception handling, and key decision-making. For new O&M personnel, the design platform and programmable framework Design Studio is required for intelligent O&M in agile iteration mode based on no code, low code, and pro code.

Feature 4: The cloud-based unified platform for AI training, knowledge management, and O&M process design support iterative evolution of telecom networks.

Future carrier networks need to build collaborative AI capabilities at the cloud, network, and NE layers.

NE AI collects and filters network data in real time, and implements fast local closed-loop management. The unified cloud AI training, knowledge management, and O&M design enable continuous dynamic iteration as well as intelligent upgrades of telecom networks.



Network AI provides online AI inference and a local knowledge base for hierarchical network autonomy, which is the key to network intelligence. In real time.

Cloud AI features tremendous computing power and abundant feature samples. It is a unified and centralized AI design and development platform. Meanwhile, cloud AI serves as a network and expert "knowledge center" and "library".

To ensure efficient collaboration among these three layers and easier model and knowledge sharing, a unified specification (for AI models, knowledge models, and inference process models) is required. Telecom networks are operated and maintained by subnet and domain, and their services are prone to changes.

This means that the three-layer AI architecture of carrier networks must have the following capabilities:

Generalization and site adaptability of AI models

Due to different service forms, networking modes, and O&M rules, network data distribution varies depending on carriers' subnets. The AI model trained for one subnet may lead to difficulties in generalization and site adaptability when being applied to other subnets. This requires that AI inference components provide relatively complete capabilities of AI model generalization and local re-optimization.

Continuous evolution of AI models

Changes and upgrades of carriers' networking and services may drive updates of AI models and network knowledge. This requires collaboration among cloud AI, network AI, and NE AI. For example, when alarm definitions change in a new device version or batteries are added to the site networking, then alarm correlation may change. If AI is utilized for network fault diagnosis, the clustering algorithms and alarm correlation rules in AI models need to be upgraded simultaneously.

In the future-oriented ADN transformation, AI will be ubiquitous throughout the entire E2E network lifecycle. The core and basis of achieving this lie in network and expert knowledge digitalization, infrastructure with simplified architecture, and hierarchical network autonomy.

In summary, to achieve the ADN L4 architecture, telecom networks need a clear target architecture that all parties agree to, which can be referenced across the industry to guide production. Based on this architecture, carriers can systematically evaluate and sort the existing architectures of OSSs, integrated EMSs, vendor EMSs (or controllers), and network devices from top to bottom, and then formulate a feasible evolution roadmap that meets their actual requirements. Based on abundant product practices and joint innovations with global customers, Huawei proposes a target ADN architecture, as shown in Figure 2-1.

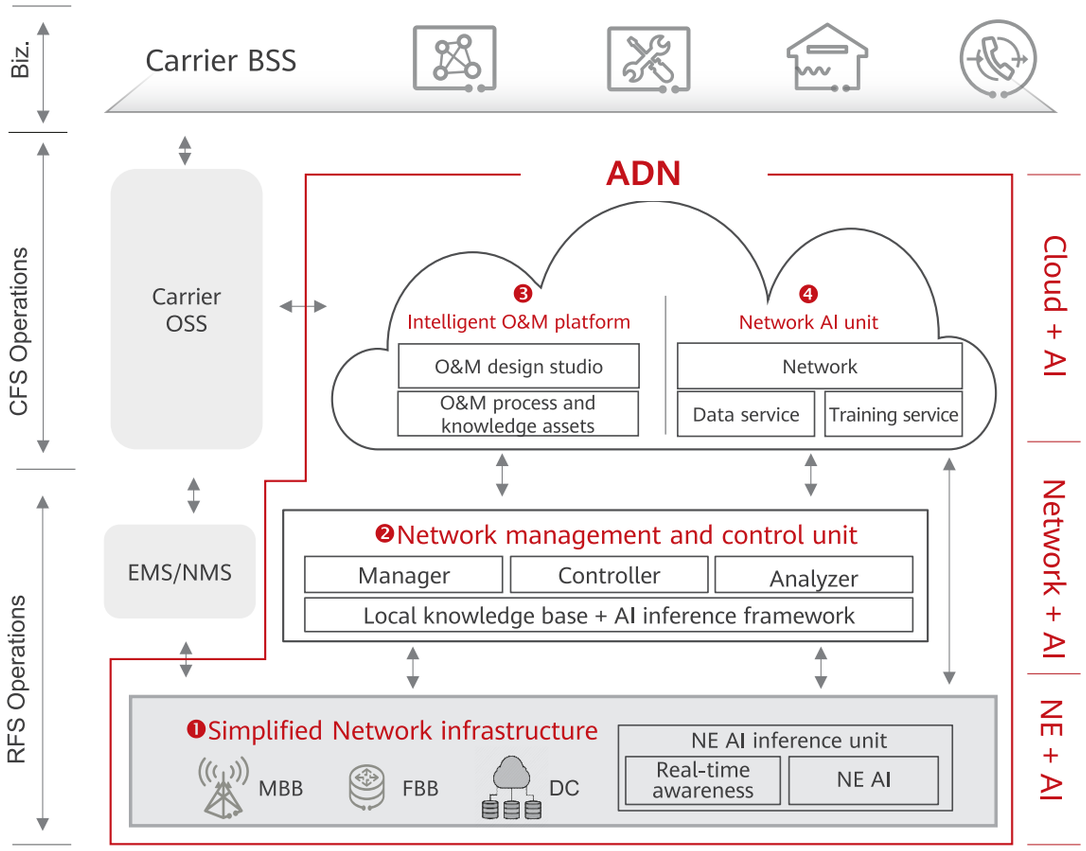


Figure 2-1 Huawei's target ADN architecture

- The simplified network infrastructure fundamentally guarantees an intelligent and hierarchically autonomous ADN.
- The simplified network architecture, protocols, devices, sites, and deployment solutions offset complexity caused by ultra-high bandwidth and vast connections, improving efficiency and customer experience throughout the network lifecycle.
- Meanwhile, more real-time sensing components and AI inference capabilities are being introduced to network devices, making them smarter. In this way, the digital sensing capability of resources, services, and surrounding environments has been enhanced, edge intelligence capabilities such as sensing analysis and decision execution are provided at the data source.

01

Simplified network infrastructure

- The ADN integrates three modules, the network manager, controller, and analyzer.
- By injecting knowledge and AI models, the ADN automatically translates upper-layer services and application intents into network behavior to implement single-domain autonomy and closed-loop management. In this way, the SLAs of network connections or functions can be committed. The network management and control unit consolidates scattered network resources, services, and status data using a digital modeling method to produce a complete intra-domain digital HD map for realization of an integrated platform that is capable of data collection, network awareness, decision-making, and network control.
- In addition, new AI models and network O&M knowledge are continuously injected from the cloud to steadily strengthen and enrich the local AI model library and network knowledge base, enabling the local intelligent awareness and decision-making capabilities to be continuously optimized and enhanced.

02

Network management and control unit

03

Intelligent O&M platform

- The intelligent O&M platform provides cloud services for O&M processes, knowledge assets, and the programmable O&M design framework. Oriented towards streamlined O&M processes and flexible service orchestration, it helps carriers quickly develop new service models, O&M processes, and service applications in iteration mode based on its network characteristics. This is the key to service agility and O&M skill enhancement.

04

Network AI unit

- The network AI unit provides an AI platform and cloud services in the telecom domain.
- It is the basic platform for network AI design and development. It continuously trains AI models and extracts knowledge based on the telecom data uploaded to the cloud, thereby generating new AI models and network knowledge. The AI models and knowledge can be injected into the network infrastructure, single-domain, and cross-domain management and control units to create an intelligent and easy to use network. The network AI unit is also a sharing center for carrier intelligence assets.
- It manages AI models and network knowledge developed and trained by carriers during planning, construction, maintenance, and optimization. Through this process, the AI models and knowledge can be fully shared and reused, which reduces the need for repeated development and training. The network AI unit provides basic services and capabilities, such as the data service, training service, course service, network knowledge base, and AI marketplace on the cloud.

Huawei ADN Solution and Products

Huawei ADN Solution

Huawei plans, designs, and develops products by adhering to the "Take Complexity, Create Simplicity" idea. ADN covers two series of products: simplified networks and intelligent O&M. The three-layer AI architecture "provides intelligence for networks and platforms for O&M", and accelerates carriers' digital and intelligent transformation.

The ADN solution provides scenario-specific sub-solutions for the FBB, MBB, and enterprise network domains to facilitate carriers' improvement in quality, efficiency, and revenue, as well as reduce costs. The sub-solutions include intelligent 5G O&M, intelligent telecom cloud O&M, 5G enterprise slicing, 5G intent-driven transport, premium private line, premium broadband, intent-driven DCN, and campus network solutions.

Based on the ADN architecture, AI has been introduced at the edge, network, and cloud layers, with the network AI unit iMaster NAIE and intelligent O&M platform iMaster AUTIN at the cloud layer, network management and control units iMaster MAE and iMaster NCE at the network layer, and network infrastructure with built-in AI capabilities, as shown in Figure 3-1.

