Full-Stack AI | Simplified Network | Intelligent O&M

ADN Issues
June 2020
01

Autonomous Driving Network

F5G + AI

Helping Progress Towards Autonomous Driving Networks

iMaster NCE Enables Intelligent O&M and Advances ADN

The Entire Industry Should Reach Consensus on Jointly Exploring Autonomous Driving Networks

Intent-Driven Autonomous Driving Engine for Access Networks, Enabling an Intelligent F5G Society

Globe Reinvented ConnectivitySolutions for Enterprise through Network Modernization and Transformation

Huawei Helps China Minsheng Bank Build a Next-Generation DC Network

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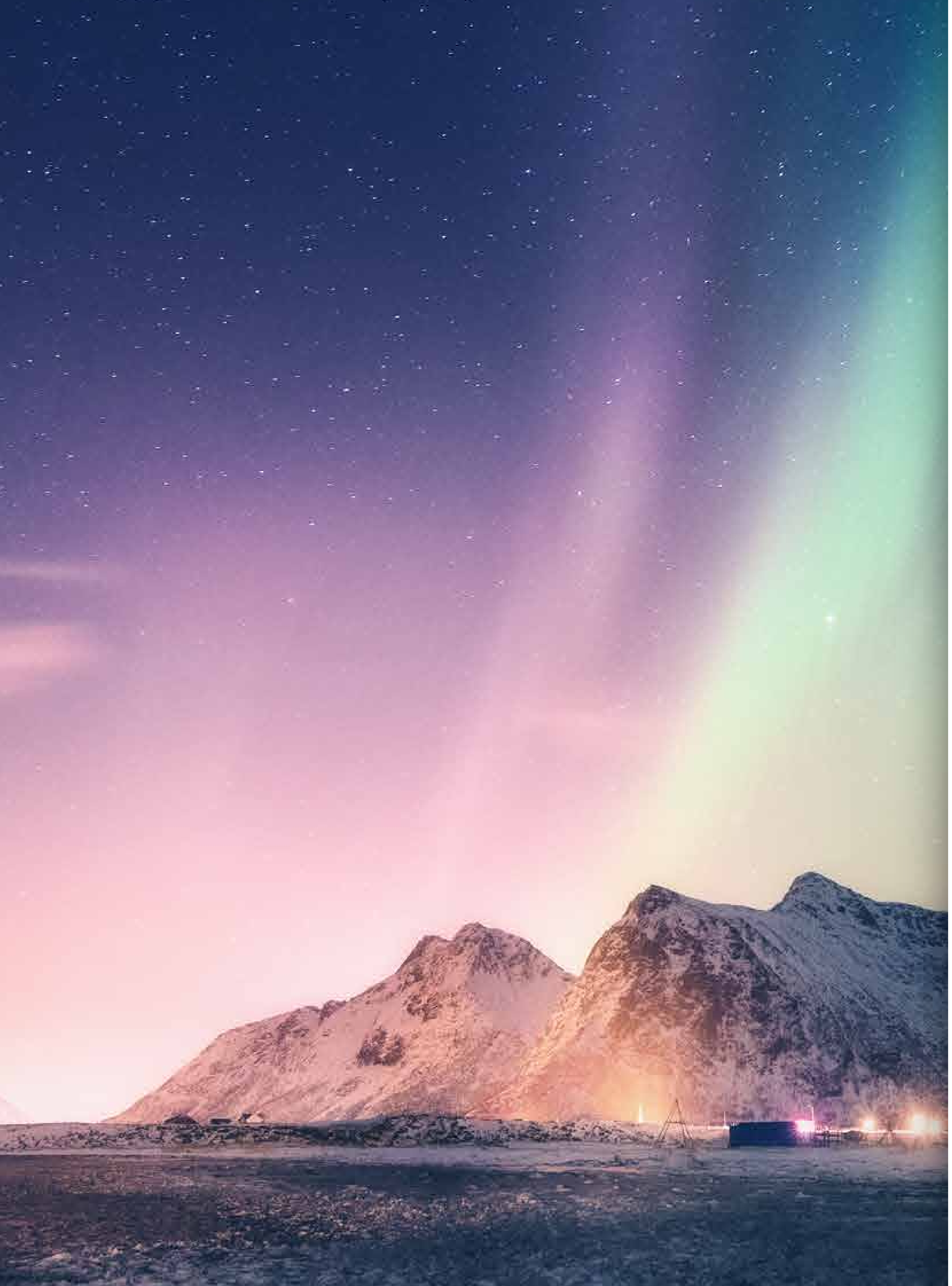


Moving Towards the Autonomous Driving Network Featuring Man-Machine Collaboration

Jessie Liu

Huawei ADN Chief Marketing Officer

In the future, a smart society with everything sensing, connected, and intelligent will emerge. Currently, the digital economy has become the world's most important new economic form, with the global economy facing great challenges and pressure in 2020. Driven by digital technology innovation, the "new infrastructure" industry will show strong growth momentum and innovative vitality. During the global battle against COVID-19, carriers' communications networks, as the foundation of online activities, are undertaking a large number of key tasks, including telecommuting, online education, and online shopping. This sudden pandemic is accelerating the digitalization of the entire industry. Both mobile and fixed network technologies are constantly evolving to adapt to the intelligent era of Internet of Everything. The advent of the 5G and F5G era will better support the vigorous development and wide application of digital intelligent applications, and promote the rapid development of the global digital economy.

While embracing new opportunities, the telecom industry is facing the following challenges. The equipment-centric network construction mode and manual O&M mode of the last decade are unsustainable. According to a report by OVUM, as networks grow in scale and services become more complex, OPEX rapidly increases, profitability decreases, and the structural contradiction becomes increasingly prominent. Network complexity is also increasing due to co-existing 2G, 3G, 4G, and 5G networks. In addition, business innovation is slow, and it takes as long as 6–12 months to respond to new digital services and applications.

We firmly believe that the telecom industry should fully, scientifically, and effectively use new technologies such as AI, big data, and automation, and leverage data and knowledge to build an autonomous network that features automation, self-healing, and self-optimization. On this network, services can be agilely enabled, optimal experience enables value monetization, and intelligent O&M achieves maximum resource and energy utilization. Over the last two years, through active exploration and practice by all industry parties, we have seen that ADN has abundant application scenarios and business values. AI is being introduced to cloud services, local networks, and devices at different layers, reshaping the telecom network's intelligence core, enabling networks to progress towards ADNs featuring man-machine collaboration, and further promoting the intelligent upgrade and sustainable development of the industry.

EDITOR IN CHIEF

02 | Moving Towards the Autonomous Driving Network Featuring an-MachineCollaboration

Knowledge and data are being leveraged to drive architecture, process, and talent transformation, enabling the DevOps capabilities of carriers' service model production, as well as O&M process design and orchestration. This reshapes the telecom industry's core and enables networks to progress towards ADNs featuring man-machine collaboration, promoting the intelligent upgrade and sustainable development of the industry.

COVER ARTICLE

06 | iMaster NCE Enables Intelligent O&M and Advances ADN

iMaster NCE is an intelligent management and control unit for FBB. As the first system in the industry to integrate Manager, Controller, Analyzer, and AI, iMaster NCE effectively connects physical networks with business intents and implements centralized management, control, and analysis of global networks.

INDUSTRY TREND

20 | The Entire Industry Should Reach Consensus on Jointly Exploring Autonomous Driving Networks

The telecom ADN revolutionizes the existing network industry. It will bring profound changes to the existing organizations, processes, support systems, network construction, and procurement methods of carriers. Therefore, all industry parties need to participate in the transformation, and collaborate to achieve win-win development.

SPECIAL REPORT

26 | ADN Enables High-Quality Monetization of All-Optical Networks

Helping optical transport networks achieve the "anytime response, on-demand transformation, and ultimate connection experience" required by emerging services in the intelligent era, will become the key for the evolution of optical transport networks into all-optical production networks, as well as the transformation from a traditional cost center to a new value center.

32 | Intent-Driven Autonomous Driving Engine for Access Networks, Enabling an Intelligent F5G Society

Big data and AI technologies are utilized to analyze and process obtained information in depth. The real-time awareness and scientific analysis results help carriers to construct, provision, maintain, and operate services, achieving automation and intelligence during the entire process.

41 | Data Center Network Autonomous Driving Engine, Accelerating Digital Transformation of Enterprises

As data center (DC) networks carry all the data and services of enterprises, network scale and complexity have increased to a level beyond the management capabilities of humans. Therefore, enterprises need a new system that combines advanced technologies, such as machine learning, machine inference, and automation, to meet business needs, simplify operations, intelligently assist human decisions, and ultimately make DC networks highly autonomous.

HOT FOCUS

49 | Globe Reinvented Connectivity Solutions for Enterprise through Network Modernization and Transformation

One of the key components of building a digital nation is building a digital enterprise, and our goal is to leverage on our data business as well as our IT-enabled services to help businesses perform more than what is usual. By being passionate as our clients are with their business, we will be able to achieve consistent growth.

54 | O&M Transformation: from Manual to AI

The rapid growth of the 5G era has seen network O&M face growing challenges. This era has witnessed a shift from cost-reducing O&M to O&M that is capable of producing benefits for carriers, driving the traffic monetization of network O&M.

59 | Huawei Helps China Minsheng Bank Build a Next-Generation DC Network

Digital transformation cannot be achieved without the innovation and construction of the data center (DC) IT infrastructure, as the infrastructure is the foundation of all digital economies and essential to the provisioning and guarantee of agile and innovative services. As cloud computing and virtualization technologies develop rapidly, new architectures and technologies are being introduced to the infrastructure.

63 | CAT Telecom Thailand: Private Line Market Leader with High-Quality OTN Networks

CAT Telecom is determined to build a nation-wide flattened network using Huawei's end-to-end OTN+iMaster NCE Solution. It aims to provide differentiated high-quality services for the digital transformation of enterprise customers in Thailand.

68 | China Mobile Zhejiang Launches Intent-Driven 5G Transport Network

Facing challenges posed to the transport network by the development of 5G services, China Mobile Zhejiang and Huawei established a 5G transport innovation project team in 2016. The team continuously invested in the exploration and research of 5G transport networks, achieving remarkable results. In 2018, the largest 5G trial transport network in China was built.

COVER ARTICLE

iMaster NCE Enables Intelligent O&M and Advances ADN

iMaster NCE Enables Intelligent O&M and Advances ADN

By Lu Haiou, director of NCE Product Dept

Lu Haiou

Director of NCE Product Dept

> The global telecom industry is experiencing rapid technological innovations brought by the Internet of Things (IoT), especially in the 5G and cloud era. An increasing number of new services, such as virtual reality (VR), augmented reality (AR), 4K live streaming, remote education, and unmanned driving, are emerging and being upgraded. As a result, there is an explosive growth in network traffic, making telecom networks increasingly complex. According to Gartner's report, the biggest challenge for carriers involves implementing network automation and intelligent O&M to improve service agility, ensure optimal user experience, and reduce OPEX.

iMaster NCE: Intelligent Management and Control Unit for FBB

The telecom industry has been exploring digitalization, automation, and intelligence. Initially, customers hoped to use SDN, NFV, and cloud technologies to improve service and network agility as well as reduce O&M complexity and costs. Progress has been made in SDN with regard to network automation in scenarios such as data center (DC), WAN optimization, and SD-WAN; whereas NFV is equipped with improved resource utilization in vIMS, vEPC, and vCPE scenarios. In addition, DevOps processes and continuous integration and delivery tools improve product development efficiency. In general, network automation still lags behind in terms of technological development — it cannot address the complexity in managing and operating old and new networks, or performance issues regarding large-scale application. A widespread challenge in the industry involves discovering an appropriate method to improve network O&M efficiency.

The autonomous driving network (ADN) was developed under this context. It takes simplified networks and simplified O&M as its core philosophy, and aims to drive the telecom industry from automation to intelligence by employing various intelligent technologies and leveraging integration advantages. Products are planned, designed, and developed according to this philosophy. ADN adopts a three-layer open architecture, which introduces AI into edges, networks, and clouds. The product components include the cloud network AI unit iMaster NAIE, cross-domain intelligent O&M unit iMaster AUTIN, network intelligent management and control units iMaster MAE and iMaster NCE, as well as network infrastructure with built-in AI. The ADN solution includes fixed broadband (FBB) and mobile broadband (MBB) sub-solutions that enable carriers to increase quality, revenue, and efficiency while lowering costs.

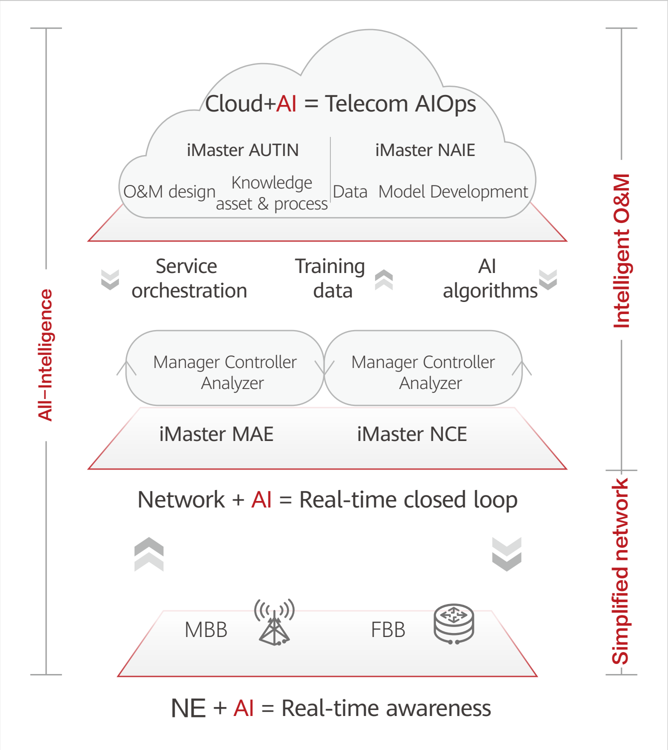

Cloud+AI = Telecom AIOps
iMaster AUTIN
iMaster NAIE
O&M design
Knowledge asset & process
Data
Model Development
Service orchestration
Training data
AI algorithms
Manager Controller Analyzer
Manager Controller Analyzer
iMaster MAE
iMaster NCE
Network + AI = Real-time closed loop
MBB
FBB
NE + AI = Real-time awareness
AI-Intelligence
Intelligent O&M
Simplified network

Figure 1: Architecture of the ADN solution

iMaster NCE is an intelligent management and control unit for FBB. As the first system in the industry to integrate Manager, Controller, Analyzer, and AI, iMaster NCE effectively connects physical networks with business intents and implements centralized management, control, and analysis of global networks. It enables resource cloudification, full-lifecycle automation, and data analytics-driven intelligent closed loops according to business and service intents, as well as provides open network APIs for rapid integration with IT systems. Mainly utilized in carrier networks, DCs, enterprise campuses, and enterprise private lines, iMaster NCE creates simple, smart, open, and secure networks while also accelerating service transformation and innovation for carriers and enterprises.

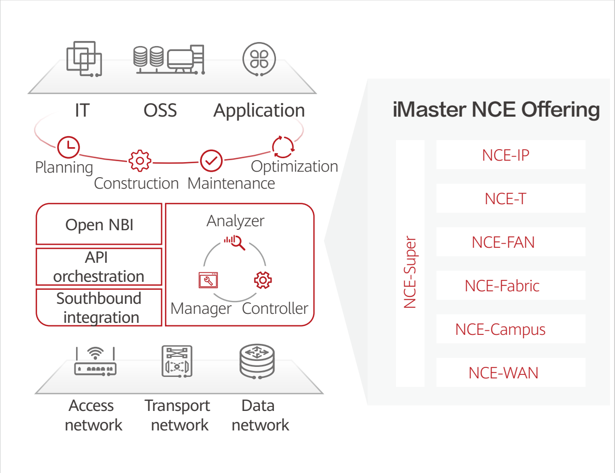

IT
OSS
Application
Planning
Construction
Maintenance
Optimization
Open NBI
API orchestration
Southbound integration
Analyzer
Manager
Controller
Access network
Transport network
Data network
iMaster NCE Offering
NCE-Super
NCE-IP
NCE-T
NCE-FAN
NCE-Fabric
NCE-Campus
NCE-WAN

Figure 2: Architecture of iMaster NCE

Manager, Controller, and Analyzer in iMaster NCE can be flexibly deployed in different scenarios, and single-domain NCE can evolve to multi-domain NCE.

Product Design Philosophy: Single-Domain Autonomy

As telecom services become intelligent and agile, telecom networks increasingly integrate with operation systems. Based on service characteristics, network technologies, and maintenance patterns, carriers divide basic networks and operation systems into different combinations, with each one being referred to as an autonomous domain. Autonomous domains can independently complete entire processes (covering data collection, analysis, control, and optimization) and provide agile network-as-a-service (NaaS) for the outside world. Conventional network operation systems involve complex processes and collaboration among dozens or even hundreds of systems, which leads to complex and time-consuming service provisioning and fault diagnosis. Operation systems can be simplified by integrating the related network management, control, and analysis systems so that they can evolve from automation to autonomy in parallel.

Manager+Controller+Analyzer: Scenario-Centered Closed-Loop Autonomy

iMaster NCE combines conventional element management systems (EMSs), SDN controllers, and performance and traffic analysis systems. To ensure that data can be shared among Manager, Controller, and Analyzer, it uniformly models network, service, and user experience data. In addition, iMaster NCE provides a unified service model and real-time network status awareness, enabling automated service provisioning and closed-loop service optimization.

For example, iMaster NCE is dedicated to implementing automation and closed-loop autonomy throughout the lifecycle of DC networks. During the planning, design, installation, and deployment phases, typical networks are designed automatically, one-click deployment is supported, and basic network construction or capacity expansion can be completed within 1 hour. During the service provisioning and change phases, no network configuration errors are made and services can be automatically rolled out within a few minutes. During the monitoring and O&M phase, typical faults can be automatically detected, diagnosed, and rectified within minutes, ensuring that services run stably.

AI: Enhanced Closed-Loop Autonomy in Complex Scenarios

Telecom network services are complex, uncertain, and subject to changes. Specifically, diversified services pose various requirements on networks, and network traffic fluctuates while service paths change during different time periods. If a network fault occurs, troubleshooting is driven by customer complaints or network alarms. Experts need operations support systems (OSSs), EMSs, or tools during manual analysis, decision-making, and fault closure. In complex scenarios, this method cannot be used to quickly rectify faults or ensure service experience.

As big data and AI technologies mature, the telecom industry is starting to introduce AI theories and engineering algorithms into complex and uncertain scenarios, including fast fault diagnosis and precise traffic prediction, to enhance closed-loop autonomy capabilities. To digitalize expert experience, iMaster NCE injects a broad range of management rules, troubleshooting methods, and additional knowledge into a centralized knowledge base that can be understood and used by computers. It also explores the industry's mainstream AI algorithms and matches the optimal ones with specific scenarios to provide proactive analysis and prediction.

Open Programmability: Simplified O&M and Open Ecosystem

Telecom network O&M is complex. One reason for this is that telecom networks usually consist of devices from multiple vendors, creating difficulties in E2E service provisioning and maintenance. Another reason is that the networking and technical solutions for different networks are not uniform, leading to different O&M processes and approaches as well as low reusability.

