ZTE

uSmart RNIA White Paper

Wireless Network Development Trend and Challenges

In the 5G era, telecommunication operators are facing great challenges

Now, we have entered the 5G era, and the telecommunication industry steps into a new decade, 5G enter into the rapid deployment phase. According to the GSMA forecast, by 2025, the number of 5G global mobile Internet users will reach to 1.7 billion, and the operators will invest over $1 billion on 5G networks.

There will be disruptive changes in technology, network, terminals, users and services in 5G era. With the deployment of 5G, wireless network will adopt ultra-intensive networking, service will spread from To C to the entire industry, and various new types of terminals will be put into use. At the same time, existing network and services will also be coexisting with 5G for a long time. The multi-mode, multi-band, multi-site network and multi-service operation and deployment will make the entire network extremely complex. Hence, telecom operators face unprecedented challenges in the 5G digital era as shown in the following.

> *New 5G technologies coexist with the current network technologies. With the deployment of 5G network, the more spectrum are used, and new technologies such as ultra-dense networking, network slicing, massive-MIMO, SDN, NFV, and MEC are widely adopted. At the same time, the current network will be in service for a long time. Thus, for muti-band, muti-mode and muti-site network, the operation, management and maintenance of the wireless network are extremely complicated.*

> *In the 5G era, the network traffic and power consumption of network increased sharply with the increasing of spectrum resources and efficiency, the decreasing of the time latency, and the increasing of the access service and the terminal. It is also a huge challenge for operators to reduce network power consumption without reduction of network performance.*

> *The acceleration of the digital transformation of operators has put forward higher requirements for new services deployment. Since the 4G deployment, the users are gradually saturated, but the network traffic has exponential growth. The gap between revenue growth and traffic growth is gradually increased, so that it is impossible to increase revenue by traditional ways relying on traffic and user. In the new era of 5G, with the improvement of network capability, personalized services are needed, meanwhile, it is necessary to develop a new blue ocean of wide industry application. These require the network to have real-time service perception, flexible resource scheduling, and precise data analysis capability, which can be used to explore individual and industry markets in real-time, precision and intelligent, and ultimately realizes the common growth of traffic and revenue.*

Network AI become the blade to cope with the challenge

In recent years, the rapid development of artificial intelligence (AI) technology has brought great changes to the society, economics and other fields. Through visual management, forward-looking prediction, high complexity analysis and optimal exploration, AI provides the brand-new capabilities for 5G network operations to helps them match the best resources, improve operational efficiency, increase revenue, and save expenditures.

Currently, operators are gradually increasing their investments in network automation/ intelligence, and seeking to use AI to achieve the full range of network improvements and find business opportunities. According to Omdia 2020 ICT Enterprise Insight survey of 400 senior ICT managers in the telecommunications industry, 80% said that reducing the OPEX and the network complexity is their first or second option. However, wireless access network accounts for a larger proportion of investment, and the management and maintenance are the most complex, so the automation and intelligence of the network become extremely important.
In another survey, "What do you think is the best way to maximize the performance of 5G networks and services?", 61% chose network automation and AI. Operators are eager to solve the following three problems by using AI technology:

> *Develop clear strategies, using AI technology to manage current and next generation wireless access networks in order to improve management efficiency, and reduce operational costs.*

> *Using AI technology to improve network performance, resource utilization and user experience in the complex wireless network.*

> *Using AI technology to gain insight into business and customer needs, provide personalized services to meet different requirements, and operate refined management to achieve revenue growth.*

Omdia predicts that by 2025, the global telecom industry will invest $36.7 billion in AI software, hardware and services.
In terms of research and practice, global operators also take network AI as an important goal.

Intelligent wireless network solution

The intelligent wireless network hierarchical evolution and vision

The ultimate goal of the comprehensive evolution of the network towards intelligence is to gradually achieve independent operations and intelligent autonomy of the network system through self-learning and self-evolution driven by data, so as to optimize the network investment and O&M efficiency.

In order to promote the network towards the intelligent autonomy target, ZTE released the Autonomous Evolving Network (uSmartNet) solution. By introducing AI in different layers of the network, ZTE enables the three major evolution: Network Evolution, Maintenance Evolution, and Operation Evolution, which can improve the level of network intelligent continuously, and realize on-demand network scheduling, simplified maintenance and intent-based service.

The Autonomous Evolving Network solution uses the principle of hierarchical closed-loop to build NE level, intra-domain level, and inter-domain level intelligent network system. With one smart brain and three types' smart engines, the AI capability can be micro-serviced and modularized, and embedded into the network element layer, management & control layer and operation layer respectively as needed to build an autonomous evolution network with continuously increasing intelligent capabilities and value.

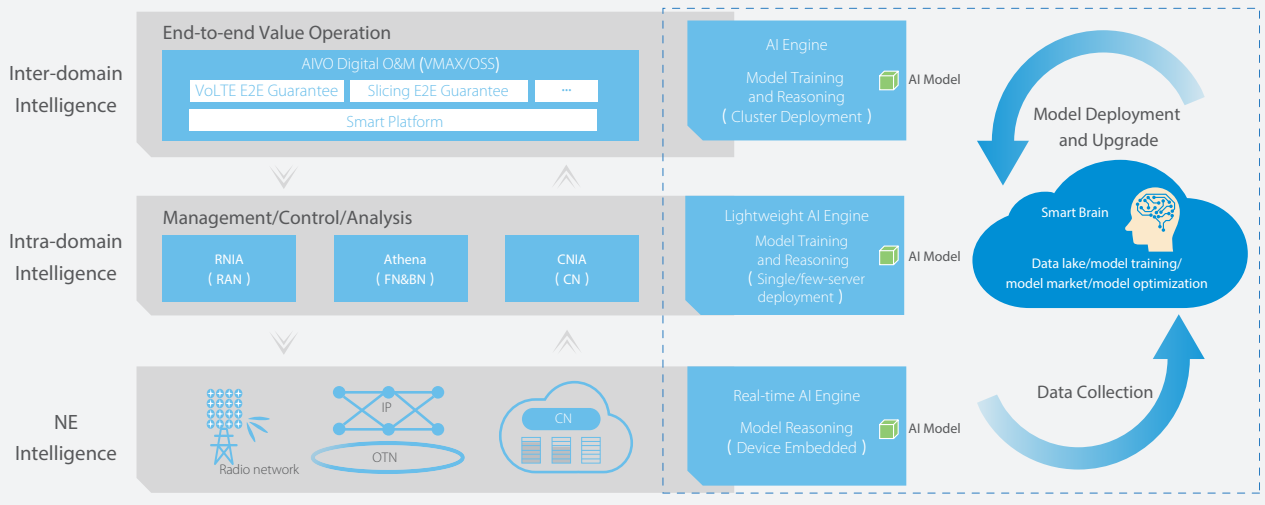


Figure-2-1 Autonomous Evolving Network Architecture

ZTE's uSmart RNIA is the intelligent wireless solution which is facing planning, construction, maintenance, optimization and operation scenarios, which is fully introduced AI through the development stages of the whole network life cycle. Based on the network analysis, control and management capabilities, build an intention drive end-to-end intelligent closed-loop, self-evolution, guarantee network connectivity and performance SLA commitment, and realize the intra domain autonomous closed-loop of wireless network. This solution helps operators to build networks in a concise and fast way, with low cost and efficient operation, and to expand individual and industry business accurately.