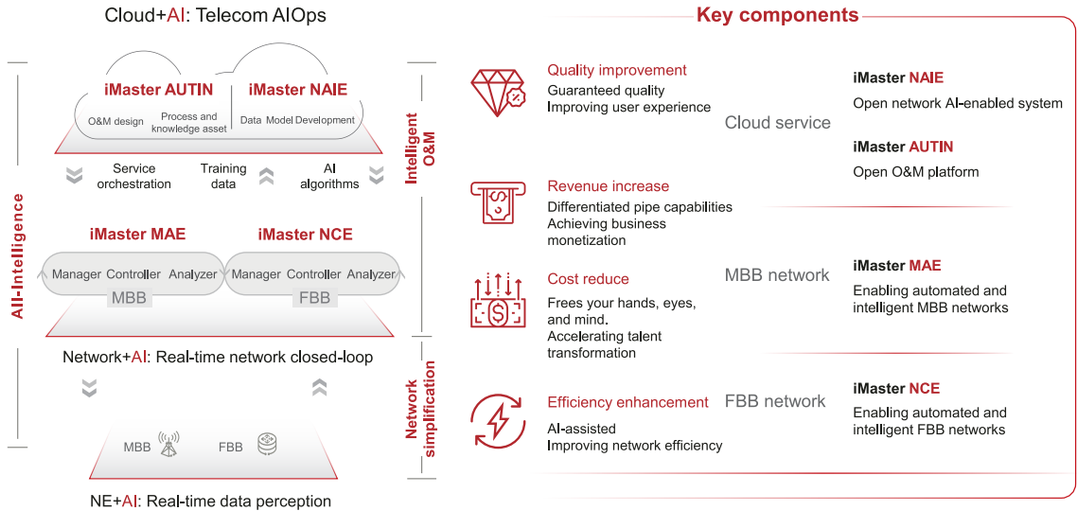


Figure 3-1 ADN solution panorama

In the FBB network domain

- iMaster NCE manages and controls fixed access networks, packet transport networks, optical transport networks, data center networks, enterprise campus networks, and integrates with iMaster NAIE on the cloud to implement data retraining and AI model update and iteration.
- It then integrates with iMaster AUTIN to implement secondary programmability of models and processes, flexibly adapting to the different IT environments and management processes of customers.
- By doing this, it provides sub-solutions such as premium broadband, premium private line, 5G transport X-Haul, intent-driven MAN, intent-driven DCN, and campus networks. iMaster NCE is also fully open to interoperate with any other OSS system(s) a customer adopts, supporting rich APIs for fulfillment and assurance.

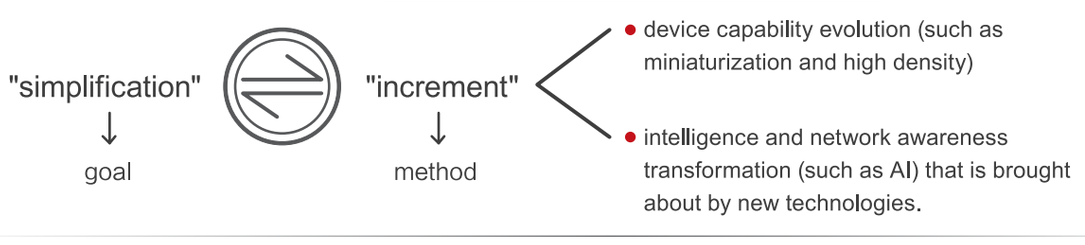
In the MBB network domain

- iMaster MAE manages and controls wireless access networks, mobile transport networks, and cloud core networks, and integrates with iMaster NAIE on the cloud to implement data retraining and AI model update and iteration.
- It then integrates with iMaster AUTIN to implement secondary programmability of models and processes, flexibly adapting to the different IT environments and management processes of customers.
- By doing this, it provides sub-solutions such as 5G E2E intelligent O&M and convergent telecom cloud. iMaster MAE is also fully open to interoperating with any other OSS system(s) a customer adopts, supporting rich APIs for fulfillment and assurance.

Simplified Network Products

Network simplification will reduce the complexity, investment, and cost of network acquisition and use. Although network construction has become easier and cheaper, network devices need to provide more complex functions and capabilities.

For example, high-density devices with new materials, technologies, and architectures are employed to reduce the size and weight of a base station. This eliminates the need for a crane and lowers investment in capital and time.



"Simplification" correlates with "increment", where "simplification" is the goal and "increment" is the method. There are two forms of incrementing: device capability evolution (such as miniaturization and high density), and intelligence and network awareness transformation (such as AI) that is brought about by new technologies.

Simplification

Agile architecture: Network convergence, resource pooling for centralized functions, and cloud-based architectures simplify O&M.

Normalized protocol: New generation advanced protocols simplify service configuration and optimize maintenance processes.

Lightweight devices: High-density and integrated blade devices are compact and simplify planning and construction.

Increment

NE AI inference capability: Built-in AI operators and neural network inference units achieve online pattern or feature matching to implement local AI inference on NEs.

Real-time NE awareness: Multi-dimensional real-time awareness is supported, including service flows, resource and topology status, and O&M events.

Collaboration with the cloud and network management and control: The capabilities of NEs, the cloud and network management and control make the edge more intelligent.

The following describes four scenarios: simplified wireless sites, simplified all-optical networks, simplified transport networks, and simplified core networks.

Simplified Wireless Site

As 5G efforts gain momentum, global carriers are accelerating 5G construction.As a result, the improved construction and maintenance of a 5G network becomes an urgent problem for most carriers.

70%

More than 70% of carriers need to maintain more than five frequency bands for a long period.

70%

Around 70% of the existing sites in urban areas cannot house new antenna installation platforms for installing 5G active antenna units (AAUs).

80%

Around 80% of sites cannot bear extra load.

80%

About 80% of sites have insufficient DC power capacity.

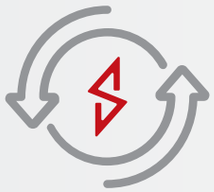
Wireless sites must be designed under the following principles:

1. No reconstruction of site infrastructure. For example, do not add poles to or reinforce antenna installation platforms and do not expand power supply units (PSUs).
2. Improve energy efficiency and reduce energy consumption. For example, keep improving the low-power design for radio frequency (RF) and baseband unit (BBU) modules; power on and off devices based on the service volume.
3. Design devices in all standards and allocate spectrums on demand. For example, enable 5G in RF and baseband modules; support spectrum sharing between LTE and New Radio (NR) in all scenarios.
4. With network bit-rate growth, base stations need to manage radio resources more accurately, improving the real-time data analysis capability of wireless networks and maximizing resource utilization.

Huawei provides an all-scenario simplified site solution with agile wireless networks. The solution has the following highlights:

Significantly simplified site

AAUs, BBUs, and PSUs are all blades. AAUs and passive antennas are highly integrated and support 2G, 3G, 4G, and 5G bands. They can be installed outdoors without adding poles or cabinets, significantly simplifying wireless sites.



Power consumption improvement

2G, 3G, 4G, and 5G services are analyzed by AI. 2G, 3G, 4G, and 5G bands collaborate with each other. Devices are dynamically powered on and off, reducing power consumption by 10% to 15%.

Frequency utilization improvement

Spectra are shared between LTE and NR in all scenarios, enabling sustainable evolution to 5G.

Site intelligence

The AI inference framework built in site devices provides more refined wireless resource management capabilities, maximizing resource utilization and improving user experience.

Simplified All-Optical Network

As 5G gathers momentum, the fixed network is also ushering in the era of Fifth Generation Fixed Network (F5G). As a result, high-quality, low-latency, reliable, and flexible connections have become universal requirements. Diversified services lead to repeated access of multiple networks and complex management, increasing the cost of network operation. The rapid development of services compels network capacity to grow continuously. How to maximize resource utilization and how to support service development using existing optical fiber and network resources become probing questions. 5G offers a feasible solution to these issues, but it pressures industries to explore this technology.

Simplified all-optical networks integrate access and aggregation networks to provide users with optimal service experience. These networks are designed according to the following principles:

- Adopt the all-optical access convergence solution to simplify network layers and improve user experience.
- Maximize network resource utilization by technical means. Implement refined network management based on existing optical fibers, equipment rooms, and human resources to enable agile and efficient networks.
- Enable network edges to be sensitive to services, meeting the various service requirements of a diverse set of industries in the 5G era.

Huawei provides a simplified all-optical network solution for all scenarios. Some core features of the solution are:

Adopt all-optical access convergence

One optical network covers home users, enterprise users, and 5G transport scenarios. In the access segment, use the E2E dynamic slicing technology to provide comprehensive network protection and differentiated SLAs for various services.

Network resource utilization and performance improvement

Employ new architectures and technologies to sharply improve network resource utilization and performance. For example,

- the industry's first OXC all-optical switching unit implements all-optical grooming, eliminating the work of manual fiber connections, cutting the cabinet footprint by 90% in an integrated cabinet scenario, and reducing the optical-layer commissioning time by more than 80% for deployment and capacity expansion.
- The Super C-band technology is used on optical NEs to expand the spectrums, increase the bandwidth of existing backbone fibers by more than half, and deliver 800 Gbit/s bandwidth per wavelength through Huawei-developed chips.
- Based on the existing OTNs, the architectures simplify the mapping from five layers to two layers, reducing the latency by 70%.
- Refined management channels raise the minimum bandwidth from 1.25 Gbit/s to 2 Mbit/s, improving resource utilization by more than tenfold.

Built-in AI capabilities

Leverage built-in AI capabilities provided by devices to improve the perception of network resources, status, and services. For instance,

- Fiber faults and application quality are predicted and detected in real time, triggering rerouting and improving performance.
- Application identification and acceleration on the terminals improves application experience with a lower latency.
- The fiber deterioration trend is proactively analyzed to drive intelligent optical-layer optimization and warning, remarkably improving the optical network availability and fulfilling the users' demands for high-quality networks.

Simplified Transport Network

Traditional multi-layer transport networks are bulky. Different services are carried independently, causing difficult O&M and high construction costs. Moreover, there are various IP protocols and the configuration is complex, which cannot meet automation requirements. Multiple services, and complex SLAs in the 5G era directly lead to inefficient network O&M and harm user experience.

Therefore, the following points must be considered when designing 5G transport networks:

1 

Converge transport networks oriented to MBB, home broadband, and enterprise private line services, reducing the number of networks, simplifying planning and design, and saving construction investment. Integrate devices to save space in equipment rooms and reduce equipment costs.

2 

Simplify protocol architectures and reduce layers in IP architectures to match network automation.

3 

Enable NEs to be aware of connection service SLAs and to collaborate with the control layer to enhance network security and detect network statuses, achieving intelligent O&M.

Huawei provides an intent-driven transport network solution for the digital transformation of networks.

Reduce network construction costs

Adopt all-service IP devices to implement unified transport of MBB, home broadband, and enterprise private lines. Furthermore, use a flattened network to reduce network construction costs.

Simplify service protocols

Simplify service protocols by deploying the SRv6 protocol in an E2E manner as required. Specifically, all protocols for a path are configured on the source node, thereby achieving fast service provisioning. Furthermore, Huawei devices support both MPLS and SRv6 (dual-stack). Regarding 4G services, the MPLS protocol is still used, however, it has no impact on existing services. The devices can smoothly support the SRv6 protocol through software upgrades, reducing the hardware replacement costs caused by protocol upgrades.