By offering an abundant set of APIs or scenario-specific O&M apps, iMaster NCE simplifies network O&M, opens network service capabilities, and enables third-party ecosystems. An API proxy service enables iMaster NCE to offer a unified API access and authentication mechanism as well as northbound and southbound network programmability. Additionally, iMaster NCE supports orchestration of atomic APIs (as scenario-specific APIs) and O&M automation (based on workflows), and its model-based development (MBD) framework can adapt to third-party devices to deliver fast, programmable third-party network integration capabilities.

4 Engines in the Core of the Product Architecture

The architecture of iMaster NCE can be summarized as one cloud platform, one digital twin network map, four engines, and one API gateway. Based on a unified cloud platform in microservice-oriented architecture, iMaster NCE is equipped with cloud architecture capabilities such as auto-scaling and load balancing. The digital twin network map is responsible for network data governance and digital mapping of physical networks to support upper-layer system applications. Four engines (automation, intent, analytics, and intelligence engines) collaborate to implement network automation and intelligence, and iMaster NCE's capabilities at each layer can be opened through APIs to quickly integrate with peripheral systems.

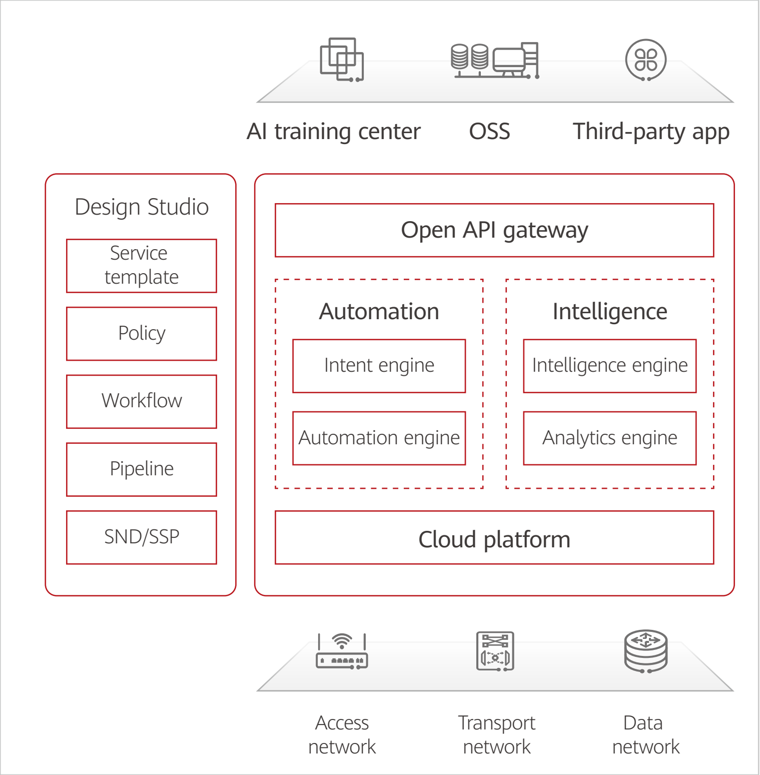


Figure 3: Product architecture with four engines as the core

Automation Engine: Automated Network Services

The automation engine integrates two important components: Manager and Controller. It provides functions such as automatic NE management, network service management, network path computation, and network optimization. When users deploy services on a network, this engine automatically computes and delivers service paths. In addition, Controller can centrally schedule global resources to meet SLA requirements and improve resource utilization. In MBD mode, the automation engine quickly integrates and manages third-party NEs as well as expands network service automation capabilities. It opens NE- and network-layer capabilities to support quick integration with third-party systems and networks.

Intent Engine: Deep Automation in Complex Scenarios

Intents refer to users' expectations for network and service status. In this regard, the intent engine enables networks and services to run based on users' intents. The intent engine of iMaster NCE can convert simple user language to complex network models and language, automatically generate call plans for services in each domain, and break down complex tasks. For example, to provision private line services across multiple network domains that use different pipe technologies (such as L3VPN or PWE3), users only need to specify the physical locations of the source and sink sites as well as bandwidth requirements. The intent engine can then automatically select the optimal network path, optimal network resources, designated pipe technology, and appropriate QoS profile to complete service provisioning efficiently.
The intent engine also supports automatic closure of intents. This involves users predefining the expected status (such as SLAs) of scenario-specific tasks, as well as corrective measures and implementation policies when the status does not meet expectations. If the intent engine discovers that the actual status and expected status are inconsistent, it automatically takes the predefined measure (for example, it recomputes paths or adjusts bandwidth) to maintain networks or services in the expected status, thereby achieving autonomous network O&M.

Analytics Engine and Intelligence Engine: Proactive Analysis and Forecast

The analytics engine mainly provides the data collection, storage, and analysis functions. By introducing the Telemetry protocol, the analytics engine collects network and service KPIs in seconds, detects network and service status in real time, processes and stores network data, extracts data characteristics, and classifies raw data. The results are used as input for the intelligence engine, which in turn uses machine learning and AI technologies and algorithms to conduct inference on the data and provide analysis results. The intelligence engine also verifies and evaluates the advantages and disadvantages of AI models, and continuously optimizes the models through local training to increase analysis accuracy.
In the future, network data will be large in scale, multi-dimensional, and of a high frequency; therefore, it will be difficult for humans to analyze, summarize, and evaluate data. To overcome this challenge, the analytics and intelligence engines of iMaster NCE quickly extract key information and provide guidance and suggestions, enabling users to proactively forecast and prevent faults.

5 Key Capabilities

In terms of product design, development, and verification, iMaster NCE provides a series of key capabilities, such as system reliability, multi-dimensional data visualization, fault diagnosis and recovery in minutes, closed-loop automation, and open programmability, enabling intelligent O&M and approaching ADN on FBB networks.

Multi-Dimensional Reliability Technologies, Keeping the System Stable

iMaster NCE uses the local redundancy and remote disaster recovery (DR) mechanisms to ensure high system reliability. The local system supports hierarchical redundancy protection, including 1+1 protection for hardware, master/slave protection for databases, cluster protection for the software platform, active/standby or cluster protection for apps, and active/standby protection for client access. When a single object is faulty, the local system automatically switches to its standby counterpart within 1 minute to quickly recover services.

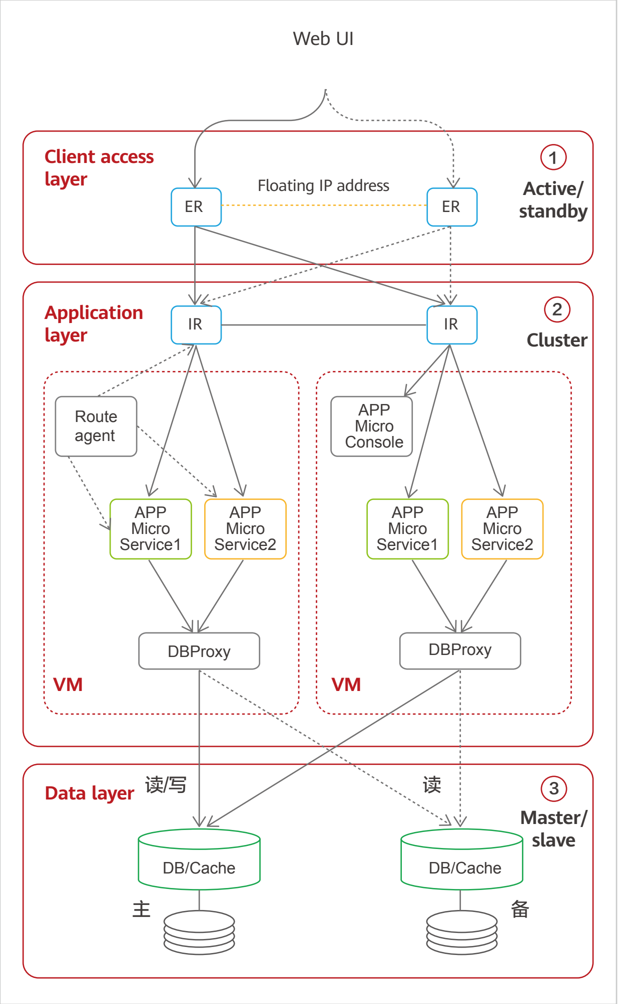

Web UI
Client access layer
Floating IP address
ER
ER
①
Active/standby
Application layer
IR
IR
②
Cluster
Route agent
APP Micro Service1
APP Micro Service2
APP Micro Console
APP Micro Service1
APP Micro Service2
DBProxy
DBProxy
VM
VM
Data layer
读/写
读
③
Master/slave
DB/Cache
DB/Cache
主
备

Figure 4: Local redundancy mechanism

DR protection is available between primary and secondary sites, and it relies on database replication. The DR service is located at the application layer (independent of hardware or virtualization platforms), and it achieves fast fault detection and automatic switchover between the primary and secondary sites. If the primary site fails, the secondary site can take over services in less than 15 minutes.

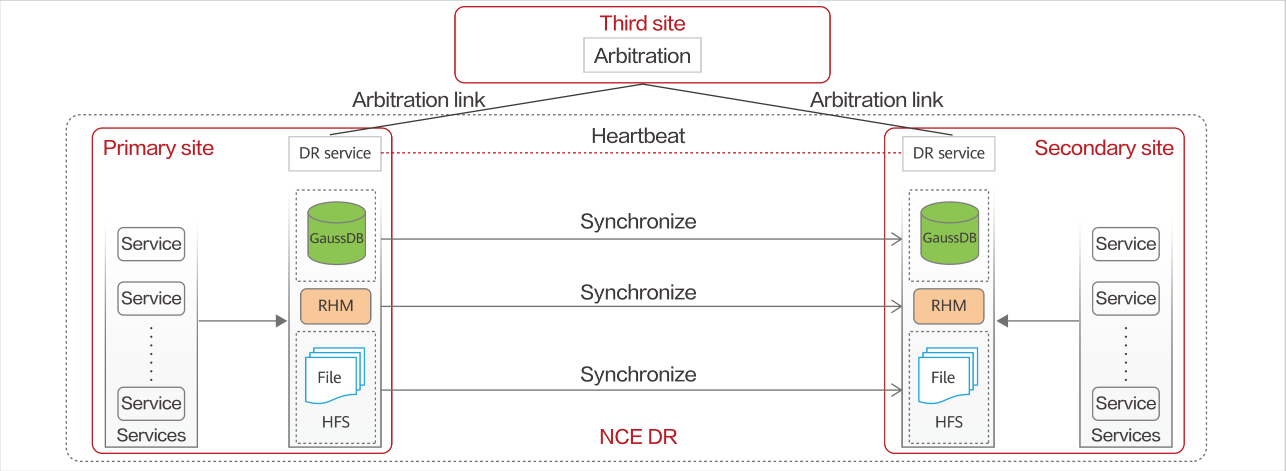

Third site
Arbitration
Arbitration link
Arbitration link
Heartbeat
Primary site
DR service
DR service
Secondary site
Service
Service
Service
Services
GaussDB
RHM
File
HFS
Synchronize
Synchronize
Synchronize
NCE DR
GaussDB
RHM
File
HFS
Service
Service
Service
Services

Figure 5: Remote DR mechanism

Digital Twin Network Map, Visualizing Multi-dimensional Data for ADN

Topology is frequently used as an O&M entrance. Conventional EMSs use topology as a visualization method, which combines with basic alarm information and status to help monitoring personnel understand networks. iMaster NCE builds a digital twin network map that aims to be a main monitor for network driving. This map combines multi-dimension information from different applications and environments into one main topology based on scenarios, thereby offering unified management and O&M of all resources as well as one-stop operation experience to network administrators.

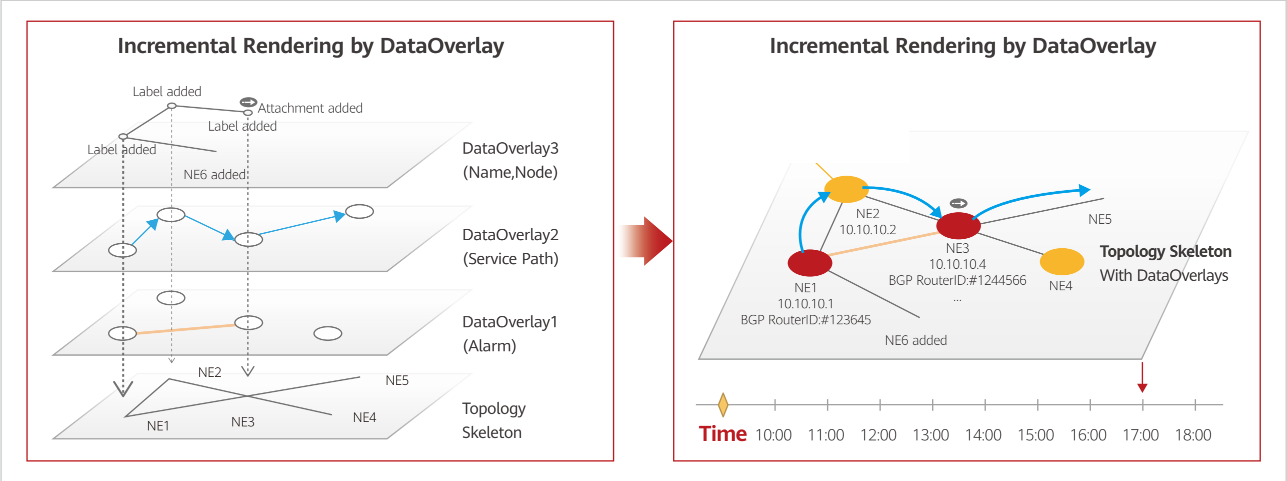

Incremental Rendering by DataOverlay
Label added
Attachment added
Label added
Label added
NE6 added
DataOverlay3
(Name,Node)
DataOverlay2
(Service Path)
DataOverlay1
(Alarm)
NE2
NE5
NE1
NE3
NE4
Topology
Skeleton
Incremental Rendering by DataOverlay
NE2
10.10.10.2
NE5
NE3
10.10.10.4
BGP RouterID:#1244566
NE4
Topology Skeleton
With DataOverlays
NE1
10.10.10.1
BGP RouterID:#123645
NE6 added
Time 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00

Figure 6: Digital twin network map

By continuously collecting and storing NE inventory data, service configuration data, performance data, alarms, and logs, Manager and Controller digitally map the physical network to the digital twin network map. Based on models, the digital twin module automatically generates a network topology and intelligently restores the physical network topology, enabling O&M personnel to quickly recognize network and device characteristics and improve O&M efficiency. At every moment, multi-dimensional information is saved as snapshots to record current and historical network status. Historical status can be replayed on demand, and snapshots at different time points can be compared to intuitively display multi-dimensional network trends.

AI-Powered "Fault 1-3-5" Service, Achieving L3 ADN on DC Networks

Network autonomy is the ultimate goal of ADN. To achieve this, humans need to gradually withdraw from participating in network O&M. iMaster NCE provides a "Fault 1-3-5" service, which refers to fault detection in 1 minute, diagnosis in 3 minutes, and rectification in 5 minutes. It is the foundation for reducing manual O&M operations and gradually achieving ADN.

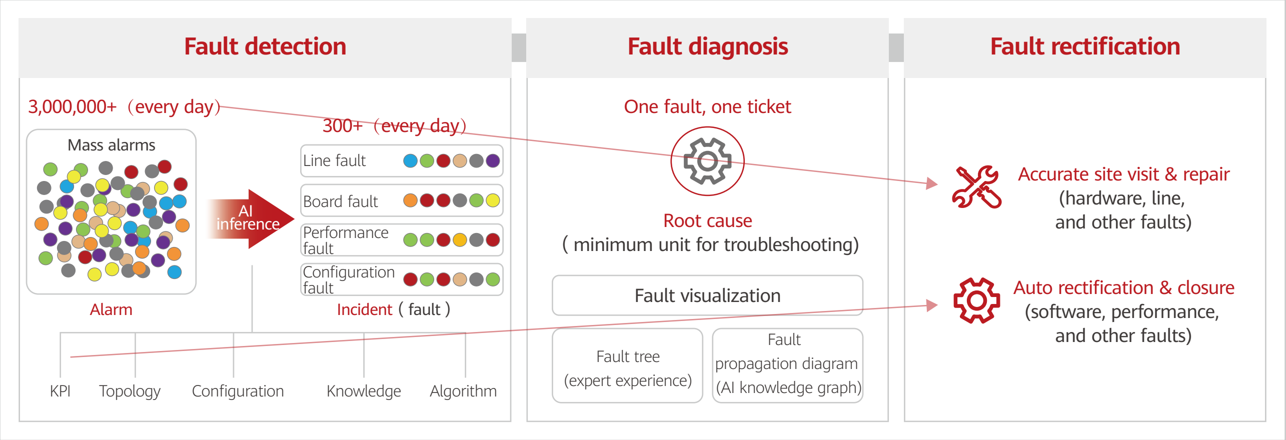

Fault detection
Fault diagnosis
Fault rectification
3,000,000+ (every day)
300+ (every day)
Mass alarms
Line fault
Board fault
Performance fault
Configuration fault
AI inference
Alarm
Incident (fault)
One fault, one ticket
Root cause
(minimum unit for troubleshooting)
Fault visualization
Fault tree
(expert experience)
Fault propagation diagram
(AI knowledge graph)
Accurate site visit & repair
(hardware, line, and other faults)
Auto rectification & closure
(software, performance, and other faults)
KPI
Topology
Configuration
Knowledge
Algorithm

Figure 7: Framework of the "Fault 1-3-5" service

Incorporating Huawei's exert experience, which has been accumulated over the last 30 years, the "Fault 1-3-5" service further develops new fault analysis rules through continuous fault model training. With the help of AI and knowledge inference, it can quickly identify the root causes of faults, judge network exceptions, forecast network risks, and recover services manually or automatically based on intents.

Fault 1-3-5 is the foundation of intelligent alarm management in iMaster NCE, and it significantly reduces the number of alarms through grouping, classification, and noise reduction, as well as makes intelligent recommendation possible through accurate root cause analysis (RCA). In collaboration with customer OSSs, it ensures "one fault, one ticket." On Henan Mobile's 5G transport network, the intelligent alarm service diagnoses approximately 200,000 alarms as 400 faults daily, with over 90% of faults being matched to tickets. iMaster NCE also applies "Fault 1-3-5" to DC networks. Based on technologies such as real-time collection with Telemetry, network health check, knowledge graph optimization, and intent-based intelligent decision, iMaster NCE can proactively detect 80% of DC network faults within 1 minute, identify the root causes of 75 types of faults within 3 minutes, and rectify typical faults within 5 minutes due to continuous learning, training, and optimization. In this way, DC networks are taking the lead in achieving L3 ADN, that is, conditional autonomous driving.

Intent-Driven Closed-Loop Automation

Intent-based network autonomy requires constant intent assurance, that is, continuous service provisioning. Intent-driven closed-loop automation implements autonomous management of the entire service lifecycle.