The evolution of intelligent networks will be a long process, and needs to be phased step by step in accordance with the specific network situation of operators, 5G technology maturity, and the network evolution strategies of operators.

From the perspective of division of labor and collaboration between human and machine, and gradual liberate of manpower, the network evolution process is divided into five stages: L1 Assisted Operation, L2 Primary Intelligence, L3 Intermediate Intelligence, L4 Advanced Intelligence and L5 Full Intelligence.

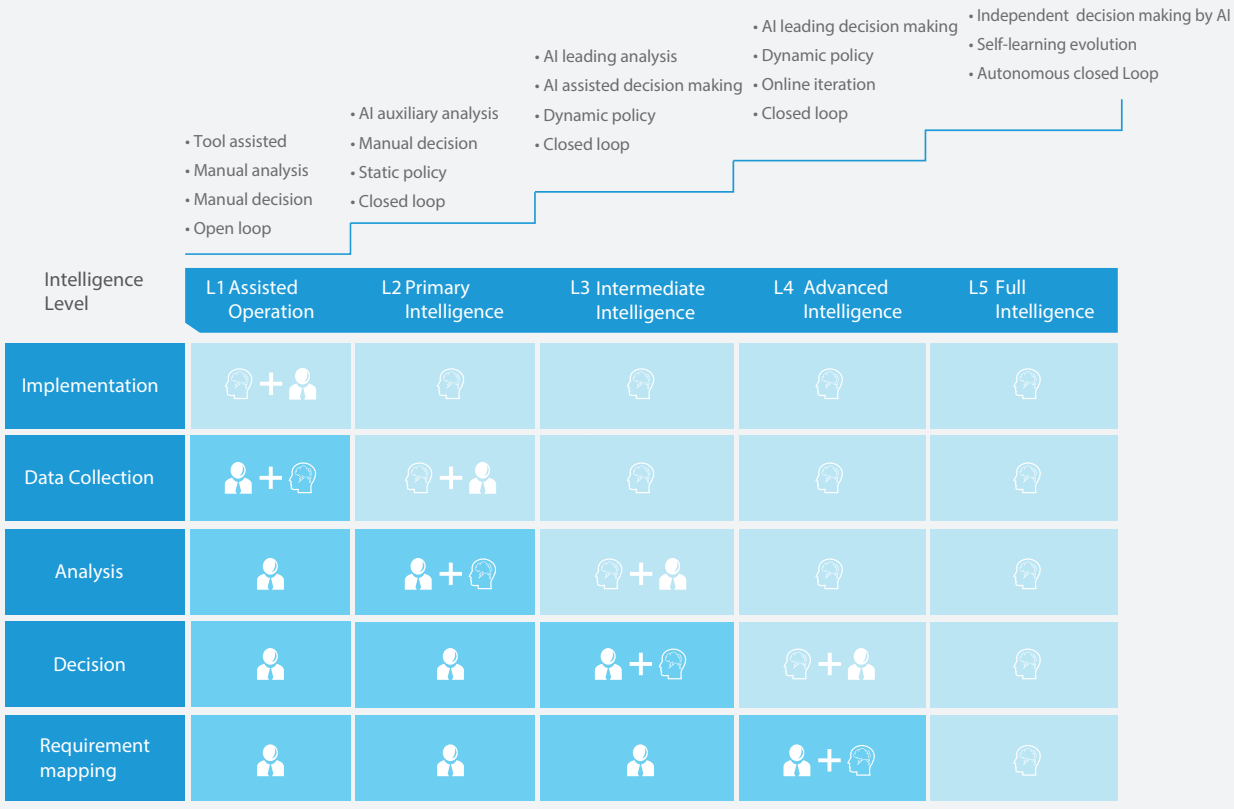


Figure-2-2 Grading of Autonomous Evolving Network

The key characteristics of each intelligent level of the Autonomous Evolving Network are as follows:

L1 Assisted Operation: In some scenarios, the tool is used to assist in data collection and monitoring according to manual defined rules. The analysis, decision and requirement mapping are performed manually. The tool is used to simplify some manual operations, and does not support intelligent closed loop of the full process.

L2 Primary Intelligence: In some scenarios, the intelligence from data perception, analysis to execution can be implemented, which mainly depends on the static strategy of expert experience. Decision-making and requirement mapping still depend on manual work. At this stage, NE-level small-scale intelligent closed loop can be implemented.

L3 Intermediate Intelligence: For most scenarios, the system automatically completes data perception, analysis and execution, and can dynamically adjust strategies within a certain range, while complex decisions are still dependent on manual work. Single-domain intelligent closed loop can be completed at this stage.

L4 Advanced Intelligence: The data perception, analysis, decision-making and execution are all automatically completed by the system. The decision-making level of the system can also be optimized iteratively. In most scenarios, the complete intelligent closed-loop can be implemented. Only in some scenarios, manual participation in requirement mapping or decision-making optimization are in need.

L5 Full Intelligence: In all scenarios, the system can implement a complete intelligent closed loop from requirement mapping, data perception, analysis, decision-making to execution, achieving full autonomy for all scenarios. The system can continuously evolve through self-learning.

With the gradual improvement of intelligent levels, the increasingly tasks can be undertaken by machines, as a result O&M manpower requirements will be greatly reduced. However, at all events the network is still under the control of people who can intervene at any time and have the supreme authority.

