HUAWEI

Key Scenarios of Autonomous Driving Mobile Network

A full 80% of mobile operators worldwide say that automation will be the most important way to reduce the operating cost of their next generation networks.

Huawei has identified seven scenarios, within the lifecycle of the mobile network, which can be automated in a step-by-step manner. Within each scenario, the operator can implement different levels of automation, starting with 4G and evolving in the 5G era.

Table of Contents

Embracing the AI Era of Mobile Networks

Today, we are standing at the entrance to a fully connected, intelligent world. As a leading ICT solution provider, Huawei has released the AI strategy and full-stack all-scenario AI portfolio. With the introduction of AI capabilities, autonomous driving is becoming a reality, and autonomous driving networks are also coming.

Currently, the OPEX of telecom operators remains high. With the advent of the 5G era, networks become much more complex, posing the following challenges: difficult network O&M due to coexistence of multiple RATs, multiple frequency bands, and HetNet; unleashing the full potential of new technologies, such as Massive MIMO; coordinating among a variety of services in real-time while ensuring service experience.

Intelligent technologies need to be introduced at edge, local, and cloud to build a three-layer autonomous driving network architecture. Mobile networks are distributed with massive sites, and there are a lot of real-time processing requirements. Local intelligence should be implemented with the coordination between site nodes and domain nodes so as to realize intra-layer autonomy and efficient collaboration.

Evolution towards autonomous driving networks cannot be accomplished at one stroke. It should be approached scenario by scenario. This white paper aims to share Huawei's insights and initiatives in this brand-new field, and accelerate the process of all-scenario autonomous driving mobile networks. Focusing on operations throughout the entire lifecycle, the white paper describes seven key scenarios and analyzes five key capabilities for each of these scenarios. It can be an insightful reference to inspire the way towards autonomous driving networks for the telecom industry.

Together, we will automate mobile networks and embrace a fully connected, intelligent world.

DAVID WANG

Executive Director of the Board
Chairman, Investment Review Board, Huawei

Introduction

> "Network automation is essential to meet the challenges of the 5G era."

Increased automation has been associated with human progress since the invention of the wheel. In mobile networks, the history is shorter, but no less significant to improving the economics of the systems.

Several years ago, the mobile industry began to explore network automation in earnest. This focused on relatively limited areas at first, mainly related to management and optimization, but even these small steps to automation delivered dividends.

But in the upcoming 5G era, the depth and breadth of current network automation approaches are far from enough. There are two main reasons:

1) The exponential growth of network complexity will make the traditional network O&M model unsustainable

With the deployment of 5G New Radio (NR), operators will be supporting multi-standard networks (2G/3G/4G and 5G NR), some for a considerable period of time. This coexistence is just one aspect of the complexity of modern heterogeneous networks, which must also be multi-band, multi-channel and multi-service. This greatly increases the complexity of network operation and maintenance (O&M).
High levels of automation are the only way to handle this complexity, while at the same time, ensuring that network resources are utilized more efficiently than ever, to reduce operating expense (OPEX) and support rapid, agile response. In other words, operators have a dual challenge–they need simplified processes to reduce cost and increase agility, but their networks are becoming ever-more complex. The message for the next generation of networks is “take complexity, create simplicity”.

2) Digital transformation accelerates new services but requires automation capabilities

This means operators must become as agile as their challengers. This is particularly urgent, as growth in their traditional mobile broadband (MBB) is weak. Although mobile data traffic has grown exponentially in the 4G era - from almost 4 exabytes globally per year in 2010 to an expected 128 exabytes in 2020, unit prices have continued to decline, making it increasingly difficult to generate growth through traditional data services alone.

1.Current status

> MNOs have a dual challenge – to increase agility while reducing network operating cost. These are important concerns in the current 4G era, and are intensified by the transition to 5G and a digital platform.

Operators call for new automation solutions

As mobile operators start to evaluate their commercial 5G strategies, automation is a central concern. Some operators are already introducing automation to some of their network processes, most commonly O&M, planning and RAN optimization. A survey of 76 mobile operators worldwide, conducted in Q3 2018 by telecoms research firm Analysys Mason, identified a modest level of automation to date, but significant plans to invest in these technologies in the years between 2019 and 2025.

Figure 1 shows that, in 2018, 56% of MNOs globally have little or no automation in their networks. But by 2025, according to their own predictions, almost 80% expect to have automated 40% or more of their processes, and one-third will have automated over 80%. The introduction of AI/ML (artificial intelligence/machine learning) will be an important part of that process for many MNOs, helping to make autonomous processes more intelligent, agile and predictive.

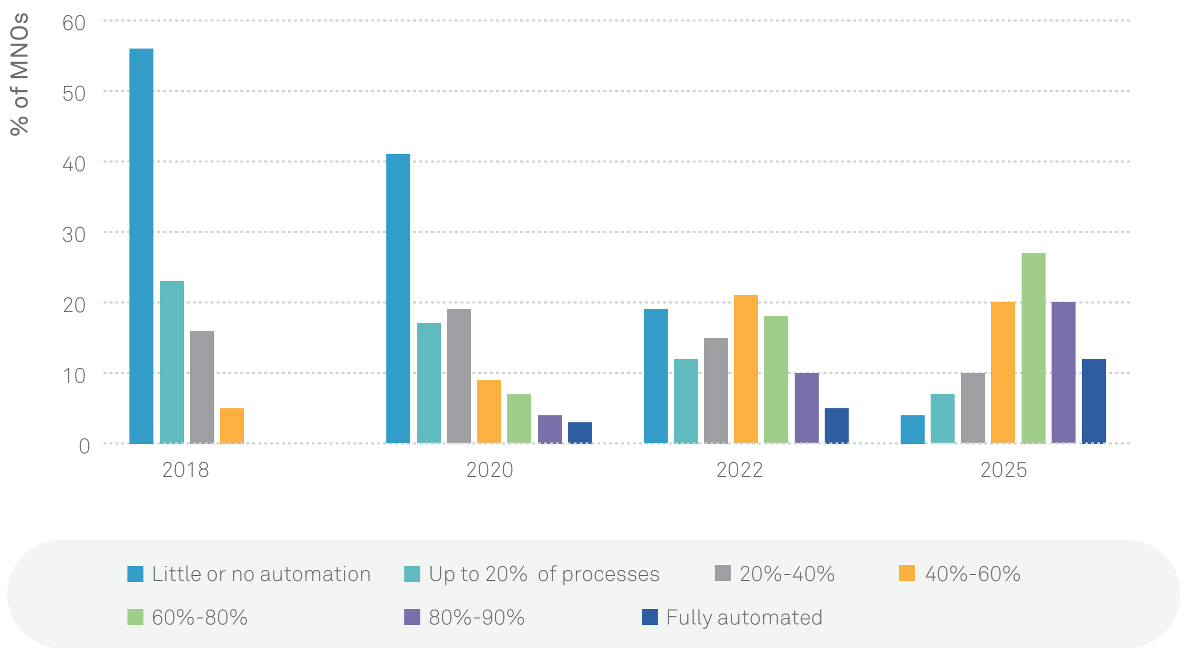


Figure 1. Forecast levels of network automation by MNOs worldwide 2018-2025
(Based on survey of 76 Tier 1 and 2 MNOs worldwide, Q3 2018). (Source: Analysys Mason)

However, most MNOs would move even more aggressively than this, if they saw technologies and services, especially in the AI/ML area, evolving more quickly than they currently anticipate. Figure 2 indicates the MNOs' expected level of automation in 2025, compared with the level they would ideally reach, if all the right enablers were available. This shows that 80% of MNOs would prefer to have automation levels above 60% in 2025.

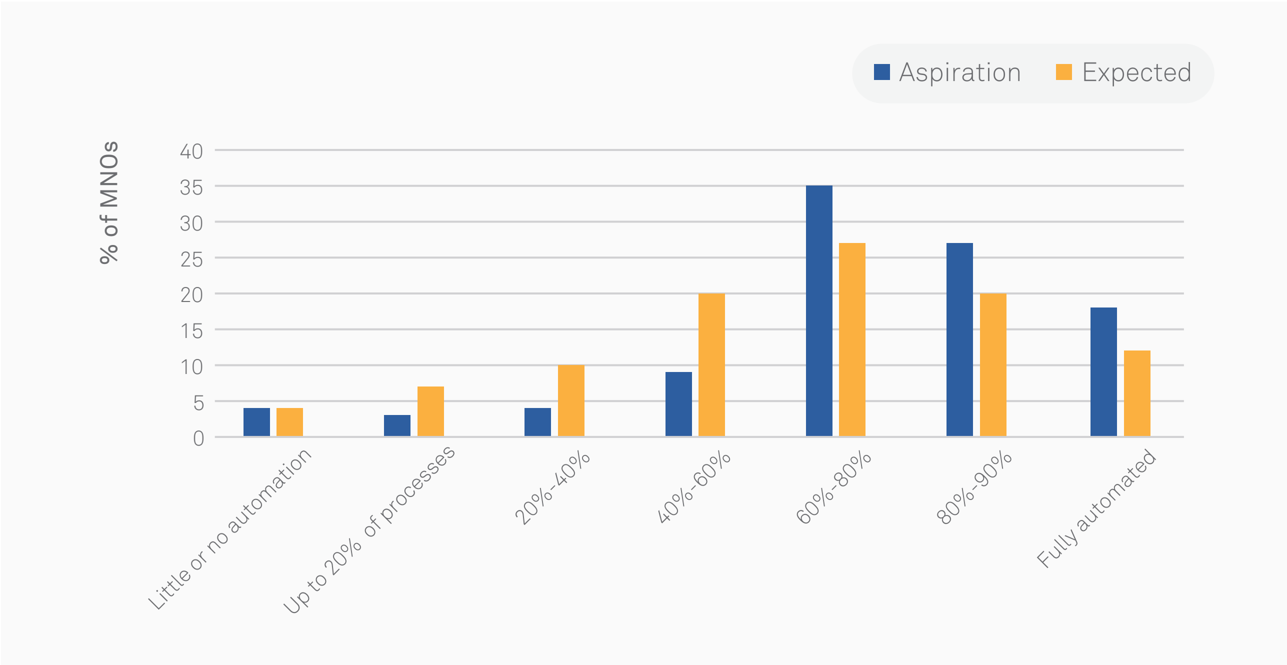


Figure 2. Expected and ideal levels of network automation in 2025 (Source: Analysys Mason)

