

# **TM Forum Best Practice**

## **China Mobile's Practice on Autonomous Networks**

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# Table of Contents

Notice .....	2
Table of Contents.....	4
List of Figures .....	5
Executive Summary .....	6
1. Background and Motivation .....	7
1.1. Background .....	7
1.2. Motivation .....	7
2. Strategy and Methodology .....	9
2.1. Overall Target .....	9
2.2. Approach and Framework .....	9
2.2.1. Layered Target Framework .....	9
2.2.2. Evaluation Driven Evolution Loop .....	11
2.3. 2.3 Methodology .....	12
2.3.1. Objects for Scenario-based Evaluation .....	12
2.3.2. Capability Granularity Level Characteristics.....	12
3. Innovative Practice .....	13
3.1. Shortcoming Identification .....	13
3.2. Inner Capability Enhancement in Network Elements.....	13
3.3. Platform Foundation for Network Management System.....	13
3.4. AI Capability Enhancement.....	15
3.5. Typical Application Cases.....	16
4. Industrial Co-Creation.....	18
5. Future Outlook.....	20
6. Abbreviations and Acronyms.....	21
7. References .....	22
8. Administrative.....	23
8.1. Version History .....	23
8.2. Release History .....	23
8.3. Acknowledgements .....	23
8.3.1. Guide Lead & Author .....	23

# List of Figures

Figure 1. China Mobile’s Autonomous Network Framework..... 10

Figure 2. China Mobile’s autonomous network evolution loop..... 11

Figure 3. China's Mobile's "2+5+N" blueprint for network management system ..... 14

Figure 4. China Mobile's AI application system of intelligent O&M ..... 15

## Executive Summary

The digital economy will continue to grow at a high speed, showing a development trend of "digital industrialization, industrial digitization, digital governance, and data's value realization". China Mobile has been responding to the times, shouldering the main force of building strength in cyberspace, enabling a digital China and a smart society, by establishing the main development path of "promoting the digital and intelligent transformation and achieving high-quality development" to accelerate the digitalization and intelligentization of network operation and maintenance domain, and strive to build an integrated, highly automated and intelligent system of cloud and network, giving full play to the core advantages of operators and consolidating the foundation of digitalization and intelligentization of all walks of life.

Upholding and practicing the concepts of autonomous network, China Mobile sets an overall goal for the company's network to reach level 4 by 2025. The digitalization and intelligentization of network operation and maintenance is accelerated to empower the support of CHBN services, improve customer satisfaction, enhance network quality, increase maintenance efficiency, reduce the operating cost and optimize management work. With the goal of supporting end-to-end services, capabilities are established at different levels. With the starting point of capability evaluation, iterative optimization is carried out in a close-loop manner. On the one hand, driven by network management system planning, capacity of operation and maintenance automation is constructed through innovative pilots of intelligent operation and maintenance and their large-scale adoption, accelerating the AI injection and enabling. On the other hand, overall plans are made for issuing technical specifications of automatic operation and maintenance support functions of network equipment, promoting the capability improvement in conjunction with the network management system.

Aiming to guide more industry partners to build consensus, share experiences, and jointly innovate to achieve the common goal of network autonomy, this article summarizes China Mobile's thinking and practices from the perspective of motivation and background, strategy and methodology, quantitative evaluation, etc. Combined with the company's follow-up planning, it gives cooperation suggestions and future prospects of industrial development.

# 1. Background and Motivation

## 1.1. Background

According to MIIT<sup>[1]</sup> and CAICT<sup>[2]</sup>, China's digital economy added value is supposed to reach 65 trillion yuan by 2025, in which the income of information service industry will increase to 20.4 trillion yuan. The digital economy will continue to grow at a high speed, showing a development trend of "digital industrialization, industrial digitization, digital governance and data's value realization". Advanced ICT technologies such as 5G, AI, cloud/edge computing are getting more mature, integrated and innovative, empowering various verticals to deepen digitalization. Enterprise customers focus on "ubiquitous intelligent connection + cloud-based data intelligence", and are committed to implementing an end-to-end overall program to promote the development of digital economy in more fields and at a deeper level.

In this context, China Mobile has taken the initiative to build strength in cyberspace, enabling a digital China and a smart society, and established the main path of development of "promoting the digitalization and intelligentization and achieving high-quality development"<sup>[1]</sup>, via five key actions: create innovative digital intelligent products, consolidate digital intelligent network, build a digital intelligent center, construct a digital intelligent organization and forge a digital intelligent ecosystem. Based on the communication network, driven by information technology and data elements, a new growth model is to be established, giving full play to the "shoulder role" of operators in promoting the innovation of information technology and the deep integration of information technology with economy, society and people's livelihood.