Intelligent wireless network architecture

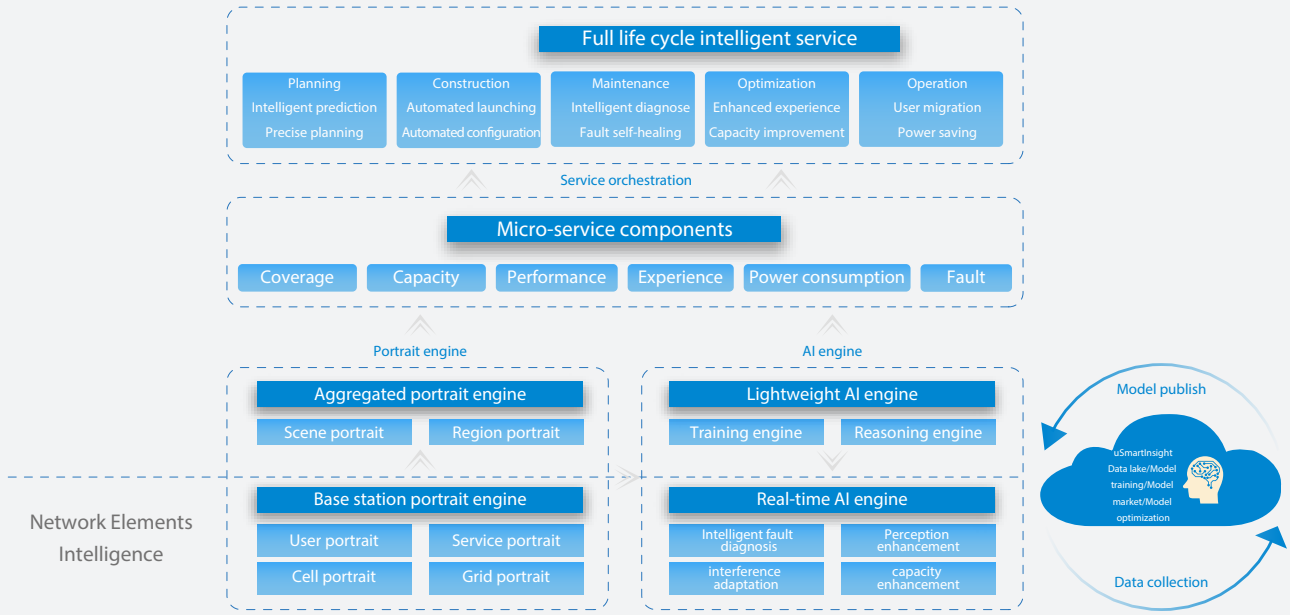


Figure-2-3 Intelligent wireless network architecture

The intelligent wireless network architecture provides the optimal service under different space-time granularity based on layered design and collaborative intelligence of network element/network management. Through the uSmartInsight intelligent brain, the quality model with deep training is continuously delivered to the intelligent module at all levels.

Network element Intelligence

Base station portrait engine: Based on the basic portrait of user, service, cell, grid and other dimensions, the target-drive portrait is generated by the service-centric application, and it can provide the basic data for the network element intelligent functions and the higher level of portrait aggregation.

Real time AI engine: Provide the network element level close loop intelligent service, such as intelligent interference detection and resource adaptation, intelligent AMC, intelligent power control, intelligent multi-user space division pairing and so on

Management and control intelligence:

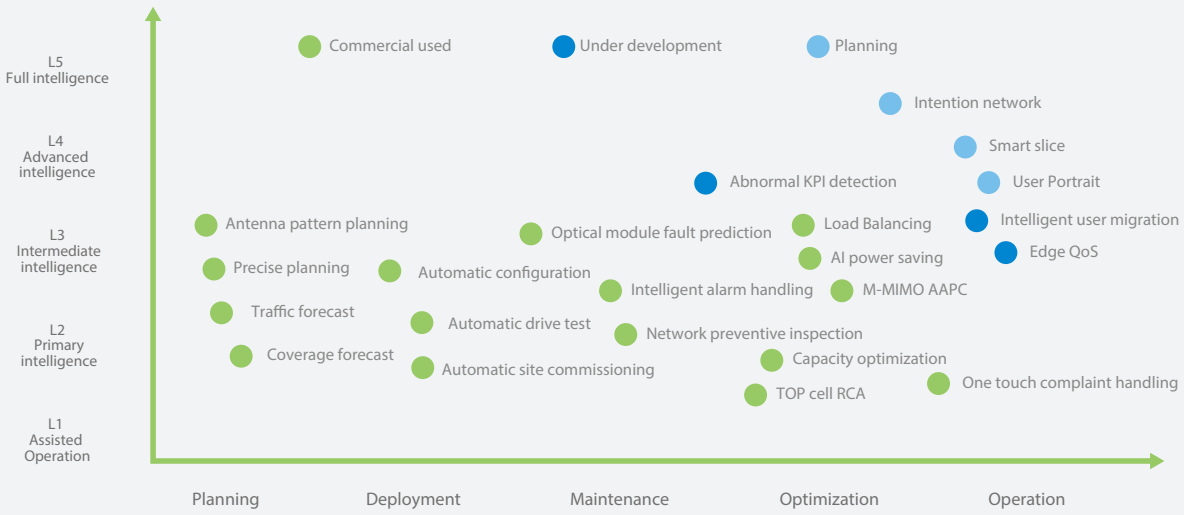
Aggregated portrait engine: Provide different levels of portrait services for scenes, regions, and cities.
Lightweight AI engine: Provide Machine Learning model training and reasoning service.

Micro-service components: Provide analysis services of basic business such as coverage, capacity, experience, etc.
Full life cycle intelligent service: Based on the fundamental services provided by the aggregated portrait engine, lightweight AI engine and micro-service components, as well as the service orchestration and application construction driven by the intention in different stage of planning, deployment, maintenance, optimization and operation, it can provide intelligent services in different scenarios and periods from network construction with the best return on investment to network operation efficiency with maximum optimization.

Overview of intelligent wireless Network applications

Based on years of hard work in the wireless field and a deep understanding of wireless telecommunications and AI technology, we believe that AI technology is used to focus on high-value scenarios in every phase of wireless network planning, construction, maintenance, optimization, and operation, and solve network operation problems which is the core demands of operators. Herein, we describe the panorama of intelligent application of wireless network according to the core demands of practical application and the requirement of hierarchical evolution of wireless network.

In the next chapter, the eight typical application scenarios are demonstrated which have been tested or applied in practice. AI can not only greatly improve the efficiency of network deployment, management, and maintenance, but also help operators precisely expand their individual and industrial businesses, and complete the “impossible task” of traditional manual work. This fully demonstrates that the "wireless telecommunication + AI" represented by 5G has a bright future.



Intelligent scenarios focus on 5G, covering full business processes of "planning,construction, maintenance, optimization and operation". At present, the overall capability is at the level of L2. After the current scenario is developed, most of the services reach L3.