The reasons for this high interest in automation relate to cost and agility, as outlined above. In the same survey, respondents were asked to list their primary business drivers to adopt network automation. Figure 3 shows the drivers which were most commonly placed in the top three by the 76 respondents. The leading reason to adopt AI-assisted automation is to reduce OPEX – almost 80% placed this in their top three drivers to invest, followed by:

- improvement to customers' network quality of experience
- efficient planning and management of dense networks
- part of an end-to-end automation strategy spanning the network and IT operations

While OPEX reduction is the most important cost-related driver, others include better alignment of network costs to the revenue that is generated; and the ability to defer some capital expenditure (CAPEX) by using existing assets more efficiently.

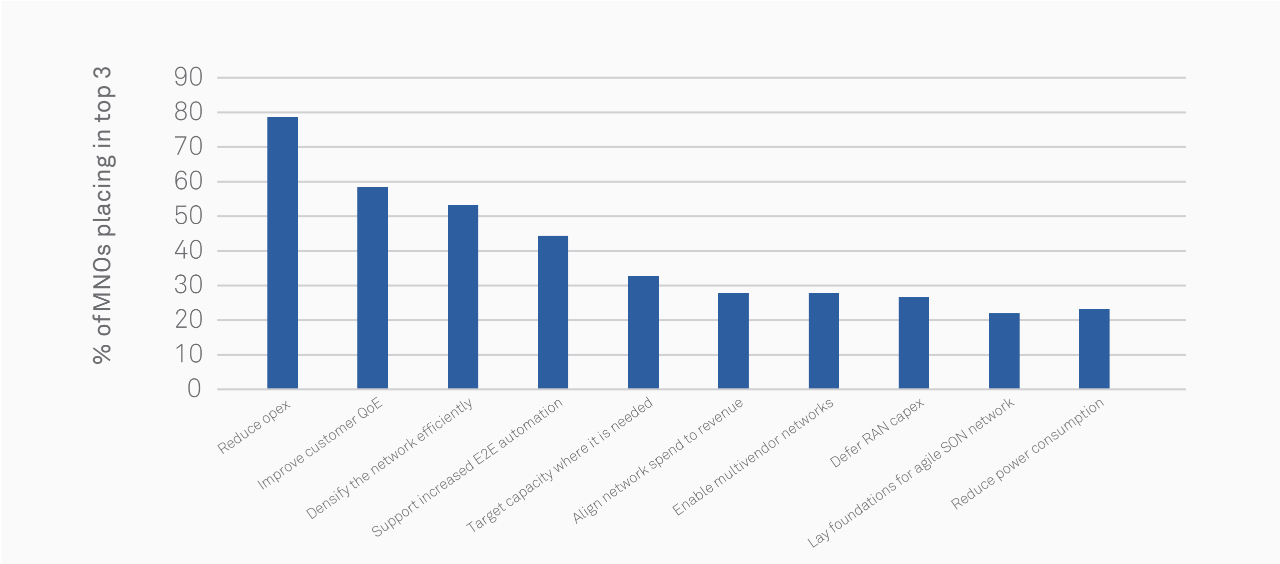


Figure 3. Key commercial drivers to deploy AI-assisted network automation
(% of MNOs placing each driver in their top three) (Source: Analysys Mason)

The importance of automation and AI in reducing operating cost will be critical to the 5G business case. 5G will involve far larger numbers of network elements – cells, antennas, gateways and backhaul connections will all explode in number to support new levels of capacity, density and coverage and so enable new use cases. These huge numbers of elements can only be cost-effectively deployed and managed with a high level of automation.

Figure 4 indicates the stages of the network life cycle in which Tier 1 and 2 MNOs expect to apply automation to reduce network OPEX between now and 2025. This shows that the large majority of operators plan to start to introduce automation to each phase of the O&M life cycle before 2022 (over 70% in planning and optimization, for example). They will continue to enhance the levels of automation over the coming years.

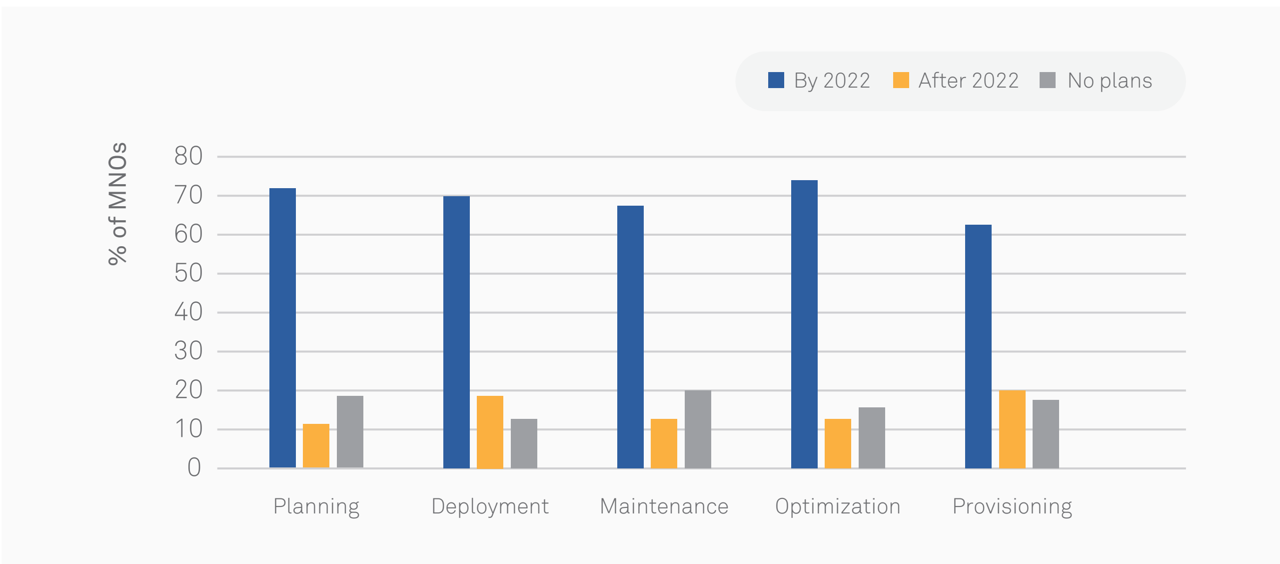


Figure 4. Percentage of MNOs which expect to introduce automation,
including AI, to each phase of the network life cycle, before and after 2022. (Source: Analysys Mason)

That will drive an increase in investment in network automation tools and services with a compound annual growth rate of 35% between 2017 and 2025.