With a complex network featured by world's largest customer scale, rapid development of ICT business and coexistence of 2/4/5G technologies, the digitalization and intelligentization is a MUST in China Mobile's network operation and maintenance domain. China Mobile is committed to build an integrated, highly automated and intelligent system of cloud and network, which consolidates the foundation of digitalization and intelligentization of all walks of life.

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<sup>[1]</sup> Ministry of Industry and Information Technology

<sup>[2]</sup> China Academy of Information and Communication Technology

## 1.2. Motivation

The digitalization and intelligentization of network operation and maintenance is the deep integration of automation and intelligence technology with the communication network's hardware, software, system, process, etc., which promotes quality and efficiency improvement, leads network technology reforms, and enables agile business innovation. The driving force mainly comes from the three following aspects:

**Rapid Expansion of Business:** As the individual user market gets saturated, the digitalization of vertical industries and enterprise consumers' lives have become highly expected potential growth points. Diversified demands are put on network services with more stringent standards in terms of connectivity, bandwidth, delay, reliability, etc.

**Technological Evolution for Network:** Infrastructure virtualization and network element softwarization not only achieve new features such as flexible resource allocation and dynamic scheduling, but also bring more equipment combinations from different manufacturers and management levels into the disaggregated network. The complexity of network collaboration increases sharply, which further aggravates the difficulty of network operation and maintenance management.

**Optimization for Operation Management:** As one of the world's largest telecom operators in terms of both network scale and users, China Mobile's network is characterized by rich domains, multiple generations, numerous levels and large region. The process coordination, information screening and automatic execution of existing O&M work such as service subscription, fault monitoring and quality optimization need to be continuously improved in efficiency.



## 2.Strategy and Methodology

### 2.1. Overall Target

TM Forum's autonomous network<sup>[2]</sup> aims to provide vertical industries and consumers with innovative network and ICT services featuring zero-wait, zero-contact, zero-fault and full autonomy, build a self-served, self-healing, and self-optimized communication network, which provides a clear target architecture and implementation path for digitalization and intelligentization of network operation and maintenance<sup>[3]</sup>.

Based on the TM Forum framework, the network autonomy is classified into 6 levels: Level 0 - Manual management, Level 1 – Assisted management, Level 2 - Partial autonomous network, Level 3 - Conditional autonomous network, Level 4 - High autonomous network, Level 5 - Full autonomous network.

With reference to the concept of TM Forum's autonomous network, China Mobile has made plans for digitalization and intelligentization of network operation and maintenance, strengthened the capacity building of automation and intelligence, and set an overall goal for company's autonomous network to reach Level 4 by 2025.

### 2.2. Approach and Framework

In order to realize the overall goal by 2025, China Mobile has made all-round thinking, applicability exploration and phased practices. Faced with complex production networks and diversified autonomous capabilities, the method of "divide and conquer" is adopted to realize the "spiral rise" of network autonomous capability construction.

#### 2.2.1. Layered Target Framework

With reference to the hierarchical architecture of TM Forum network<sup>[4]</sup> and combined with production practices, China Mobile put forward an internal practice framework of "4 layers and 3 closed loops", as shown in Figure 1.