Figure-2-4 Overview of intelligent wireless Network applications

Typical scene of intelligent wireless network

Precise Planning

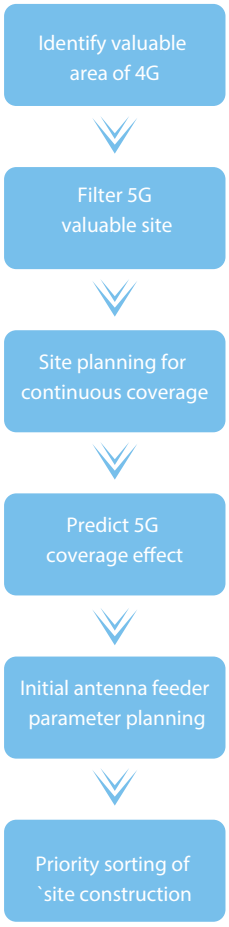


Figure3-1 5G network precise planning work flow

Wireless network construction and expansion cannot achieve without network planning. Traditional network planning, especially expansion planning, requires on-site drive test and survey, and analyzed together with network management statistic data. The whole process is a manual operation with high cost and long planning period, and it is difficult to achieve network-wide precise planning. As a result, the network is adjusted for many times or the budgets in some areas are insufficient, affecting the overall network quality and user experience. With the introduction of big data and AI technology, accurate network-wide automation planning has become a reality. The network precise planning of 4G is based on big data, automation, and AI technologies to collect MR and network performance data of users. Combine with field project parameter and map information, the network valuable building area (high-value and low-user experience area) can be identified from multiple dimensions, such as network coverage, competition difference, and capacity/traffic/user perception after AI in-depth mining. Sites are automatically planned for network valuable construction areas, matching appropriate site types. Then, models are built based on AI algorithms to predict the effect after base stations are added. Finally, the priority of site construction is sorted and the planning report is automatically output.

Precise planning of 5G network firstly filters the high-value 5G sites based on the valuable area/network hot spot of 4G network. Under the condition that 5G network coverage is continuous, the system can automatically finish 5G site planning in the remaining areas and intelligent predict the coverage effect of the 5G network planning. Based on AI algorithms, the planned 5G site and its coverage scenario are automatically matched with the optimal initial antenna feeder parameters to reduce the workload of subsequent network optimization and shorten the RF optimization period. Finally, the planned 5G sites are ranked by value to determine the construction priority.

Based on the network precise planning of big data + automation +AI, the network precise planning can efficiently complete the whole network insight and predict the future, so as to make the network planning more in line with the actual service development requirements. In this way, the coordinated planning of 4G/5G coverage and capacity can be realized to make the investment more accurate and maximize the benefit.

The precise planning is generally at "L3 intermediate intelligence" level. For most scenarios, the system can automatically complete data perception, analysis and execution, and also supports dynamic parameter adjustment within a certain scope. It can complete single-domain level intelligent closed-loop. The complex decision still relies on manual operation.

In the future, with the abundance of input data and actual cases, the automation and AI algorithms are continuously improved. In precise planning, only network planning parameter needs to be set manually, while the system can automatically make decision and output the optimal network planning solution without any manual adjustment.

Currently, ZTE has completed network planning and analysis in the telecom market more than 70 projects by using the precise expansion platform. In the first half of 2020, precise planning has been applied to more than 20 projects, of which 18 have completed 5G intelligent pre-planning.
In one mobile project, this solution is used to help customers quickly identify the 7 cells where traffic is suppressed in the network and output a capacity expansion solution. The total traffic in busy hours is increased from 39.1 GB to 55.5 GB after the capacity expansion is accomplished, increased by 42%.

Automatic Site Commissioning

With the continuous maturity of 5G technology, operators have begun to deploy 5G network on a large scale, leading mobile communication to a new stage. In the early stage of deployment, operators mostly focus on commissioning and access of 5G site, so as to complete basic coverage as soon as possible, and achieve market competitiveness.
Basic parameter configuration is critical to site commissioning, network access and KPI acceptance criteria. As for new NSA/SA 5G sites, neighbor cell configuration, ENDC X2 and Xn configuration, as well as subsequent neighboring cell optimization and PCI optimization, are the first step of network commissioning and initial quality optimization and improvement. Inefficient manual operation has become a difficulty in large-scale network commissioning.
In order to solve the field problem, 5G SON (Self-Organizing Network) solution based on AI could find problems, improve maintenance efficiency, and enrich maintenance methods. It realizes intelligent identification, self-organization, orchestration and error correction of neighbor cells and links, helping the rapid construction of 5G network.

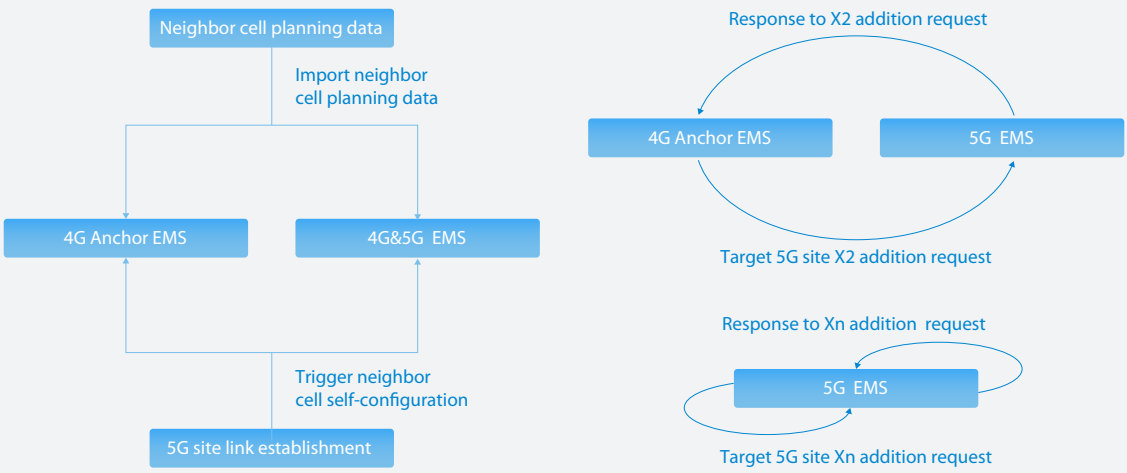


Figure-3-2 Self-configuration work flow of neighbor cell and X2/Xn

According to the intelligence classification of wireless network, automatic site commissioning is at "L2 primary intelligence" level. Automatic site commissioning mainly refers to the self-establishment, self-configuration and parameter self-optimization of base stations according to the planning parameters, and the automatic deployment of base stations is implemented. The main function is to realize automation and improve the efficiency of engineering deployment. It provides convenient and fast ability of site commissioning for engineers. At present, it is based on the EMS configuration operation. In the future, automatic configuration, operation, and monitoring will be realized by AI technology in future. More flexible and efficient site commissioning will be achieved.
At a 5G project in one province, the SON function reduces the commissioning time from 20 minutes for one site to 3 minutes for 100 sites. The system also implements automatic monitoring to ensure that no data configuration is missing and the efficiency is increased by hundreds of times. The self-optimization function saves operation time of network optimization engineers by 40%. It greatly improves the efficiency and accuracy of 5G network deployment and improves network quality.

Intelligent Alarm Handling

Alarm handling is an important work of network O&M. There are many types of NEs in the wireless network such as base station, transmission, power supply, etc. In addition, base station also has BBU and RRU, which are related to each other. A fault often generates a lot of non-root cause alarms. Quickly finding out the root alarm and fast troubleshooting are very helpful to build a high-quality network. The intelligent alarm handling solution AAX (Alarm Automation eXpert) uses AI technology through big data mining and analysis to achieve alarm automation correlation and to reduce the number of alarms. Then AAX can rapidly locate fault causes and present them through graphic UI. With these functions AAX can help operator greatly shortening time for alarm location and help network O&M reduce costs and increase profit.