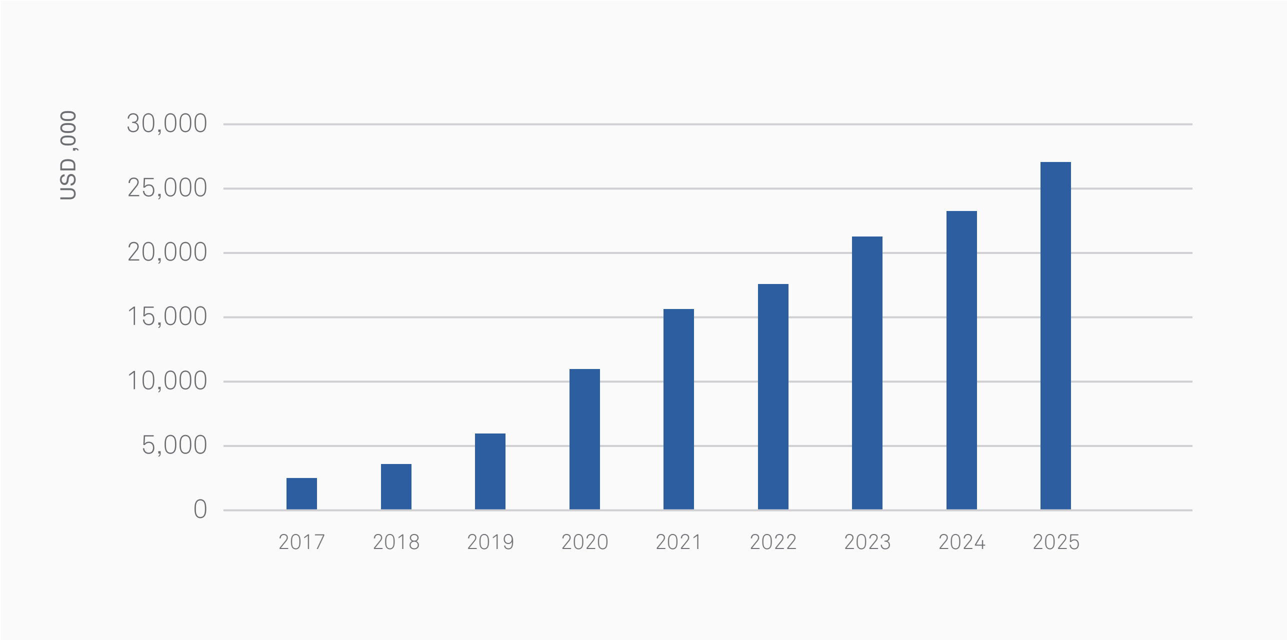


Figure 5. Investment in network automation tools and services, including AI, from 2017 to 2025.

2.Automation must start now

> It is important to take an approach which enables automation to be implemented immediately, to deliver benefits on existing network, and deliver more benefits to future 5G networks.

Take complexity, create simplicity

A key challenge for mobile network automation is the timescale. As the operator survey revealed, many MNOs believes automation is very significant to their 5G case, However, many also believe it will not be fully deployable for several years to come and there is a gap between their near term requirements, and available solutions. That raises the risk that they will delay rolling out wide-scale 5G networks, or they will deploy, but will not derive the full benefits in terms of OPEX reduction and business agility.

Huawei believes those solutions are available now, if a scenario-based approach is taken, which enables different levels of automation to be adopted at different stages.

The driverless car may not be fully in use until the 2030s, but operators cannot wait that long for the autonomous driving network. Instead, it is important to take an approach which enables automation to be implemented immediately in certain scenarios, to deliver benefits for existing 4G networks, as well as first-phase 5G. Then, as technologies and business requirements evolve, increased levels of automation can be applied to emerging scenarios, delivering even more benefits.

With this approach, value is unleashed scenario by scenario, and level by level. This is comparable to the different levels seen in the evolution of the autonomous vehicle.

The autonomous driving mobile network has two essential elements in common with the autonomous car:

- There are different levels of automation, relating to different timescales and scenarios
- Intensive use of artificial intelligence (AI) is essential

These two elements are the foundations of Huawei's vision of the autonomous mobile network.

2.1 Five levels of network automation

Huawei has set out five levels of autonomous driving for the mobile network (Figure 6). The lower levels can be applied now and deliver immediate cost and agility benefits in certain scenarios. An operator can then evolve to the higher levels, gaining additional benefits and addressing a wider range of scenarios. These scenarios are fully described in Part 5 of this paper.

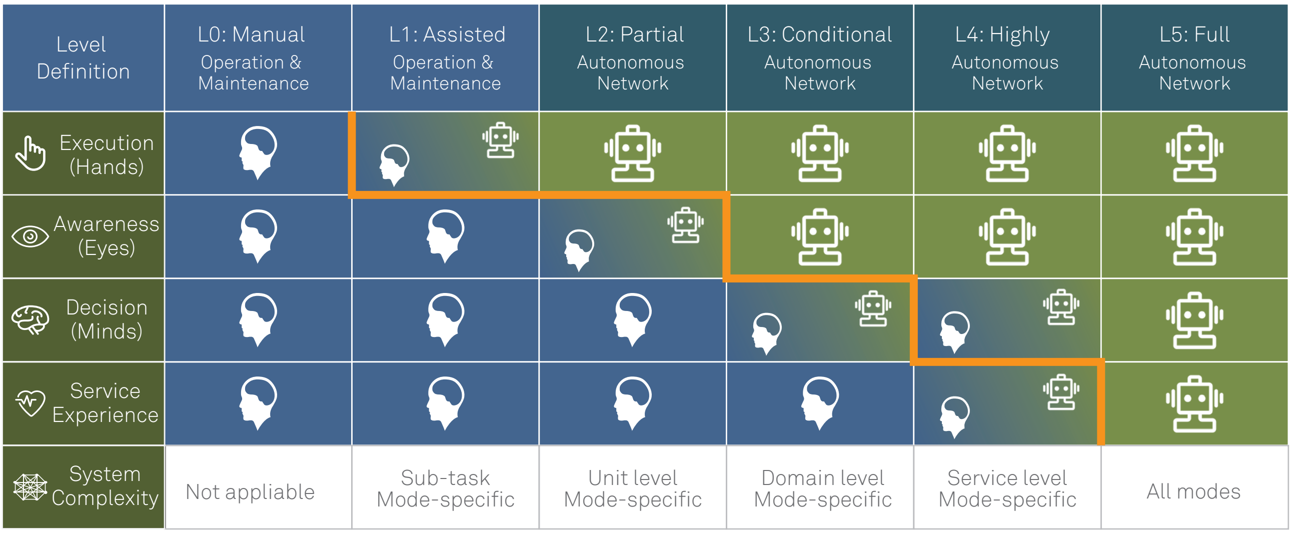


Figure 6. Five levels of automation in the autonomous network (Source: Huawei)

-L0: manual O&M: The system delivers assisted monitoring capabilities, which means all dynamic tasks have to be executed manually.

-L1: assisted O&M: The system executes a certain sub-task based on existing rules to increase execution efficiency.

-L2: partial autonomous network: The system enables closed-loop O&M for certain units under certain external environments, lowering the bar for personnel experience and skills.

-L3: conditional autonomous network: Building on L2 capabilities, the system can sense real-time environmental changes, and in certain domains, optimize and adjust itself to the external environment to enable intent-based closed-loop management.

-L4: highly autonomous network: Building on L3 capabilities, the system enables, in a more complicated cross-domain environment, predictive or active closed-loop management of service and customer experience-driven networks. This allows operators to resolve network faults prior to customer complaints, reduce service outages and customer complaints, and ultimately, improve customer satisfaction.

-L5: full autonomous network: This level is the ultimate goal for telecom network evolution. The system possesses closed-loop automation capabilities across multiple services, multiple domains, and the entire lifecycle, achieving autonomous driving networks.

2.2 Wireless AI reshapes the boundaries of automation

Huawei launched Wireless AI at its Mobile Broadband Forum (MBBF) in 2017. Huawei believes that mobile networks will be fertile ground for the development and rapid uptake of wireless AI applications. AI and mobile networks will eventually achieve deep integration, driving unprecedented levels of O&M efficiency and network performance and breaking down business siloes.

The use of AI is essential to the autonomous network because:

- Mobile networks have a naturally distributed structure. In effect, this makes cellular signals work as the world's largest sensor system, with each cell site generating petabytes of data each day. For autonomy, all this data needs to be analyzed and lessons learned in near-real time.
- The mobile network shifts and changes according to different usage scenarios and times of day. That means each cell site, and even each connection, has personalized configuration and scheduling requirements. Fully efficient allocation of spectrum resources needs near real-time scheduling, which is only achievable with the use of AI.
- For near term application of AI, mobile networks have the advantage over some other applications. There is a relatively clear and established evaluation and feedback system for mobile networks, which have accumulated nearly 30 years of historic data and experience. This provides a strong base for AI and machine learning.

The application of Wireless AI to network operations will achieve efficiency and agility that are impossible for human processes alone. That will, in turn, extend the boundaries of network automation and enable operators to move to the higher levels.

3.Scenario-oriented Network Automation

> The autonomous driving network needs an O&M approach that is based on daily usage scenarios.

Unleashing network automation dividends, scenario by scenario

In the previous section, we outlined Huawei's five-level roadmap for network automation evolution, which it is recommending to standard organizations in order to accelerate adoption.

The work on a multi-level network automation roadmap mirrors the approach to the autonomous car. In that industry, commercial trials have begun at Level 3 of the autonomous driving vehicle. For example, Tesla recently released the "Navigation on Autopilot" feature. The driver only needs to enter the destination and choose the route, and the car does the rest. This is an example of achieving fully autonomous driving by implementing features that relate to different scenarios or driver requirements, rather than focusing on different car components.

Huawei believes that autonomous driving in the network also needs to move from an O&M approach that is focused on network elements, to one based on usage scenarios. This means that process changes relate directly to a particular result, defined by the operator, and with a business value.

Progress will be accelerated if a core set of scenarios is defined, which will be of value to all operators. Development of the related autonomous driving solutions can then be prioritized accordingly.

So what are the core scenarios in mobile networks that need to be promoted across the industry?