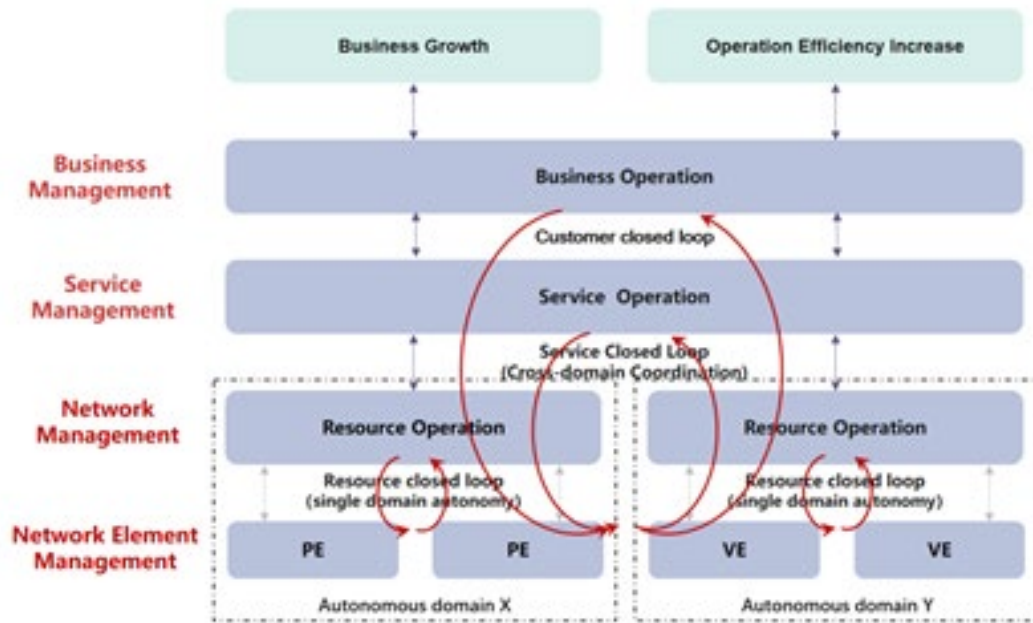


Figure 1. China Mobile's Autonomous Network Framework

As is shown in Figure 1, “the 4 layers” refer to:

- **Network Element Management:** provides the built-in autonomous O&M capabilities of network elements.
- **Network Management:** provides network-oriented autonomous O&M capabilities within a single technical domain.
- **Service Management:** provides cross-domain autonomous O&M capabilities toward network and services.
- **Business Management:** provides customer-oriented autonomous service management and customer touch-points uniformly.

“The 3 closed loops” include:

- **Resource Closed Loop:** resource management for single domain to achieve single domain autonomy.
- **Service Closed Loop:** service-oriented, cross-domain end-to-end management to achieve cross-domain collaboration.
- **Customer Closed Loop:** customer and business management including customer information, sales, billing, customer service, etc.

Taking it as a reference, targeting at quality improvement, efficiency increase and cost reduction, China Mobile builds systematic capabilities at different levels to realize network autonomy.

### 2.2.2. Evaluation Driven Evolution Loop

In view of multiple differences among provincial companies in customer scale, business type, O&M process, and supplier partnership, a unified evaluation system is developed, and a comprehensive quantitative evaluation of autonomous capability is conducted in all 31 provincial companies, triggering the evaluation driven evolution loop to iteratively accumulating capability in three steps, as shown in Figure 2.

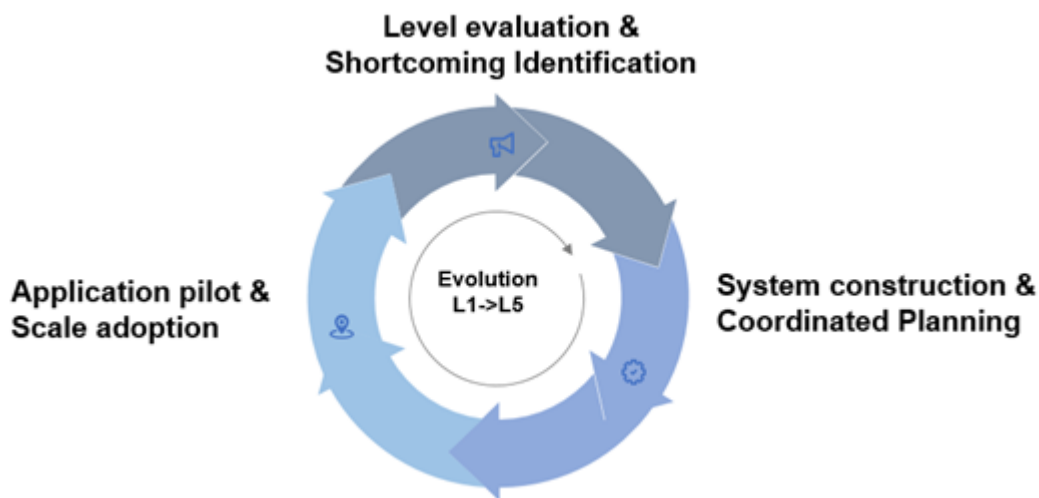


Figure 2. China Mobile's autonomous network evolution loop

**Level Evaluation and Shortcoming Identification:** Based on the general principles of TMF evaluation framework, more detailed guidelines are proposed to evaluate scenario-based autonomy capability for O&M process. After grading all 31 provincial companies' capability, common problems and shortcoming differences could be identified, targeted measures and deployment plans could be developed.

**System Construction and Coordinated Planning:** Unified plans are made for all provincial companies to strengthen and accelerate the renewal of new network management systems. The function and technology specifications for network equipment in all domains are to be further detailed on the basis of general function specifications, guiding network equipment suppliers to achieve upgrading for equipment autonomy.