AAX correlation analysis is from two dimensions, vertical dimension (cell-AAU-DU-CU/cell-RRU-BBU) and horizontal dimension (inter-station/inter-CU/inter-DU), extracting characteristic data such as NE ID, alarm code, alarm location, generation time, recovery time, etc. After this, AI training will be implemented based on millions of historical alarm data from network, using algorithm of Pearson Correlation Coefficient, Frequent Item Sets, Confidence Coefficient to complete optimization and modeling. After the rules are confirmed by network service experts and offline verification, the alarm correlation rules can be deployed in network. When the rules are activated, alarm correlation analysis is automatically executed. Many children alarms can be merged into one root alarm, which can help operator quickly locate faults.

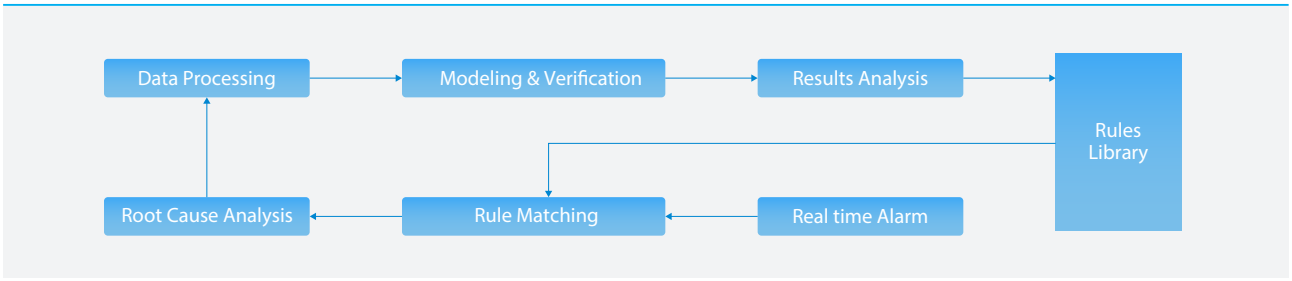


Figure 3-3 Alarm root cause analysis work flow

AAX alarm one-click diagnosis automatically diagnoses the root cause of alarm from the two dimensions EMS and NE. AAX comprehensively analyzes current alarm data from various dimensions, automatically executes troubleshooting step by step, and outputs diagnosis report.

Intelligent alarm Handling is currently at "L3 intermediate level of intelligence" level. For most scenarios, the system automatically completes data collection, analysis and execution. Strategies can be dynamically adjusted within a certain range. Complex decision-making is still rely on human. Single-domain level intelligent closed loop can be completed.

In the future, more alarm correlation rules will be dig from big data of network to achieve a higher alarms reduction rate. Automatic diagnosis and self-healing of faults will be achieved in case of faults which require no manual intervention. Specific suggestions will be provided for faults which require manual intervention.

In one case, field test and verification of the alarm root-cause location of network equipment has been completed. The test results shows that compared with the original expert experience strategy, the intelligent fault location further reduce the number of alarm by 47%.

According to the results of the network verification, after the alarm correlation rules are enabled, 52.7% reduction rate has reached for out-of-service alarms. One-click diagnosis result and alarm handling suggestions are effective and specific, which greatly improves the efficiency of troubleshooting. AI technology truly achieves cost reduction and profits increase of network O&M.

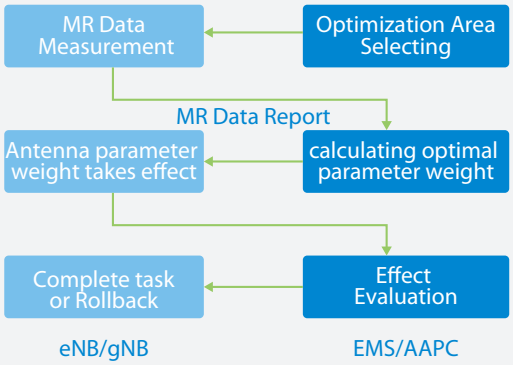
Automatic Antenna Pattern Control

Massive MIMO (Multiple Input Multiple Output), one of the key technologies of 5G, uses large-scale array antennas and 3D beamforming to effectively improve the three-dimensional depth coverage and system capacity in complex scenarios. It is also a basic feature of 5G commercial networks.

Compared with traditional antennas, Massive MIMO with large-scale array antennas have more parameter adjustment dimensions, including horizontal beam width, vertical beam width, azimuth, down tilt, and number of beams. Each dimension can be fine-tuned. One cell has tens of thousands of possible antenna parameters in theory. In the network, it is almost impossible to complete multi-cell collaborative optimization and adjustment manually to fit for different scenario or service.

AAPC (Automatic Antenna Pattern Control) solution based on MR data and intelligent search algorithm. It achieves automatic data collection, automatic optimization analysis, automatic parameters activation and automatic verification. The entire process is automated, which greatly saves manpower and time, meanwhile improves network optimization efficiency.

Figure 3-4 AAPC optimization work flow



After selecting the target area, system collects UEs information in the target area such as RSRP, location and path loss. It comprehensively considers coverage and interference, sets optimization goals and iteration times, and finds the optimal solution with AI search algorithms. Massive MIMO antenna has many parameter combinations. In case of multi-cell coordination, the number of parameters combinations is very large, and the system computation requirement is very high. The search time using traversal algorithm is too long to be acceptable. The AAPC scheme is based on the balance between the acceptable optimization objectives of the actual network and the search duration. It optimizes the solution space (antenna parameter group). Through simulation learning, the weight group with less obvious effect was discarded, and the maximum number of iterations was set to reduce the requirement for computing power and significantly reduce the search time for the optimal solution. According to different scenarios, user distribution and optimization goals, AAPC searches out optimization parameters and sends to NEs. After parameters are activated, optimization effect is verified through the data reported by UEs. And then it continues to the next optimization iteration. If KPI deteriorates, the previous parameter group will be restored immediately.

After selecting the area and starting the task, AAPC automatically analyzes, processes and executes according to the optimization goal, it is a closed loop system. AAPC is now at "L3 Intermediate Intelligence" level.

In the future, AAPC will enrich application scenarios, and realize automatic optimization of coverage parameters through close association of alarm and performance data for problem areas and emergency areas.On the premise of the stable improvement of network macro coverage quality, more refined and targeted optimization can be realized at the micro level.

In a field pilot, the verification work that originally required 40 man-days can now be completed with only 2 man-days, which is highly efficient and effective. After the AAPC optimization and adjustment, the overall coverage has been improved significantly, with RSRP increased by 5.5dB and SINR increased by 2.4dB.