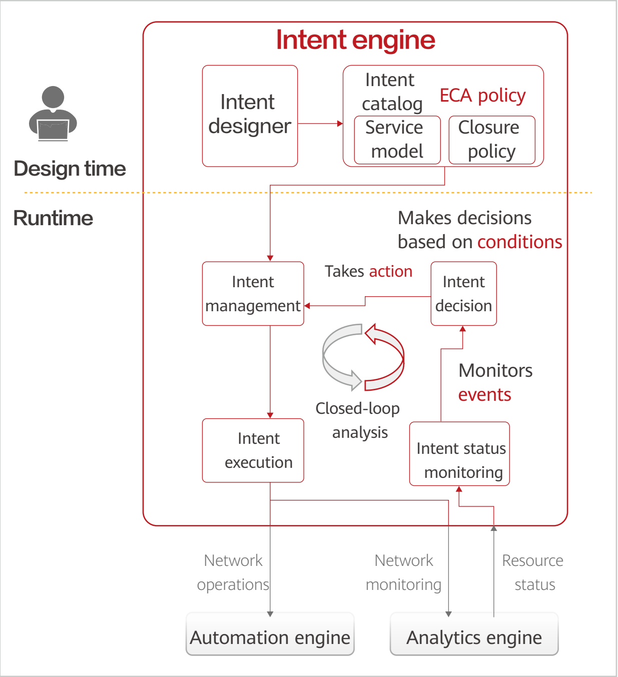

Intent engine
Design time
Runtime
Intent designer
Intent catalog
ECA policy
Service model
Closure policy
Makes decisions based on conditions
Takes action
Intent management
Intent decision
Monitors events
Closed-loop analysis
Intent execution
Intent status monitoring
Network operations
Network monitoring
Resource status
Automation engine
Analytics engine

Figure 8: Intent-driven closed-loop automation

The intent engine defines Event-Condition-Action (ECA) combinations to cope with network accidents in line with customer intents. It can work with "Fault 1-3-5" to promptly detect deterioration in network quality and re-optimize network resources for high-priority services based on SLA requirements.

During design, users can customize ECA policies, which will be automatically executed at runtime. After intents are delivered, iMaster NCE monitors the events defined in the ECA policies. After the defined events are generated and reported, iMaster NCE makes decisions based on the preset conditions and takes the preset actions according to the decisions. The decision process supports risk evaluation. Users can intervene and select actions or let the system take actions automatically. If no ECA policy has been defined, users can select the closed-loop policy provided by the system to automatically re-allocate network resources and restore services.

For example, to balance traffic on a DC network, users first define service intents for balancing traffic on leaf nodes. Based on the intents, monitoring tasks are automatically created and delivered to the intelligent analysis module, which collects and analyzes traffic and other KPIs on each leaf node in real time. If the traffic on a leaf node exceeds the preset threshold, an event will be reported to the decision module, which then decides (based on initial service intents) that some VMs need to be migrated from that node to alternative idle leaf nodes. After the decision passes simulation verification, iMaster NCE automatically delivers service and network configurations to keep traffic well balanced among leaf nodes.

Design Studio, Building a Secure and Easy-to-Use Network Openness Platform

IDesign Studio is an open network programming module of iMaster NCE. It provides a graphical integrated development environment, Python framework, and a series of service templates and model packages to help users quickly develop and verify scenario-specific APIs and apps, which can then be released to iMaster NCE in just one click to meet continuously changing O&M requirements.

Currently, iMaster NCE provides programming tools, such as Agile Open Container (AOC) and Workflow Engine (WKE), in different scenarios. AOC provides a programming environment for third-party NE management, and based on YANG models, it can quickly interconnect with third-party devices that support NETCONF or YANG without coding. When using AOC to develop automation services, users only need to focus on service logic. AOC simplifies service deployment by encapsulating northbound interfaces, southbound interfaces, transaction management, as well as data storage and query. In addition, AOC supports configuration rollback as well as driver and service plug-in upgrades without interrupting services, ensuring secure service provisioning and service traceability.

Currently, AOC has helped China Unicom Guangdong develop a function to automatically activate multi-vendor IP RAN devices in 5G transport scenarios, shortening the period from 6–9 months to just 1 month.

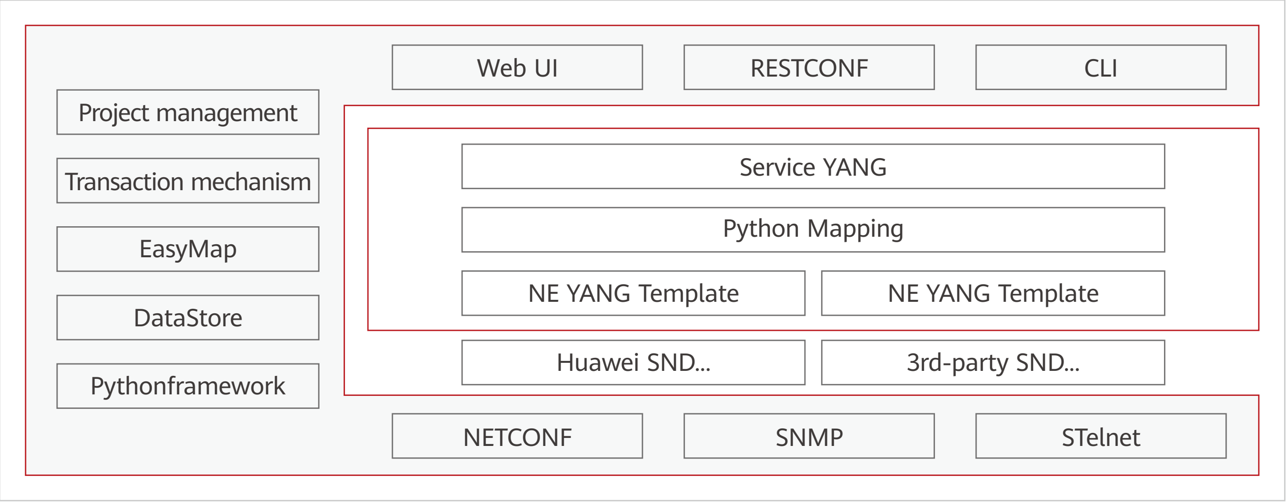

Web UI
RESTCONF
CLI
Project management
Transaction mechanism
EasyMap
DataStore
Pythonframework
Service YANG
Python Mapping
NE YANG Template
NE YANG Template
Huawei SND...
3rd-party SND...
NETCONF
SNMP
STelnet

Figure 9: AOC framework

WKE provides a programming environment for customizing network O&M processes. It provides a library with several atomic API templates and supports graphical, drag-and-drop programming. In addition, WKE orchestrates associated atomic APIs as scenario-specific service APIs, reducing the number of interfaces and parameters that OSSs integrate. Furthermore, the service APIs support hot release and version decoupling, eliminating the need for version upgrades.

For example, during automatic ONT service provisioning in home broadband service scenarios, WKE can orchestrate the 8 atomic APIs originally integrated by OSSs as 1 scenario-specific API, reducing network parameters from more than 100 to fewer than 20, and shortening the integration period from 6–9 months to 3 months.

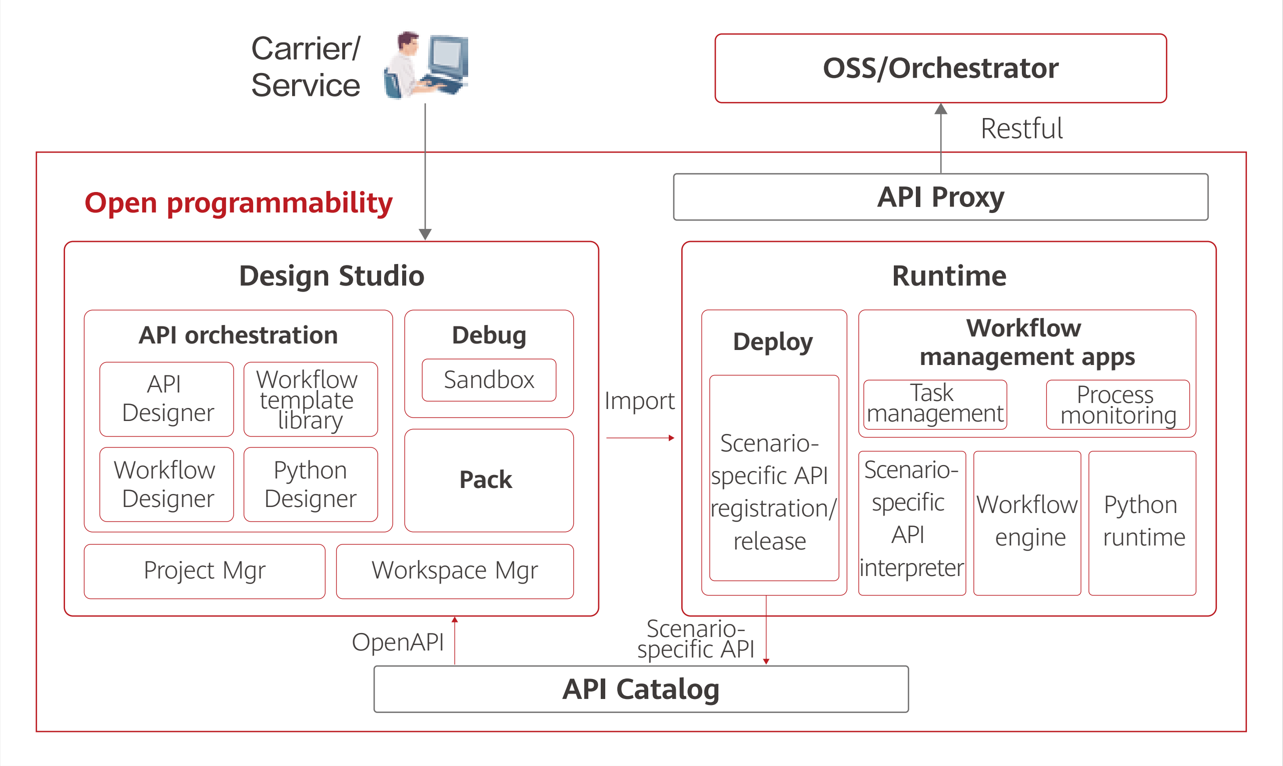

Carrier/
Service
OSS/Orchestrator
Restful
Open programmability
API Proxy
Design Studio
API orchestration
API Designer
Workflow template library
Workflow Designer
Python Designer
Debug
Sandbox
Pack
Project Mgr
Workspace Mgr
Import
Runtime
Deploy
Scenario-specific API registration/release
Workflow management apps
Task management
Process monitoring
Scenario-specific API interpreter
Workflow engine
Python runtime
OpenAPI
Scenario-specific API
API Catalog

Figure 10: WKE framework

Commercial Use of iMaster NCE

Huawei is committed to building an ADN that "leaves complexity to itself and brings simplicity to customers", and the company focuses on two core objectives: simplified network and simplified O&M. By the end of 2019, iMaster NCE had incubated more than 50 use cases in 5G, home broadband, private line, enterprise campus, and DC network scenarios through continuous innovation and customer cooperation. It has been commercially deployed on a large scale by more than 200 carriers and 1000 enterprises worldwide.

In addition, Huawei works with both upstream and downstream industries to build an open ecosystem. By the end of 2019, iMaster NCE had been certified and integrated by more than 40 partners from different industries, including orchestrator and network VAS industries. Furthermore, Huawei has been cooperating with third-party certification organizations such as EANTC and SDNCTC to interconnect with controllers from mainstream vendors. Based on Huawei's DevCloud platform, Huawei provides partners, developers, and customers with DevOps services from learning to development and verification. At the close of 2019, more than 600 APIs were provided to accelerate network capability openness.

Throughout network planning, construction, maintenance, and optimization, iMaster NCE will help global carriers and enterprises move toward highly automated and intelligent networks, and ultimately ADN.

INDUSTRY TREND

Gather industrial consensus,
Towards the era of automatic driving network

The Entire Industry Should Reach Consensus on Jointly Exploring Autonomous Driving Networks

By River Huang

River Huang

General Development Dept CTO

Industry Cooperation Is Required to Overcome the Challenges of Exploring Autonomous Driving Networks

Like autonomous vehicles, the telecom autonomous driving network (ADN) is facing great complexity. First, as telecom networks carry multiple services simultaneously, the autonomous driving system needs to accurately understand the differentiated intent of different services. Second, the telecom network (road conditions) contains "highways", including data centers and backbone networks, as well as "country roads", such as home broadband access, wireless networks, and microwave networks. Therefore, the autonomous driving system needs to adapt to complex environments involving multiple vendors and technical fields. Finally, with the large-scale deployment of 5G, 5G networks are becoming more complex, operating

costs are increasing, and new 2B services are posing various requirements. The autonomous driving system needs to quickly meet the diversified requirements of different service roles. The ADN system involves multiple existing service systems and the service organizations of carriers and suppliers. The entire industry needs to cooperate to address the complex challenges of exploring the network system.

According to results, current network automation progress does not address the complexity brought by network construction and development. According to OVUM, the global average ratio of carriers' OPEX to revenue increased from 62% in 2005 to 75% in 2018. To cope with the challenges faced by carriers using ADNs, new technologies and ideas, such as cloud, big data, and AI, must be introduced, O&M must change from passive response to proactive prevention, as well as from manual and independent tool mode to single-domain network autonomy and cross-domain network collaboration mode. The decision-making method has changed from depending on experts' experience to collaborative decision-making between humans and machines. Based on these design changes, carriers and suppliers need to use common data buses, data models, AI models, and standard APIs to enable interconnection and interoperability between management and control systems in different domains. To implement new ideas and achieve new objectives, efficient industry collaboration, cross-industry cooperation, and complementary advantages are required. Furthermore, the industry division, roles, and interaction interfaces need to be optimized from a business perspective.

If consensus on industry's requirement baseline and reference architecture in the ADN domain is reached, it can be used to guide the continuous development of all parties, expand space, and share values. For carriers, industry consensus can be used to guide their enterprise-level architecture, learn from successful industry experience, gather supplier capabilities, and innovate on demand. For suppliers, the unified architecture and objectives are used to align with customer plans and guide the development and design of ADN products and solutions.

The telecom ADN revolutionizes the existing network industry. It will bring profound changes to the existing organizations, processes, support systems, network construction, and procurement methods of carriers. Therefore, all industry parties need to participate in the transformation, and collaborate to achieve win-win development.

Major Progress of the ADN Industry

In 2019, great progress has been made in the exploration and application of ADN industry standardization. Through the joint efforts of multiple carriers, including China Mobile, China Unicom, China Telecom, Orange, and BT; industry organizations, including TMF, ETSI, GSMA, ITU-T, 3GPP, and CCSA; as well as other equipment and OSS/BSS vendors, a large amount of work had been completed by the end of 2019. This includes the writing of white papers, application cases, and interface definitions.

TMF believes that the ADN is an essential part of SP digital transformation and has been committed to integrating a wide range of industry ecosystems to reach industry consensus on ADN classification and maturity level definition. In May 2019, TMF established the Autonomous Networks project and released a white paper to describe the framework, 5-level definition, methods, and application scenarios of ADNs.

ETSI believes that to achieve network transformation, the traditional NMS must be transformed to the ADN. ETSI ENI describes the five-level definition of AI-based network autonomy in the report released in November 2019. In August 2019, ETSI ZSM released the general integration framework requirements, architecture, and terminology V1.1.1 for GS ZSM network full-life-cycle automation.

GSMA believes that to implement intelligent autonomous networks, the entire industry needs to have a unified understanding of this concept, continuously clarify it, specify each corresponding development phase and objective, and jointly nurture related cases. GSMA released AI in Network Use Cases in China in October 2019, which describes the three-layer architecture and five-level definition of intelligent autonomous networks.

Orange proposed at the TM Forum summit in November 2019 that the various definitions and implementation methods are major obstacles to implementing the ADN. Therefore, a consistent ADN vision must be formulated; otherwise, the platforms and solutions of different carriers and vendors cannot interoperate with each other.

Huawei proposed the vision, objectives, five-level evolution roadmap, and system architecture of telecom networks towards autonomous driving in September 2018, and called on the industry to jointly define clear standards that guide technology innovation and implementation. Since then, Huawei has been committed to working closely with all industry parties. In May 2019, Huawei, TMF, and China Mobile jointly released the AN V1.0 white paper at the TMF Nice Summit. In July 2019, Huawei collaborated with TMF, certain carriers, and OSS vendors to develop the AN V2.0 white paper, AN V1.0 standard architecture, and AN classification and evaluation standards, and planned to release them at related summits or exhibitions such as the 2020 TMF. In November 2019, Huawei held an ADN discussion panel at ETSI. In January 2020, Huawei collaborated with China Mobile in CCSA TC7 to support the project, which is based on intelligence levels, of mobile communications network management. In addition, Huawei has established joint project teams with China Unicom and China Mobile to innovate live network-based practices, promote the formulation of ADN enterprise standards, and continuously promote the fully developed standards and business value verification through real-world application.

Suggestions for ADN IndustryDevelopment

To implement the commercial use of ADNs, all collaborators in the industry need to work together from the business perspective and focus on developing their specialized areas to improve the efficiency of collaboration. For example, operators can focus on innovating business operations and network O&M. Providers of network devices can focus on continuously simplifying the technical difficulties of network technologies for application developers as well as providing various scenario-based APIs and single-domain closed-loop products and solutions. OSS vendors can focus on providing E2E cross-domain and cross-vendor service O&M platforms and solutions. BSS suppliers can focus on providing customer-, ecosystem-, and partner-oriented business intelligent operation platforms and solutions. Finally, industry alliances, standards, and open source organizations will 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 suggestions based on the joint practices of Huawei and global partners from the previous few years. All collaborators in the industry are called upon to jointly invest in the reference architecture, interface standards, assessment system, and cultivation of talent.

First, define the ADN reference architecture and interface standards to promote collaboration in the industry.

The ADN standard architecture connects service requirements and solutions. Based on the TOGAF methodology as well as practical experience, the ADN architecture should include the business, application, information, and API architectures. On the industry architecture map, all collaborators in the industry work together and supplement required capabilities through open standard interfaces. Moreover, the architecture standards should be reviewed from the perspective of future development, and all collaborators in the industry should jointly develop the L4 open reference architecture and interface standards to promote efficient collaboration and division of labor among industry partners in the coming 2 to 3 years. During this process, it is important to work with customers to find breakthrough points based on application scenarios and promote the realization of phased business results through fast iteration.

Second, define ADN rating and evaluation criteria to drive industry development.

ADNs need to be iteratively developed level by level and it is recommended that the industry continuously deepens the construction of the ADN evaluation system based on the original five-level rating standards to promote intergenerational ADN evolution and realize the L3 goal in 2022. Specifically, it is advised to start this process from two aspects: First, develop the ADN classification standards, which requires analysis of typical scenarios and services based on the full life cycle of network planning, construction, maintenance, and optimization, and specification of the key capabilities and features of the corresponding level of automation. Second, build the assessment system for ADNs, that is, develop the acceptance, testable, and measurable assessment system capability for segmented scenarios based on customer experience and business intent, which can support as-is assessment, set achievable improvement targets, and assess the benefits.