**Application Pilot and Scale Adoption:** Provincial companies are guided to actively introduce advanced automation and intelligent technologies, in collaboration with network equipment suppliers and network management system integrators. Considering that there are differences in automation levels among provincial companies, pilots are carried out in selected provincial companies at early stages, and then be promoted nationwide if the feasibility were verified.

## 2.3. 2.3 Methodology

### 2.3.1. Objects for Scenario-based Evaluation

Combined with the actual O&M management organization system of production network, the model of evaluation object framework for autonomous network is formed on three dimensions of "O&M scenario, Network domain and Service category", which includes specifically:

**Key O&M Scenarios:** 6 first-class scenarios, including: planning, development, maintenance, optimization, operation and resource management. 11 second-class core scenarios, including: network planning, design and deployment, monitoring and troubleshooting, patrol inspection, testing, network analysis, network optimization, service subscription, network complaints, resource change management and resource data management.

**Key Network Domains:** Core network, Radio network, IP network, Transport network, and Telecom cloud.

**Key Service Categories:** Individual services including mobile Internet, voice, SMS; home services including home broadband Internet, IPTV; business services such as 5G industrial network, APN, IMS, transport VPN, Internet VPN, transport VPN, cloud VPN, MPLS VPN.

In use of the methodology mentioned above, combined with the characteristics of each network domain and service category, the second-class O&M scenarios are further decomposed into a group of O&M core capability set as scenario-based evaluation objects.

### 2.3.2. Capability Granularity Level Characteristics

Based on the guiding principles of TM Forum network grading framework<sup>[5]</sup>, combined with the actual needs of network O&M management evaluation, from the perspective of guiding IT system implementation, the following requirements for different levels are defined:

- Level 0: offline manual implementation.
- Level 1: manual implementation, online recording.
- Level 2: automatic implementation ruled by statically programmed rules.
- Level 3: automatic implementation ruled by dynamically programmable policies.
- Level 4: automatic implementation ruled by AI assisted (if needed) knowledge, featuring with continuous learning and rapid evolution.
- Level 5: automatic implementation capable of self-evolution and adapting to changes.

Applying those level-differentiated features to core capability sets, the detailed classification rules of scenario-based autonomy for each core capability set are obtained. A quantitative evaluation model is proposed based on aggregation principles such as weighted average, which can help the company obtain the quantitative score of the network O&M autonomous level in each scenario, each process, each domain and cross-domain area as required from the finest-grained evaluation results, providing powerful support for making all-round evaluations, comprehensively analyzing the level differences in multiple dimensions and accurately identifying common shortcomings.

## 3. Innovative Practice

### 3.1. Shortcoming Identification

All provincial companies are required to conduct network O&M capability evaluation through self-assessment in single domain, horizontal comparison of multiple domains, etc., so as to identify the shortcomings. At present, the overall level of China Mobile's production network (for selected services, networks and operation domains) is rated as L1-L2, and some provincial companies as above L2.

Shortcomings in different degrees are identified in network equipment from various aspects including integrated deployment, potential risk prediction, fault isolation and failover, optimized simulation, sensing test, data reporting granularity and real-timeness.

Network management system needs to be further strengthened on automatic and intelligent support capabilities in terms of end-to-end registration of home and enterprise services, cloud-network coordinative scheduling, end-to-end quality perception and analysis of services, and on-site manual operation support.

### 3.2. Inner Capability Enhancement in Network Elements

Network elements' inherent support for automation and intelligence of operation and maintenance lays the foundation to achieve autonomous network. The required automatic O&M capabilities of network element management layer for each domain include:

- (1)**Equipment Monitoring**: enhances the automatic data sensing capability with multiple-dimension, real-time and fine-grain, which includes traffic flow, resource capacity, topology, operation events, equipment energy consumption, etc.
- (2)**Resource Allocation**: speeds up the construction of dynamic routing calculation, service configuration activation and other capabilities in transport network, IP network, etc.
- (3)**Service Guarantee**: provides automatic diagnosis, isolation, migration and recovery of network faults.
- (4)**Service Optimization**: ameliorates capabilities in optimizing resource utilization, business quality and energy efficiency.
- (5)**Service Test**: provides connectivity testing and service testing capabilities on network element level, module level and link level in core network, transport network, etc.

### 3.3. Platform Foundation for Network Management System

In terms of network management and service management, China Mobile proposed a "2+5+N" blueprint for network management system, guiding systematically the capacity building of network management system, as shown in Figure 3. On the one hand, 2 core platforms and 5 capability centers are built to pull through the O&M process, complete the automation configuration activation, consolidate the data base, strengthen the end-to-end services guarantee, and achieve the reuse and sharing of capabilities. On the other hand, application of

emerging IT technologies will be further strengthened such as artificial intelligence, big data, cloud nativity, etc.