NE intelligence

Deploy intelligent transport NEs and provide remote sensing and edge intelligent services to evaluate connection service SLAs. Employ a built-in AI inference framework to download and run AI algorithms from the cloud, thereby perceiving network resources and statuses. For example, optimize health performance of connection service SLAs, compress network alarms, and detect exceptions in real time.

Simplified Core Network

The core network usually operates in cloud-based deployment model. A large number of NEs are deployed in many key locations. It is very time consuming and labor intensive to configure, upgrade, and maintain the core network. On top of that, since the core network has high requirements on reliability, lots of tests need to be performed, which is time consuming. These factors lead to a long TTM, generally 3 to 9 months, for service establishment and change.

Simplified core networks must be designed under the following principles:

1 Optimize the network architecture, simplify the topology, and employ automatic management of global topology to lower deployment and maintenance costs.

2 Converge the data planes, control planes, and user planes across 2G, 3G, 4G, and 5G core networks.

3 Automatically design mobile edge computing (MEC) NEs for efficient deployment.

Huawei helps carriers build simplified core networks with extreme agility, convergence, and efficiency.

- Huawei provides a fully-contained 5G core network, which uses a global-local architecture to meet the requirements of 10 billion connections in the future. Data on 2G, 3G, 4G, and 5G core networks are converged to reduce OPEX. A microservice architecture is employed for software, which enables agile version release management, gray upgrade, and online testing, thereby shortening the TTM.

- Huawei's Single Voice Core solution uses single voice core network to process voice services on fixed and wireless 2G, 3G, and 4G networks.

- Huawei's MEC one-stop full-service solution supports dynamic service loading and independent upgrades, and improves the overall performance by 50% to 100%.

- Huawei also provides intelligent edge services and network awareness to improve user experience. For example, AI-based in-depth packet analysis implements functions such as QoE awareness of encrypted videos, IP intelligent traffic steering, network optimization, and network security prediction.

iMaster Intelligent O&M Series Products

Conventional O&M of telecom networks faces many challenges. In 2019, Huawei services provided

580 thousand
580,000 incidences of technical support for over 1700 networks worldwide

10 thousand
Over 10,000 incidences of fault handling

130 thousand
Over 130,000 incidences of major network operations support

According to the data analysis of Huawei services in the past few years

80% of O&M activities still rely on manual intervention.

The scale of network O&M scale keeps increasing at a rate of 5% every year.

Networks are becoming increasingly complex, and manual O&M with siloed tools will be difficult to sustain in the future. Applying the iMaster intelligent O&M series products to the production and operation processes of carriers' planning, construction, maintenance, and optimization can achieve a series of intelligent O&M objectives, such as agile service provisioning, intelligent pre-event warning, fast post-event locating, unattended operation at night, and automatic remote O&M. This human-machine collaboration evolution is an inevitable trend for network O&M.

In 2020, Huawei launched a full series of iMaster-based intelligent O&M products for the ADN solution, including

iMaster NAIE (network AI unit)

iMaster AUTIN
(intelligent O&M platform)

iMaster MAE (MBB network management and control unit)

iMaster NCE (FBB network management and control unit)

FBB Management & Control Unit — iMaster NCE

Huawei iMaster NCE is positioned as a network management and control unit for FBB networks. It can manage fixed access, IP bearer, optical bearer, microwave bearer, data center, and enterprise campus networks.

It aims to construct a digital twin for FBB networks, implement intra-domain autonomy and closed-loop management, and usher in a user experience-centric era of automated and intelligent networks.

With its unified cloud architecture, iMaster NCE integrates Manager, Controller, and Analyzer systems, and uses big data and AI technologies to implement centralized management, control, and analysis of intra-domain networks. It meets the automation and intelligence requirements of users and services throughout the entire lifecycle of FBB networks, including planning, construction, maintenance, and optimization phases. Furthermore, iMaster NCE supports on-demand deployment and flexible scalability based on different network technology domains and service domains. Through open orchestration-enabled APIs, southbound integration, and Layer 3 open programmability, iMaster NCE enables users to orchestrate and develop new services based on real-world scenarios and service characteristics.

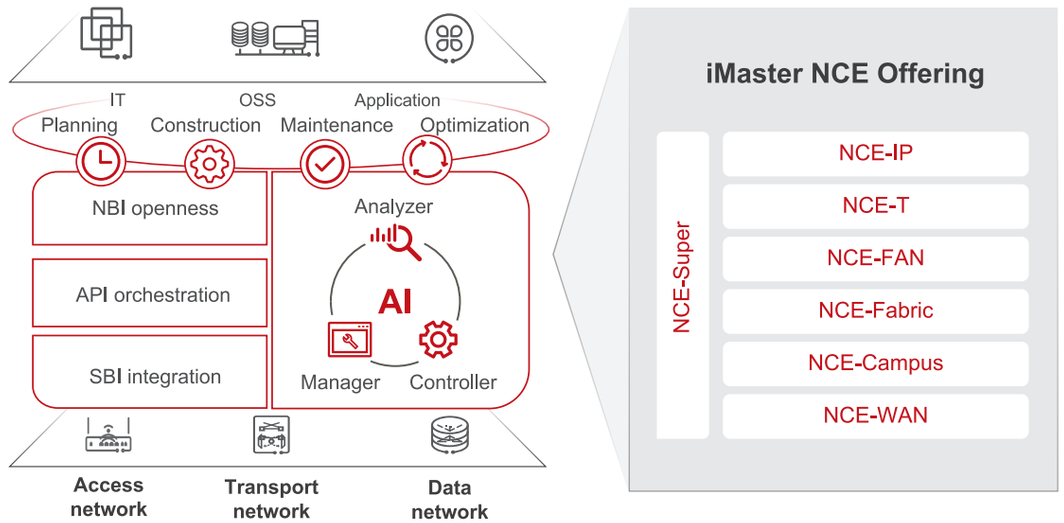


Figure 3-2 iMaster NCE product architecture and offerings

iMaster NCE, the intelligent center of the FBB network domain, has the following features:

- **Integration of Manager, Controller, and Analyzer, implementing scenario-based autonomous closed-loop management**

iMaster NCE integrates the traditional network management system, SDN control system, and performance and traffic analysis system. It integrates the network, service, and user experience data distributed among these systems into one platform, streamlines data models, and provides scenario-based intent APIs or apps for services in different scenarios. It also automatically transforms external business and service intents into network languages, and performs data analysis based on hierarchical NE, network, service, customer, and application models to provide real-time insight and decision-making, driving self-adjustment, self-optimization, self-healing, and autonomy of FBB networks.

- **Cloud-premise synergy and AI-enabled predictive network maintenance**

iMaster NCE is deployed on the local customer network. It collects E2E native network data of networks and services in real time through the Telemetry protocol, continuously performs local short- and medium-term online automatic training and mid- and long-term offline training on the cloud iMaster NAIE by injecting AI algorithms into different analysis and decision-making models. It provides functions such as real-time network traffic visualization and prediction, automatic network fault identification and prediction, and historical service experience playback and prediction, changing the network from passive O&M driven by complaints to preventive maintenance driven by data analysis.

- **Openness and programmability, creating an open app ecosystem**

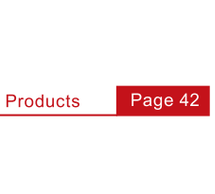
iMaster NCE provides a programmable integrated development environment Design Studio and a developer community and implements interconnection with third-party network controllers or network devices in the southbound direction and fast integration with cloud-based iMaster NAIE, iMaster AUTIN, and third-party IT applications in the northbound direction. Customers can flexibly purchase native automation and intelligent apps provided by Huawei, and develop and integrate apps by themselves or through third-party system integrators.

iMaster NCE Application in Premium Broadband Scenarios

Massive user access, increasingly complex home networks, and passive optical networks (PONs) pose great challenges to home broadband network O&M. The iMaster NCE Premium Broadband solution integrates Manager, Controller, and Analyzer, and provides data and AI analysis capabilities to help carriers significantly improve O&M efficiency, reduce unnecessary home visits, improve user experience, and gain more revenue.

First of all, among home broadband user complaints, 50% are related to home network faults, and 25% are related to PON optical path faults. Traditionally, carrier management reaches only ONTs, and the home network is a black box for O&M. Due to the lack of effective O&M methods, more than 60% of issues require home visits.

iMaster NCE provides functions such as segment-based speed tests, automatic fault identification, and one-click diagnosis to achieve remote demarcation within 1 minute and proactive fault analysis within minutes. Expert agents are not required to perform manual association analysis, implementing quick troubleshooting and providing optimization suggestions. Automatic adjustment and optimization are supported for configuration faults.



In addition, data analysis shows that home networks are the bottleneck for network speeds. For example, the 200 Mbit/s package provided by a carrier is subscribed to by 68% users, but 76% of users experience speeds much lower than 200 Mbit/s.

By continuously collecting and analyzing big data, iMaster NCE can accurately identify poor-QoE users and network speed bottlenecks, turn complaints into opportunities, and promote advanced home Wi-Fi networking services, improving both customer experience and the ARPU of package upgrade.

Moreover, the PON optical path has long lines and complex construction scenarios. Performance deterioration faults are especially difficult to locate, and must be checked segment by segment onsite. This leads to time-consuming troubleshooting and low user satisfaction.

iMaster NCE continuously collects the real-time running status and KPIs of OLTs, automatically identifies typical fault types and fault locations of PONs based on the automatic restoration capability of PON optical path topologies, and intelligently identifies the causes and locations of weak optical signals. In this way, proactive rectification for weak optical signals can be performed in a targeted way, improving the rectification efficiency.

iMaster NCE Application in Premium Optical Private Line Scenarios

Enterprise cloudification is an inevitable trend. According to the survey, high-end customers, mainly government departments, financial institutions, and industry VIP customers, account for more than 70% of carriers' private line revenue.

However, these customers have high requirements on private line quality, including high reliability, low latency, fast provisioning, self-service, and hard pipe isolation. iMaster NCE provides valuable applications such as the latency map, fast provisioning, scheduled bandwidth adjustment (BOD), and private line SLA assurance, helping carriers efficiently provide differentiated high-quality services before, during, and after sales.