Beam Type	Time	Avg. SSB RSRP（dBm）	Avg. SSB SINR（dB）
Single Beam	Before optimization	-92.77	4.74
	After optimization	-87.25	7.1

Table 3-1 Coverage performance comparison before and after AAPC optimization

Abnormal KPI Detection

Key Performance Indicator (KPI) of wireless networks reflects network quality. Anomalous fluctuation of KPI often indicates that a problem occurs in the network. The O&M engineer handles hundreds of KPIs and alarms every day. Therefore, KPI monitoring cannot be implemented accurately and rapidly, the abnormal KPI is not found until the user complains, and then the process is started. Using AI, machine learning and expert rules, ZTE wireless intelligent operation and maintenance system can automatically detect and diagnose anomalous KPIs. It is equivalent to a 24-hour network health monitoring and diagnosis instrument that provides O&M engineer with data analysis and root cause diagnosis.

Abnormal KPI detection is an intelligent tool that takes CM/PM/FM/Log as the data source and focuses on KPI evaluation and analysis. It has the following features:

>Real-Time monitoring abnormal KPI

The anomaly of the network can be found in time within the first time granularity when the KPI degradation.

> The detection method based on dynamic threshold can avoid false report and missing report.

The system learns the normal range of network KPIs based on historical network data, and predicts KPIs in the future granularity to avoid false report and missing report caused by tidal effects and differences in basic network conditions.

>Root cause analysis of anomalous KPI based on machine learning, greatly improve efficiency and save manpower.

Based on the correlation analysis in the network time dimension and the solidified learning model of expert experience, the system provides real-time root cause analysis of anomalous KPI, greatly reducing the troubleshooting time and improving efficiency.

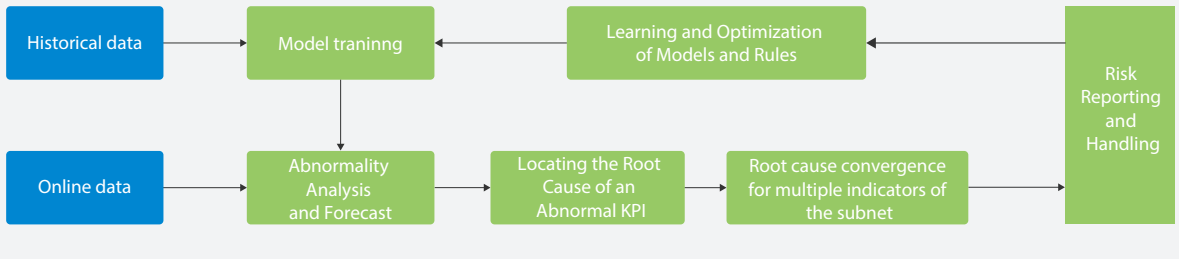


Figure 3-5 Abnormal KPI detection work flow

Abnormal KPI detection is currently at "L3 intermediate intelligence" level. For most scenarios, the system automatically completes data perception, analysis and execution, and can dynamically adjust strategies within a certain range. The complicated policy decision still relies on human. The system can complete close-loop single-domain intelligent.
In the future, all of the data perception, analysis, decision-making, and execution of abnormal KPI detection will be automatically executed by the system. The system decision-making level is being continuously optimized. Complete intelligent closed loop is formed in most scenarios. Only in some scenarios it need manual participation in requirement mapping or decision-making optimization.
In the future, after the location of root cause, closed-loop processing will be implemented in most scenarios. Manual intervention is required only in a few scenarios where automatic processing is impossible. For example, for an abnormal KPI caused by coverage problems, the system can calculate the optimal antenna parameters, automatically deliver activation, and automatically verify the closed loop. If the KPI is not good, the system automatically rolls back the parameters to achieve complete intelligent closed loop.

In one case, the LTE E-RAB setup success rate of a subnet suddenly decreased from 99.9% to 99.2%. The system quickly discovered the root cause of abnormal KPI, and rapidly located the faulty base station. It found that the success rate of a cell in this base station decreased to 0, leading to the anomalous fluctuation of the corresponding indicator in the whole network. According to the alarm association analysis, when the KPI is anomalous, the RRU is out of service once, which leads to the conclusion that the RRU fault causes the KPI to decrease. It takes less than 10 minutes to locate and analyze the fault. In the past, through manual analysis, an experienced engineer would collect statistics of KPI analysis indexes through the EMS to correlate alarms and logs, and on site analyzing of Top N cells until the problem is located. It would take at least two hours.

AI Power Saving

Network power consumption is highly related to base station. The number of base station in the wireless network is far greater than that of other equipment. With the increase of coverage and capacity, the proportion of their power consumption can reach up to 65%-80%. In the 5G era, due to the large number of MIMO RF modules and high output power, the power consumption of 5G base station is several times higher than that of 4G base station, which may become a new-generation “Energy Vampires”. Power saving has become an urgent challenge for operators. Adhering to the environmental protection concept, ZTE has launched AI-based intelligent power saving solution to effectively reduce power consumption of base station.

With the data perception capability, analysis capability and intention insight capability of artificial intelligence, ZTE AI power saving solution introduces AI accelerator at the network equipment layer to carry out fast training and modeling of the existing network data, so as to maximize the power saving effect of the base station without affecting the services.

Key technology 1:Scenario identification, one policy for one base station. By training and analyzing engineering parameters, MR data , power saving policies, configuration data, and historical traffic data, the system automatically distinguishes power saving scenarios, and generates cell-level AI power saving policies for each base station.

Key technology 2: Cell-level traffic prediction to maximize the duration of power saving. According to historical data, three types of cells are distinguished, which are positive effect, negative effect, and invalid effect. The forecast model with the best calculation performance and the best optimization effect is obtained by using the second-order exponential smoothing prediction algorithm together with the intra-week and intra-day sub-sequence split prediction method and the impact of holiday factors on prediction indicators. By comparing the number of RRC connection users and the uplink/downlink PRB utilization rate with the actual traffic of the site at a granularity of 15 minutes, the forecast accuracy rate exceeds 90%, and gets an accurate time window for power saving.

Key technology 3: KPI-based iterative optimization of online parameter thresholds to find the best balance between performance and power consumption. The system dynamically learns the best threshold for triggering power saving by cell, for example, the uplink/downlink PRB usage and the number of RRC-connected users. The system adjusts and rolls back the power-saving switch-on/off threshold in real time to find the optimal power-saving threshold.