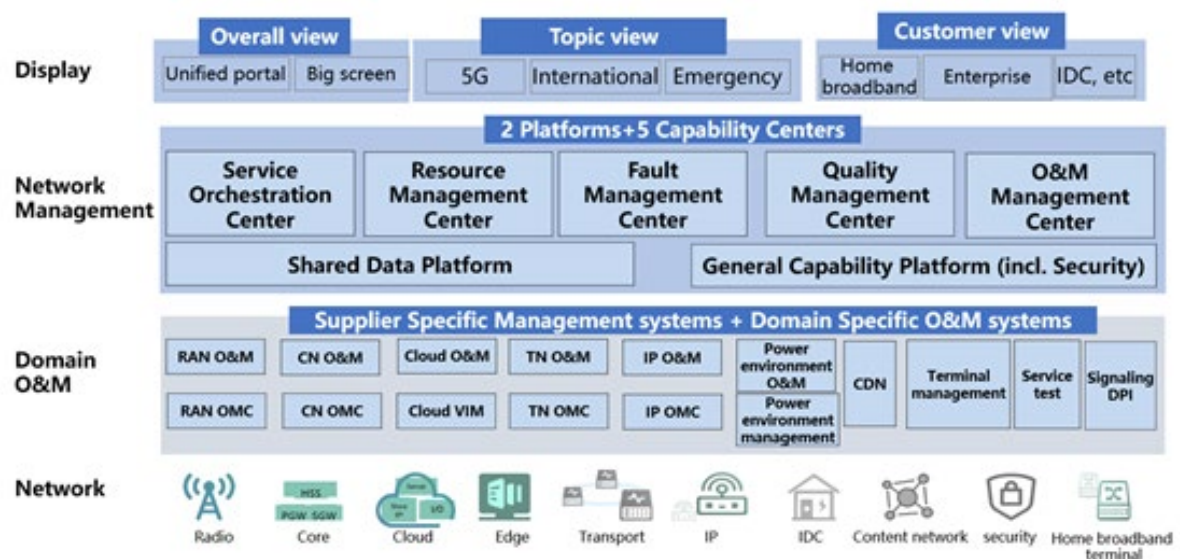


Figure 3. China's Mobile's "2+5+N" blueprint for network management system

#### (1) 2 sharing platforms

**Shared Data Platform:** It provides unified data collection, storage and sharing in network management domain.

**General Capability Platform:** It provides service-independent general platform capabilities and network security management capabilities for all kinds of systems in network management domain.

#### (2) 5 O&M capability centers

**Service Orchestration Center:** It achieves design and orchestration capability of high-level end-to-end process for service registration, coordinates the scheduling of cross-domain sub-processes, and provides a unified interface docking business operation system.

**Resource Management Center:** It realizes network resource data management, resource access management, resource scheduling management, end-to-end resource topology view and other applications for all domains, and provides various resource services.

**Fault Management Center:** It implements centralized network monitoring and provides open network monitoring capability.

**Quality Management Center:** It makes end-to-end analysis of network and service quality, as well as analysis on various topics.

**O&M Management Center:** It provides centralized dispatching management of operation and maintenance, as well as automatic dispatching and other services.



### (3) O&M systems for “N” Domains

It achieves automatic O&M and automatic configuration activation of domain specific and supplier specific management capabilities.

## 3.4. AI Capability Enhancement

China Mobile builds a four-layer relationship model of application, algorithm, data and computational power (as shown in Figure 4) around the four types of intelligent O&M scenarios including intelligent perception, intelligent diagnosis, intelligent prediction and intelligent control, actively carries out the innovation pilot and achievement promotion of AI technology in image recognition, big data analysis, complex computing and other O&M domains.