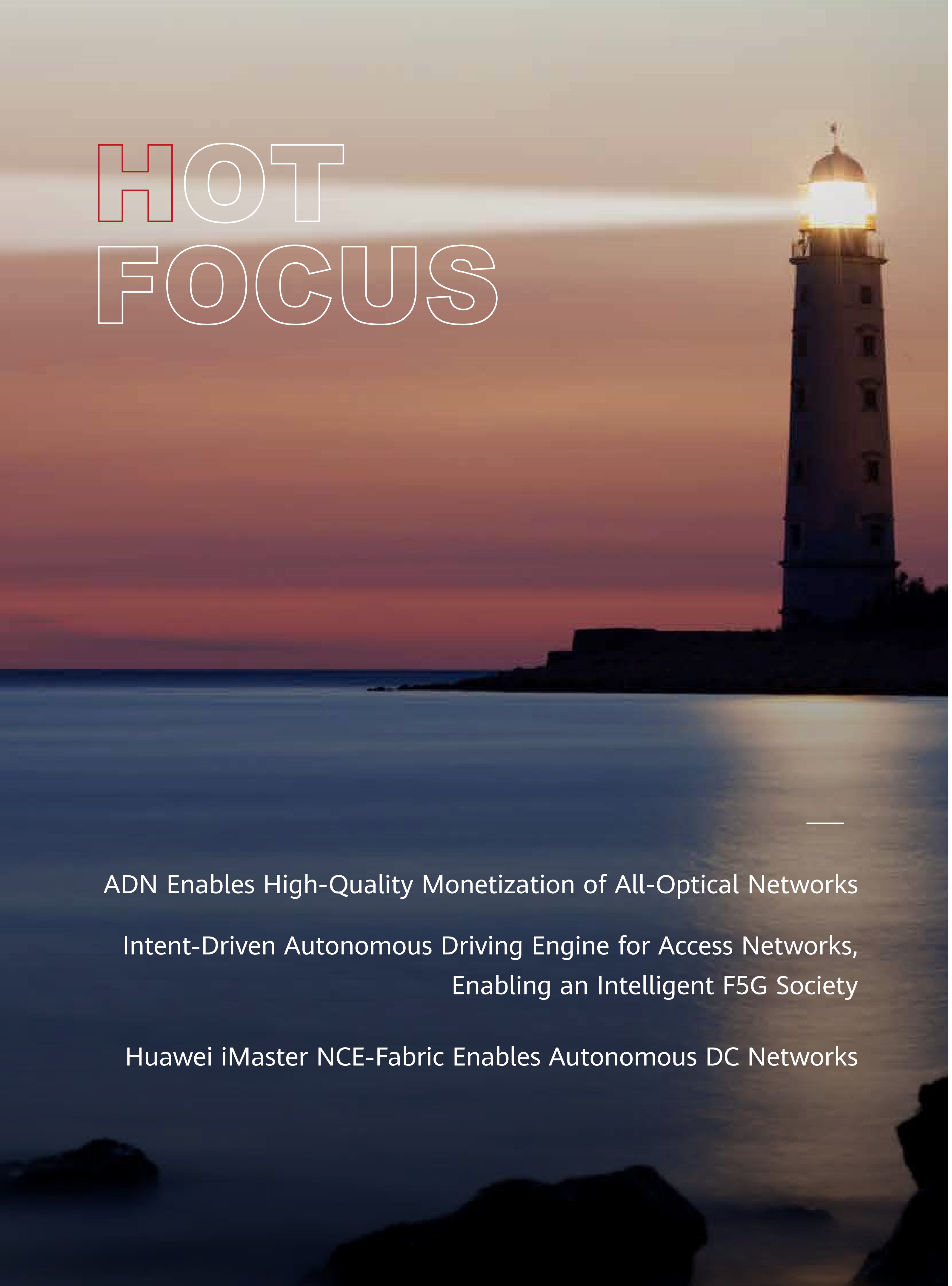
For the industry, the rating and evaluation standards not only help guide the intergenerational ADN evolution, but also promote the cohesion of all collaborators. Carriers can use the black-box hierarchical evaluation system to evaluate the network status quo, help formulate network evolution policies and development plans, and promote phase-based business monetization. Suppliers should fully understand customers' black-box and performance requirements, and provide support for making decisions in terms of technology introduction, product planning, and implementation.

Third, promote the cultivation of talent 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, rather, overlays and integrates them. It is necessary to systematically study the strategy of smooth network architecture evolution and the effects of man-machine collaboration on organizations and personnel, explore new developments in the talent's skills based on new methods and skills in the telecom industry, and enable enterprise employees to become more involved with the assistance of AI. In the future, new O&M positions such as network strategists, orchestration engineers, and data analysts will emerge, and people will still play an integral role in intent design, incident handling, and key decision-making. In particular, the introduction of AI technologies will change the knowledge and work habits of existing personnel. It is also necessary to strengthen understanding of AI, development and application skills, as well as practice summarizing and sharing of methods to develop existing processes and talent.

To fully unleash the potential of ADNs, talent cultivation, integration and optimization of existing capabilities, and development of organization capabilities are as important as other strategic initiatives. Huawei firmly believes that talent needs to be cultivated and development plans need to be formulated with the intelligent upgrade of networks.

The development of the ADN industry requires the collaboration of global industry organizations, equipment vendors, and OSS/BSS vendors to promote the upgrade of technologies and design ideas, as well as the innovation practices and business guidance of carriers. We believe that the industry should draw from the development rules and successful experience of mobile communications 3G/4G/5G, and continuously iterate new technologies to jointly develop L4-oriented reference architectures and standards. In the next one to two years, the industry should focus on improving and refining level-3 standards and application scenarios to accelerate the realization of phased business value. Huawei is willing to work closely with all collaborators in the industry toward the early realization of the ADN.



HOT FOCUS

ADN Enables High-Quality Monetization of All-Optical Networks

Intent-Driven Autonomous Driving Engine for Access Networks, Enabling an Intelligent F5G Society

Huawei iMaster NCE-Fabric Enables Autonomous DC Networks

ADN Enables High-Quality Monetization of All-Optical Networks

By Yuegang Song

Song Yuegang

President of iMaster NCE-Transmission & Access Domain

An optical transport network has inherent advantages, including high bandwidth, low latency, and ultra-stable performance. Since it first emerged, the optical transport network has been the core foundation of the entire communications network. On a communications network, a cross-layer architecture is normally used, and an optical transport network is positioned as a bottom-layer hub network bearing an IP network and a PON network, so as to implement long-distance transmission of data on these service networks. Therefore, the optical transport network has, to a large extent, become the construction center of the entire network of carriers, supporting the monetization of other service networks. This position determines carriers' investment strategies on different networks. For example, carriers bind the business plan of the PON network and home broadband services and invest them concurrently. The business plan of the IP network and mobile services is also bound, particularly the binding and investment of base stations. Carriers' investment strategy reflects their business requirements; however, optical transport networks, functioning as bottom-layer hub networks, are usually constructed and invested based on traffic requirements, lacking foresight.

In the intelligent era of IoE, HD video, VR/AR, cloud data center, and emerging services of Industry 4.0 place more stringent requirements on communications networks. Communications networks must support the rapid growth and on-demand change of explosive connections brought by emerging services, as well as provide experience assurance for different services. In the future, carriers will achieve business success based on differentiated user experience. In this way, adjusting a cross-layer network to a simplified architecture can greatly reduce network complexity and improve data transmission throughput and efficiency. In addition to high bandwidth, low latency, and high stability, optical transport networks leverage MS-OTN and Liquid OTN technologies to implement full-service access and 2 Mbit/s small-granularity stepless speed adjustment. In consideration of hard strength, building a flat all-optical transport service network will become the optimal choice for carriers to meet differentiated user experience in the intelligent era. Helping optical transport networks achieve the "anytime response, on-demand transformation, and ultimate connection experience" required by emerging services in the intelligent era, will become the key for the evolution of optical transport networks into all-optical production networks, as well as the transformation from a traditional cost center to a new value center.

Quality Monetization - Natural Advantages of Optical Features Help Gain Business Growth

Of the three main advantages of all-optical networks (high bandwidth, low latency, and high stability), bandwidth has mature business models, with low latency and high stability also showing great potential. The business logic of "bandwidth = price" is the most direct monetization method of all-optical networks.

According to a report by Tabb Group (a financial market research and strategy consulting company), "If a broker's electronic trading platform is 5 milliseconds behind the competition, it could lose at least 1% of its flow; that's $4 million in revenues per millisecond. Up to 10 milliseconds of latency could result in a 10% drop in revenues." Therefore, low latency is the basic market requirement for business monetization.

Traditional O&M systems do not have a latency management system; latency is manually calculated, including intra-site latency and link latency (fiber distance and fiber loss). As a result, cost is high and precision is low. Moreover, there is no clear logical relationship between latency indicators and services; nor is there professional management and monitoring support. This discovery is the key breakthrough for low latency monetization. In order to address the latency issue of WDM private line services, Huawei launched the comprehensive latency map solution based on the real latency measurement of flows to implement quality monetization. Firstly, based on the G.709 standard, the latency measurement mode is defined for OTN devices to accurately collect link latency data. Secondly, latency data is restored in a visualized manner and displayed on a dashboard in real time, implementing high-precision E2E monitoring and management of network latency. This industry innovation has been quickly put into commercial use by multiple carriers, such as China Unicom, China Mobile, China Telecom, Italy Fastweb, and Germany ARD, leading the optical transport industry into the low-latency digital management and control era.

The advantages of high stability are clear. In the era of 5G and big data, many enterprises and industries are willing to pay more for better stable and reliable connections. This is particularly the case in Europe and Asia, where some carriers' product packages have been priced based on different availability rates. However, the industry is only currently able to define the estimated availability rate based on different protection levels of services, and cannot consider comprehensive factors such as the fiber length and fiber quality. The estimated availability rate is inaccurate and cannot be used as a commitment to commercial monetization. Huawei iMaster NCE is working closely with carriers to jointly innovate not only the availability map, but also build an availability system that supports full-dimensional evaluation of optical fibers, devices, and service types. This industry innovation will once again utilize high stability to bring commercial monetization.

Ultra-fast Provisioning - Automatic Monetization Based on Real-Time Service Response

Emerging services often require anytime connection setup response and on-demand connection adjustment to cope with unknown and variable service innovation requirements. To implement "anytime response and on-demand adjustment", a two-pronged approach is required:

Firstly, agile provisioning and bandwidth adjustment of massive connection services

Many services, such as public cloud and big data, require periodic cross-regional data synchronization. Online shopping malls face traffic surges; for example, during Double 11 and Black Friday, where they must respond to new connections and adjust existing connections at any time. Accordingly, carriers need to be able to quickly establish and adjust connections, as well as open this capability to users through the online platform, so that various application providers can easily cope with service changes anytime, anywhere.

Secondly, fast deployment of CPEs and automatic service provisioning

In addition to real-time online response and on-demand adjustment of connection services, we also need to focus on the deployment of CPEs.

These devices are edge connection devices deployed in the customer's equipment room. Generally, multiple site visits are required for installation, deployment, and acceptance; according to data from Chinese carriers, three site visits are required for CPE deployment, including hardware installation, software commissioning, and service acceptance. In addition, software commissioning requires cooperation between software engineers at remote sites and O&M personnel at the NOC of the carrier through mobile phone communication. This entire process takes 3 to 5 working days, and so it can be concluded that CPE deployment is costly and inefficient.

To reduce the number of site visits and avoid coupling operations between the remote site and NOC, the industry continuously calls for plug-and-play solutions. Plug-and-play in the all-optical network domain requires the collaboration and innovation of CPE devices, other optical transport devices, and the upper-layer management and control platform to solve problems such as automatic device discovery, model-based configuration, connection pre-establishment, as well as fault tolerance and self-adjustment in each phase.

1. Preconfigure the CPE configuration template at the NOC to streamline the CO-to-CO pipe, avoiding repeated onsite planning.
2. After the customer applies for a private line, the site engineer carries CPEs to customers for installation to go online automatically.
3. Personalized customer services are automatically supplemented to establish service connections. Manual service provisioning is not required after CPEs go online, shortening the waiting time from deployment to connection.
4. Meter-free automatic service acceptance reduces one more site visit.

With the preceding two key capabilities, the system can respond to service requirements at any time, greatly reducing service provisioning costs and implementing automatic monetization.

Intelligent O&M - AI-Powered Monetization

The inherent advantages of optical transport networks mean a highly complex system. For example, the comprehensive application of signal modulation, amplification, frequency mixing, noise reduction, and dispersion compensation technologies brings difficulties to system maintenance and fault locating.

According to Gartner (a global research and advisory firm), 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 on telecom networks. Combining AI with other technologies can significantly improve O&M efficiency; it can replace existing manual operations once required to solve large numbers of repeated and complex computing tasks in the telecom field. It can also improve communications network prevention and forecast capabilities based on big data volumes, enabling highly automated and intelligent telecom network operations.

Huawei uses a three-layer AI framework consisting of "device+AI", "network+AI", and "cloud+AI" to build intelligent probes, such as oDSP, OTDR/OFDR, DL, and LS on underlying devices, enhance computing capabilities, as well as implement data acceleration and local processing for edge AI. On the cloud, the data lake, training platform, AI marketplace, and inference framework built by iMaster NAIE are used to efficiently normalize, model, train, and infer massive data generated on the communications network, and the output algorithms are verified through iMaster NCE and the network in a closed-loop manner.

How can the root cause of a fault be intelligently located from a large number of alarms?

In 2019, we used intelligent alarm compression and root cause analysis technologies to help Chinese carriers aggregate and analyze nearly 20,000 alarms to less than 1000 incidents every day, with an alarm convergence rate of over 96%. How did we achieve this? First of all, we performed noise reduction and filtering on massive alarms on the live network. That is, we identified and marked invalid alarms such as repeated, engineering, and intermittent alarms, and performed coarse filtering to reduce the number of alarms. Secondly, we aggregated alarms based on correlation rules. For example, alarms are aggregated based on the topology, context, and fault occurrence time association of the alarm objects to form associated incident events. Finally, we used AI algorithms to identify the root cause, fault scenario, and service impact within and between incident events to find the root alarm that causes the incident events, and convert alarms into accurate network fault tickets.

How can performance deterioration of fibers and optical channels be prevented?

In addition to accurately identifying root causes of faults, AI big data can also implement precise resource forecast through comprehensive analysis of network performance, service trends, and network resource data. Huawei iMaster NCE helps Asia-Pacific carriers forecast monthly network capacity expansion with an accuracy of over 90%, avoiding the long service waiting time caused by emergency capacity expansion.

Further, we know that over 60% of optical network faults are related to fiber faults. The key to improving the quality of an optical network is to reduce the fiber fault rate. However, traditional optical network O&M is usually used to quickly locate faults that have occurred, but lacks effective fault prevention. Therefore, we need to proactively evaluate and manage fiber health to reduce the fault rate of fibers, and adjust them in advance to reduce the impact of fiber faults on services. Huawei iMaster NCE accurately collects optical line subhealth indicators, including the fiber (OTS) power, optical attenuation, wavelength (OCh) optical power, bit error rate (BER), and optical signal-to-noise ratio (OSNR), and implements real-time monitoring, data analysis, and algorithm modeling to forecast the optical line deterioration trend. In this way, potential service risks on the network can be identified in advance, greatly reducing network interruption or quality accidents. Currently, the forecast accuracy in the lab has exceeded 90%. And so, with AI technologies, iMaster NCE transforms the O&M of telecom services from manual analysis to automatic analysis, and finally to proactive prevention.

Epilogue

Huawei iMaster NCE adopts three concepts, including quality monetization, ultra-fast provisioning, and intelligent O&M, implements system-level innovation through software and hardware integration based on the three-layer AI architecture, and enables all-optical networks to gradually evolve to autonomous driving networks. While AI enables autonomous driving networks, traditional O&M personnel are also proactively transforming into new O&M talent with rich network O&M experience and AI knowledge, which become key elements for connecting the network and business worlds. Based on the open and programmable platform capability, network technologies and O&M experience are accumulated as automatic and intelligent platform capabilities, and are quickly integrated into differentiated O&M processes of different carriers. The pre-sales, in-sales, and after-sales teams of carriers are enabled with the "quality monetization" capability; end users are enabled with the ultra-fast network provisioning capability on the online self-service platform; the intelligent O&M capability is embedded into carriers' full-lifecycle O&M process to achieve forecast and preventive maintenance through man-machine collaboration.

The future is bright, but the journey will be long. As a practitioner of "autonomous driving" of all-optical transport networks, Huawei has put iMaster NCE-T into commercial use in more than 100 customer sites around the world. Looking forward, Huawei will continue to cooperate with global carriers, jointly innovating to gradually enhance the intelligent level of the "autonomous driving optical transport network", enriching its business potential.

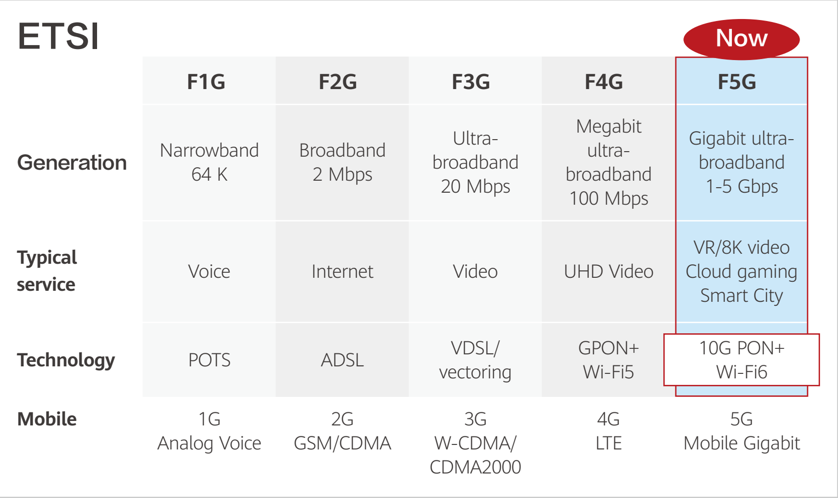
Intent-Driven Autonomous Driving Engine for Access Networks, Enabling an Intelligent F5G Society

文/曾 小龙

> "The advancement of communications technologies brings ubiquitous video, gaming, and enterprise interconnection. The significant developments bridge a way to an era of gigabit networks. The synergy of two mainstream access modes — fixed fiber access and 5G wireless access — will accelerate the migration from a physical world to a digital world. A fully connected, intelligent world is emerging and the fixed fiber access entering the fifth-generation Cloud VR era represented by 10G passive optical network (PON) technology, also called the Fifth Generation Fixed Network (F5G)."

Zeng Xiaolong

Director of NCE-FAN Service Product Unit



ETSI

	F1G	F2G	F3G	F4G	F5G (Now)
Generation	Narrowband 64 K	Broadband 2 Mbps	Ultra-broadband 20 Mbps	Megabit ultra-broadband 100 Mbps	Gigabit ultra-broadband 1-5 Gbps
Typical service	Voice	Internet	Video	UHD Video	VR/8K video Cloud gaming Smart City
Technology	POTS	ADSL	VDSL/ vectoring	GPON+ Wi-Fi5	10G PON+ Wi-Fi6
Mobile	1G Analog Voice	2G GSM/CDMA	3G W-CDMA/ CDMA2000	4G LTE	5G Mobile Gigabit

Network Evolution Embraces the F5G Era and Carriers Face New Challenges

Carriers provide various F5G-based applications for customers, promoting the informatization and intelligence of the entire society. Tens of thousands of home users are using network, voice, video, and smart home services; enterprises in various industries obtain Internet access, interconnection, and cloudification; and base station data backhaul and enterprise campuses are provided with integrated bearer solutions.