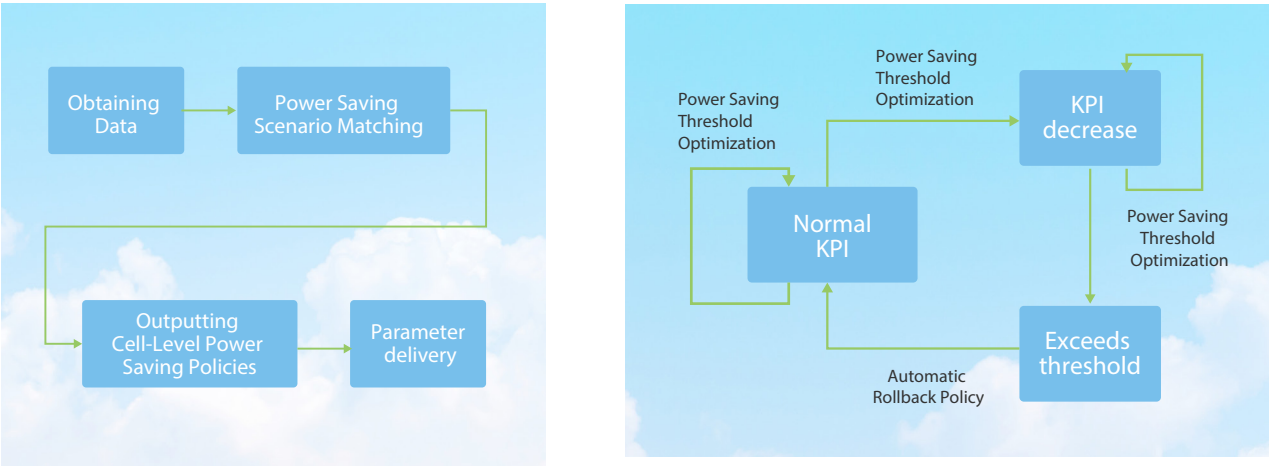


Figure 3-6 AI power saving

The AI power saving solutions is at "L3 medium level intelligence" level. For most scenarios, the system automatically completes data analysis, traffic prediction and policy execution. It can dynamically adjust strategies within a certain range. It completes the intelligent power saving closed loop of the wireless network.

In the future, AI power saving solutions will be capable of more scenario identification and function selection. For example, automatic multi-technology policy optimization, automatic identification of multi-layer coverage cells, and ultimately autonomous closed-loop.

In the commercial test, 100 + cells, 1000 + cells, and 10000 + cells have been tested, this solution achieved significant power saving and emission reduction.

Traditional power saving solution takes half a year to deploy, while the AI power saving only takes one week, which greatly saves manpower cost.

The time of effective power saving activation has increased by 150% to 300%, and the average power saving time is 2.5 times of the traditional power saving solution.

The whole network (more than 10000 cells) can save more than 21000 kWh, that is 20.6 tons less carbon emission per week, 10% power saving for the whole network.

Comparing to manual power saving approach, intelligent power saving has more stable system KPIs and better user experience.

If 60% of the 4 million sites in China activates AI intelligent power saving, 780 million kWh of electricity could be saved or 620,000 tons carbon emissions can be reduced every year.

Intelligent user migration

At the beginning of 2020, the Ministry of Industry and Information Technology of China (MIIT) released a notice to accelerate 5G development, aiming to promote 5G network construction, application promotion, technology development, security assurance, and promote the user migration to 5G. In order to respond the requirements of MIIT, the operators in China constantly consolidate the construction of 5G network. By means of network deployment and marketing conduct, the legacy 2/3/4G users are continuously migrated from the low-efficiency network to the advanced 5G network, thus enhancing the economic benefits and society influence of the 5G network. ZTE has developed a complete intelligent user migration solutions for this. On one hand, this solution maximizes the efficiency of 5G networks through intelligent marketing strategy + intelligent optimization, and on the other hand, maximizes the potential of investment returns through intelligent and accurate planning. In addition, ZTE forms a large cycle of migration from 4G users to 5G networks, and ensures the maximum return on investment of 5G networks through full-process intelligent migration. Specifically, it includes the following points:

Intelligent identification and precise marketing of potential users. For 5G terminals, high-value and high-traffic users are identified through the core network and the terminal information, marketing strategies are customized based on service models to promote users' terminal upgrade

Intelligent planning based on coverage evaluation. If there are 5G terminals without 5G network coverage or with 5G weak coverage, by using the intelligent precise planning, a high value areas can be identified, new sites can be planned, improving 5G coverage effectively.

Intelligent user identification invoking the 5G function. When the terminals with 5G functions within the coverage of the 5G network, but not connect to the 5G network. For these users, intelligent identification and marketing strategies are used to encourage users to turn on 5G function.

Intelligent parameter optimization based on network evaluation – identifying the residence time ratio and traffic distribution of the 4/5G; formulating residence policy through intelligent parameter optimization to improve the utilization of 5G services;

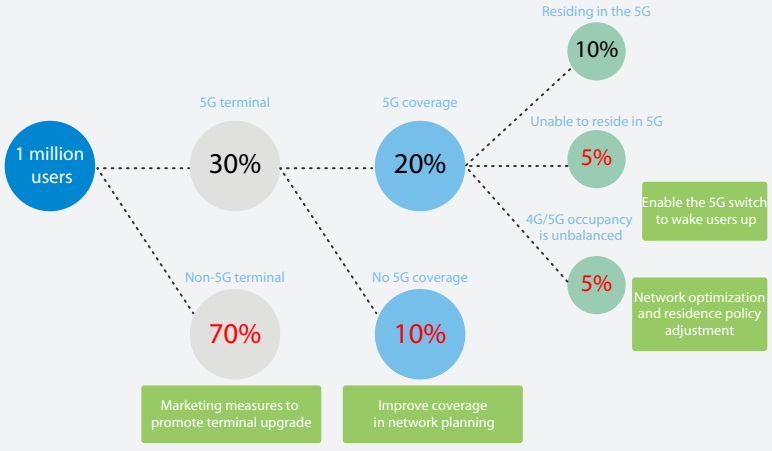


Figure 3-7 Intelligent user migration

Intelligent user migration is currently in the "L3 intermediate intelligence" level. It can realize intelligent analysis, and accurately support decision-making in various aspects such as marketing, optimization and planning.

Terminals are basic elements for network service growth, and precise user migration is the driving force for improving network profitability. In the future, intelligent user migration will drive the development and efficiency of 5G networks through the evolution of the following two aspects:

Scene-level, region-level, and city-level intelligent scanning, and macro-micro coordination to optimize migration strategies

Instant benefits and user experience (especially for high-value users) collaborate with intelligent analysis to balance short-term benefits and long-term potential.

The second phase of 5G NR network construction in China is coming to an end. However, the overall 5G network utilization is very low, and the number of commercial users is very low. How to migrate the users residing in the 4G LTE network to the 5G network needs to be actively promoted. Intelligent terminal capability analysis, using UE 5G capability analysis which is carried out through call detail record residing in LTE UE to assess UE 5G capability comprehensively and accurately in the network, such as the NR version and frequency band. With this information and the measurement report location information, we can obtain the cell-level and GIS-level terminal capability distribution information.