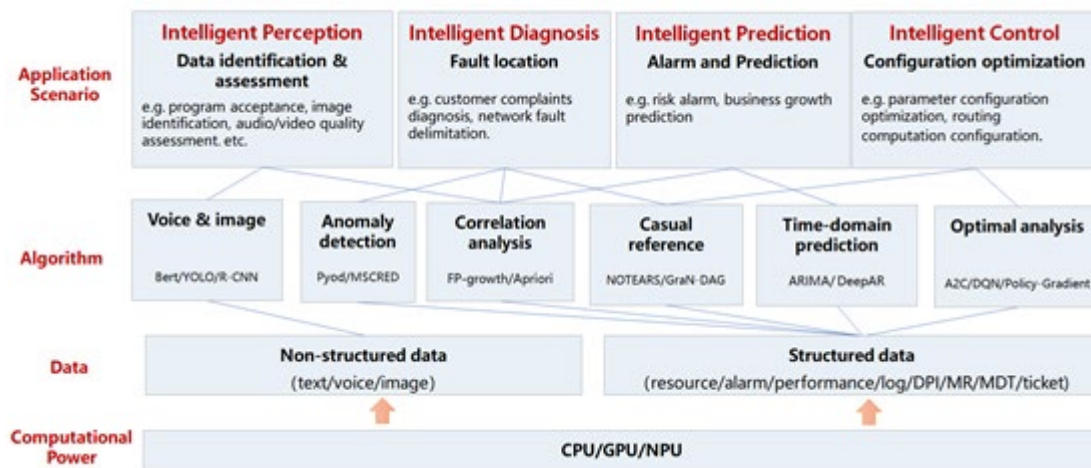


Figure 4. China Mobile's AI application system of intelligent O&M

**Application Layer:** Intelligent perception analyzes and assesses data and identifies network status through AI technology. Intelligent diagnosis takes input from faults, complaints and poor quality, in order to diagnose network problems. Intelligent Prediction is to estimate business and capacity trends and predict network changes. Intelligent control is to work out network optimization strategies and adjust network parameters.

**Algorithm Layer:** AI algorithms commonly used in the intelligent O&M domain, including voice recognition, image processing, anomaly detection, relationship analysis, causal inference, time series prediction, optimization analysis and other categories.

**Data Layer:** PB-level structured and unstructured network data generated by front-end services, network management systems and network equipment.

**Computational Power Layer:** deploy mixed computational power clusters to support large-scale heterogeneous parallel computing.

### 3.5. Typical Application Cases

China Mobile adopts the R&D mode of "self-development+cooperation", in conjunction with partners, actively launches innovative pilots for the whole process of network O&M planning, development, maintenance, optimization and operation<sup>[6]</sup>. Every pilot application gets promoted promptly once it gets mature. Typical application cases include:

**Intelligent Acceptance of 5G Base Stations:** Traditional completion and acceptance of base stations requires multiple manual inspection and long acceptance periods, highly dependent on human experiences, adding difficulties to locate problems timely and accurately. In the peak period of 5G construction, the efficiency and quality of base station acceptance work makes great difference. China Mobile has innovatively applied a new intelligent acceptance mode requiring "no-boarding", which is able to complete automatically 18 target detections with 95% accuracy by means of identifying various pictures of wireless equipment installation process, equipment connection and computer room environment and facilities. Applying in Zhejiang existing network, it has reduced single station acceptance time from 7 days to 1 hour.

**Automatic Opening of Cloud-network Dedicated Line:** Traditional opening of cloud-network dedicated lines relies on manual configuration of O&M personnel, involving multiple steps including business analysis, resource exploration, instruction writing, verification and testing, etc. It usually takes several days to make an end-to-end opening. Based on SR-TE technology and time series prediction algorithm, China Mobile establishes the automatic opening capability by adopting containerized and micro-service architecture, sensing real-time network status, proactively predicting business trends, dynamically calculating the optimal path and automatically configuring network equipment. With its wide adoption on the whole network, the whole process from front-end business acceptance to back-end cloud private network configuration and distribution is completed with zero contact, and the opening time is shortened to minutes, which significantly improves the satisfaction of enterprise customers.

**Automatic Handling of 5G Faults:** With the rapid growth of 5G network scale, average daily network alarms from provincial companies exceed 10 million, involving multiple network domains, long collaborative chain and complex dependency relationship. China Mobile has built a fault management framework with comprehensive real-time sensing, alarm correlation and compression, automatic diagnosis anomaly, cross-domain accurate positioning and intelligent decision-making, enabling a series of capabilities including the all visual network quality monitoring capability, the large-capacity alarm processing capability of 2000 alarms per second, the alarm compression and dispatch capability of 1000:1, the automatic diagnosis capability of 300 types of fault scenarios, and the network configuration capability of 800 flexible combinations. With its applying in the existing network in Zhejiang, main faults can be cleared within 30 minutes, with average processing efficiency remarkably increased by 40%, which effectively guarantees the quality of 5G network and provides customers with the ultimate experience.