We have identified scenarios which best meet these three criteria:

- **Extent of digitalization:** Reflects the technical readiness of the scenarios. Digitalization is the foundation of automation, and the extent to which it is supported determines the extent to which automation can be achieved immediately;

- **TCO contribution:** Reflects OPEX savings and the improvement to CAPEX efficiency in the given scenario;

- **O&M life cycle:** Reflects the ability to build differentiation in each phase of the life cycle in order to achieve full autonomous driving across many scenarios. The O&M life cycle spans planning, deployment, maintenance, optimization and provisioning of the network and scenarios have been identified for each one.

Based on those criteria, we selected seven typical key scenarios, as outlined in Figure 7. Figure 6 indicates the degree to which these eight core scenarios meet the three criteria of digitalization, TCO contribution and lifecycle size. It indicates the extent to which the scenario has been digitalized; its position in the life cycle; and its potential contribution to TCO reduction (bubble size).

Key scenarios of network automation

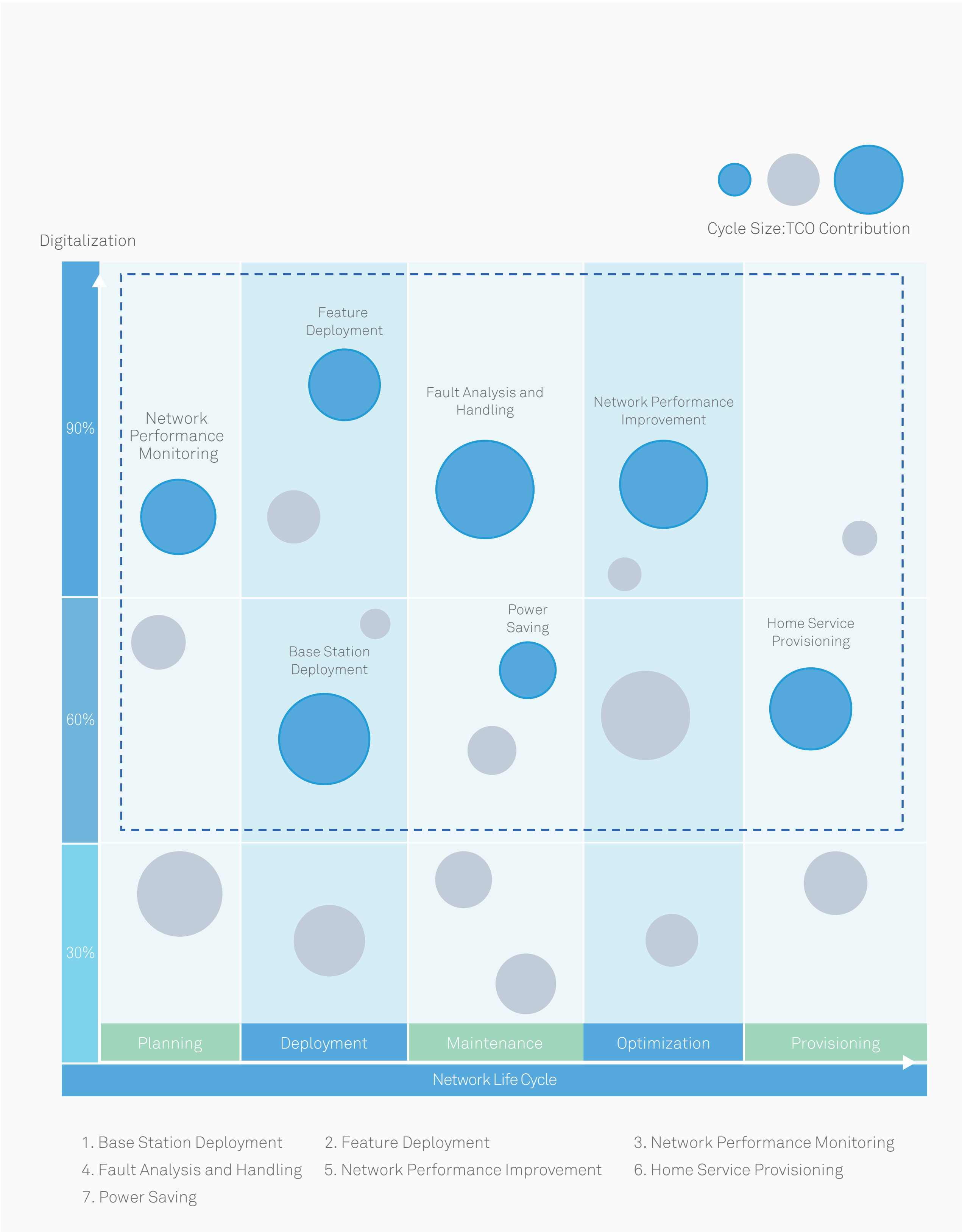


Figure 7. Key scenarios of network automation

4.Five Core Automation Capabilities

"Automated full-scenario requires critical network capabilities analysis."

Programmable, Online, Bridging, Sensibility, Intelligence

A typical automation scenario is usually made up of a series of TASKs, which will initially be built around the operator's existing workflow (either routine workflow, or triggered by events).

We believe that all the mobile network automation scenarios rely on five core capabilities to support those tasks. These can be summarized as POBSI:

-Programmable:
The software's definable extent and real-time orchestration are necessary to support different sub-scenarios with different characteristics, and allow for individual approaches.

-Online:
the degree to which the task can be done online, which typically relates to how far a task can be performed remotely.

-Bridging:
The smooth movement of data between tasks in the flow; the core purpose is to eliminate data siloes between tools/systems and flow silos between tools/systems. This allows data to be coordinated and analyzed in every aspect of the task.

-Sensibility:
The extent of dependence on network data, terminal data, and third-party data during the automation process in a certain scenario.

-Intelligence:
Extend of dependence on key AI capabilities such as scene recognition, network prediction, wireless positioning, and multidimensional analysis, during the automation process in a certain scenario.

Different automation scenarios, different sub-scenarios, and different life cycle automation scenarios all have their own requirements for various combinations of the five automation capabilities.

For example, optimization requires a relatively high level of intelligence, and it is necessary to support time-related and dynamic adjustment of the network to meet changing traffic patterns. Meanwhile, the core requirements for the base station deployment scenario are to build Online capability and Bridging capability, to approach the idea of "Zero touch" deployment.

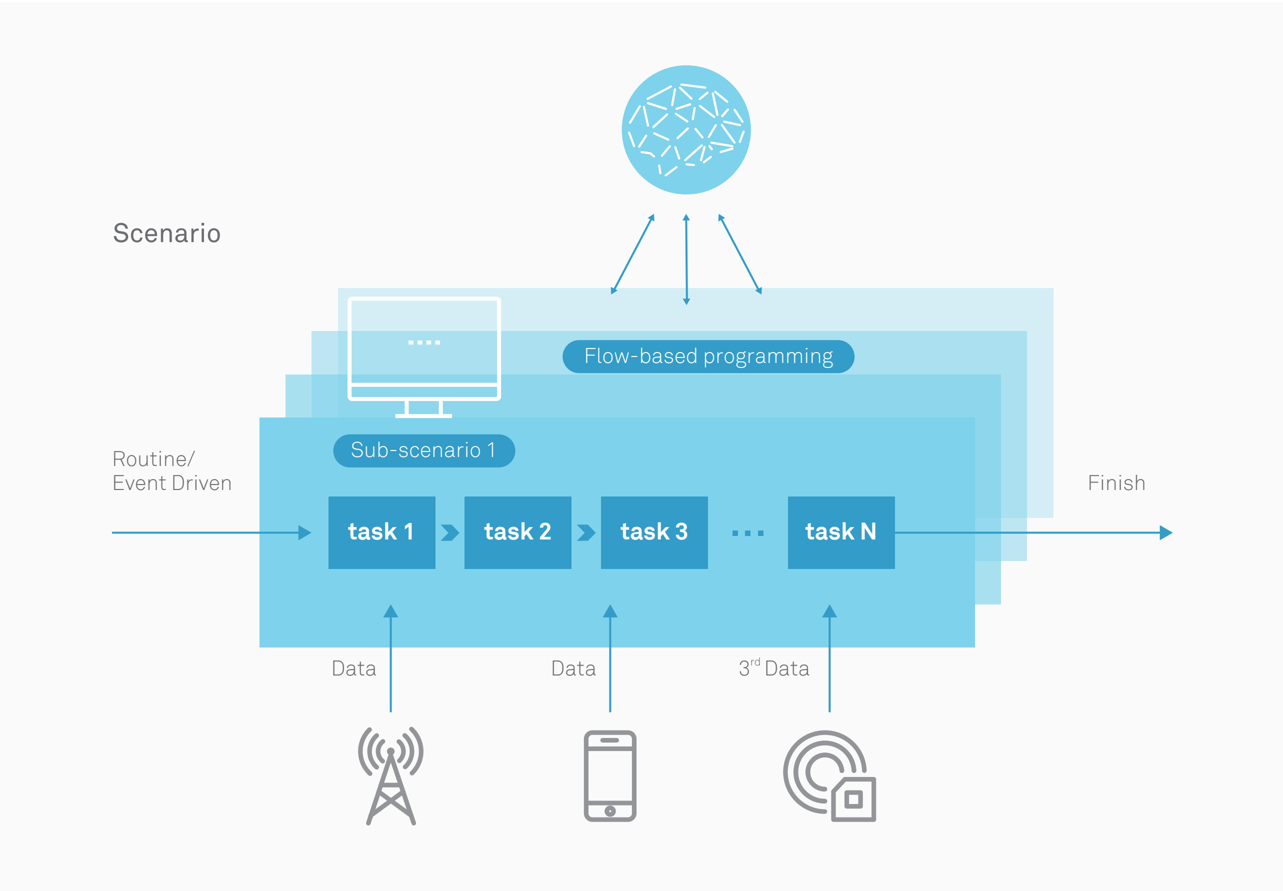


Figure 8. Programmable Workflow

5.Key Scenarios of Network Automation

> Identifying key scenarios is the most important step to achieve full network automation.