Furthermore, together with the UE capability analysis function, the 5G network planning and deployment, network management indicators, and core network data, user migration can be categorized into four types:

1. *No 5G terminal: 5G terminal promotion*

2.*No 5G network: strengthen network planning and enhance the NR network coverage.*

3.*User manually set to reside on LTE only: using market measures to persuade user to enable the 5G function.*

4.*Unbalanced 4/5G service traffic ratio: adjust the 4/5G interoperability parameters, optimize the network performance, improve the 5G application ratio, enable the user to have better experience, and increase the 5G residence ratio.*

Edge QoS

In 5G applications, the customer requires the network to provide determined performance for the specified terminals and services in determined scenarios, which requires stable low latency and guaranteed high reliability. However, the traditional cell-level average KPI guarantee measures for customers are far from the requirements. Edge Quality of Service (Edge QoS), which based on technologies such as AI/ML and edge computing, it enables precise identification of user-level channel quality and service features, matches technologies such as PDCP Duplication, differentiated retransmission strategy and precise scheduling. It enables low latency and high reliability service with precise, determined and continuous to the industry customer, achieving the best profitability per bit in 5G.

The Edge QoS component running on the wireless base station MEC uses the AI intelligent algorithm to identify the service features of the uplink and downlink services of the base station, and generates the service model parameters and guarantee requirements (packet size, business cycle, arrival time, bandwidth and direction), such as dynamic QoS and air interface guarantee. The Edge QoS component uses the intelligent algorithm to identify the video service stream bearer, dynamically generates the service feature parameters and maps them into the wireless network QoS parameters for dynamic QoS guarantee of the base station. Measurement and reporting: The Edge QoS evaluates the QoS guarantee result and optimizes the intelligent algorithm strategy online according to the SLA measurement information reported by the base station.

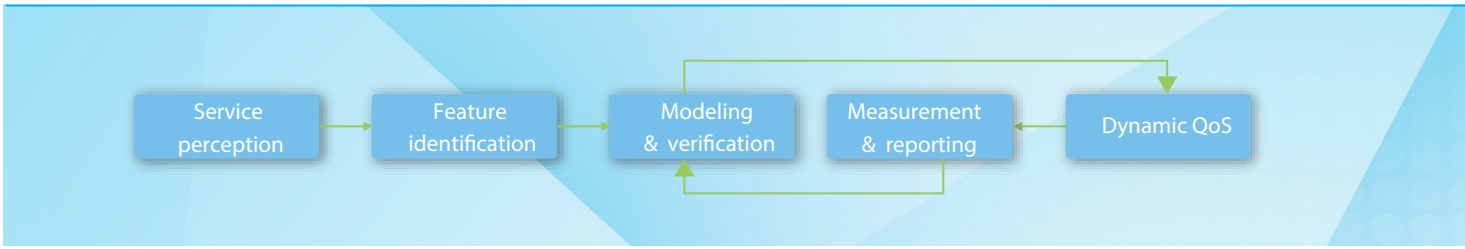


Figure 3-8 Edge QoS

Edge QoS is currently in the "L3 intermediate intelligence" level. For most scenarios, the system automatically collects data, analyzes and implements, dynamically adjusts strategies within a certain range. The complex decisions still rely on human, and it can complete the closed loop single-domain intelligent.

In the future, through AI and big data, the edge cloud will provide policy-driven application guidance and features, intelligent model training and update, generate a non-real-time policy, and deliver it to the base station Edge QoS. The base station Edge QoS will implement near real-time reasoning, generate near real-time policies, and send them to the base station to implement real-time closed loop intelligent.

The Edge QoS service generates the corresponding network control parameters according to the service feature model, which can provide service-level QoS guarantee, so that the entire service process can be measured and visible end-to-end. This solution solves the problems of high costs, difficult to maintain, and high labor intensity of remote control scenarios based on video surveillance by industry customers. It is widely used in scenarios such as remote control, telemedicine, production AGV and AR/VR.

Prospect of Wireless Network Intelligence

It is the irresistible trend of the wireless networks evolve to the intelligentization. Now, it is still in the initial stage. We believe wireless network will achieves complete intelligence in the following three aspects step by step:

Firstly, consolidate basic functions such as base station portraits to achieve RAN digitalization. At the same time, upgrade NE side computing power, deploy research and develop algorithms and features that are valuable to customers, so that AI can solve practical problems.

Secondly, knowledge plane is introduced on the vertical dimension. Raw data and pre-processed data are collected at different levels of the RAN, and then converted into knowledge through machine learning, then knowledge guide decision making.

> *NE layer: The base station portraits on the NE layer are aggregated by scenario and region, so that data can be more easily fetched by upper-layer applications.*

> *2) Management and control layer: Based on the real-time intelligent engine, it expands the training engine and the reasoning engine to form the lightweight intelligent engine to implement a large range of intelligent applications in medium period. The portrait engine, AI engine, and traditional basic function components (such as coverage, capacity, and performance) are used for service capability orchestration to flexibly realize the intelligent full lifecycle of wireless networks.*

Finally, digital twins, which include the following three phases, are introduced to enable the intelligent closed loop of wireless networks.

> *1) Network portrait: It refers to the digital modeling of the external environment and service features of each NE entity to form a "base station profile" or "user profile," and form a "network profile" to accurately map everything in the physical world to the digital world.*

> *2) Twin simulation: The core algorithm and implementation code of 5G products are modeled on the digital twin simulation platform in 1: 1 real mode. Motivated by the real input data stream of the "network profile," the real product features are simulated to the maximum extent, and the real performance of products in the complex field environment is reproduced in 1: 1 mode.*

> *3) Intelligent closed loop: The real-time and interactive character is strengthened by breaking through the traditional and lengthy mechanism of pure modeling -> simulation -> feedback. In this way, the virtual digital world system is integrated with artificial intelligence as brain, self-growing, iterating, making the conclusion works on the real physical world in real time.*

The road of wireless network intelligence takes steps. We will work together with operators and partners to promote the development of wireless network intelligence, taking openness, cooperation and win-win as our objective.

Abbreviation	Description
AAPC	Antenna Automatic Pattern Control
AI	Artificial Intelligence
KPI	Key Performance Indicator
MEC	Multi-Access Edge Computing
MIMO	Multi-Input Multi-Output
MR	Measurement Report
NFV	Network Functions Virtualization
NSA/SA	Non Standalone/Standalone
PDCP	Packet Data Convergence Protocol
PRB	Physical Resource Block
RAN	Radio Access Network
RRC	Radio Resource Control
RSRP	Reference Signal Receiving Power
SDN	Software Defined Network
SINR	Signal to Interference plus Noise Ratio
SON	Self-Organizing Network
SLA	Service-Level Agreement
UE	User Equipment

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