**Intelligent Diagnosis of 5G Voice Quality:** At early stages of 5G development, 5G voice services generally fall back to 4G, with signaling switches frequently between 4/5G. The problem of poor 5G voice quality involves more than 10 types of network equipment, 50 more data interfaces and is quiet difficult to accurately diagnose and quickly dealt with. China Mobile has developed the ability of intelligent quality difference location, horizontally pulls through multi-dimensional index data such as KPI of network performance and KQI of user perception,



deeply extracts the quality characteristics of 5G voice service, proactively warns the potential risks of 5G voice quality degradation based on time series prediction model, and accurately locates the root cause of quality difference based on FP-growth correlation analysis model. Applying in Beijing's existing network, it helped reducing 5G voice fault location time to minutes, increased the processing efficiency by 60%.

**Intelligent Diagnosis of Network Quality for Home Broadband Services:** Existing problems such as insensitive perception, inaccurate positioning and untimely processing, could greatly affect the user experience of home broadband services. China Mobile has developed an end-to-end quality analysis application for it, using Xgboost algorithm to analyze the various code stream of videos and games traffic in real time, finely identify traffic types, and perceive the quality problem of different traffic according to the preset differential threshold. For the link diagnosed with poor quality, spectral clustering algorithm is used to analyze the performance index such as optical current, power, bit error rate and so on, quickly locating the end-to-end network problems. After being applied in Henan existing network, 450,000 cases of poor quality problems, 8,000 poor quality lines and 150 poor quality content sources were actively identified. The diagnostic rate reached 90%. The network problems were dealt with ahead of customer complaints, which effectively improved the satisfaction of home broadband services.

**5G Intelligent Power Saving:** Energy consumption per bit of 5G is lower than that of 4G, but largely improved throughput has arisen an overall energy consumption, bringing huge added cost to network operation. Based on expert experience, the traditional energy-saving method of base stations sets a fixed night energy-saving time window for idle base stations. However, facing numerous base stations, each with various wireless environment and service load, together with their highly coupled relations, it is impossible to achieve refined energy-saving by one single set of static energy-saving strategies. China Mobile developed 4/5G intelligent energy-saving technology of "one scheme for one station", which used time series prediction algorithm to actively predict the service trends according to the historical service volume and the dynamic features of user distribution, calculate the optimal configuration scheme in real time, and automatically control the energy-saving parameters of the cell. After being applied in Jiangsu existing network, energy consumption saving of base station is further improved from 8% to 11%, which effectively saves the network operation cost.

**Intelligent Air Conditioner in Data Center:** Energy saving of large data center is an important work for China Mobile to realize low-carbon innovation, reduce costs and increase efficiency. Usually, high-cost hardware optimization schemes are adopted such as upgrading air-conditioning equipment and optimizing refrigeration architecture. In terms of software it is difficult to find out the software optimization scheme quickly by manual statistical analysis method due to more than 1,000 parameter combinations in IDC air conditioning system. China Mobile developed the "Smart Cooling" IDC air-conditioning system, which adopts multi-index time-space series prediction and deep neural network algorithm, actively predicts the subsequent operating conditions and air-conditioning energy consumption according to the historical data of outdoor temperature and humidity, cooling demand and air-conditioning energy consumption, automatically finds the best air-conditioning parameter scheme, and dynamically optimizes the operating parameters in real time. After applying the system in Anhui existing network, energy consumption of data center refrigeration is reduced by 8%, and each data center saves 140,000 kWh per month, which tremendously reduces carbon emissions.

## 4. Industrial Co-Creation

Although the practice of China Mobile's autonomous network construction has entered the stage of systematic deployment, there is still a long way to go for the L4 goal. Only by joint efforts can we lead the industry to achieve common goals. Hence these 4 cooperative initiatives are proposed:

**Reach Consensus on Target Architecture:** To achieve the high-level goal of autonomous network, it is necessary to lead the coordinative evolution of network and network management system under the guidance of a unified architecture and on the basis of active practice and verification. A sound management system needs to be established for digital knowledge assets such as business rules, expert experience, AI models, etc. All parties in the industry are guided to establish a cross-organization cooperation platform for the whole process of building the network automation capability system<sup>[7]</sup>, promote common advancement of network equipment and network management system, and implement in all respects of network planning, development, maintenance, optimization and operation. It is proposed that all industry standards organizations will strengthen communication and cooperation in terms of the target framework, unified evaluation model and technical path of autonomous network, promote mutual recognition of achievements, enhance complementarity, jointly draw a common blueprint and build a common set of standards.