With the continuous evolution and development of network technologies and services, higher requirements are posed to carriers in providing access to these integrated services:

· PON is used for integrated access. The integration of "construction, installation, maintenance, and operation" for multi-service scenarios determines the operation cost control capability.

· In the era of information explosion, the level of data governance determines the profitability of operations.

· Continuous service changes and network openness determine the future-oriented adaptability.

These three challenges are revealed in carriers' operation processes and raise critical issues that need to be addressed in each phrase of operation, construction, service provisioning, and maintenance.

•Operation phase

Gigabit applications are gradually enhanced. How can carriers quickly develop target users and secure a large customer base? What is the user experience of gigabit applications? If user experience is poor, what are the possible causes?

•Construction phase

How can carriers evolve the existing network toward the next-generation 10G PON? What is the pace of evolution? How do carriers identify key areas for preferential upgrade? How do carriers guarantee effective return on investment (ROI)?

•Service provisioning phase

How do carriers ensure data accuracy of optical route resources and improve the one-time service provisioning success rate? How do carriers reduce the number of required visits for onsite installation or even eliminate the need for onsite installation during service provisioning?

•Maintenance phase

How do carriers identify problems in advance to avoid performing O&M in response to customer complaints? How do carriers eliminate reliance on onsite maintenance and manual fault locating? How do carriers shorten the fault response time and reduce the frequency of site visits?

Autonomous Driving Engine for Access Networks Driving Positive Business Cycle of F5G

Positive business upgrade cycle: operations → services and products → networks

To overcome new challenges, carriers need to further improve digital operations and then enable customers to see the digital capabilities. In the past, carriers' digital capabilities were insufficient and mainly used internally. In the F5G era, applications grow rapidly, and service experience has become the primary factor for customers when selecting carriers. Therefore, transforming digital capabilities into a service experience that customers can enjoy is key for F5G operations. Carriers who can provide a better user experience will benefit in future competition. Based on service capabilities visible to customers, carriers package "hardware and service SLAs" into new products. This way, customers can enjoy better service experience and are more willing to try new packages, helping to ensure revenue for carriers. In this case, carriers can invest more resources in network upgrades, further improving the level of services and forming a complete positive business cycle.

Autonomous driving engine for access networks improves digital operation capabilities

Digital operation is based on the digital visualization of an all-optical access network, to enable carriers to detect any changes in the physical network in real time. Big data and AI technologies are utilized to analyze and process obtained information in depth. The real-time awareness and scientific analysis results help carriers to construct, provision, maintain, and operate services, achieving automation and intelligence during the entire process.

The capability abstraction from automatic sensing, to analysis, and then to application is the autonomous driving engine for access networks. The following describes the capabilities of the autonomous driving engine in several sections:

Automatic sensing: migration from the physical world to the digital world

The real-time awareness of physical access networks is classified into four types:

· Business environment information (such as building information, residential community information, pipes, poles, manholes, and hand holes)

· Physical device information (such as optical line terminal (OLT) device information, optical distribution network (ODN) device/port/fiber core information, and physical device location information)

· Logical network information (such as the network topology/link information, network configuration/performance/alarm information, and mapping between the topology/link and physical inventory)

· User service information (such as user service package information, user service experience KPIs, and mapping between service category/traffic/quality and topologies)

Obtaining and collecting physical network information is the first and most important step for carriers to build an autonomous driving engine for access networks. Only with the real-time awareness capability of the information can carriers have the basis of intelligent analysis, without which algorithms and tools cannot work, regardless of their effectiveness. Among the four types of data, user service experience data is the most difficult to obtain. The big data AI algorithm can be used in place of data packet inspection (DPI) to analyze user experience based on traffic characteristics, which prevents user privacy infringement.

Intelligent analysis: ultimate presentation of data value

Based on real-time awareness of physical network information, carriers can further mine data value. Data value is reflected in three aspects: the reduction of carriers' operating expense (OPEX), revenue increase, and assistance in network planning to ensure ROI. Information and data can be processed with focus on:

•Increasing operating revenue

Based on user data collection and modeling analysis, carriers can use the engine to identify bottlenecks in user experience and sell package portfolios accordingly to increase the average revenue per user (ARPU) as well as carriers' revenue. User experience bottlenecks can be classified on the basis of bandwidth and application experience. After identifying the two types of bottlenecks, carriers can take measures accordingly to monetize the value.

•Assisting in network planning to ensure ROI

Carriers focus on precise planning and investment in the integrated service access area of the 10G PON. Analysis of the physical location information, the traffic peak and packet loss trends of devices on the live network can help carriers in 10G PON planning and construction, effectively protecting carriers' investment.

•Reducing OPEX

O&M costs have always been an important part of carriers' expenditure. In the F5G era when the fiber infrastructure is increasingly popular, customer have raised concerns on the faults of passive ODNs and ONT home Wi-Fi networks, accounting for over 75% of user complaints. Therefore, proactive identification and prevention of faults on passive ODNs and home Wi-Fi networks are vital for carriers.

Application of analysis results: improving the automation and intelligence of the entire process

Based on real-time awareness of physical network information and AI intelligent analysis of big data, carriers can apply these results to various production processes to comprehensively improve the automation and intelligence of these processes, and cope with difficulties and challenges in construction and operation of gigabit all-optical access networks.

•Operation phase

The autonomous driving engine identifies bottlenecks of user experience and accurately locates target customers, makes clear commitments on the experience SLA, provides packages with premium prices, as well as improves the brand image.

•Construction phase

The autonomous driving engine identifies high-value areas for preferentially upgrading 10G PONs, and promotes gigabit packages and applications to ensure the ROI. The ODNs are visible and manageable, and resources are effectively used.

•Service provisioning phase

The autonomous driving engine improves resource accuracy and provides a high one-time provisioning rate. The ONT supports plug and play (PnP) and does not require onsite installation.

•Maintenance phase

The autonomous driving engine proactively identifies faults on ODNs and home networks, and accurately locates fault causes and locations, avoiding unnecessary site installation and maintenance engineer visits.

iMaster NCE: Huawei Intent-Driven Autonomous Driving Engine for Access Networks

To help carriers build the autonomous driving engine for access networks and also address challenges in the F5G era, Huawei has launched the iMaster NCE-FAN premium broadband solution (NCE-FAN for short) based on the big data intelligent platform that integrates the Manager, Controller, and Analyzer. NCE-FAN implements different capabilities of the autonomous driving engine to promote the upgrade of carriers' digital operation capabilities. Carriers improve the digital operation capabilities of home broadband based on NCE-FAN and launch better services and products, including commitment for Wi-Fi rate, packet loss, latency, and fault response time. This not only effectively improves users' broadband experience, but also increases operating revenue, and brings network device upgrade and replacement, achieving a positive business cycle.

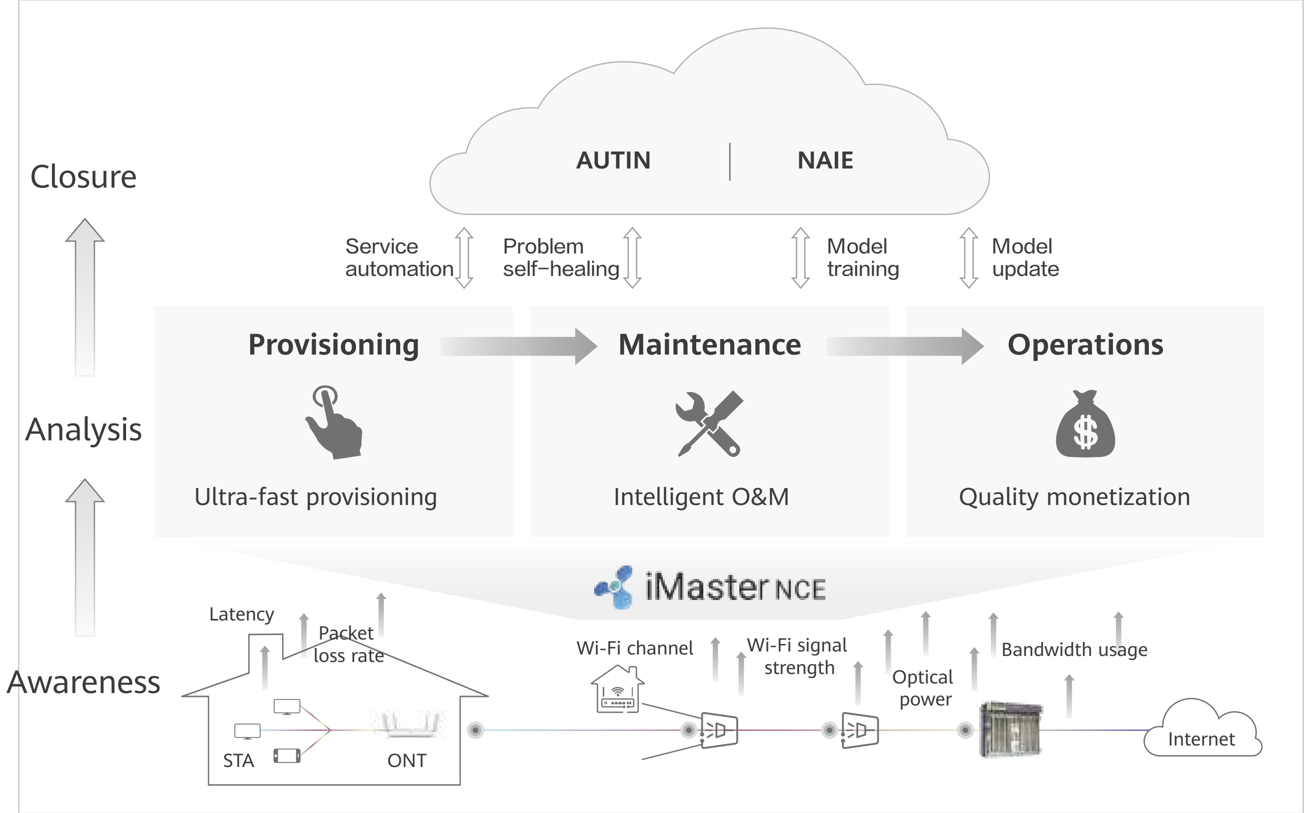
NCE-FAN improves carriers' home broadband digital operation level

As the first system integrating the Manager, Controller, and Analyzer in the industry, NCE-FAN effectively connects physical networks with business intents and implements centralized management, control, and analysis of global networks. It enables resource cloudification, full-lifecycle automation, and data analytics-driven intelligent closed-loop management according to business and service intents, and provides open network APIs for rapid integration with IT systems.

Based on the capabilities of access network devices, NCE-FAN collects network data in several seconds to detect network information in real time, including device and network information, as well as service experience information.

Based on AI algorithms and big data analysis capabilities, NCE-FAN builds three capabilities: ultra-fast provisioning, intelligent O&M, and quality monetization, which correspond to service provisioning, maintenance, and operation in the carriers' service production process.

These three capabilities are embedded into carrier's production processes through Huawei AUTIN and NAIE systems and are implemented in service provisioning, maintenance, and operations.



The following describes the three capabilities of NCE-FAN:

•Ultra-fast provisioning

NCE-FAN provides a control module oriented to automatic installation and deployment scenarios. The module provides access network automation capabilities, simplifies OSS interconnection through service-level APIs, and supports service process programmability, achieving PnP of ONTs and frees software commissioning in OLT deployment.

The passive attribute of ODNs and continuous construction changes in installation and maintenance cause inaccurate data in the resource system, resulting in resource waste. NCE provides a passive-ODN-oriented management module to visualize, manage, and remotely accept ODNs. AI image recognition does not require manual data input and achieves 100% accurate ODN resource management. Remote acceptance of optical route construction reduces labor costs, and carriers can implement fine-grained management of ODN resources to ensure effective resource utilization.

•Intelligent O&M

The difficulty in access network O&M lies in the ODNs and home networks. To cope with the two O&M difficulties, NCE-FAN develops fault diagnosis capabilities based on the big data intelligent platform.

For ODNs, NCE-FAN provides a unit for collecting and analyzing the overall data of access networks. It supports optical path data collection, intelligent big data analysis, over 10 built-in optical path fault mode libraries, and an optical path topology restoration accuracy of 95%. Therefore, NCE-FAN achieves access network SLA visualization and assurance, accurately locates optical path faults and locations, improves troubleshooting efficiency, detects weak optical signals on optical paths in advance, and eliminates potential complaints.

For home Wi-Fi networks, NCE-FAN provides a unit for home network data collection and analysis. By collecting and analyzing home Wi-Fi data, NCE-FAN can remotely locate 53.5% of home network issues, resolve 11.3% of the issues, and accurately identify over 1000 poor-QoE routers. By identifying interference and coverage problems, NCE-FAN supports remote Wi-Fi optimization, avoiding the need for onsite troubleshooting by O&M engineers.

•Quality monetization

For end users, NCE-FAN provides a unit for user-experience-oriented data collection and analysis to detect poor-quality broadband services. NCE-FAN develops its own capabilities in user experience, which is classified into bandwidth experience and application experience.

A bandwidth experience bottleneck refers to a point on the home network, which makes the bandwidth experienced by users lower than the subscribed bandwidth. The bottleneck may be caused by network cables, low-quality routers, or single-frequency optical modems. In this case, NCE-FAN can accurately locate the bandwidth experience bottleneck of the home network based on home network information awareness and big data analysis. Currently, NCE-FAN supports bearer capability evaluation for five types of services. For each scenario that does not meet the service bearer capability requirements, NCE-FAN can further identify bandwidth experience bottlenecks, such as insufficient bandwidth, single-frequency gateways, and self-purchased routers with an identification accuracy of more than 90%. Based on these capabilities, carriers can sell specific networking packages and provide bandwidth assurance for users, improving user satisfaction and increasing revenue.

Application experience bottlenecks refer to points on gigabit applications such as games, VR, and distance education, measured by the main KPIs such as bandwidth, latency, packet loss, and jitter. NCE-FAN can accurately identify these experience bottlenecks through network information awareness and analysis, helping carriers launch package services accordingly, for example, the game broadband and education broadband, and provide VIP experience assurance. Further, NCE-FAN can eliminate bottlenecks to support SLA commitments of carriers' popular services and applications, thereby increasing sales revenue.

NCE-FAN commercial use progress

Huawei is committed to building an autonomous driving engine that "leaves complexity to itself and brings simplicity to customers" and focuses on two core objectives: reducing O&M costs and increasing operation revenue. Through continuous innovation and customer cooperation, the NCE-FAN premium broadband solution has been successfully deployed in over 80 sites around the world. It helps customers build an autonomous driving engine and enable automation and intelligence for access networks, improving ultra-broadband experience for end customers and promoting intelligent F5G society's arrival.

Launch of Business Joint Innovation Center (BJIC) case of China Telecom, Hebei:

With NCE-FAN home network management capabilities, China Telecom Hebei improves the home network operational level. It is able to remotely monitor and rectify home network faults, evaluate home bandwidth bottlenecks, and sell networking packages accordingly. As a result, China Telecom Hebei released the "Premium Home Network Service 2.0" advanced package in November 2019. The 200 Mbit/s products and services for the living room, bedroom, and whole home are well accepted by users. The marketing success rate has been improved fivefold, and O&M efficiency has increased by 30%. By making commitments on the installation duration, maintenance duration, and experience bandwidth for customers, carriers can improve customer experience and achieve rapid service development. This is the result of digital operations capabilities perceptibility.

Data Center Network Autonomous Driving Engine, Accelerating Digital Transformation of Enterprises

B Wang Hui

Enterprises' Digital Transformation Sparks New Challenges for Networks

Wang Hui

Director of NCE-E Service Product

In the era of digital transformation 2.0, the aim of enterprise digitalization has changed from cost effectiveness to survival. Recently, COVID-19 has magnified the importance of enterprises' ICT capabilities. From telecommuting to end-to-end R&D, production, and sales, enterprises' digital capabilities determine their response capacities and innovation capabilities.

According to IDC's global IT report 2020, enterprises' IT expenses are still mainly focused on digitalization, cloud, and security; furthermore, digital products and services will lead enterprise transformation. Gartner also predicts that global IT spending will increase by 3.7% in 2020, and more than 60% of enterprises will consider networks to be the core of their digital strategies by 2023.

As data center (DC) networks carry all the data and services of enterprises, network scale and complexity have increased to a level beyond the management capabilities of humans. Therefore, enterprises need a new system that combines advanced technologies, such as machine learning, machine inference, and automation, to meet business needs, simplify operations, intelligently assist human decisions, and ultimately make DC networks highly autonomous.

In fact, with wide deployment and mature commercial use over the past few years, SDN has solved the problem of automatic DC network service provisioning, as well as taken DC networks to a new automation level. However, DC networks are facing more problems and challenges in the entire lifecycle (network planning and design, installation and deployment, and O&M). For example:

- Large enterprises and carriers usually have more than 10,000 servers, and the number increases linearly with data explosion. An increasing number of projects are set up to build or expand DC networks; however, current network construction efficiency lags significantly behind business development.
- Enterprises explore business opportunities and unlock new revenue through continuous innovations. They need to develop and roll out numerous new applications and make service changes frequently. For example, Huawei's financial customers may make more than 3000 changes a year, bringing great challenges to network teams. Furthermore, humans cannot complete certain tasks without errors. About 70% of network teams focus more than half of their efforts on network changes, including pre-change solution design, evaluation, and post-change verification. However, up to 40% of DC network faults are caused by human errors.
- During the O&M phase, minute-level network monitoring cannot meet application development requirements. For example, a large number of applications, such as mobile payment and flash sales, require second-level service experience. It means that upper-layer applications are faster than networks in detecting faults and making complaints, putting network teams in a passive position and under significant pressure in terms of causing serious business losses. Fault diagnosis still depends on experience. Segment-by-segment triage, flow-by-flow analysis, and packet capture make the entire process inefficient (more than 76 minutes on average).
- Cloud applications are deployed across heterogeneous or multi-cloud infrastructures; however, consistent network services are required. Therefore, enterprises have to provide unified, intent-driven management for the heterogeneous environments and shield device differences and private interfaces to further prevent vendor lock-in.

Huawei iMaster NCE-Fabric Enables Autonomous DC Networks

Based on extensive experience and a deep understanding of automation and O&M accumulated from 9200 commercial DC networks, Huawei has integrated AI, big data, and automation technologies with DC networks and launched an autonomous network management and control system, iMaster NCE-Fabric.

iMaster NCE-Fabric ("NCE-Fabric" for short) is an automatic and intelligent platform that integrates management, control, and analysis, as well as connects business intents and networks. Through the centralized management, control, and analysis of DC networks, NCE-Fabric provides users with intent-centric, highly automated capabilities throughout the entire lifecycle, spanning DC network planning, construction, maintenance, and optimization. With an intelligent decision subsystem, NCE-Fabric is no longer a network tool that passively executes user instructions; instead, it has become an expert system that proactively assists users with decision making.

The following lists some of the typical applications and major benefits that NCE-Fabric offers to DC networks.

Simplified Network Construction, Improving Deployment Efficiency Threefold

During the initial phase of DC planning and design, experts design DC networks, including network structure, device selection, and system collaboration, based on factors such as the planned service volume, security, network performance, technology evolution, and long-term capacity expansion. This process entails a heavy workload with low efficiency. As no real devices are involved, experts can only analyze the service volume, reliability, and network traffic models theoretically, which cannot ensure that designs meet expectations. Furthermore, deliverables during the design phase, such as low level design (LLD), cannot be seamlessly adapted into the network construction phase. As such, engineers still have to manually enter certain parameters or import configuration files, and this process is both repetitive and complex. After deploying networks, they also need to manually execute acceptance test cases to verify the networks, which is a time-consuming, labor-intensive, and error-prone process.