Pre-sales phase

- iMaster NCE provides precise latency visualization and committed latency of private line services. Marketing personnel can use the Latency Map app to estimate whether the inter-site latency, bandwidth, and availability meet tenant requirements in real time, implementing quick network resource matching and monetization of differentiated capabilities.

Sales phase

- Fast service provisioning is one of the key competitiveness of carriers. iMaster NCE provides the CPE plug and play (PnP) and fast service provisioning capabilities, reducing the CPE installation and commissioning time from 4–6 hours to 30 minutes. In addition, iMaster NCE integrates with carriers' BSS/OSS, enabling service provisioning within minutes.

After-sales phase

- In addition to real-time visualized SLA management for private line services, iMaster NCE also provides optical network health prediction to proactively analyze the health status of each fiber and channel. It predicts fault risks, provides warnings to prevent service interruption in advance and avoid SLA violation penalties.

iMaster NCE Application in 5G Transport Scenarios

5G networks require more base stations than 4G, increasing maintenance and configuration workload. In the 5G era, conventional manual, layer-by-layer configuration involves a heavy workload, requires high skills, and is error-prone.

- First of all, iMaster NCE provides the simplified Zero Touch Provisioning (ZTP) deployment solution to quickly bring access ring devices on the 5G transport network online and automatically provision services, reducing the required attendance of network operations center (NOC) personnel.
- In addition, iMaster NCE provides automated transport slicing capabilities for 2B market innovation, and provides full-lifecycle intelligent O&M capabilities such as automated slice deployment, visualized O&M, and on-demand capacity expansion, enabling fast service and innovation for 5G in 2B industries.

Moreover, in terms of transport network O&M, iMaster NCE provides intelligent O&M based on In-situ Flow Information Telemetry (iFIT) technology in 5G transport scenarios, supports real-time collection and aggregation analysis of large-scale network KPIs, and implements micro visualization of SLA indicators such as latency and packet loss on the bearer side of each base station service. Faults can be detected within 1 minute.

In addition, with the dynamic IP routing analysis and restoration capabilities of the entire network, iMaster NCE quickly starts intelligent hop-by-hop analysis along with flows for deteriorated or faulty services and quickly locates the faulty NE or link within 5 minutes, narrowing down the scope to the root cause of the fault.

Root cause analysis can be performed in depth for typical faults with knowledge graph AI algorithms. Automatic identification and root cause analysis can be performed for more than 200 typical faults in seven categories.

iMaster NCE Application in Data Center Scenarios

With the advancement of digital transformation in various industries, a large number of new services are rolled out and services change frequently. Therefore, the requirement for fast service rollout is urgent. For example, a bank has more than 2000 service changes in a year. The business department requires that today's work orders that arrive before 15:00 be handled today, and that work orders after 15:00 be handled the next day. Although the mature and widely commercialized SDN solution solves automatic deployment of logical networks, a large number of manual operations are still required for application rollout, network provisioning, and network changes. Frequent changes cause frequent human errors.

According to statistics, nearly 40% of data center network faults are caused by human error.

iMaster NCE is integrated with customer services

Based on the understanding and translation of customer services and network intents, a proper network deployment solution is recommended to enable E2E automatic service provisioning and implement full-lifecycle automatic closed-loop management of intents. iMaster NCE provides a simulation verification module.

iMaster NCE provides a simulation verification module

Based on the live network configuration, topology, and resource information, iMaster NCE uses network modeling and formal verification algorithms to display detailed connectivity and mutual access relationships based on whether the remaining network resources on the simulated live network are sufficient, and analyze and evaluate the impact of changes on original services.

Therefore, network engineers can use iMaster NCE to pre-evaluate change risks, thoroughly resolve human-caused problems such as design logic vulnerabilities, and ensure zero network configuration errors.

In the O&M phase, a large number of applications, such as mobile payments and flash sales, require second-level response. As a result, upper-layer applications detect faults and make complaints before the network, and the network is under great pressure.

In addition, network fault locating mainly relies on expert experience, segment-by-segment demarcation, flow-by-flow analysis, and packet capture, which is inefficient. The data analysis shows that the mean time to repair (MTTR) of data centers exceeds 70 minutes.

iMaster NCE uses Telemetry to collect traffic on the management, forwarding, and data planes throughout the entire network and comprehensively evaluates network health based on service experience. It proactively forecasts faults and detects existing faults within 1 minute.

With Huawei's proprietary AI algorithm, iMaster NCE performs in-depth feature mining and learning to locate the root causes of 75 different types of typical faults (grouped into 7 categories) within 3 minutes.

In addition, an intelligent decision-making system enables iMaster NCE to analyze the fault impact and recommend preferred troubleshooting methods for quick rectification of these faults within 5 minutes.

iMaster NCE Application in Enterprise Campus Scenarios

With the rapid development of enterprise digitalization, campus networks are developing towards wireless, cloud, and intelligence. New services are emerging continuously. The exponential growth of network scale, frequent roll-out and adjustment, and user experience assurance pressure pose significant challenges to campus network administrators and operators.

iMaster NCE integrates the Manager, Controller, Analyzer, and AI functions of campus networks to implement full-lifecycle automatic management and intelligent O&M of networks.

In the network planning and deployment phase

iMaster NCE supports one-stop network planning, deployment, and automatic policy provisioning based on service intents, accelerating service rollout.

In small- and medium-sized campus network scenarios such as stores and hotels

iMaster NCE automatically generates the network topology, brings devices online, and provisions services based on the industry scenarios and service requirements selected by customers. This accelerates campus network deployment from 3 days to half a day.

In the maintenance phase

iMaster NCE predicts and analyzes network faults based on a dynamic baseline and multiple AI algorithms. 85% of faults can be identified.

In addition, the intelligent learning engine deployed on the cloud continuously trains and enriches the fault knowledge base, so that nearly 90% of all network faults can be processed in minutes.

MBB Management and Control Unit — iMaster MAE

Huawei iMaster MAE is a management and control unit that delivers unified management of MBB networks (RANs and cloud core networks). Based on cloud-based EMSs, iMaster MAE applies AI, big data, and automation technologies to MBB network O&M for MBB network autonomy.

Functioning as the automation engine for MBB networks, iMaster MAE provides the following core functions:

① Integrates management, control, and analysis functions as the brain in control of mobile networks, and provides networks with new capabilities such as scenario awareness and identification, network prediction, and self-learning.

② Matches and builds a solution to meet any customer workflow in the entire network lifecycle, including network planning, deployment, maintenance, optimization, and service provisioning.

③ Implements hierarchical closed-loop autonomy, shields the complexity of mobile networks, provides scenario-based service APIs, enables efficient coordination with customer workflows, and simplifies service workflows, helping carriers with evolution to network autonomy.

iMaster MAE-M

After 5G networks are deployed, mobile carriers will find themselves in a difficult situation in the long term, as different standards (2G, 3G, 4G, and 5G NR) coexist; frequency bands are increasingly complex, and diversified services need to be provisioned. This situation will bring many challenges to network O&M, performance improvement, and service experience assurance, aggravating the OPEX pressure on MBB networks. Therefore, a breakthrough architecture and solution are necessary to address such challenges and the OPEX pressure.

Based on traditional EMSs, iMaster MAE introduces cloudification and AI capabilities to innovate both the architecture and use cases. iMaster MAE has the following features:

Transformation from NE-centric management to scenario-centric intelligent O&M

- Functioning as the automation engine for MBB networks, iMaster MAE provides scenario-specific solutions based on a cloud data platform and powerful network forecast and inference capabilities. It fits perfectly into carriers' deployment, maintenance and optimization, and provisioning scenarios, achieving E2E closed-loop automation in all scenarios.

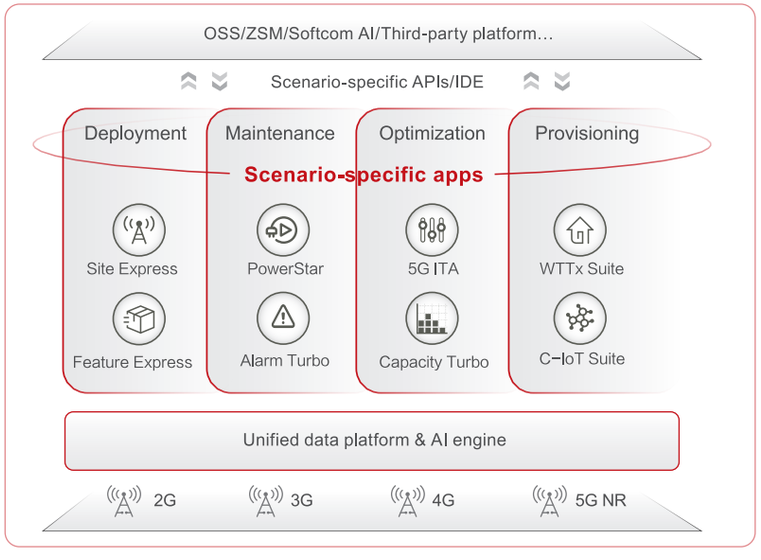


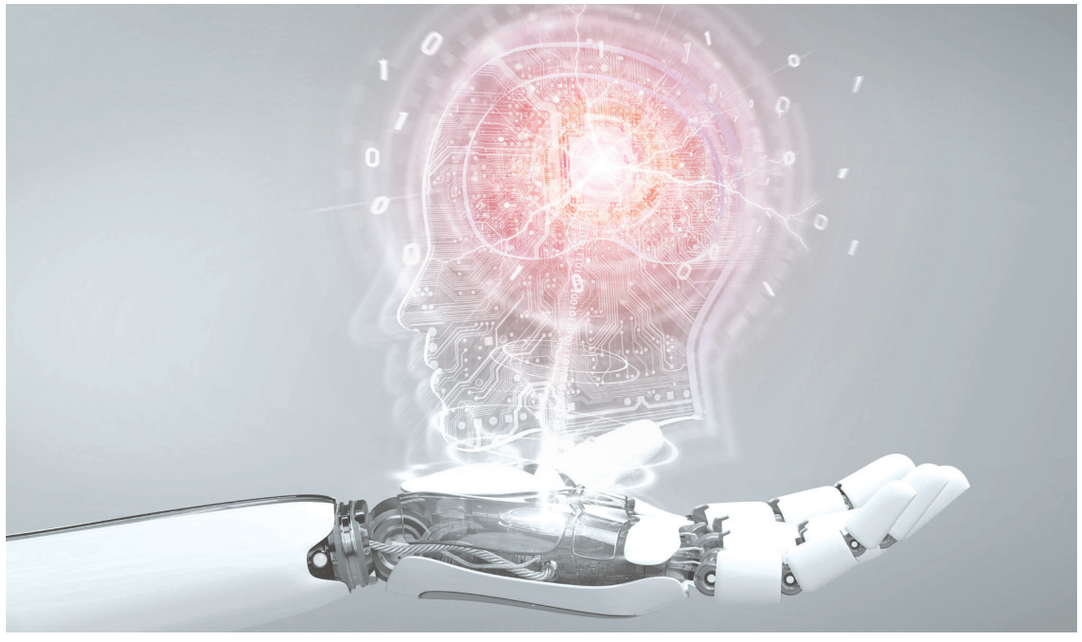
Figure 3-3 iMaster MAE in RANs

AI-Inside

- After AI technology is introduced into MBB networks, automation capabilities will be built at three layers: cloud, network, and site. These layers are autonomous and vertically collaborative and are the smallest units for independent closed-loop management.