5.1 Base Station Deployment

1) Definition and Description of Scenario

The base station deployment scenario refers to the entire process after site survey, including network planning and design, site design, configuration data preparation, site installation, site commissioning and site acceptance.

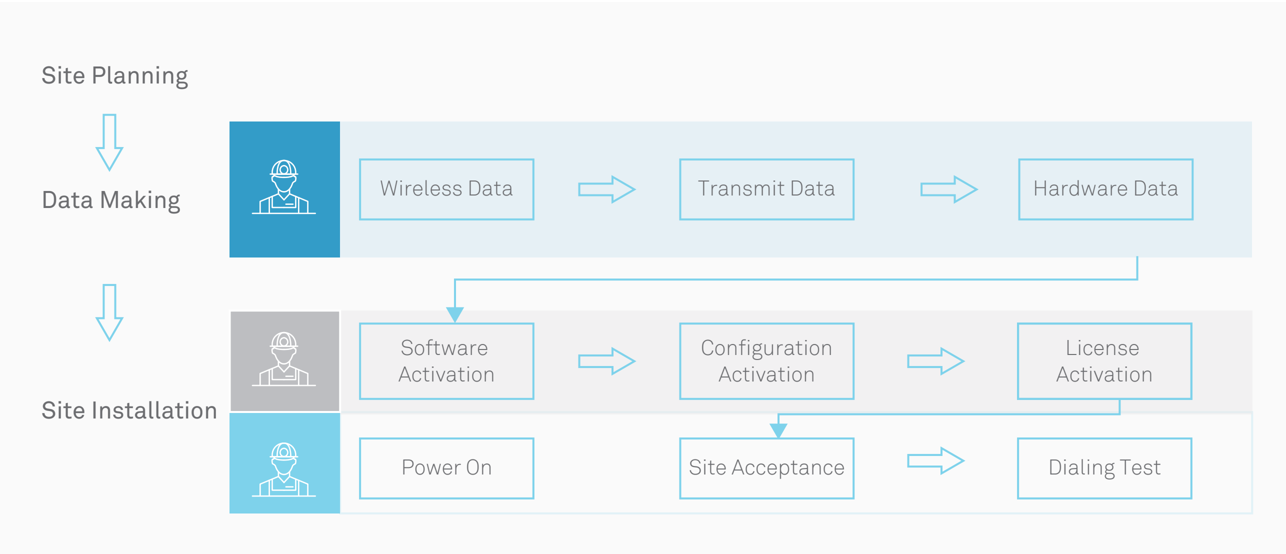


Figure 9. Flow of Base Station Deployment

2) Automation Classification

Level 1: The O&M tool helps some elements of the process to be automated, but configuration and site acceptance have to be done manually.

Level 2: Some hardware can be detected and configured automatically, and configuration data is simplified based on rules.

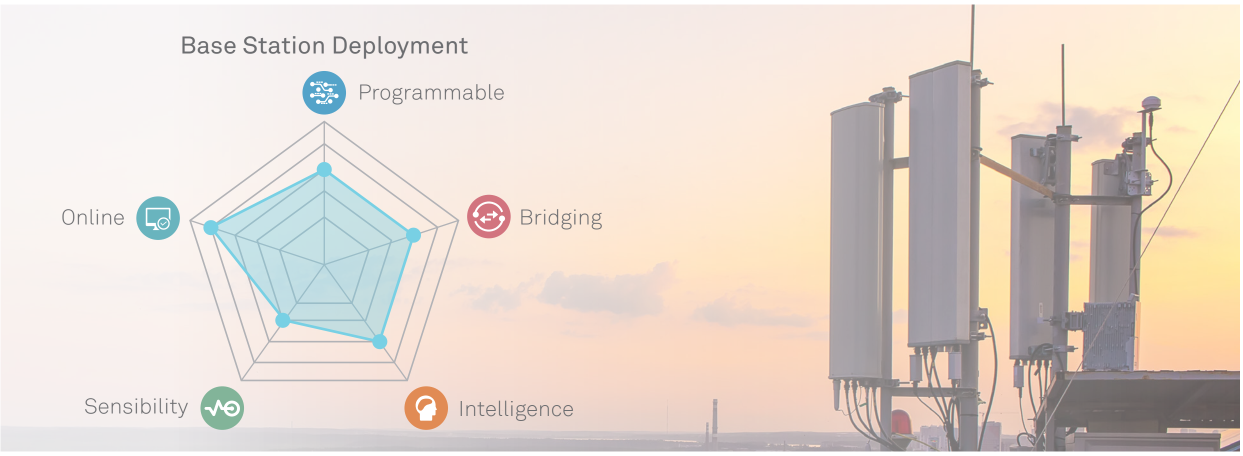
Level 3: E2E automation: radio parameter self-planning, hardware self-detection and self-configuration, self-acceptance without dialing test.

3) Industry Status

The large number of configuration parameters make data preparation challenging. Also, the asynchronization of site planning and site installation, and manual dialing tests, result in long site visit times and frequent site visits.

At present, the site deployment scenario is between Level 1 and Level 2. However, some leading platforms have just reached Level 3, with E2E automation of site deployment processes on the horizon.

4) Key Capabilities Required



The core requirement for base station deployment automation is to build the Online and Bridging capabilities.

-Programmable:
The deployment tasks of base stations can be automatically orchestrated, according to different policy, such as new site, site expansion, and site reconstruction. In addition, it can be customized online to meet the flexible requirements in different scenarios.

-Online:
During the progress of site deployment, all of the process including data planning, configuration data preparation, and dialing test acceptance are completed online.

-Bridging:
A unified workflow is formed from the power-on to software and data download, and the following process. The workflow with planning system, site design, and inventory system should be streamlined.

-Sensibility:
Awareness of site data needs to be enhanced. Active components in base stations can be automatically detected and identified, for example, engineering parameters, azimuth, and tilt angle can be automatically detected. The passive devices such as combiner in site can be automatically identified.

-Intelligence:
The site deployment scenarios can automatically identified, and wireless parameters can be planned automatically based on the identified scenarios and the surrounding sites.

5.2 Feature Deployment

1) Definition and Description of Scenario

Wireless networks are becoming more and more complex. How to choose the most appropriate software features, in order to achieve the greatest gains through optimal configuration, is one of the most important challenges in feature deployment for current networks.

Feature deployment scenarios match the best features with the network, through automatic recognition and analysis of the network scenarios. They then, generate the feature configuration parameters which best support the scenarios, and launch automatically.

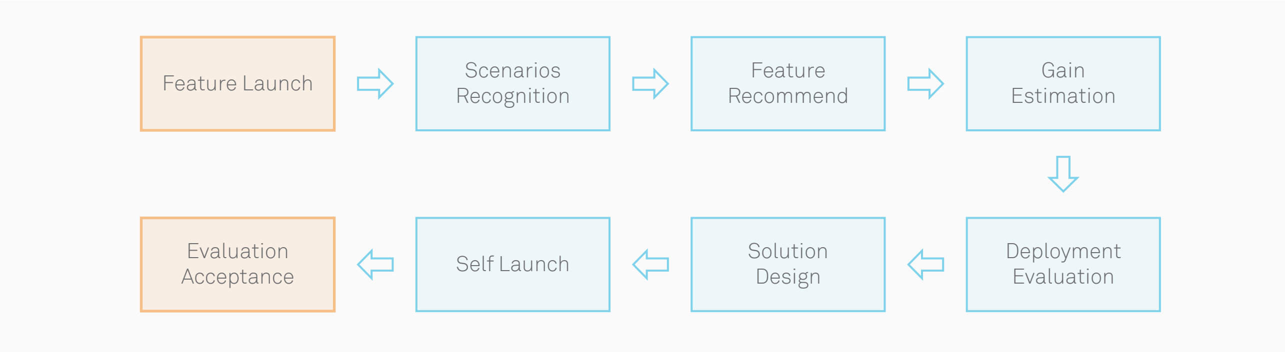


Figure 10. Flow of Feature Deployment

2) Automation Classification

Level 1: O&M tools aid configuration, manual feature selection, and design based on experience;

Level 2: Tools generate configuration data automatically and activate one button;

Level 3: E2E closed-loop feature launch: scenario self-recognition, feature self-recommendation, configuration self-generation, self-launch, self-acceptance.