To overcome the preceding challenges, NCE-Fabric is able to intelligently design DC networks, recommend design schemes based on customer intents, and undertake network construction. For example, if a customer wants to build a highly reliable DC network with 1000 servers, NCE-Fabric can automatically detect the customer's intents, design a network, as well as model and simulate the results to evaluate traffic, link reliability, and device reliability. Subsequently, it recommends the optimal scheme to the customer, along with configuration scripts and evaluation reports. The customer can then review and adjust the scheme according to their requirements. After the scheme is confirmed and devices are connected and powered on, NCE-Fabric automatically deploys and tests the network in just one click. It also provides the customer with an acceptance test report.

As an expert system, NCE-Fabric not only provides network design schemes, but also tests and deploys DC networks. From network design to construction, it fundamentally resolves issues such as low efficiency and human errors. Furthermore, the time and costs of network construction have been slashed considerably — for example, time has shortened from 1 month to less than a week.

Accurate Changes, 0 Errors in Network Configurations

One of the main missions of DC networks is to carry services and data; therefore, they must be able to quickly respond to service requirements. As previously mentioned, a large number of services are rolled out or changed. To put it into perspective, Huawei's financial customers may make more than 3000 changes a year. About 70% of network teams focus more than half of their efforts on network changes, including pre-change solution design, evaluation, and post-change verification. In fact, most changes are made to mutual access relationships and policies, driving network administrators to adjust cross-VPC, service chain, firewall, and load balancing policies within or across DCs. In the past, network administrators needed to design a change scheme based on their experience, evaluate impacts, implement changes, and perform manual checks. Due to network complexity, it was impossible to manually change networks without making errors.

Currently, NCE-Fabric can recommend network change schemes based on customer intents, evaluate risks and impact through modeling and simulation, automatically implement changes, and verify the changes against expectations, thereby ensuring zero network configuration errors. In addition, customers can create continuous monitoring tasks to ensure that services run properly.

Intelligent O&M, Closing Faults in 5 Minutes

Intelligent O&M has two distinct advantages. One is proactive, timely fault detection and intelligent troubleshooting during routine O&M. The other is predictive maintenance — risks are detected before they incur faults.

Based on the Telemetry technology, NCE-Fabric collects data in real time, comprehensively evaluates the health status of devices, networks, protocols, Overlay, and services, and generates reports. Furthermore, NCE-Fabric intuitively displays the overall network quality, proactively detects about 80% of network faults within 1 minute, as well as optimizes and then applies knowledge graphs to networks. Through continuous study and training, it can identify the root causes of 75 types of faults within 3 minutes. Its intelligent decision subsystem can analyze fault impact and recommend the optimal troubleshooting approach to quickly rectify typical faults in 5 minutes. Based on the quick and intelligent characteristics of fault detection, analysis, and troubleshooting, we refer to this as "Fault 1-3-5" in short.

To deliver accurate warnings, NCE-Fabric breaks through technical bottlenecks to predict the probability of failure in a component, or the time when the quality of a service will deteriorate. For example, it can predict the status of network-wide optical modules based on logic and linear regression algorithms, as well as detect abnormal optical links before services are affected.

1 Basic+3 Key Capabilities as the Core of NCE-Fabric

NCE-Fabric is an autonomous network management and control system. In addition to long-established automation capabilities, one basic capability (digital twin model) and three key capabilities (intent recommendation, simulation verification, and intelligent decision) have been added to it. With these capabilities, NCE-Fabric can function as an expert system to provide network design/change and troubleshooting schemes, assist with human decision-making, continuously ensure stable service operations, and achieve intent-centric, closed-loop full lifecycle management (network planning, construction, maintenance, and optimization).

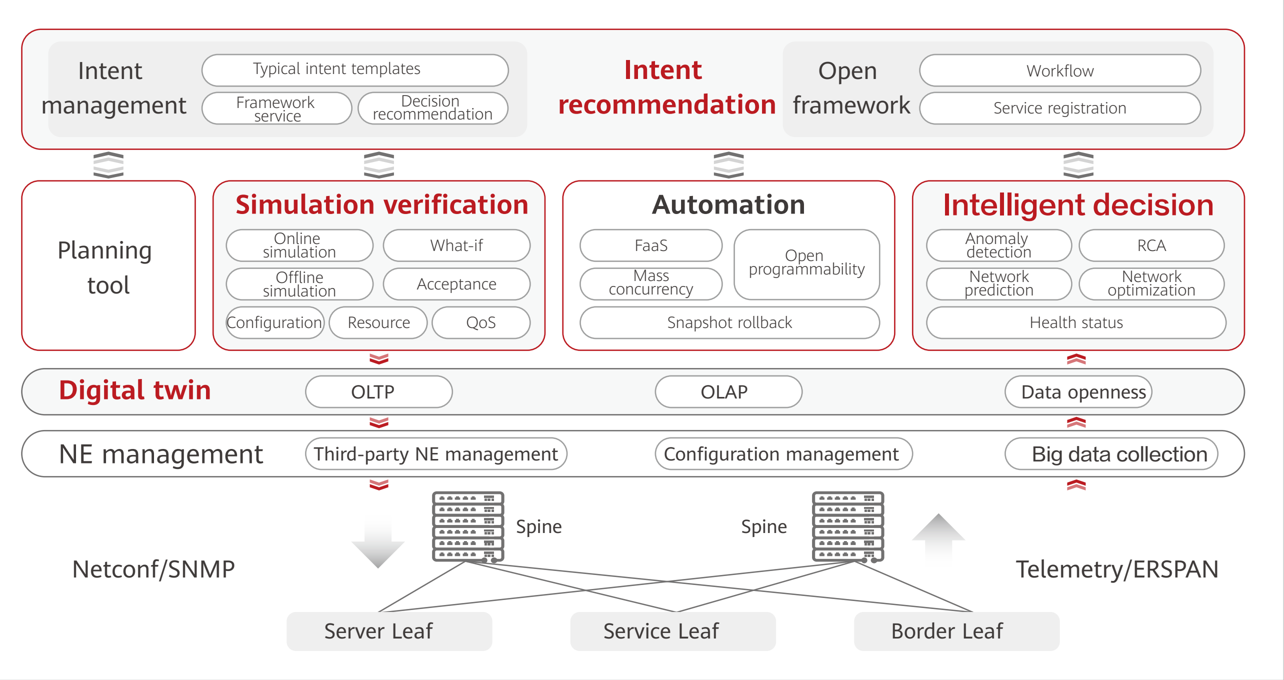

Intent management
Typical intent templates
Framework service
Decision recommendation
Intent recommendation
Open framework
Workflow
Service registration
Planning tool
Simulation verification
Online simulation
What-if
Offline simulation
Acceptance
Configuration
Resource
QoS
Automation
FaaS
Open programmability
Mass concurrency
Snapshot rollback
Intelligent decision
Anomaly detection
RCA
Network prediction
Network optimization
Health status
Digital twin
OLTP
OLAP
Data openness
NE management
Third-party NE management
Configuration management
Big data collection
Netconf/SNMP
Spine
Spine
Telemetry/ERSPAN
Server Leaf
Service Leaf
Border Leaf

Figure 1: Architecture of NCE-Fabric

Digital Twin: Map Physical Networks to Digital Models

The digital twin module maps physical networks to digital models. To build digital models, NCE-Fabric needs to collect historical network data, including NE inventory data, service configuration data, performance data, alarm data, and logs. The data warehouse processes the collected raw data to build a three-dimensional five-layer model.

Based on this model, the digital twin module automatically generates a network topology and intelligently restores the physical network topology, enabling O&M personnel to quickly recognize network and device characteristics and improve O&M efficiency. At every moment, multi-dimensional information is saved as snapshots to record current and historical network status. Historical status can be replayed on demand, and snapshots at different time points can be compared to intuitively display the multi-dimensional network trends.

The digital twin module is the foundation of autonomous DC networks. It uses collected network data to study and train upper-layer key capability modules, and provides digital models to support simulation, verification, analysis, and decision-making. For example, Fault 1-3-5 is a series of fault detection and diagnosis capabilities enabled by the digital twin module. In addition, it studies the impact of historical network configurations to identify the optimal network change scheme for the live network.

Intention Recommendation: Enable the System to Understand Intents and Objectives

The autonomous DC network solution is intent-centric throughout the entire lifecycle. An intent decision module is responsible for detecting customer intents and recommending the optimal network deployment solution.

Initially, templates were used for intent detection, requiring users to adjust parameters based on site requirements. Users can customize intent templates or generate new templates from old ones. In addition, open programmability is provided for users or upper-layer systems to call. The intent detection and conversion capabilities increase as new technologies are introduced and applied. Continuous study and training enable the intent engine of NCE-Fabric to require less parameter input or adjustment from users. After the intent engine converts service intents to a network language, solutions start being recommended.

Based on digital models, the intent engine combines the experience accumulated from 9200 commercial DC networks with AI algorithms to provide candidate solutions. After the simulation verification module evaluates these solutions, the most suitable one for the live network will stand out.

Simulation Verification: Avoid Human Errors orNegligence

For DC networks, customers are most concerned about whether services can remain online while running stably and reliably. However, due to frequent service rollout and changes, errors or accidents regularly occur. The simulation verification module is the key to eliminating human errors in DC networks, and it plays an important role in network planning and design, accurate service rollout and changes, as well as closed-loop fault recovery. In addition, it supports simulation of physical network connectivity and routing protocols. Before deploying a logical network, it evaluates whether network resources meet requirements, as well as whether existing services will be affected.

Based on digital twins, NCE-Fabric uses optimized formal verification algorithms to deduce and compute the entire network, and it uses mathematical algorithms to fully verify network changes. This ensures accurate verification results, low resource usage, simple and fast operations, as well as network simulation at different scales.

Intelligent Decision: Break the Limits of Human Experience

Compared with conventional EMSs and controllers that passively execute instructions, NCE-Fabric is a closed-loop system with a smart brain — intelligent decision.

A typical application of intelligent decision is RCA and closed-loop fault recovery. It breaks the limits of human experience and employs AI to solve issues such as fault diagnosis and prevention. First, NCE-Fabric uses an AI chip to collect all flows and detect network exceptions in real time. Then, it analyzes the impact of faults using the fault clustering function of knowledge graphs. Finally, based on rules and AI models, its simulation verification module offers a roubleshooting plan whose effect is then verified by the knowledge inference function of knowledge graphs.

Essentially, automation involves humans enabling systems to execute automatically; whereas digitalization involves systems making and implementing decisions independently. Huawei's autonomous DC network solution meets the requirements of enterprises undergoing digital transformation. It intelligently senses business intents, makes and implements decisions independently, and accelerates the monetization of business values. Needless to say, autonomous DC networks cannot be achieved overnight; therefore, Huawei plans to achieve highly autonomous networks in three to five years. This undertaking not only needs close collaboration from industrial organizations and partners but also relies on innovation practices and business guidance from global customers. Huawei is ready to closely collaborate with the industry and customers to realize autonomous driving on DC networks.

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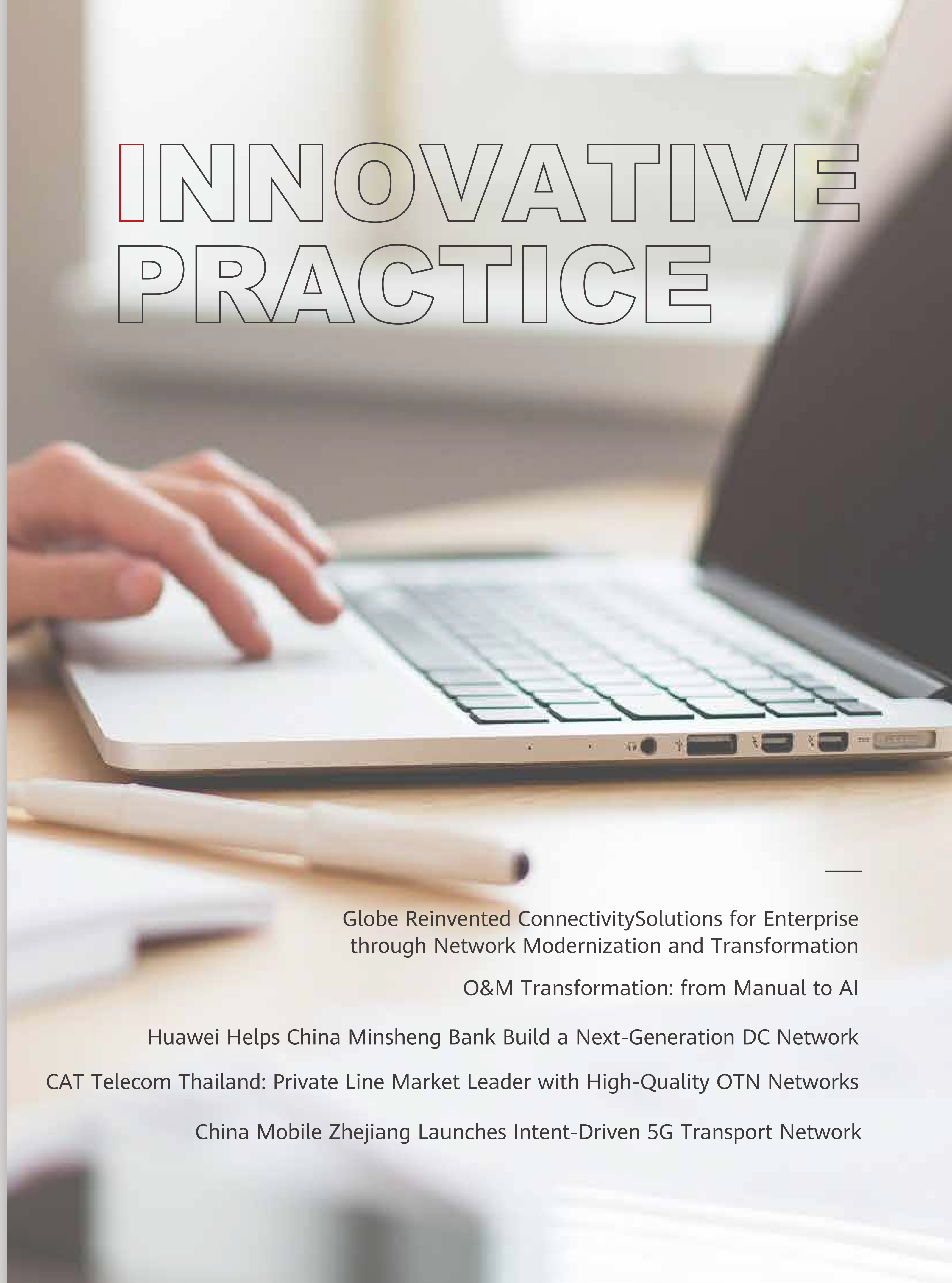


INNOVATIVE PRACTICE

Globe Reinvented ConnectivitySolutions for Enterprise through Network Modernization and Transformation

O&M Transformation: from Manual to AI

Huawei Helps China Minsheng Bank Build a Next-Generation DC Network

CAT Telecom Thailand: Private Line Market Leader with High-Quality OTN Networks

China Mobile Zhejiang Launches Intent-Driven 5G Transport Network

Globe Reinvented Connectivity Solutions for Enterprise through Network Modernization and Transformation

By Constantine A. Serafica

Constantine A. Serafica

Head Of Transport Network Division

In a world that is rapidly moving and evolving, there is great opportunity to innovate and spread the benefits of access to modern technologies. To survive and thrive, companies must stay ahead of the curve by initiating change, and providing a digital experience that enables more people to benefit from having modern technologies in their lives. This has been prompting telecommunications players to move away from the traditional "utility" business model and adopt digitalization trends to counter declining revenue and growing cybersecurity, data traffic, and disruptive technologies. These global trends are rapidly transforming the way people live and work, while creating commercial, regulatory, and societal challenges. Globe Telecom can potentially shape assessments and perceptions about the company’s ability to create value over time, driving highly customer-centric value with keen focus on enriching Filipino lives in the digital age. True to its nature of innovation and going beyond achieving business success, Globe sought and found a purpose larger than itself to serve customers more meaningfully.

Digitization, or the process of converting information into digital format, continues to grow among companies of all sizes, industries, and geographic locations. The overall economic value of digital transformation to business and society is expected to top US$100 trillion by 2025 (World Economic Forum). Yet even with the onset of modern technologies such as 5G and artificial intelligence, the Philippines still lags behind in digitization (Asian Digital Transformation Index 2018 published by the Economist Intelligence Unit). The lack of adequate digital infrastructure, human capital, and industry connectivity were cited as primary reasons for the country’s poor ranking (10th out of 11) in the EIU’s 2018 Asian Digital Transformation Index.

"One of the key components of building a digital nation is building a digital enterprise, and our goal is to leverage on our data business as well as our IT-enabled services to help businesses perform more than what is usual. By being passionate as our clients are with their business, we will be able to achieve consistent growth." — Albert M. de Larrazabal, Chief Commercial Officer

As part of the company’s strategy of bringing its business partners and customers to the digital era, Globe focused on building the foundation to drive its digitalization ambition. The company continues to invest in and build the necessary ICT capabilities, and digitize internal processes to enhance the pace of innovation and provide superior customer experience. Globe has also taken great strides to help make businesses — large or small — flourish. As a major telco player and technology partner of businesses, Globe is in a unique position to enable local enterprises to achieve global competitiveness, helping businesses reap the benefits of modern technologies.

The fixed voice and narrowband revenue from enterprises in Philippines has been declining over the years and is expected to continue to gradually decline. On the other hand, revenue from fixed broadband and dedicated connections have been growing steadily and is expected to grow stronger driven by the increased demand of data connectivity from enterprises of different sizes, the growing requirements for connectivity at higher bandwidth and the increased uptake of cloud services by enterprises. The revenue from dedicated connections will continue to dominate the market, and currently the price of dedicated connection is determined by the bandwidth, regardless of the technology used to provide the connection, such as IP/MPLS, SDH or OTN. Considering the current situation of the market and the rapidly increased demand from enterprises, Globe senses a big opportunity to capture the market.

Anchored on providing the best digital experience to the customers, Globe reinvented new connectivity solutions for enterprises in Philippines through a series of network modernization and transformation projects, leveraging on Optical Transport, IP, SDN and NFV state-of-the-art technologies, creating value through relevant transformation, Globe will be able to deliver an even better customer experience and empower more digital Filipinos enterprise.

A Hybrid network is needed to meet enterprise’s broad range of connectivity requirements

"Previously there is the perception the legacy services based on TDM/SDH will be drastically removed in favor of the Ethernet solutions. However, the enterprise customers have maintained that gradual transition towards the Ethernet platform is needed. Therefore a Hybrid Ecosystem needs to be built looking into a broad range of capacity below 1G until the more recent 100G," said Globe Telecom Transport Network Division Head Constantine A. Serafica when asked about the key changes in the enterprise’ s connectivity requirements.

Digital Marketing

Globe has undertaken a series of network transformation and modernization projects to provide best customer experience

"Globe’ s strategy is anchored on providing best customer experience. We focus on enhancing the customer journeys by undertaking a series of network transformation and modernization projects," added Serafica.