- The embedded AI inference framework and AI model injection capabilities enable iMaster MAE to perceive and identify scenarios based on user measurement data analysis, generate network optimization policies based on user policies and traffic models, provide suggestions on multi-parameter optimization, and translate upper-layer services and intents into network behavior. In this way, iMaster MAE can continuously ensure network connectivity and performance and automatically manage and control MBB networks.

- Edge AI in sites builds up capabilities, such as scenario matching, data collection and extraction, and low-delay intelligent algorithms, to analyze data in real time and intelligently infer low-delay paths, thereby maximizing resource efficiency. For example, increased refined management is provided for wireless channel status.



Network openness through intent APIs

- MBB networks and services are undergoing continuous changes and development. The MBB network architecture is extremely complex, and networks must be open to adapt to network and service changes. iMaster MAE provides an open platform for the O&M ecosystem, scenario-specific APIs, and a development suite for developers. Scenario-specific APIs shield the complexity of MBB networks. Networks and upper-layer systems interact at the intent level instead of instruction level, simplifying interconnection and vertical collaboration.

Through scenario-specific APIs of WTTx Suite — an app in iMaster MAE

Customers can quickly obtain accurate WTTx package provisioning suggestions in one-click mode. The development suite allows customers to quickly customize apps to carriers' differentiated O&M requirements and reshape their workflows.

Using the site deployment APIs of iMaster MAE

Customers can quickly develop a 5G site deployment app for the target network within several weeks. This app shortens site deployment time by resolving any issues and starting deployment with a single click.

High-Value Use Cases of 5G RANs

5G site deployment and go-online

- When evolving to 5G, carriers need to consider site types, hardware types, networking modes, and other factors on the existing network. For non-standalone (NSA) networks, they also need to consider 4G anchor sites. As such, all of these factors make 5G site deployment complex, multifaceted, and therefore more difficult.
- Global experts' experience and project experience are incorporated into the intelligent O&M platform. During site deployment, iMaster MAE accurately matches differentiated scenarios with the help of the open process orchestration capability provided by Site Express. Open interfaces smooth away breakpoints among deployment steps. This combines with hardware self-identification, a scenario library, and a rule library to enable hardware self-detection, parameter self-configuration, and site self-acceptance in the site delivery step, which improves site delivery quality, site deployment concurrency and accuracy, and site integration efficiency.
  - **improves site delivery quality**
  - **site deployment concurrency and accuracy**
  - **site integration efficiency**
- After 5G sites are deployed, there are still many KPI performance issues on the network, such as weak coverage, overshoot coverage, pilot pollution, and handover exceptions. However, the spatial diversity and time-varying characteristics of RANs mean RANs are dynamic and complex.

iMaster MAE uses AI for scenario awareness and identification

- It can differentiate between roads, stadiums, and indoor and outdoor scenarios, forecast and analyze traffic and user experience, and perceive the scenario change trend in advance.
- It generates network optimization policies based on user policies and traffic models, and performs online iterative optimization with the help of AI algorithms.
- In this manner, networks are adjusted in real time for optimal performance.

5G network maintenance and optimization

- Keeping networks running securely and reliably is a major mission in the O&M phase. Here, the key is to detect and rectify network faults promptly. However, network troubleshooting is always a labor-intensive job in network O&M.

According to carrier statistics, millions of alarms are generated, and over 7000 trouble tickets are created each month. It takes an average of 480 minutes to rectify a fault.

- Using intelligent techniques such as symptom aggregation and knowledge graph, the Alarm Turbo app in iMaster MAE changes passive analysis to proactive prevention and performs intelligent multi-dimensional data analysis to locate root causes. This achieves a transformation from manual fault analysis to automatic root cause analysis. Alarm Turbo implements automatic fault monitoring, analysis, locating, and rectification, effectively reducing the number of alarms. Minute-level precise alarm locating and analysis effectively reduces the number of invalid trouble tickets, shortens fault recovery time, and improves RAN stability.
- In the future, Alarm Turbo will predict and rectify alarms and faults in advance, based on the trend analysis of alarm, performance, and network data, improve proactive fault handling capabilities, and implement fully automated fault handling.
- Using iMaster MAE, the PowerStar solution achieves three-level (device, site, and network) energy saving.

Network-level co-coverage automatic identification, multi-RAT coordinated energy saving, and AI-based refined energy saving policies enable a wider energy saving scope and increased energy saving time, while ensuring stable KPIs. PowerStar helps reduce power consumption by 10-15%.

5G network service operations

- Advantages such as easy installation and low cost single-bits mean wireless home broadband services have become a new foundational service of mobile carriers in the 5G era. To meet personalized requirements of different home broadband service packages, wireless network resources need to be automatically adapted to ensure the personalized service experience. Fast provisioning, accurate evaluation after provisioning, and network development planning become the key to the development of new wireless home broadband services.

WTTx Suite in iMaster MAE

- WTTx Suite in iMaster MAE uses AI to analyze live-network data, generate a customized spectral efficiency feature database, and forecast network capacity. It can then provide accurate number allocation suggestions and achieve coordinated development of multiple home broadband services on MBB networks.
- After home broadband services are provisioned, WTTx Suite combines with association analysis of wireless network data and user data, to help carriers analyze user experience, proactively manage users, and resolve customer complaints.
- WTTx Suite provides openness and can interconnect with business operation systems such as business hall systems and customer service systems, enabling customers to integrate an automatic closed-loop number allocation process.

- 5G not only provides rich user experience for both individuals and families, but also enables a wide range of industries. Therefore, in front of industry apps, it is necessary to overturn network O&M and operation patterns. Carriers must shift from the traditional "Best Effort" pattern to an SLA-centric experience assurance pattern. The SLA Coverage function accurately translates industry service intents. Based on AI-enabled channel-level simulation, it can evaluate network resources that meet industry SLA requirements. In addition, the Add-on architecture is used to flexibly isolate network resources, quickly deploy private networks over public networks, monitor service performance online, and forecast industry requirements, ensuring the fulfillment of industry SLA requirements.

iMaster MAE-CN

In the 5G era, technologies such as NFV, slicing, MEC, and microservice pose new O&M challenges, such as complicated core networks, more managed objects, and frequent changes. These challenges aggravate the OPEX pressure on carriers. In addition, as vertical industry apps gain momentum, carriers are more concerned about how to monetize differentiated network services and quickly roll out new service apps.

To address the OPEX pressure and monetization challenges, service providers must take architectural innovation on core networks.

By integrating EMSs, MANO, NSMF, NSSMF, MEAO, and MEPM, and introducing technologies such as AI, data native, and automation, iMaster MAE provides integrated core network management, control, and analysis, cloud-edge synergy, and capability openness. iMaster MAE helps carriers build intelligent, simplified, and agile 5G core networks.

Generally, iMaster MAE has the following three features:

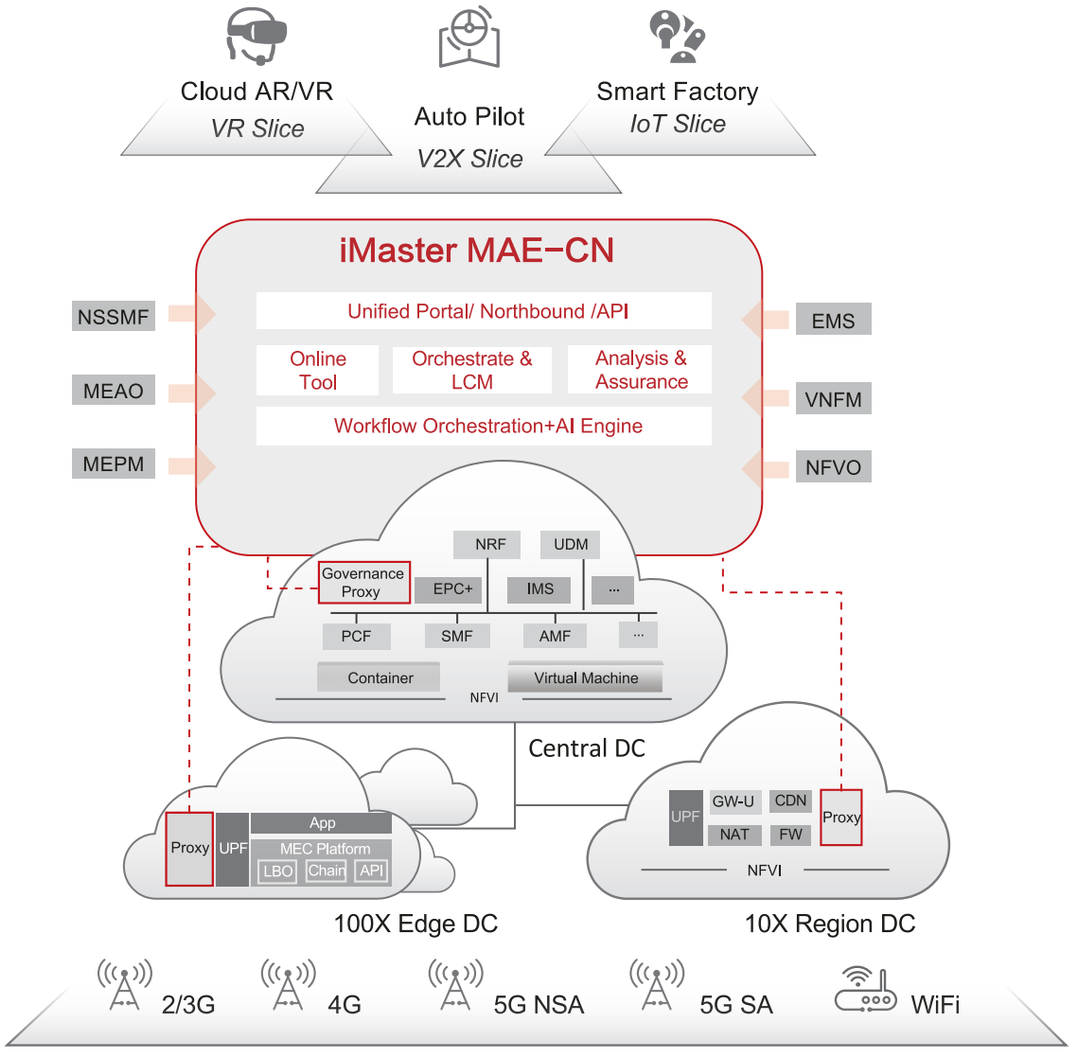


Figure 3-4 Product architecture for applying iMaster MAE to core networks

Integrated management, control, and analysis

- The management modules (EMSs, VNFM, VIM, NSSMF, and MEPM) are integrated with orchestration modules (NFVO and MEAO) on core networks, and the data native and big data analysis modules are added. The analysis, policy, and execution units in the closed-loop control process are enhanced to dynamically and flexibly adjust network services, parameters, and virtual resources based on business intents or intelligent policies.

Cloud-edge synergy

- The central cloud undertakes autonomy, and edges undertake collaboration. The central cloud is located on the management plane. Focused on network-level closed-loop automation (low real-time performance), it explores user intents, collects network-wide data, centrally trains and infers global policy models, and controls networks in a closed-loop manner. Edges are close to NEs. They analyze the collected network data in real time and implement NE-level closed-loop control (high real-time performance) based on trained policies. The central cloud and edges work together to implement E2E closed-loop autonomy on core networks.

Network capability openness

- In the 5G era, industry apps create opportunities for network value monetization. For diversified network functions and SLA requirements of vertical industries (such as industrial Internet, IoV, smart healthcare, and smart robot), communication networks must have customized openness capabilities. Currently, the network slice and MEC openness capabilities are provided. The slice openness capability meets different requirements from massive vertical industries on network functions and SLA levels. In the design phase, each industry can customize a slice template to make slice resources adapt flexibly to service requirements. The MEC open capability implements on-demand app deployment and tenant O&M monitoring, greatly improving user experience and meeting the low-delay and localization requirements on regional services (in places like enterprise campuses).

High-Value Use Cases of 5G Core Networks

5G slicing

- E2E automation is available in the 5G slicing scenario, to help carriers with full-lifecycle slice management, including automatic slice management, fast service provisioning to industry tenants, template-based slice design and orchestration, one-click slice deployment, and automatic SLA monitoring and assurance.

- In the slice design phase, a rich set of basic slice templates are provided to meet the differentiated requirements of different industries, and further, slices can be graphically customized through drag-and-drop.
- In the slice provisioning phase, a series of slice service models with self-learning capabilities are used to fully automate slice subscription, instantiation, and acceptance testing, which shortens TTM for new services in all industries.
- In the slice O&M phase, slice SLAs are intelligently monitored; SLA exceptions and deterioration can be detected early, and exception reports are pushed automatically.

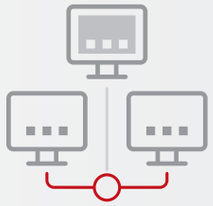
- Slice-level automatic elasticity enables the dynamic and reasonable allocation of slice resources and real-time response to resource requirements in seconds. As the SLA assurance center based on self-learning policies, iMaster MAE determines and initiates appropriate processes for optimizing slice SLAs in an E2E manner.

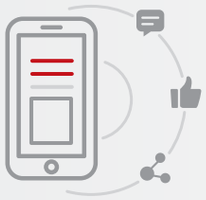
MEC

- MEC edge devices are plug-and-play, and third-party apps can be quickly rolled out. iMaster MAE has centralized management and O&M capabilities, enabling fast site deployment, as well as single-site innovation and network-wide replication.

Automatic MEC site deployment

MEC site can be automatically deployed as the following work is automated: establishing network connections, managing edge devices, and configuring, testing, and rolling out site services. Plug-and-play devices reduce installation and deployment costs. Services are provisioned with a single site visit, shortening the site deployment time from weeks to days.





Flexible app deployment

App providers can quickly deploy apps in navigation mode, which greatly lowers learning costs and skill requirements. After apps are deployed, the app software, traffic distribution rules, and policies are managed in a centralized manner, and the apps can be automatically copied to other sites based on user-defined deployment policies, achieving single-site innovation and network-wide replication.

Centralized O&M and edge autonomy

The central cloud and edges work together to monitor all MEC devices and conduct remote batch upgrades and policy delivery, reducing the O&M costs caused by frequent site visits. Furthermore, edge sites can be scaled automatically (to make 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 self-recovered quickly.)

Intelligent O&M of core networks

- In the routine monitoring scenario, traditional O&M has few fault identification methods. Faults are located only after NE alarms are triggered by KPI deterioration or user complaints are received. However, this is inefficient, time-consuming, and error-prone. Huawei's core network ADN solution continuously learns historical KPI data, which facilitates dynamic threshold setting and maintenance for massive KPIs, reduces labor cost, and improves detection accuracy. It identifies exceptions in the sub-health state before faults occur. Additionally, this solution supports multi-dimensional association detection and analysis of incidents. O&M personnel can quickly triage faults and analyze root causes based on time and space correlation.

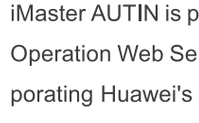
- In the network change scenario, versions are released more frequently in the 5G era, and a large number of network changes (such as upgrade, cutover, and configuration change) are performed, greatly increasing the probability of faults. Huawei's core network ADN solution builds three lines of defense for change scenarios: before, during, and after a change, to detect and prevent 40% of issues caused by changes in advance. Additionally, an online health check is performed before a change occurs. Change preparation and operations are automatically performed based on specifications, and exception detection is performed during the change process and attendance phase. Multi-dimensional event aggregation and root cause analysis are supported to quickly triage faults, prevent issues caused by the change, and implement intelligent online machine attendance.

Intelligent O&M Platform — iMaster AUTIN

iMaster AUTIN is positioned as an intelligent O&M platform and cloud service for ADNs. It is enabled by the Operation Web Services (OWS) and O&M intent-driven programmable framework Design Studio. By incorporating Huawei's abundant product knowledge and O&M experience, this new generation O&M platform provides O&M process and knowledge assets to create value. It aims to help carrier O&M engineers and partners quickly develop O&M cloud services that adapt to O&M scenarios and improve the skills of new O&M personnel such as network strategists, data analysts, and orchestration engineers.

Network O&M is evolving from separated human-powered, tool-assisted O&M to collaborative man-machine O&M. The iMaster AUTIN intelligent O&M cloud service reshapes O&M processes step by step, transforms new O&M personnel, and implements closed-loop value management and continuous evolution based on real-world O&M requirements.

Each O&M process can be evolved iteratively. Huawei has abstracted structural O&M processes and knowledge assets for general use with its extensive global O&M experience, and the intent-driven APIs of the network management and control unit. As a result, the open design-time workbench (Design Studio) can enable carrier O&M engineers to develop intelligent O&M applications and adapt them to AI models in an agile and flexible manner based on their network O&M characteristics and requirements.



Until now, more than 9000 O&M personnel (developers) globally have been working together to build an open and shared developer ecosystem. More than 900 apps have been developed, and best practices have been quickly replicated worldwide.

iMaster AUTIN has the following features:

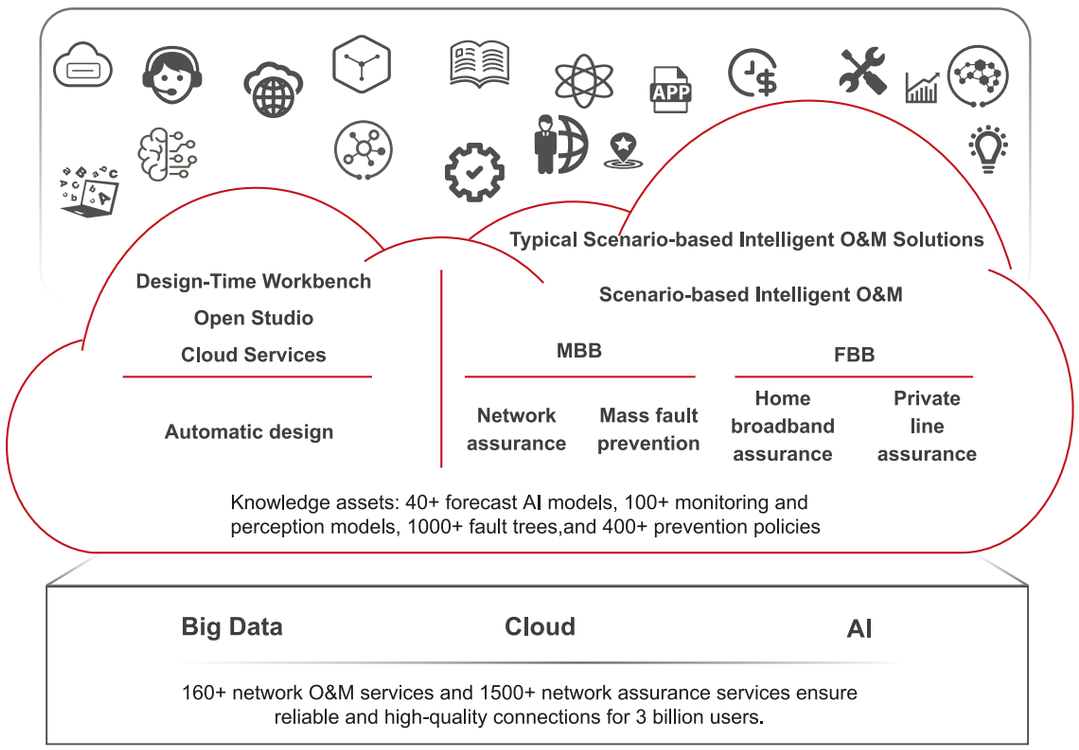
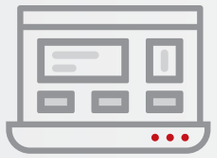


Figure 3-5 Architecture of the iMaster AUTIN intelligent O&M open platform

Digitalization of abundant network O&M knowledge

iMaster AUTIN abstracts more than 30 years of Huawei's communication product technologies and O&M experience in more than 160 networks as structural knowledge assets and provides them to carriers as cloud services, helping carriers gradually implement intelligent O&M. There are currently over 80 commercial contracts worldwide.