3) Industry Status

Today, scenario recognition, gain estimation, deployment evaluation and solution design, within feature deployment, mostly rely on manual experience, assisted by multiple tools, with an average launch time of 20 days per 1,000 sites. The automation level in the industry is mostly at Level 2.

4) Key Capabilities Required

The key elements of feature deployment are scene recognition, gain estimation, solution automatic design and bridging capability:

-Programmable:
According to the parameters set by the operator, the launch process can be organized and customized to meet those individual requirements.

-Online:
Feature recommendation, gain evaluation, feature acceptance and other aspects of feature deployment need to be online.

-Bridging:
Closed loop with planning system and O&M system.

-Sensibility:
The automation capabilities of scenario recognition, gain estimation and solution design require online access to sufficient real-time network data, business data, terminal measurement data, etc.

-Intelligence:
The AI-supported ability to realize online scenario recognition, learn from historical experience, and predict upcoming feature gains.

5.3 Network Performance Monitoring

1) Definition and Description of Scenario

The mobile network has entered the stage of very precise planning sites and resources: on the one hand, to identify and forecast high traffic areas, and allocate resources precisely to support business goals; on the other hand, to identify and forecast high-frequency temporary traffic, scheduling resources to meet business objectives.

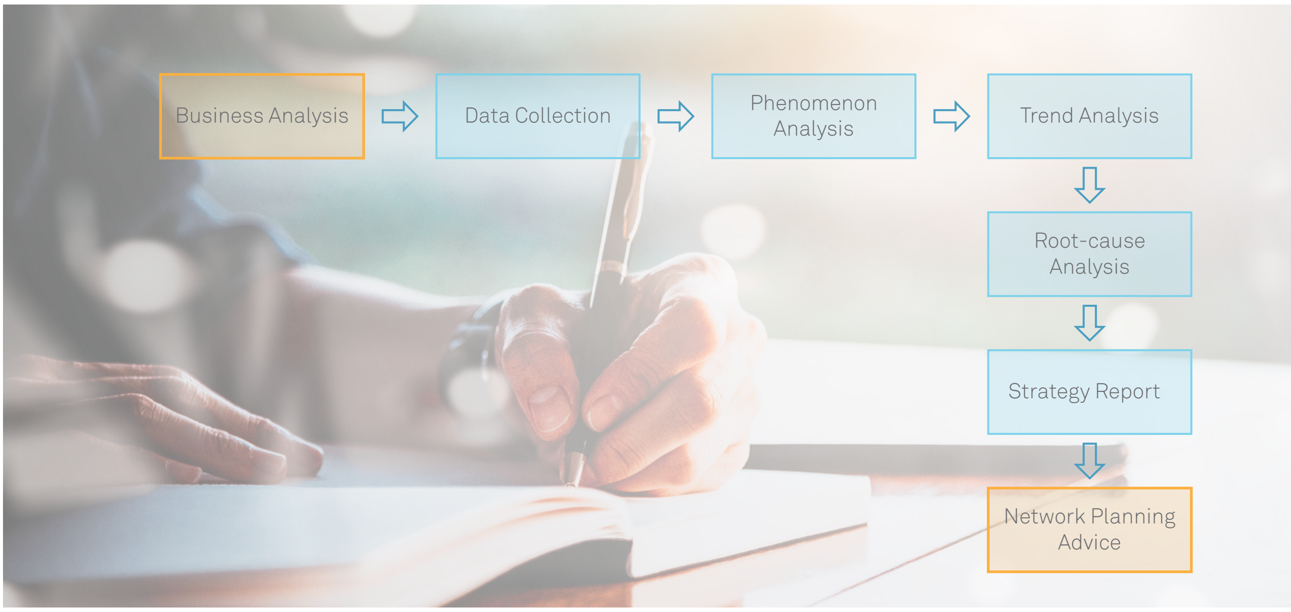


Figure 11. Flow of Network Performance Monitoring

2) Automation Classification

Level 1: Network quality is consistent, and network anomalies can be discovered by tools;

Level 2: 3D presentation of network quality and anomalies, and network planning is self-generated;

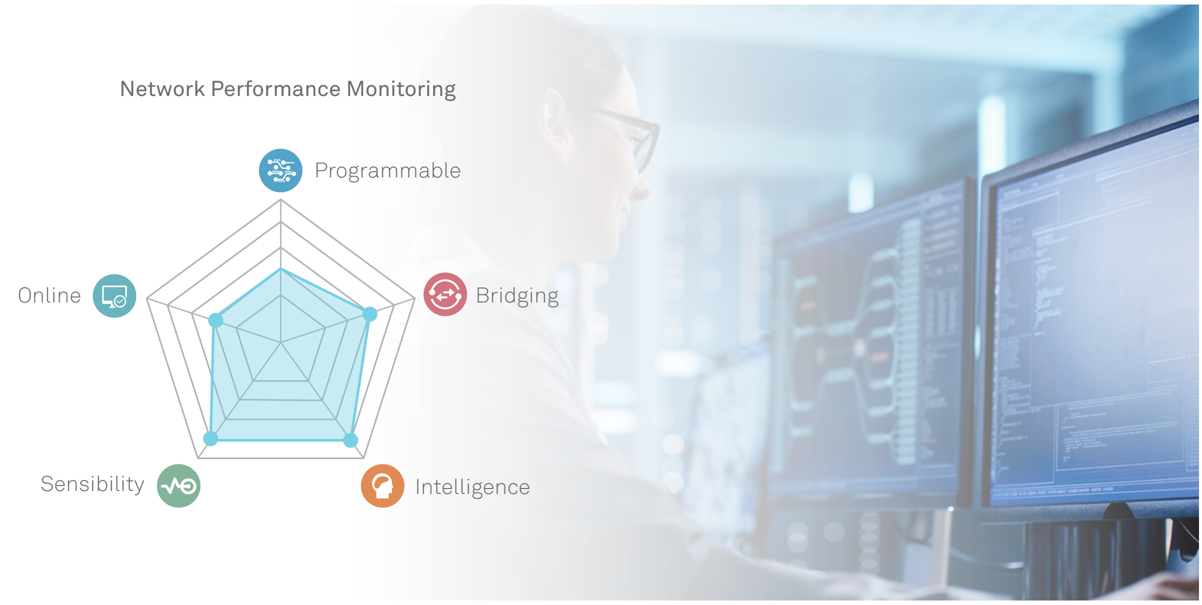
Level 3: E2E closed-loop monitoring and planning: predicting network development according to historical network information, finding value areas and hidden problems, recommending the best network planning and estimating the gain automatically.

3) Industry Status

Today, network-level KPI monitoring and analysis are the main solutions. There are many manual and low precision problems in high-precision analysis. There are many tools in each stage of monitoring and planning, but the E2E closed-loop is not realized.

The automation level in the industry is still at Level 1 to Level2.

4) Key Capabilities Required



-Bridging:
Closed loop with planning and fault diagnosis system.

-Sensibility:
Reliable network performance monitoring relies on massive multi-dimensional data, including network data, business data, engineering parameters, maps and other data, especially the structured and standardized processing of data, which is the key challenge in the industry.

-Intelligence:
Time-based business prediction, 3D positioning based on wireless big data, self-recognition of business scenarios and self-evaluation of business experience.

5.4 Fault Analysis and Handling

1) Definition and Description of Scenario

The security and reliability is the most important mission of the network, so quick alarm detection and quick fault healing are important. The fault analysis and handling scenario comprises several steps, including alarm monitoring, root cause analysis, and fault remediation.

Monitoring: Real-time monitoring of network alarm, performance, configuration, user experience, and other information.

Analysis: By analyzing the correlation between alarms and other dimensions data, root cause of fault and fault repairing can be achieved quickly.

Healing: Repair fault remotely or by site visiting based on the repairing suggestions.

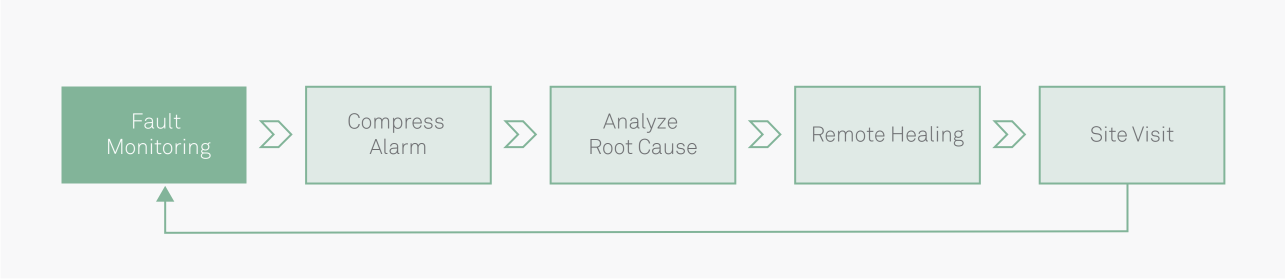


Figure 12. Flow of Fault Analysis and Handling

2) Automation Classification

Level 1: Some tools are used to simplify alarm processing, but thresholds and alarm correlation rules are set manually based on expert experience.