Globe has built a high capacity network with the flexibility to provide converged services. This is based on high capacity Optical Transport not only deployed on the Core and Distribution but also extended to the Access. "In fact, as we speak, we are deploying DWDM network elements towards the Access loops to form hub and spoke topology. As a result, capacity for each node will increase significantly, from sharing 10G capacity on the access ring to having dedicated multiple 10G to potentially 100G." explained by Serafica on the first network modernization project focusing on Optical Transport driven by high capacity requirement from enterprise and 5G.

Globe also worked on IP network consolidation and simplification by rationalizing the architecture and protocols used. This initiative not only flattens the network for easier administration, but also creates synergies between the consumer and enterprise networks. This paves the way to using Segment Routing resulting into network programming which complements 5G and next generation enterprise services.

Besides working on the optical and IP transport layer, Globe also completed the SDN deployment where automation and advanced functions are realized, such as end-to-end service provisioning, Bandwidth-on-Demand, Bandwidth Calendaring and end-to-end topology visibility.

Huawei has been the chosen technology partner in the transformation journey

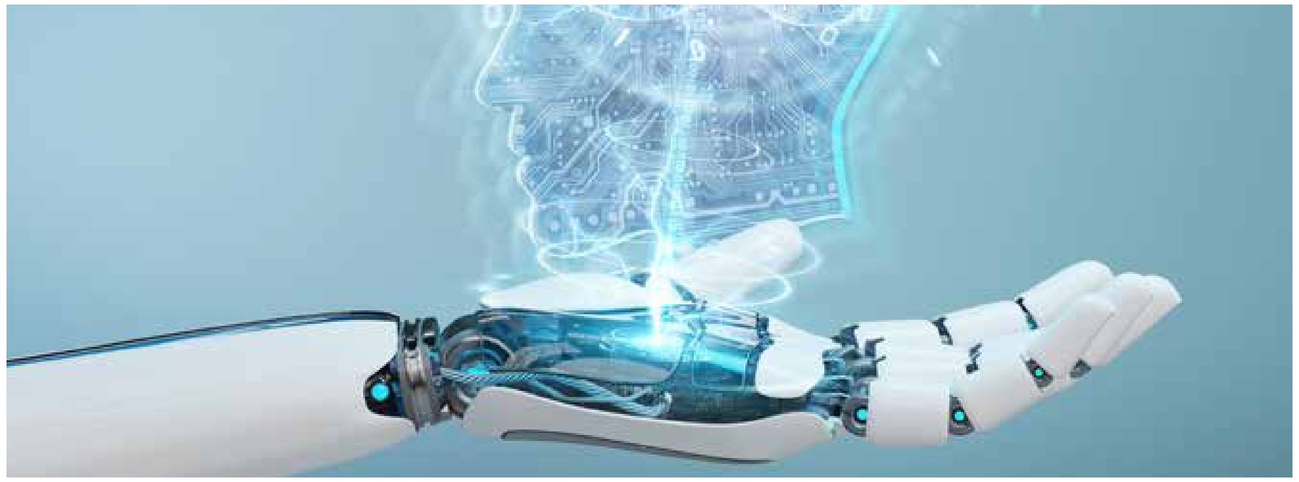
"Huawei has been our partner since 2008 in laying the foundational layer of transport and enterprise networks. Mutually, we have both benefited from this partnership - both learning what the industry needs. The collaboration has paved the way for companies to develop new products and services," said Serafica when asked about who is the technology partner for these transformation projects.

For Globe’ s enterprise network modernization project, Huawei’ s OSN/ATN/RTN series are deployed to provide the optical, IP and microwave functionalities. This enhances the capacity and resiliency in Globe network.

"On our IP Consolidation efforts, aside from the OSN and ATN on the distribution and access – we are using the NE40 to merge core functionalities allowing higher and faster processing times," shared by Serafica on Globe' s IP consolidation effort.

"For our SDN Deployment, thus far, the NCE have demonstrated that it can work in a multivendor environment and interoperability is possible through the use of the standardized models of REST and YANG - we are proud to say that we are now successfully managing through the NCE platform the various domains of OTN, IP, GPON and Microwave. Globe together with Huawei is pioneering this range of SDN-based services," shared by Serafica on the SDN achievement working together with Huawei.

Globe continuously deploys the latest technologies to build its infrastructures and systems. By remain digitally agile and advanced, Globe is able to extend these advantages and technology leadership to its enterprise customers with the reinvented connectivity solution, enabling enterprises to catapult their business towards success.



O&M Transformation: from Manual to AI

By Ye Xiaobin

The rapid growth of the 5G era has seen network O&M face growing challenges. This era has witnessed a shift from cost-reducing O&M to O&M that is capable of producing benefits for carriers, driving the traffic monetization of network O&M.

Traditional O&M is typically a manual process, combining semi-manual and semi-automatic operation that is gradually evolving towards full automation.

Even if full automation is achieved, the service rollout speed of traditional O&M is too slow and cannot meet the requirements of the new era. From the end-to-end process perspective, traditional O&M still separates development from O&M. That is, carriers raise requirements, equipment vendors develop and release products, and then carriers accept and use the products.

Communication concerning product requirements between carriers and equipment vendors is complicated and this consequently lengthens the development process. It can take carriers between half a year to two years from raising their requirements to using the products.

Ye Xiaobin

O&M Director of China Unicom Guangdong

From Traditional O&M to DevOps

To transform network O&M, the traditional thought process first needs changing. More specifically, a change from separated development and O&M to integrated development and O&M is required. To implement such a change, carriers' O&M departments must adopt the DevOps mindset, but the scope of DevOps is too big. For this reason, this article describes only the development part.

Development is not as simple as developing several programmers for business develo

From the software perspective, software development requires a software platform that provides the following:

(1) Basic running platform, such as the message bus and database
(2) Component shelves, such as image processing component and timer component
(3) DFX mechanism, such as reliability/availability, security, and privacy
(4) Basic service capabilities, such as transaction and rollback
(5) Basic business services, such as logs and alarms
(6) ...

pment. On January 23, 2019, a French regulator fined Google EUR 50 million (approximately USD 56.8 million) for collecting data for the purpose of targeted advertising, accusing Google of failing to effectively obtain users' consent. This is the biggest penalty so far under a new European privacy law and is one of the most severe regulatory actions taken by regulators based on the General Data Protection Regulation (GDPR) that took effect in the EU in 2018.

The software platform covers a wide range of areas, and different people have different understandings of this. If no software platform exists, the development of network O&M software is just empty rhetoric. For example, the privacy issue mentioned in the preceding case requires a software platform to build the privacy security of the entire system.

In addition to the software platform, network O&M development also requires a service framework. A major feature in the network O&M field is multi-vendor co-existence, which is also a difficulty to cope with. For network communication, vendors must adhere to unified communication standards. In the network O&M field, there is a lack of feasible standards and the management interfaces of different vendors are not cross-compatible. Even the management interfaces of different device types and versions of a vendor lack cross-device compatibility.

To resolve this problem, a service framework that provides abstract service processing and plug-in mechanisms is required to separate abstract from concrete and service processes from atomic realization. Through abstract service processing, sharing can be maximized and repeated development can be avoided, while separation helps achieve decoupling and incremental development.

Specifically, carriers can develop their own O&M systems only when they have a proper software platform and service framework. Figure 1 is a schematic diagram example of a software platform and service framework.

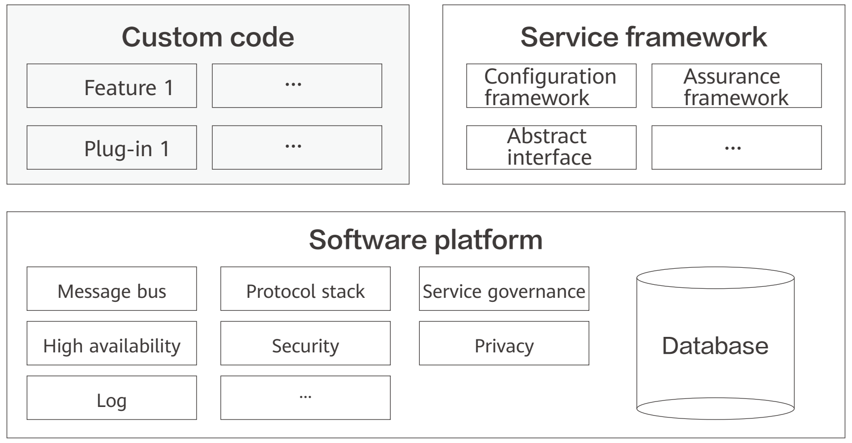


Figure 1:Software platform and service framework

Figure 1 illustrates the significance of the software platform and service framework for O&M development.

Despite its significance, it only involves pure software development. Before software development, requirement analysis and service design are necessary. Everyone has their own strengths and weaknesses, and carriers' O&M personnel are no exception. Some are good at service design, while others are good at software coding. We do not expect or require all O&M personnel to be all-round capable at analysis and coding.

Therefore, O&M development must comply with objective rules and have different roles: service designer and software developer.

Since roles are divided (there is a high probability that different roles are taken by different people), there is a huge gap in communication between roles, which is time-consuming, even if these roles are present within the same carrier.

Linus Torvalds, the founder of Linux, once said, "Talk is cheap. Show me the code". Can we implement "show me the code" between service designers and software developers? As mentioned earlier, it is not feasible to simply require service designers to deliver code. This is a hopeless problem. Fortunately, the emergence of model-driven technologies can better bridge the gap between the two roles.

Service designers devote themselves to the design of service models and import these models into the Model Driven Development Frame (MDD). The MDD parses and analyzes the models, combining them with the software platform and service framework, allowing software developers to develop plug-ins. In this way, the MDD can effectively resolve the problem of role assignment and the communication gaps between roles.

According to Maslow's theory, human needs are divided into five levels. Based on the preceding analysis, network O&M development is also divided into five levels, as shown in Figure 2.

Figure 2 includes development and debugging, as well as building and release, which are not described in this article. After the O&M development requirement levels are clearly defined, construction can be performed based on these levels. However, construction is not as simple as it sounds. Some network O&M departments have a small number of employees, and are in the transformation phase. Therefore, such a construction is almost impossible. It appears the first step of O&M transformation is difficult to pass, so does this mean DevOps is impossible?

Learning from others can make one grow. The AOC of Huawei iMaster NCE meets carriers'

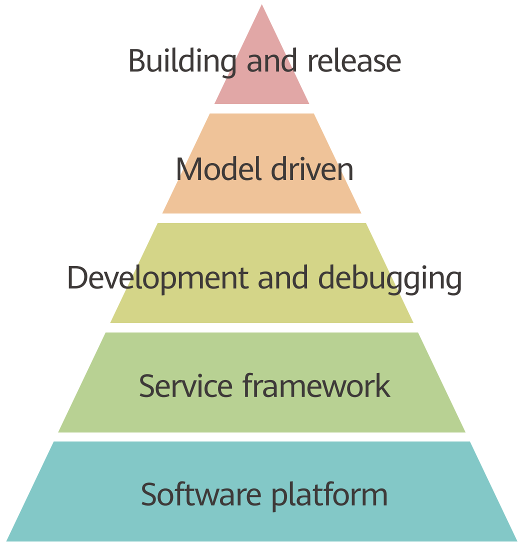


Figure 2: Levels of O&M development requirements

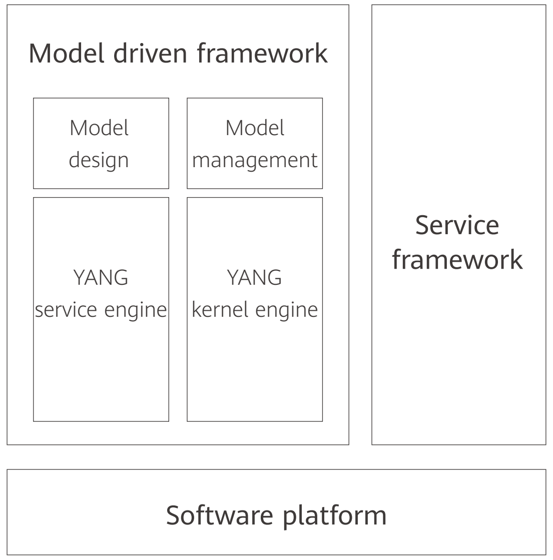


Figure 3: AOC architecture

requirements for network O&M transformation, becoming almost an enabler tailored for O&M transformation, as shown in Figure 3.

Figure 3 shows a simple AOC architecture. It integrates the industry-leading Huawei network cloudification platform and the service framework abstracted from years of network O&M. In addition, it uses YANG, which is recognized in the network O&M field, as the modeling language.

The AOC thoroughly meets the requirements of network O&M transformation, enabling carriers to focus on service development. This seamlessly integrates the network service design and software development processes.

Another key advantage of the AOC is that it can interconnect with Huawei's network O&M product NCE, which is especially important in the O&M transformation phase, as shown in Figure 4.

NCE in Figure 4 resembles carriers' traditional O&M mode, whereas the AOC embodies DevOps. During the early stages of O&M transformation, carriers cannot abandon the traditional O&M mode. This stage is long and it requires cooperation between traditional O&M and DevOps to speed up O&M transformation. The AOC effectively builds a bridge between the traditional O&M and DevOps.

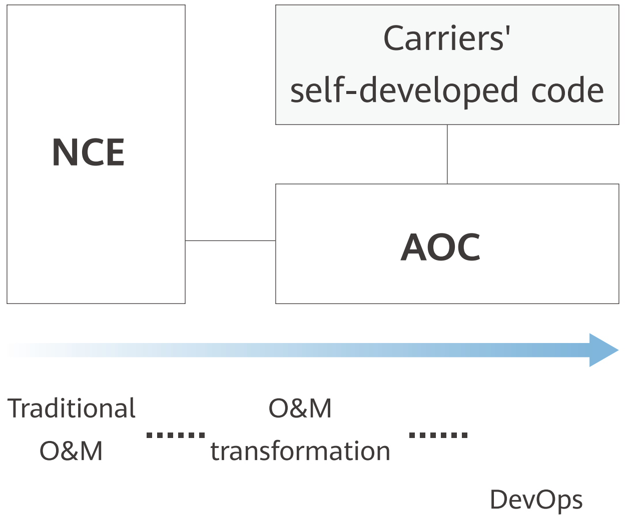


Figure 4: Changes in the O&M mode

From DevOps to AIOps

DevOps is by no means the end of carriers' O&M transformation. In fact, it is just the starting point. As mentioned earlier, future O&M seeks to be profitable. Beyond O&M mode change, the O&M concept also needs to change from the traditional OSS scope and vision to the network intelligence field, particularly autonomous driving and network autonomy. Network O&M transformation needs to leap from DevOps to NoOps, a change that is driven by AIOps.

AI is based on algorithm and data. The current dilemma is that the algorithm lacks sufficient data to become mature and is therefore stuck in an infinite loop. As a result, carriers are afraid to use it, so the technology will not mature.

To break this deadlock, carriers must transform their O&M. Carriers' O&M personnel are well acquainted with networks and user services, but they are not familiar with algorithms. Developers of equipment vendors are only familiar with algorithms, but lack sufficient information about networks or services. This requires equipment vendors to provide enablement for carriers' O&M personnel so that the O&M personnel can effectively train and achieve AI.

The enablement from equipment vendors is not just AI training for O&M personnel, although they must master necessary AI knowledge. Like the DevOps enablement provided by the AOC, the enablement provided by equipment vendors should be a powerful enabler that meets the requirements of each layer. In this way, carriers' O&M personnel can develop their own AI services, train AI through simulated networks, and apply AI in gray mode on the live network.

Currently, network intelligence (autonomous driving and network autonomy) is still in uncharted territory, and is waiting for equipment vendors and carriers to explore. During this process, both parties need to enhance their cooperation by fully understanding each other's advantages and disadvantages. Furthermore, carriers should also strive to be bold and dedicated, and play a leading role in exploring this uncharted territory.

Network O&M must be profitable. This value transformation is also a road to network O&M transformation, as shown in Figure 5.

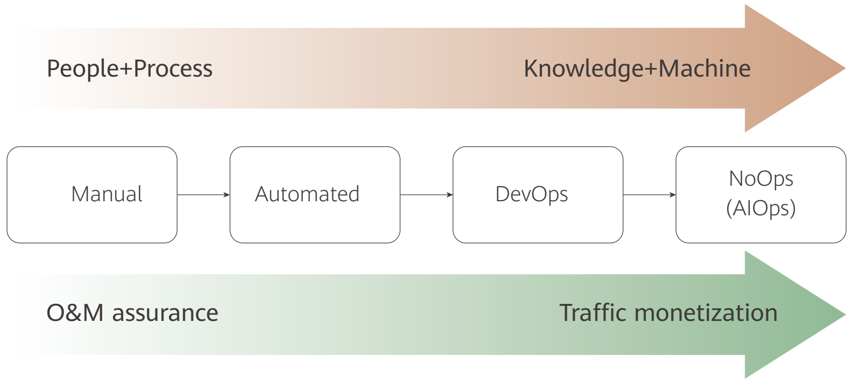


Figure 5: Network O&M transformation

The autonomy era is nearly here. If network O&M transformation is not achieved, it will be left behind by this era. The traditional manual O&M mode of "people+process" must be transformed to the AI O&M mode of "knowledge+machine". This is a difficult road, but an arduous journey of a thousand miles begins with a single step. Change yourself before serving customers.

Huawei Helps China Minsheng Bank Build a Next-Generation DC Network

By Li Gao, Senior Technical Manager of China Minsheng Bank

"The future is already here — it's just not evenly distributed." Digitalization has gradually penetrated into every corner of society. In the digital era of expanded customer groups, new channels, and new business models, the focus is on improving service capabilities and accelerating business transformation of commercial banks through scientific and technological innovation and guidance.

According to a report by McKinsey, in the digital era, user consumption habits and service forms keep changing. By 2025, if banks do not actively respond in time, the five retail services (consumer finance, mortgage loaning, SME loaning, retail payment, and wealth management) might decrease in revenue by 10% to 40% and in profit by 20% to 60%.

DC IT Infrastructure Innovation and Construction Faces New Challenges

Digital transformation cannot be achieved without the innovation and construction of the data center (DC) IT infrastructure, as the infrastructure is the foundation of all digital economies and essential to the provisioning and guarantee of agile and innovative services. As cloud computing and virtualization technologies develop rapidly, new architectures and technologies are being introduced to the infrastructure. As one of the three major components of a DC, networks must provide the following capabilities to quickly respond to service requirements and support service innovation:

· Support resource pooling to improve utilization of resources and avoid isolated, repeated network construction, as well as support auto scaling.

· Allocate network resources on demand to meet the requirements for fast iteration and deployment of online financial apps.

· Provide flexible traffic steering and precise management to meet the differentiated requirements of different services.

· Enable network-wide traffic visualization, simplify O&M, and ensure compliance. Visualization of network-wide traffic helps detection of the blind spots of network traffic monitoring in a cloud environment.