**Enhance Business Driving Forces:** The ultimate goal of autonomous network construction is to support the growth of operators' business. During this process, we must always strengthen the evolution of network and network management automation capability driven by business, and advance in an orderly manner around the four major markets, namely, C (individual Customer), H (Home customer), B (Business/enterprise customer) and N (New customer), so as to realize the coordinated development. In practice, China Mobile needs to cooperate closely with network equipment suppliers and network management system integrators, achieving steady improvement of various business support capabilities of CHBN, promoting value management with high-quality and differentiated guarantee, empowering business development and improving O&M efficiency.

**Pool Ecological Strength:** Continuously improving the level of network autonomy involves the gradual transfer of network O&M responsibilities from people to network equipment and O&M systems, and expansion of the basis for system decision-making from interpretable experience to artificial intelligence algorithm models that are difficult to understand intuitively, which is not a simple technical problem. As the pioneer of autonomous network building, China Mobile is eager to join hands with industrial organizations, network equipment suppliers, network management system integrators, research institutes and other internal and external innovative R&D forces to jointly explore the deep integration, theoretical innovation and engineering realization of advanced technologies including communication network and AICDE<sup>[1]</sup>, and realize the goal of digitalization and intelligentization of network operation and maintenance. It is proposed that each partner of "industry, education, academia and application", based on their respective expert fields, will enhance the cross-domain horizontal collaboration in multiple fields, push for the cross-domain (horizontal) and cross-level (vertical) collaboration, and make joint efforts to create an open innovation platform that is business leading, application driven, technology empowered and brings win-win for all parties.

**Share Industrial Growth:** Predicted by Tractica/Ovum, total investment on AI software, hardware and services from global telecom industry will reach 36.7 billion USD by 2025, and network /IT operation monitoring and management will become the largest AI application in telecom industry, accounting for 61% of AI expenditure in telecom industry. As a telecom enterprise with the largest number of customers, the largest network scale, the most complex network architecture and the most abundant network services in the world, China Mobile wishes to give full play to company's advantages to promote the implementation of autonomous network, realize the scale benefits of cost reduction, efficiency improvement and quality improvement for its own good, set an exceptional example for the digitalization and intelligentization of the communication industry, and provide practical support for the standard system of the autonomous network.

## 5. Future Outlook

In 2019, China Mobile began to promote collaboration of related standards organizations, open source communities, and industrial forums. In May 2019, China Mobile jointly issued the TM Forum Autonomous Network White Paper<sup>[2][9]</sup>. One year later, serving as Chairman of the Board of Directors of Linux Network Foundation, it initiated an industrial research toward demands, strategies and applications of intelligent network O&M. Since February 2021, China Mobile has been actively contributing to the autonomous network standard development in TM Forum in terms of level evaluation of autonomous networks<sup>[10]</sup> and cross-organization standard collaboration<sup>[7]</sup>.

Looking forward, China Mobile will continue to exert its influence in international standards, open source community and industrial cooperation, as well as promote industrial partners including industrial organizations, network equipment suppliers, network management system integrators and third-party R&D institutions to reach consensus, make joint efforts and unite forces, to accelerate the innovation of products, solutions and business models, speed up the creation of autonomous network capabilities, enabling digitalization of society, quality improvement and benefits generation of services, and cost reduction and efficiency increase of O&M, helping digital economy construction and digitalization and intelligentization of various industries.

## 6. Abbreviations and Acronyms

Abbreviation	Definition
AI	Artificial Intelligence
AICDE	Artificial Intelligence, Internet of Things, Cloud Computing, Big Data, Edge Computing
CHBN	Customer, Home, Business, New
FP-growth	Frequent Pattern Growth
ICT	Information and Communications Technology
KPI	Key Performance Indicator
KQI	Key Quality Indicator
SR-TE	Segment Routing-Traffic Engineering
Xgboost	eXtreme Gradient Boosting

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[1] Artificial Intelligence, Internet of Things, Cloud Computing, Big Data, Edge Computing

## 8. Administrative

### 8.1. Version History

Version Number	Date Modified	Modified by:	Description of changes
1.0.0	28-May-2021	Alan Pope	Final edits prior to publication.
1.1.0	30-Jul-21021	Alan Pope	Final edits prior to publication.

### 8.2. Release History

Release Status	Date Modified	Modified by:	Description of changes
Pre-production	28-May-2021	Alan Pope	Initial release
Production	26-Jul-2021	Adrienne Walcott	Updated to reflect TM Forum Approved status
Pre-production	30-Jul-2021	Alan Pope	Updated to v1.1.0
Production	17-Sep-2021	Adrienne Walcott	Updated to reflect TM Forum Approved Status

### 8.3. Acknowledgements

#### 8.3.1. Guide Lead & Author

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Lingli Deng	Lead Researcher & Technical Manager	China Mobile
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