Level 2: Automatic alarm correlation and root cause analysis.

Level 3: Closed-loop of alarms analysis and handling process: Based on the intelligent correlation analysis of multi-dimensional data, accurate location of alarm root cause, precise fault ticket dispatching, and fault self-healing could be reached successfully.

Level 4: Proactive troubleshooting: Based on the trend analysis of alarms, performance, and network data, alarms and faults could be predicted and rectified in advance.

3) Industry Status

Fault analysis and handling usually requires cooperation between multiple departments, and manual intervention. So, overall automation level is still below Level 2 currently. However, some leading platforms have been exploring Level 3 and Level 4 capabilities, and building automation capability gradually in different scenarios.

4) Key Capabilities Required

-Online:
Only some of the alarms can be cleared remotely online currently. A large number of fault recoveries need to be manually performed offline. Therefore, the proportion and times of site visits need to be reduced gradually.

-Bridging:
The automation of fault analysis and handling requires interconnection between different systems – for instance, between different O&M platforms, or between the monitoring center and the ticket dispatching system.

-Sensibility:
Alarms are strongly correlated with network performance data, hardware performance data, and UE behavior. Obtaining as much data as possible is the basis for efficient root cause analysis.

-Intelligence:
Intelligence is used to analyze the common features of big data, identify trends, generate root causes with multi-dimensional data analysis, predict trends, and assess the probability of faults, based on historical data.

5.5 Network Performance Improvement

1) Definition and Description of Scenario

Wireless networks are geographically very distributed, and activity varies significantly in different places and at different times of day. This makes the network very dynamic and complex. That complexity is further increased by the diversity of services and of terminal performance, and by the mobility of users. If the network cannot achieve the benchmark KPIs or SLAs (service level agreements), or enable good user experience, it must be adjusted to meet or exceed those requirements. This is the function of network performance improvement or optimization.

The complete process of network performance improvement or optimization includes several stages:

- network monitoring and evaluation
- root cause analysis of performance problems
- optimization analysis and optimization decision-making
- optimization implementation
- post- evaluation and verification

This is shown in the following figure:

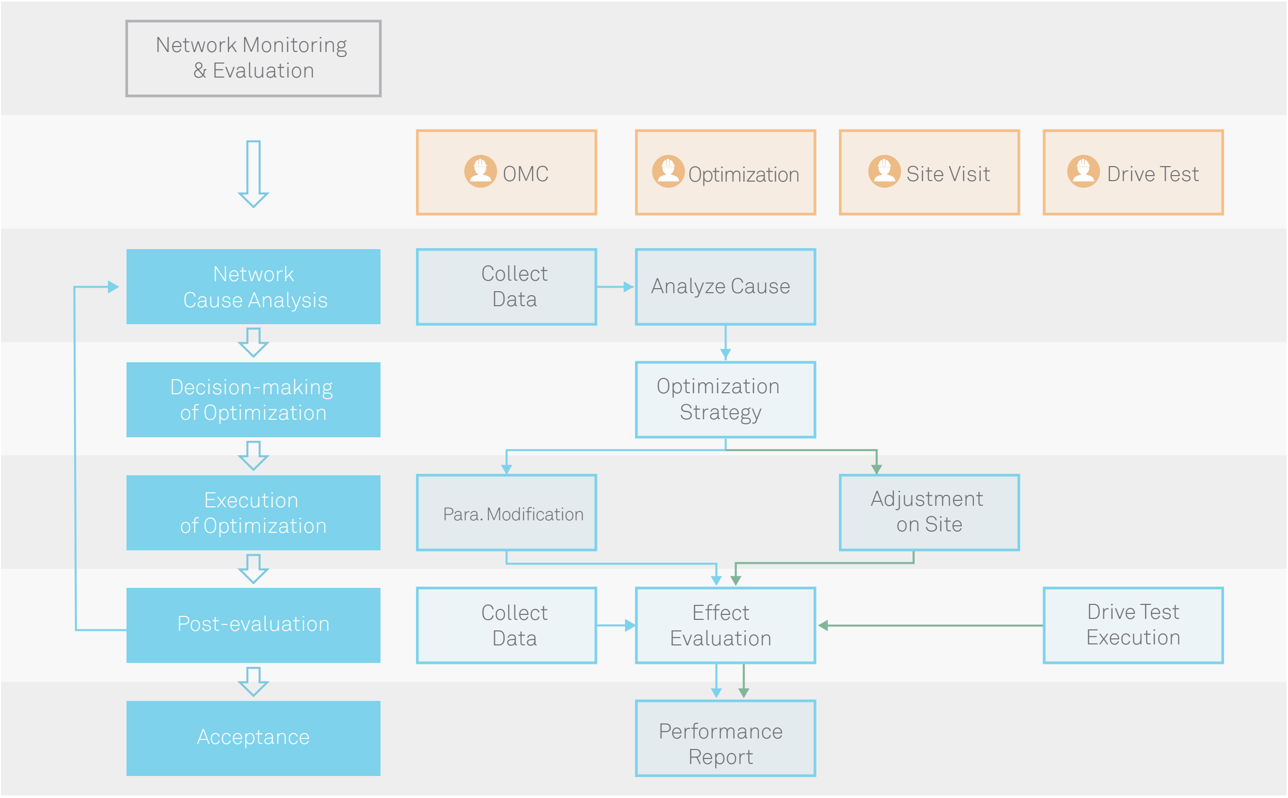


Figure 13. Flow of Network Performance Improvement

Data collection: A large amount of data needs to be collected automatically, including Measure Report (MR), Minimization of Drive Tests (MDT), Performance Management (PM), Configuration Management (CM), Fault Management (FM), engineering parameters, and terminal data.

Cause analysis: Based on the objects and problems entered from the "Network Monitoring & Evaluation" step, the collected data is analyzed to generate the root cause.

Decision-making of optimization: Based on the cause analysis results, the network optimization engineer or automation system provides adjustment suggestions.

Currently, experts are mainly responsible for decision-making, though some scenarios have been automated.

Implementation of optimization: Network configuration parameters can be adjusted automatically in some scenarios. However, as the antenna system is not capable of complete remote adjustment, improving the capability of remote antenna parameter adjustment is key to achieving fully automation.

Post-Evaluation: This activity involves data collection and network evaluation. In addition, Drive Test (DT) verification is usually required for engineering optimization, and DT are not required for routine network optimization.

2) Automation Classification

Level 2: Drive test evaluation is not required for coverage optimization. Adjustment suggestions are provided automatically.

Level 3: Closed-loop of network performance improvement: Automatic identification of network coverage and quality problems, automatic configuration of performance parameters, and automatic evaluation.

Level 4: Dynamic adjustment is implemented based on the scenario awareness and prediction to achieve the optimal network performance. Network prediction capability is available: scenario change trends could be perceived, and network configuration could adjusted real-time to achieve optimal performance.

3) Industry Status

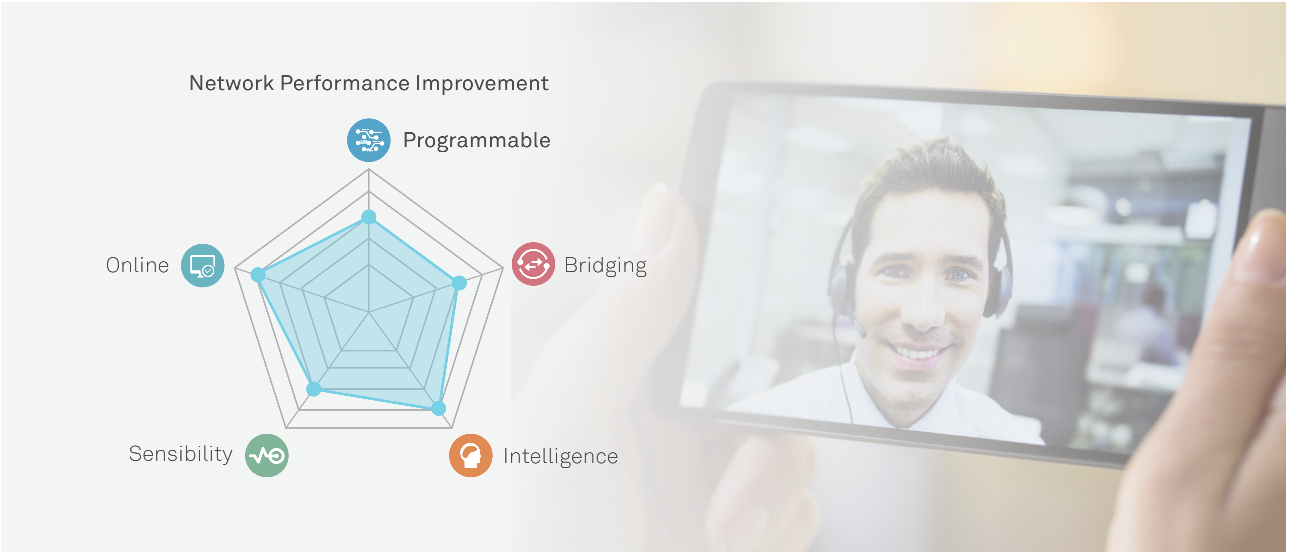
The automation capability of the performance improvement domain is gradually improved by using AI technology, but in general, the degree of automation is currently between Level 2 and Level 3.