Build a Next-Generation DC Network Based on the SDN Architecture

After comprehensive research and testing at the initial stage of digital transformation, China Minsheng Bank (CMB) decided to build a next-generation DC network based on the software-defined networking (SDN) architecture. It used Huawei's iMaster NCE to build its digital operation capabilities based on SDN and big data. It innovated in terms of basic architecture, network self-service, and intelligent O&M and seizes the opportunity to construct a DevCloud for branches to build its pilot SDN network. In this way, CMB avoided repeated network construction among branches, maximized resource utilization, enabled the development and testing networks at different branches to meet the requirements of frequently varying test services, and enabled the monitoring of network traffic in virtualization environments.

DC Network Reconstruction for Network Resource Pooling Management

With the rapid growth of services, information, and users, traditional DCs face increasing challenges in terms of space and efficiency. These traditional DCs are deployed per project and servers are deployed per application. The deployment process is slow, server density is low, and capacity expansion is difficult. As services and applications continue to grow, the network becomes increasingly complex and inefficient.

Huawei's DC network solution adopts the SDN overlay technology, which applies the large Layer 2 design to the network architecture. This solution uses virtual extensible local area network (VXLAN) networking to separate the physical bearer network from the logical service network, and uses iMaster NCE for centralized management and automated deployment of the network.

The solution provides the following benefits to the network: First, by decoupling the physical network from the service network, this solution enables flexible migration of virtual machines (VMs). Services can be flexibly deployed in any position, and VMs can be accessed from anywhere, at any time, which is optimal for network resource pooling. Network auto scaling is also enabled. Second, network resources are pooled, and iMaster NCE is used to allocate resources on demand and manage networks in a centralized manner. This significantly improves network utilization and simplifies network management. Third, tenant-based management effectively isolates services. Based on the actual situation of CMB, branch users share hardware resources, but these resources are logically isolated. Different service departments or network service areas are logically isolated for differentiated management and security policy deployment.

DC Network Architecture with Cloud-network Synergy, Enabling Service Provisioning Within Minutes

Network deployment automation is key to the next-generation DC network. In traditional DCs, network devices need to be manually configured or configured using scripts, and configurations need to be frequently adjusted, which is prone to errors, time-consuming, and inefficient. In addition, separated computing, storage, and network resources pose huge challenges to the rapid rollout of new services.

iMaster NCE interconnects with OpenStack to enable cloud-network synergy in the DC architecture, empowering this architecture to centrally manage computing, storage, and network resources as resource pools, schedule resources on demand, and rapidly and automatically deploy services. This improves application deployment efficiency and shortens service provisioning time from hours to minutes. In addition, this architecture provides the service capabilities of logical switches, logical routers, distributed virtual firewalls, and virtual load balancers by using APIs, as well as provides secure, isolated logical network planes for branches and internal tenants, enabling automated E2E service provisioning. The deployment efficiency is 10 times that of the traditional solution, significantly accelerating service rollout at CMB's branches. This solution enables CMB to provide better services to customers externally, as well as improve the office and management efficiency internally.

Visualized Network O&M, Improving Network O&M Capabilities

Large, dynamic, automated next-generation DCs pose higher requirements on network O&M. It is impossible to keep up with the flexible changes in logical networks and services from the traditional device layer, and VM management displays only the information of virtualized elements. In addition, network administrators cannot view the overall network and service status in traditional management mode.

To solve these issues, iMaster NCE restores the topology of services delivered by the OpenStack cloud platform, displays the physical, logical, and application networks and their mappings based on the physical network topology, and detects service forwarding paths between VMs on demand. Network administrators can use iMaster NCE to view the mappings between services and the physical network, overall network status and performance, and network-wide resources, traffic, and service paths, improving network O&M and compliance.

中国民生银行
CHINA MINSHENG BANK

Achievements

Innovative technologies enable CMB to build an automated, intelligent next-generation DC network. In joint cooperation with Huawei for innovation, CMB started with digital transformation from the most basic digital network platform and successfully tested the next-generation DC network architecture featuring cloud-network synergy. This architecture effectively improves efficiency in service provisioning and reliability of deployment, marking the first step towards digital transformation.

CMB will extend its innovative practices to AI, big data analytics, and automatic fault rectification to comprehensively implement intelligent network reconstruction. The WAN optimization solution is being deployed. With iMaster NCE's network-wide visualization and optimization capabilities, this solution effectively provides application-level steering and management of WAN traffic between DCs as well as between branches and headquarters of CMB.

In line with the principle of "From the People, For the People", CMB is committed to providing more efficient and high-quality services through digital transformation featuring proactive O&M, fault forecast, and intelligent network management.

CAT Telecom Thailand: Private Line Market Leader with High-Quality OTN Networks

By Dai Pei

Dai Pei

Transmission Marketing Support Dept of Huawei

[Introduction] CAT Telecom is determined to build a nation-wide flattened network using Huawei's end-to-end OTN+iMaster NCE Solution. It aims to provide differentiated high-quality services for the digital transformation of enterprise customers in Thailand.

In 2016, the Thai government proposed the Thailand 4.0 model to accelerate Thailand's economic and social development for the next 20 years. The Thai government plans to leverage digital technologies to transform traditional agriculture, small- and medium-sized enterprises, and service industries into intelligent agriculture, enterprises, and high valued-added industries, fueling the growth of the digital era. Therefore, developing the digital economy has become an important strategy that is driving Thailand's economic transformation, ICT innovation, and the Thailand 4.0 model.

To realize this aim, Thailand's major enterprises are embracing innovative technologies such as cloud computing, big data, and artificial intelligence (AI), while businesses are accelerating their own cloudification strategies. CAT, a state-owned telecom operator in Thailand, is striving to build an economical and high-quality network infrastructure that supports the Thailand 4.0 model. Once built, this infrastructure will provide premium private line services for major enterprises in Thailand.

Establishing the Premium Private Line Strategy and Reshaping the Market Landscape

Only recently have enterprises in Thailand accelerated their digitalization strategies. However, this has not benefitted CAT as expected. CAT’ s revenue has been decreasing gradually, and the lack of differentiation of private line products among different operators in Thailand has resulted in the gradual decline of CAT’ s private line market share. Currently, CAT has the third highest share (16%) in the enterprise private line market. To differentiate its private line services, CAT has comprehensively analyzed the private line market in Thailand and concluded that enterprise private line services are mainly used in the following scenarios: large-capacity point-to-point data center interconnections, cloud connections for vertical industries such as government and finance, VPN connections for large- and medium-sized enterprises, international IPLC connections for multinational enterprises, and broadband services for homes as well as small- and medium-sized enterprises.

Currently, the technologies used by these private line services are mainly Ethernet and MPLS VPN. The price is determined by bandwidth and the services are differentiated with simple Service Level Agreements (SLAs). Meanwhile, ring topology is used for protection, and the maximum availability is only 99.9%. Network resources are not visualized, and service provisioning needs to be confirmed node by node, leading to long service provisioning period, complex configuration, and difficult bandwidth adjustment. After services are provisioned, private line services and other services are transmitted together, and therefore may affect each other during peak hours. Additionally, due to the homogeneity of technologies and services, a large number of operators and ISPs are competing in the market on price to attract customers, driving down the yearly price.

To adapt to the changing market trend and seize new opportunities, CAT has decided to offer differentiated and premium private line services.

Building a Unique Premium Private Line Network with the Existing Network

CAT has customers in the government, finance, banking, and transportation industries, which all involve international services. After reviewing these customers, CAT discovered that they are mainly based in the Bangkok area. Therefore, to exploit this density CAT can build premium private line networks within this area using the existing 100G networks, and will also look to expand the coverage of the private line network and improve experience by adding and reconstructing a number of sites.

· First, two new OTN aggregation sites will be deployed in Bangkok area to cover 10 times more customers, among which 70% are large or ultra-large enterprises, and data centers.

· Second, 10+ existing ROADM sites and ILA sites will be transformed into OTN aggregation sites so that the entire network can support another 150+ large enterprises, 10+ super-large enterprises, and four data centers.

· Third, the entire network will use unified controllers to manage and provision services, which will improve network resource utilization.

After the project is complete, the network built by CAT and Huawei will become the first OTN premium private line network in Thailand.

By using Huawei's E2E OTN+ iMaster NCE solution, CAT built a nation-wide flattened network. The iMaster NCE intelligent management and control system was used on the entire network to implement E2E management, achieving one-hop connection to government and enterprise customers' clouds through OTN-based hard pipes.

+2.11 %
-1.11 %
+7.14 %
-3.12 %
+17.26

The premium private line network features:

- **High security and wide coverage:** OTN hard pipe isolation, exclusive bandwidth, and full coverage in Thailand.
- **High availability:** Services are ASON protected, and link availability is higher than 99.99%.
- **Guaranteed ultra-low latency:** Guaranteed low latency and real-time latency visualization.
- **Intelligence and agility:** Plug-and-play CPE and provisioning of private line services within days
- **Enhanced experience:** Network resource visualization and online service survivability analysis

The entire premium private line network was completed in 2019 and immediately started serving large- and medium-sized enterprises in Thailand.

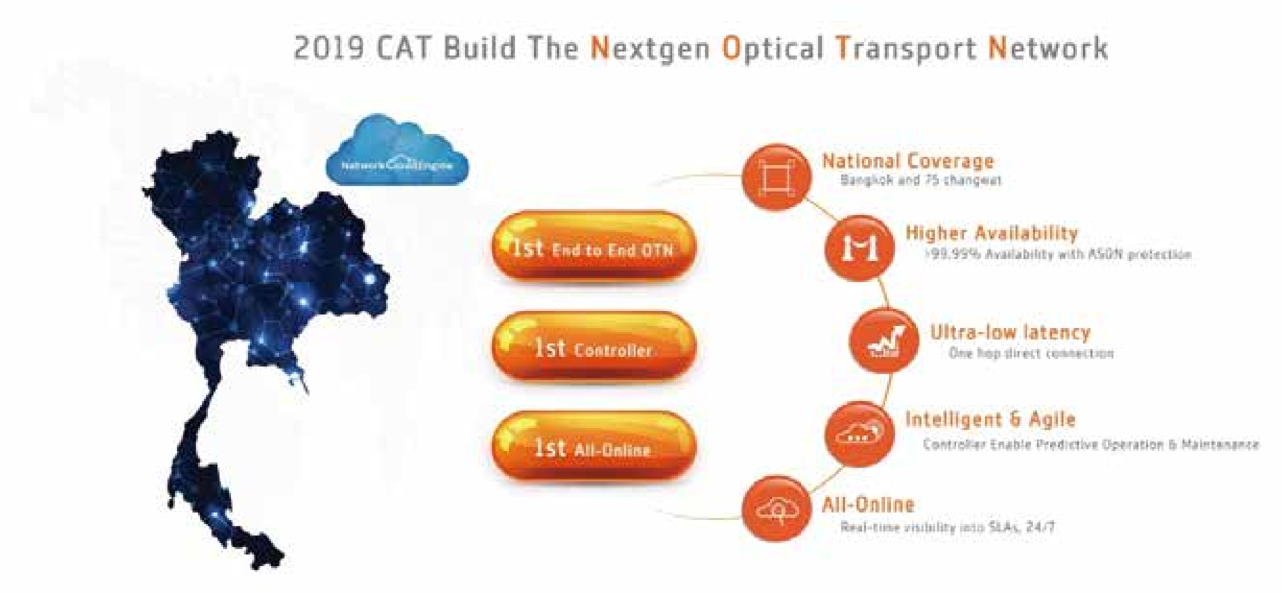

2019 CAT Build The Nextgen Optical Transport Network
NetworkCloudEngine
1st End to End OTN
1st Controller
1st All-Online
National Coverage
Bangkok and 75 changwat
Higher Availability
>99.99% Availability with ASON protection
Ultra-low latency
One hop direct connection
Intelligent & Agile
Controller Enable Predictive Operation & Maintenance
All-Online
Real-time visibility into SLAs, 24/7

Figure 1 CAT completed the next-generation optical transport network in 2019

Providing Premium Private Line Services for Enterprise Customers in Thailand

This OTN premium private line network now enables CAT to provide differentiated services for its enterprise customers.

•**Private line interconnection for large-scale Internet enterprise data centers:** CAT premium private line products support fast switchover and recovery upon occasional faults, with a network availability of 99.99%.

•**Financial industry:** The unique millisecond-level low latency of CAT's premium private line ensures real-time transmission of information such as transactions, settlement, and market information query. This enables financial enterprises such as securities companies and banks remain competitive.

•**Transportation industry:** Hard pipe isolation facilitates secure and reliable scheduling.

•**Intelligent healthcare industry:** High reliability and low latency allow surgical interns to remotely observe operations performed by experts. Furthermore, adjustable bandwidth allows medical images to be quickly uploaded to the cloud for analysis.

On December 16, 2019, CAT and Huawei officially released Thailand's first OTN premium private line network and recommended it to 150 customers from 70 enterprises across Thailand. These enterprises operate in various industries, ranging from information and communications technology (ICT), banking and investment, payment security, as well as logistics and transportation. At the launch event, the Thai government data and cloud service center (a third-party data hosting center for government agencies) reached a cooperative agreement with CAT.

> Looking to the future, CAT will further cooperate with global partners such as Huawei to promote the application of innovative OTN technology in Thailand, build a leading OTN premium private line network, and accelerate the digital transformation of enterprises in Thailand.

The Nextgen Optical Transport Network

Figure 2 CAT and Huawei officially released Thailand's first OTN premium private line network

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China Mobile Zhejiang Launches Intent-Driven 5G Transport Network

By Zhao Gang

Zhao Gang

iMaster NCE Solution Marketing Expert

China Mobile Group Zhejiang Company Limited (China Mobile Zhejiang) has led the mobile transport network field in China since the 4G era. Facing challenges posed to the transport network by the development of 5G services, China Mobile Zhejiang and Huawei established a 5G transport innovation project team in 2016. The team continuously invested in the exploration and research of 5G transport networks, achieving remarkable results. In 2018, the largest 5G trial transport network in China was built.

In addition, to improve the automation and intelligence capabilities of 5G transport networks, China Mobile Zhejiang and Huawei initiated a NetCity joint innovation project for the Intent-Driven Network (IDN). During this project, the DevOps mode was used to quickly introduce innovative solutions that promote the agile deployment and automatic O&M of 5G transport networks and innovate services in the 5G era.

Jointly Innovating with Huawei NetCity to Explore 5G Transport Intelligence

Currently, the global pace of digitalization and intelligence is accelerating. IDC forecasts that by 2021, at least 50% of global GDP will be digitalized, and the proportion of China's digital economy will reach 55%. Furthermore, digital products, operations, and partnerships will drive the growth of various industries. Gartner's survey report indicated that 83% of surveyed enterprises would complete digital transformation in 2019. Evidently, global industries are accelerating their digital transformation. As the supporting pillar and foundation of this transformation, intelligent carrier networks are essential, and 5G networks will be updated first.

With more vertical industry requirements, 5G services are more diversified than 4G services, posing higher requirements on network deployment, adjustment, and O&M. The device-centric network architecture and manual O&M of 4G networks cannot be sustained in the 5G era. It is imperative that we improve network deployment and O&M efficiency by introducing automated and intelligent O&M methods. In the third quarter of 2018, China Mobile Zhejiang and Huawei officially launched the NetCity project, researching and exploring intelligent 5G transport solutions to build a leading position for China Mobile Zhejiang in 5G transport networks.

NetCity is a future city construction project jointly initiated by Huawei and global carriers. It builds broadband, cloud-based, and intelligent network infrastructure based on the intelligent, simplified, ultra-broadband, secure, and open IDN released by Huawei at MWC 2018. Its goal of enabling all humans to progress towards a fully connected, intelligent society is highly aligned with the strategic development requirements of China Mobile Zhejiang's 5G transport intelligence.

The core of the IDN is the Network Cloud Engine (NCE), which consists of the Intent Engine, Automation Engine, Analytics Engine, and Intelligence Engine. The Intent Engine translates business intents into network languages, and simulates network design and planning. The Automation Engine changes network design and planning to specific network commands, which are automatically performed by devices through standard interfaces. The Analytics Engine uses technologies such as real-time telemetry to collect and analyze user network data, including the delay, jitter, and packet loss rate of transport networks. The Intelligence Engine provides risk forecast and handling suggestions by using algorithms such as AI and continuously upgrading the experience library on the basis of the Analytics Engine. Based on these four engines, the IDN builds a data-driven digital twin network. It provides intent-driven automatic configuration, data-driven real-time situational awareness, and global insight for full-lifecycle network O&M, and it implements predictive as well as proactive operations centered on customer and service experience. As a result, this solution has become China Mobile Zhejiang's preferred choice for exploring 5G transport intelligence.

Intent-Driven Transport Network Emerges, Laying a Solid Foundation for Large-Scale 5G Commercial Use

To further improve deployment efficiency during the construction of China Mobile Zhejiang's 5G transport network, China Mobile Zhejiang and Huawei established a special work group to jointly explore solutions that shorten the base station deployment period, accelerate network fault locating, and enhance network reliability, achieving phased results.

To shorten the 5G base station deployment deployment period, after in-depth analysis, the group discovered that the main causes of the long cycle included decentralized cross-departmental management, ticket-driven manual operations throughout the whole process, excessive configuration steps, high skill requirements for personnel, and an error-prone process. The work group plans to introduce an intelligent platform that ensures the entire online process is automated during base station deployment, spanning resource planning, network design, basic configuration application to new NEs, service configuration application, and service verification. Automatically applying service configurations after hardware is installed will reduce requirements on personnel skills and improve the efficiency of base station deployment.

Difficulty in network fault locating is mainly caused by device information that is independently displayed and the lack of a detailed path to base stations. The transport network cannot detect base station service deterioration and passively responds to complaints from peripheral departments. In addition, due to the difficulty in fault demarcating, multiple teams are required to locate faults, leading to inefficiency. As faults on the transport network cannot be corrected, the work group innovates technologies as well as implements E2E path and quality visualization for base station services through service-layer flow-based performance monitoring mechanisms. As a result, faults can be detected within seconds and quickly demarcated and located within minutes, making it possible to resolve problems before receiving customer complaints. In addition, thresholds are preset for network KPIs (including delay, jitter, and packet loss rate), and if a KPI exceeds the threshold, an alarm is reported to proactively prevent faults and avoid passive response to trouble tickets.

To address the long 1588 clock planning and deployment period, as well as the requirement for measuring fiber asymmetry on-site, the work group designed an intelligent clock solution. This solution supports one-click clock path planning and configuration application, and works with base stations to automatically compensate for fiber asymmetry, achieving zero site visits, which greatly improves the efficiency of deploying the 1588 clock. In addition, functions including network clock health monitoring, historical performance playback, and automatic fault source tracing facilitate the implementation of automatic fault locating within minutes for 90% of faults, thereby simplifying clock O&M.

The work group analyzed factors affecting network reliability and discovered that service interruptions are caused by difficulty in accurately detecting multi-point faults, as well as quickly and correctly switching to available paths. Based on the conclusions of the analysis, the group has designed a better network protection mechanism to enable quick multi-point fault awareness, implementing permanent service 1:1 protection and quick restoration after failures to ensure services are always online. At the same time, the group is continuously analyzing and conducting research on the difficulty in analyzing a large number of device alarms, as well as the difficulty in evaluating the impact of new services on the network.

China Mobile Zhejiang is significantly improving its 5G transport network deployment and O&M efficiency through NetCity joint innovation. With the continuous improvement of the entire 5G transport network field's intelligence level, O&M efficiency will be continuously optimized to fully support China Mobile Zhejiang's 5G service innovation and business success.