Open work platform for new O&M personnel



Intelligent O&M is not a substitute for human labour. Instead, it enables people to play a greater role with the assistance of machines. New O&M positions are emerging, such as network strategists, orchestration engineers, and data analysts. People will still play an important role in intent design, exception handling, and key decision-making. New O&M personnel can use the programmable framework provided by Design Studio, with its "No code, Low code, and Pro code" feature to perform O&M in agile iteration mode.

iMaster AUTIN provides scenario-based solutions in the form of cloud services through operation consulting and software as a service (SaaS) to digitally transform carrier O&M.

iMaster AUTIN has been applied to MBB intelligent O&M and home broadband intelligent O&M, reducing site and home visits by 20%, and user complaints by 15%. In addition, the man-machine collaborative O&M has been adopted in new NFV & 5G scenarios, improving NOC efficiency by 50% to 90% and first-time troubleshooting by 30%. B2B service monitoring and automatic analysis and diagnosis ensure 98% SLA compliance and improve customer complaint handling efficiency by 30%.

Network AI Unit — iMaster NAIE

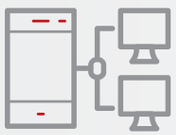
The NAIE Is an ADN AI Model Design and Development Platform

The NAIE, as an autonomous driving network (ADN) enabling unit, provides data the service, training service, course service, AI marketplace, and network AI applications.

For data problems in the telecom field

It also provides the data service, helping carriers efficiently manage data and reduce the data preparation time by 90%. These problems include professional telecom data, difficult data acquisition, time-consuming data preparation, high data labeling costs, and an insufficient amount of effective data samples. The data service includes data asset management, dataset, and data generation.

As of May 2020, the data service had accumulated more than 2.2 billion data samples. More than 50 million high-value samples are labeled using professional labeling tools and expert experience. These samples cover 90% of typical scenarios in the telecom field and more than 40,000 feature dimensions.



Facing high requirements on and long period of AI model development and application

The NAIE provides the training service to simplify AI model development, improve development efficiency, and facilitate model application for carriers. The model training service provides an integrated development environment (IDE) with numerous functions, including data processing, feature extraction, model training, and verification. This IDE integrates the telecom knowledge and experience gained by Huawei over the last three decades and offers more than 50 telecom domain assets, including project templates, algorithms, as well as feature analysis and processing SDKs, significantly shortening network AI model design and exploration

For difficulties in AI feature deployment in telecom networks

The NAIE features a cloud-premise synergy architecture supporting various deployment modes, including cloud, single-domain (MAE/NCE) and cross-domain (AUTIN) management and control units, as well as NE integration. In addition, this architecture facilitates AI feature deployment on telecom networks. The NAIE provides network AI training services for the entire telecom industry, facilitating the transformation and cultivation of AI talent. The training courses include online learning, offline face-to-face teaching, and career certification. The NAIE will collaborate with carriers and partners to advance the network AI industry.

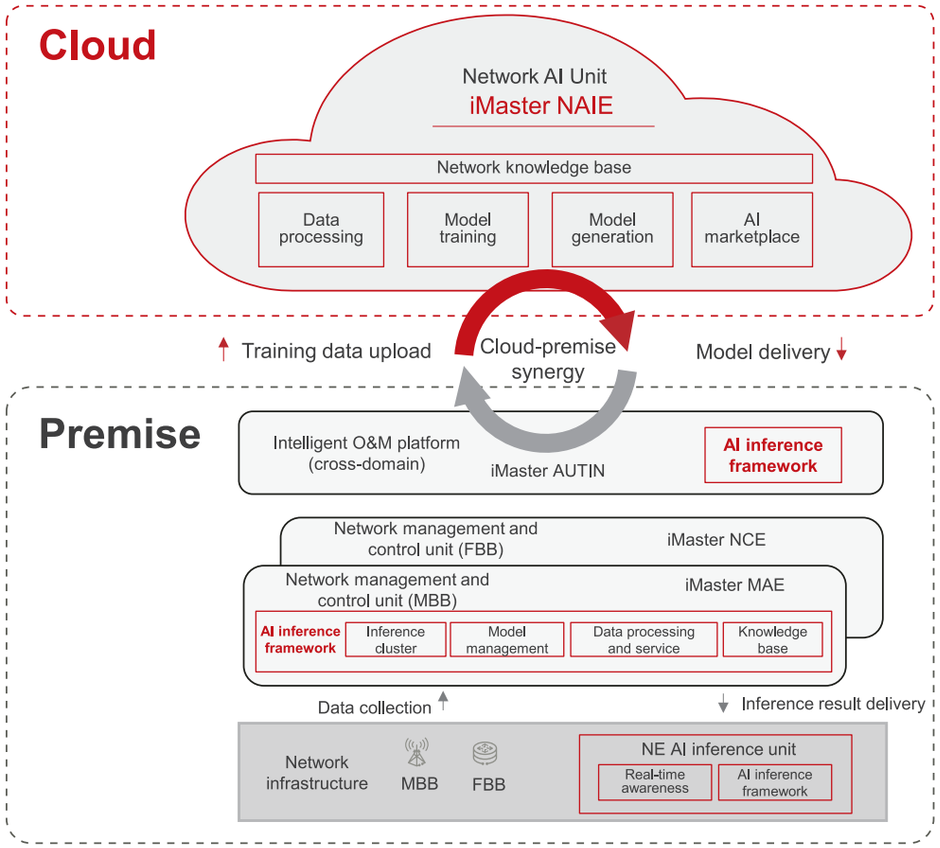


Figure 3-4 iMaster NAIE product architecture

The NAIE Leverages AI Technologies to Make Telecom Network O&M Less Repetitive, Less Complex, and More Predictable, Improving Carriers' O&M Efficiency

The key to facilitating the deployment of automated, intelligent telecom networks lies in AI. The Network AI Engine (NAIE) has been introduced to make telecom network O&M less repetitive, less complex, and more predictable. The NAIE begins with use cases that significantly improve carriers' O&M efficiency, and it continuously enriches use cases to apply AI throughout carrier networks via data collection, algorithm enhancement, knowledge accumulation, deployment mode exploration, and other methods. The typical application of NAIE in carrier networks can be summarized as "three dramatic increases" regarding O&M efficiency, energy efficiency, and resource efficiency.

	Scenario	Problem	AI Technology	Effects
Predictive	Base station energy saving	Users have to set custom carrier shutdown parameters based on the forecast traffic volume of each base station, without affecting KPIs. However, manual forecast for massive numbers of base stations is not possible.	**LSTM neural network**	Base station energy consumption reduced by 10% to 15%
Repetitive	Fault identification and RCA	If the transmission equipment of a base station is powered off, 11 tickets will be generated for power, transmission, and the base station. It is inefficient to handle many tickets manually — RCA can take more than 2 hours.	**Frequent item mining,clustering, knowledge graph**	RCA accuracy > 90% Intra-domain RCA: 5 minutes; cross-domain RCA: 10 minutes
Complex	Massive MIMO pattern optimization	The horizontal and vertical beams, downtilts, and azimuths of 5G antennas may form up to tens of thousands of different combinations, which may take several weeks to find the optimal combination manually.	**Reinforcement learning, deep learning**	Able to find the optimal combination in a matter of days

Figure 3-4-2 AI Is Critical to Improving Telecom Network Automation and Intelligence

Application case 1: core network KPI anomaly detection

Large-scale 5G deployment makes telecom networks more complex. The coexistence of 2G, 3G, 4G, and 5G networks creates tremendous network O&M challenges. The core network plays an important role in 5G networks and has a substantial impact on user experience. A single core network device serves up to tens of millions of users, and timely network fault identification and prevention are essential. KPI anomaly detection, as a key component of core network O&M, can promptly identify anomalies and facilitate further anomaly analysis. Currently, KPI anomaly detection is performed manually. A threshold must be set for each KPI as a static threshold based on expert experience for KPI anomaly root cause locating.

Manual operations bring the following challenges to core network O&M

- The core network is complex, involving multiple NEs, interfaces, and protocols. Manually monitoring a large number of KPIs is simply impossible.
- Traditional static threshold-based detection is prone to false negatives and false positives. Anomaly detection and root cause analysis require the manual comparison of a large number of KPIs, which is a time-consuming process.

The NAIE uses AI algorithms to learn historical KPI data and generate models, which automatically set dynamic KPI thresholds based on real-time KPI data changes and perform multi-KPI association analysis to analyze the root causes of KPI anomalies for different mobile services. Powerful AI computing is performed to monitor thousands of KPIs, identify anomalies prior to large-scale user complaints, and detect potential network risks in advance. This improves the efficiency of fault locating and reduces the impact of network problems on user experience.

The KPI anomaly detection service is applicable to various fields in the telecom industry, such as the VoLTE core network, EPC, and radio access network, and it supports multiple KPI modes, such as periodic, abrupt change, and trend.

This service integrates many intelligent algorithms, such as BoxPlot, xgboost, and Holt-Winters to detect more than 100,000 KPIs simultaneously, with accuracy of up to 85%.

Application case 2: fault identification and root cause locating service

The radio access network (RAN) is the most important troubleshooting scenario. The troubleshooting cost of the RAN accounts for a very large proportion of maintenance costs for the whole carrier network.

Two major challenges in fault locating

- There are many alarms and trouble tickets, and the O&M costs are high. According to the statistics of a carrier site, the number of raw alarms received by the NMS on the RAN per day is approximately 30 million.
- Cross-domain/cross-vendor faults are difficult to accurately and quickly locate, and massive alarms reported by various NEs are difficult to accurately compress and associate. Furthermore, fault identification depends on manual analysis and processing, which is a time-consuming process.

The NAIE fault identification and root cause locating service builds abstract fault propagation diagrams based on AI algorithm mining and service labeling. Fault propagation diagrams are used for runtime real-time fault identification. O&M efficiency has improved, while corresponding costs have reduced. In training time, the service builds fault propagation diagrams through expert experience injection, the relationship discovery algorithm, Hedex document learning, and other methods based on historical alarm data and corresponding topology data. In runtime, the service applies fault propagation diagrams based on the real-time alarm data and latest topology data collected by the northbound interfaces of the management and control unit. The service also uses the streaming fault aggregation, dynamic fault duration prediction, and graph search algorithms to aggregate and identify trouble events (TEs) and faulty root cause NEs in real time. This helps carriers improve O&M efficiency and reduce repeated trouble tickets.

The NAIE fault identification and root cause locating service can accurately locate faults.

100%

The fault recall attain 100%.

95%

The precision rates attain 95%.

5%–10%

Reduce trouble tickets by 5% to 10%, and effectively reduce O&M costs.

Cloud-Premise Synergy Enables Fast and Large-Scale Deployment of AI on Telecom Networks

The ADN supports the cloud-premise synergy feature.

- Cloud refers to cloud AI (NAIE), such as cloud intelligence (including data service, training service, coaching, AI marketplace, and network knowledge library) deployed on the public cloud, private cloud, and HCS.
- On-premise AI includes network AI integrated in the single-domain management and control unit (MAE and NCE) and cross-domain management and control unit (AUTIN), as well as NE AI integrated in NE devices.

Cloud AI is centrally deployed on carriers' AI platforms, and it supports cross-layer, cross-domain, and cross-vendor AI capability development, reducing repeated investment. It features tremendous computing power, abundant feature samples, and a global perspective. Cloud AI is not only an agile tool for carriers to perform AI training and development, but also a network knowledge center and library. In addition, it supports model publication and sharing to reduce repeated development, deploy an AI ecosystem, as well as facilitate replication and promotion.

On-premise AI focuses on real-time network data collection and filtering and implements AI-based real-time closed-loop inference locally.

Cloud-premise synergy features three advantages: unified cloud-based generalization training for higher model precision, unified O&M for fast AI model upgrade, and unified knowledge management for a knowledge center.

The cloud owns preconfigured high-quality labeled data and is interconnected with multiple management and control units (NCE/MAE/AUTIN). It can collect all local data and use tremendous cloud computing power to perform training, improving model precision. In addition, cloud AI is the unified O&M center of AI models. The cloud centrally monitors model statuses (invoking times, status, precision, and retraining report), making the applications of AI evident. The cloud can perform policy-based automatic retraining and optimal upgrade on models, facilitating automatic O&M. In addition, it can centrally manage multi-site, multi-version models, and implement direct model delivery using the AI market-place. Compared with the traditional software upgrade spanning months, the model upgrade has shortened to hours. Cloud AI can aggregate multi-site data, centrally manage knowledge, and centrally label fault propagation relationships through experts, forming a knowledge center for service faults.

The premise collects local site data using the management and control unit and NEs, performs incremental training based on labeled data, and performs local learning with a few samples. The premise can also manage and monitor local site data, and perform policy-based automatic retraining, knowledge inference, status monitoring, as well as evaluation and optimal upgrade.

The cloud and premise are connected using cloud-premise physical channels, and on-premise data is automatically uploaded to the cloud using northbound interfaces in real time. The cloud performs unified generalization training and functions as a unified O&M center and knowledge center. Cloud-premise synergy implements synchronous update and upgrade of AI models and network knowledge, effectively supporting continuous telecom network evolution.

ADN Industry Development Suggestions

ADN represents an upgrade in the telecom industry and will have a profound impact on network architecture, network O&M, and business operation. To achieve the ambitious goal of ADN, we should refer to the development rules and success of 3G, 4G, and 5G, and develop the intergenerational standards of ADN L3, L4, and L5 in a three-stage strategy: development, research, and exploration. We should continuously evolve the standards based on service and technology development.

In the next three to five years: the network will have perception analysis, where AI can fully assist in decision-making.

In the next five to seven years: the network will be in its first stage of autonomy. In some network and service scenarios, the network will be highly self-determined.

In the next seven to ten years: the industry will take on the ultimate goals of full-scenario, full-lifecycle network self-decision-making and self-evolution.

To implement ADN commercial use, all parties in the industry need to complement each other from a business perspective and focus on their own areas to improve the ADN industry collaboration efficiency.

- Carriers can focus on business operation and network O&M process innovation to create more opportunities and mechanisms for rapid innovation.
- Network equipment providers can focus on continuously simplifying the difficulty of network technologies for application developers, and provide abundant scenario-based APIs and single-domain closed-loop products and solutions.
- New service developers can focus on scenario-based APIs to quickly develop various B2C, B2H, B2B, and B2G applications and monetize business with the help of the intelligent 5G IoT connection platform.
- BSS suppliers can focus on providing platforms and solutions for intelligent business to customers, ecosystems, and partners.
- OSS suppliers can focus on providing E2E cross-domain and cross-vendor service O&M platforms and solutions, and work with network providers to optimize scenario-based intent APIs and accelerate service innovation.
- Industry alliances, standards organizations, and open source organizations should play a significant role in formulating industry technical specifications, architecture references, interface standards, and industry cooperation models.

To better promote the development and collaboration of the ADN industry, Huawei proposes the following three initiatives based on the joint practices of Huawei and global partners in the past few years. All parties in the industry are called upon to jointly invest in the reference architecture, interface standards, assessment system, and talent transformation.

1

Define the ADN reference architecture and interface standards to promote industry collaboration.

2

Define ADN rating and evaluation criteria to drive industry development.

3

Promote talent transformation in the telecom industry and maximize the value of O&M personnel.

Define the ADN reference architecture and interface standards to promote industry collaboration

The ADN standard architecture bridges service requirements and solutions. According to the TOGAF methodology and practical experience, the ADN architecture should include

- Business architecture
- Application architecture
- Information architecture
- API architecture

Based on the TMF high-level business architecture, the architecture standards should be further refined in the next two to three years.

With a standard architecture, all parties in the industry can develop a consensus on ADN business requirements and technical capabilities, guide product development, business application, and cooperation strategies, expanding the market space, and sharing value.

For carriers

The industry standard architecture can guide carriers' enterprise-level architecture, draw on industry-level success, aggregate supplier capabilities, innovate on demand, and support Internet of Everything (IoE).

For suppliers

It can align their unified architecture thinking and layered solutions with customer plans, and guide the development and design of ADN products and solutions.

On the industry architecture map, work with partners to leverage their expertise in each field and supplement required capabilities through open standard interfaces. Finally, the architecture standards should be reviewed with the future in mind, and the industry-oriented L4 open reference architecture and interface standards should be developed to promote efficient collaboration and division of labor among industry partners. During this process, work with customers to find breakthrough points based on application scenarios and promote business results in stages through fast iteration.

Define ADN rating and evaluation criteria to drive industry development

ADNs need to be iteratively developed level by level. It is recommended that the industry continuously deepen the construction of the ADN evaluation system based on the original five-level rating standards to promote the intergenerational ADN evolution and achieve the L3 goal in 2022.

Specifically, the following two aspects can be considered

Optimize the ADN rating standards

Analyze typical scenarios and services based on the full lifecycle of network planning, construction, maintenance, and optimization, and specify the key capabilities and features of the corresponding automation levels.

Build an ADN evaluation system

Based on customer experience and service intent, build a testable and measurable evaluation system for specific scenarios to support status evaluation, set reasonable improvement objectives, and evaluate benefits.

For the industry, the rating and evaluation standards not only help guide the evolution of ADN between its generations, but also promote the cohesion of all parties.

For carriers, the black-box hierarchical evaluation system can be used to evaluate the network status, help formulate network evolution policies and development plans, and promote phase-based business monetization.

For suppliers, fully understand customers' black-box requirements and performance requirements, and provide decision-making support for technology introduction, product planning, and implementation.

Promote talent transformation in the telecom industry and maximize the value of O&M personnel

The intelligent O&M of man-machine collaboration does not directly abandon the existing O&M system, tools, and experience, but overlays and integrates them. It is necessary to systematically study smooth network architecture evolution as a strategy and the impact of man-machine collaboration interaction on organizations and personnel. It is also necessary to explore new talent and skill development, and new skills in the telecom industry. Enable enterprise employees to play a greater role with the assistance of AI.

New O&M positions will emerge in the future, such as network strategists, orchestration engineers, and data analysts. People will still play an important role in intent design, exception handling, and key decision-making.

In particular, the introduction of AI technologies will change the knowledge and work habits required by existing personnel. It is necessary to strengthen AI understanding, development, and application skills, and practices must be summarized and shared to transform existing processes and talents.

To realize the full potential of ADNs, talent cultivation, integration and optimization of existing capabilities, and organization development are as important as any other strategic initiative. Huawei firmly believes that talent cultivation and development plans need to be formulated to match the upgrade to an intelligent network.

Summary

Huawei is committed to exploring the future evolution of networks, practicing the ADN strategy, and addressing the structural challenges of the telecom industry through an innovative architecture to improve network O&M efficiency, resource utilization, energy efficiency, and customer experience. Huawei works with global carriers and partners in various industries to jointly promote intelligent industry upgrades as well as sustainable and healthy development. Huawei ADN is not a single product innovation but an innovative system architecture and O&M mode for all scenarios and series.

There is still a long way to go to realize ADNs fully. To make this dream a reality, all parties in the telecom industry must work together to forge ahead. Huawei is committed to taking complexity and creating simplicity, and embracing the fully-connected intelligent world with its customers.

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