For example, basic network performance optimization, such as neighboring cell, PCI (physical cell identity), and MLB (mobile load balancing) have been automated. However, RF optimization depends on engineering parameters, positioning, and antenna capabilities.

These factors limit the automation of RF optimization to date. Recently, the industry has made some progress in the application of AI to automatic performance automation.

Where optimization of user experience is addressed using adaptive configuration responding to traffic changes, Level 2 has been surpassed.

4) Key Capabilities Required



-Programmable:

Automatic identification of different scenarios, automatic matching of optimization with those scenarios, and orchestration of different basic optimization methods within different scenarios. This means that performance automation has high requirements for key functions such as scenario-based models, scenario identification, root cause analysis, and function orchestration.

-Online:

Network performance optimization currently relies heavily on expert experience. In the future, there needs to be a closed-loop online spanning problem evaluation, cause analysis, decision-making, implementation, post-evaluation, and decisions based on post-evaluation.

-Bridging:

Enhancing future capabilities in this area must address interconnection with external systems, such as drive testing, antennas from different vendors, and third-party digital maps.

-Sensibility:

Decision-making in optimization is affected by many factors such as engineering parameter accuracy, network positioning, network performance data, and terminal data, and relies on AISU, MDT, and OTT (over-the-top), and others.

-Intelligence:

In the future, full-stack automation capabilities need to be built, including: scenario-based models and automatic identification

- prediction of network performance and traffic
- automatic parameter optimization in different scenarios
- automatic clustering and migration learning capabilities in different scenarios self-learning and optimization capabilities with no dependence on expert.

5.6 Home Service Provisioning

1) Definition and Description of Scenario

WTTx is Huawei’s 4G or 4.5G-based broadband access solution, which uses fixed wireless access (FWA) to provide fiber-like performance. Broadband wireless networks must serve everyone from individuals to homes, businesses and governments. In order to meet the individual requirements of different kinds of services and users, wireless network resources need to be adapted automatically to ensure the best user experience.

WTTx has become a foundational service for mobile operators because of its convenient installation and low cost of single bit. Rapid launch of WTTx service, accurate evaluation after launch, and network development planning have become important supports for new business development.

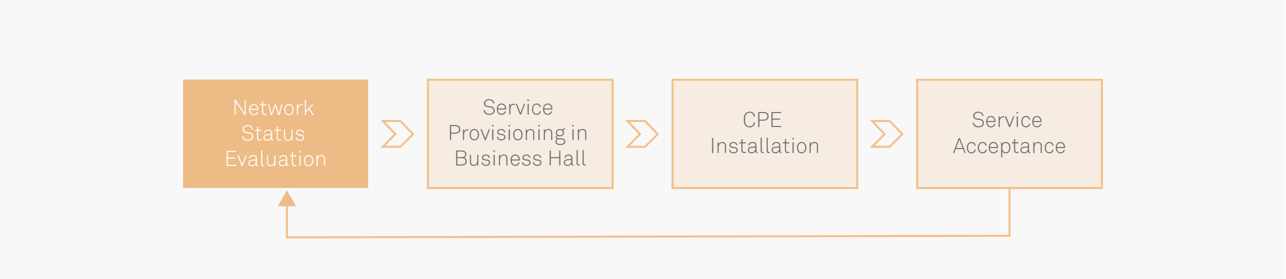


Figure 14. Flow of Home Service Provisioning

2) Automation Classification

Level 1: Blind launch;

Level 2: Automation tools to assist the launch, check the coverage and capacity of the user's location before the business hall, and experience evaluation;

Level 3: Closed-loop for business launch: Integrated with BOSS system to achieve one-step precise launch, remote account launching, CPE installation, fault self-diagnosis and complaint analysis;

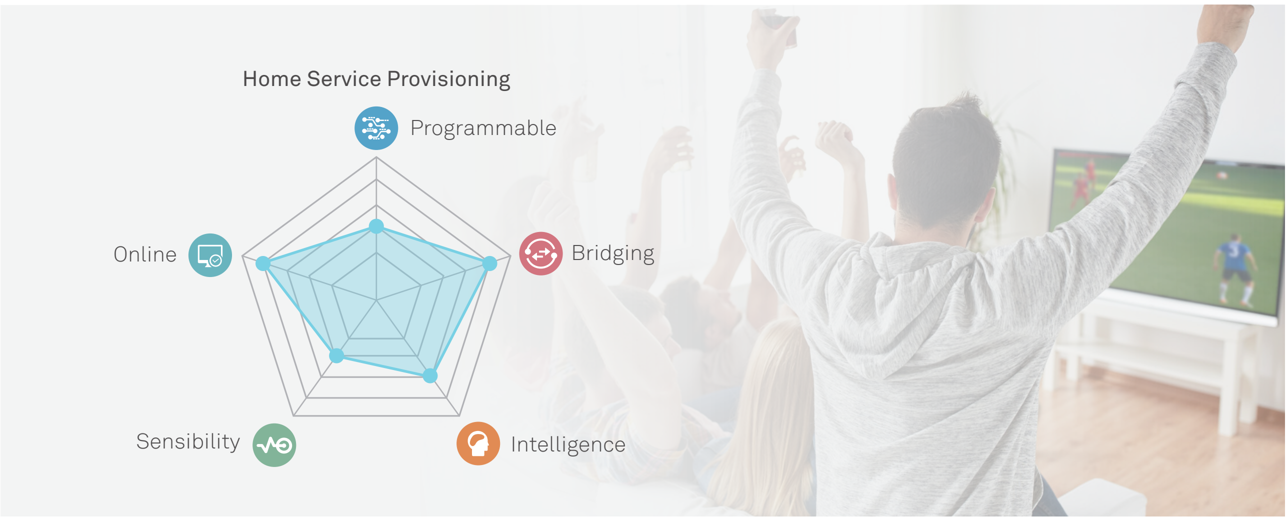
Level 4: Auto-balancing of multi-service, automatic value areas identification and network planning recommendation based on network problems forecasting.

3) Industry Status

Today, WTTx launch relies on reliable map-assisted evaluation, and the automation level in the industry is generally between Level 2 and Level 3.

4) Key Capabilities Required

The key capabilities for WTTx launch are the prediction of user experience and seamless integration with the operator's systems.



- Programmable:
According to the operator's personalized business strategy, flexible scheduling is implemented to achieve SLA protection for multiple services.

- Online:
It is necessary to build automatic evaluation system without drive tests or door-to-door service.

- Bridging:
Integrating launch information with CRM (customer relationship management) systems, and integrating with the Call Center to address complaints and identify poor performance proactively.

- Sensibility:
Sensor capabilities need to be extended to passive devices, such as antennas for outdoor CPEs, to support remote analysis of outdoor CPE installation. The CPE can then report valuable business information that goes beyond the base log, such as throughput, video and voice quality. Outdoor CPE can also report accurate GPS location information, while indoor CPE can support APP positioning and other ways to report high accuracy location information.

- Intelligence:
In order to build intelligent service launch capabilities and meet the different business needs of various users, operators need automatic and intelligent multi-service balancing, using mobile big data, to maximize resources usage efficiency.

5.7 Power Saving

1) Definition and Description of Scenario

Site power consumption cost accounts for more than 20% of network OPEX. Although network traffic declines greatly during idle hours, equipment continues to operate, and power consumption does not dynamically adjust to the traffic level, resulting in waste. It is necessary to build the "Zero Bit, Zero Watt" capability.

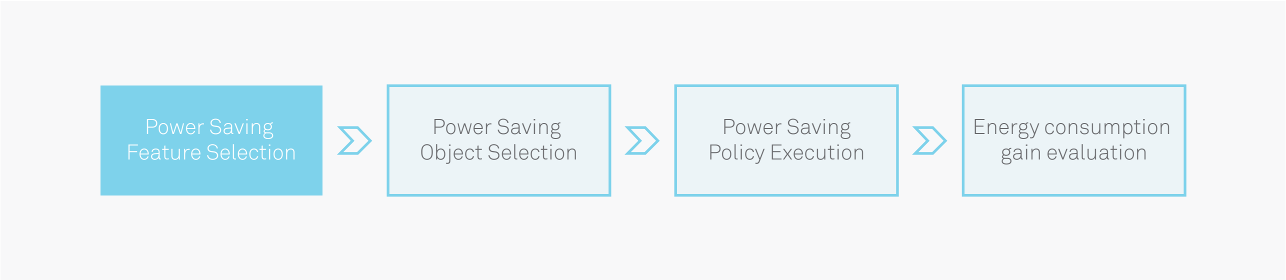


Figure 15. Flow of Power Saving

2) Automation Classification

Level 2: Tool aided execution;

Level 3: Power-saving closed-loop: Based on the analysis of traffic trends, self-adaptive generation of power-saving strategies, effect and closed-loop KPI feedback;

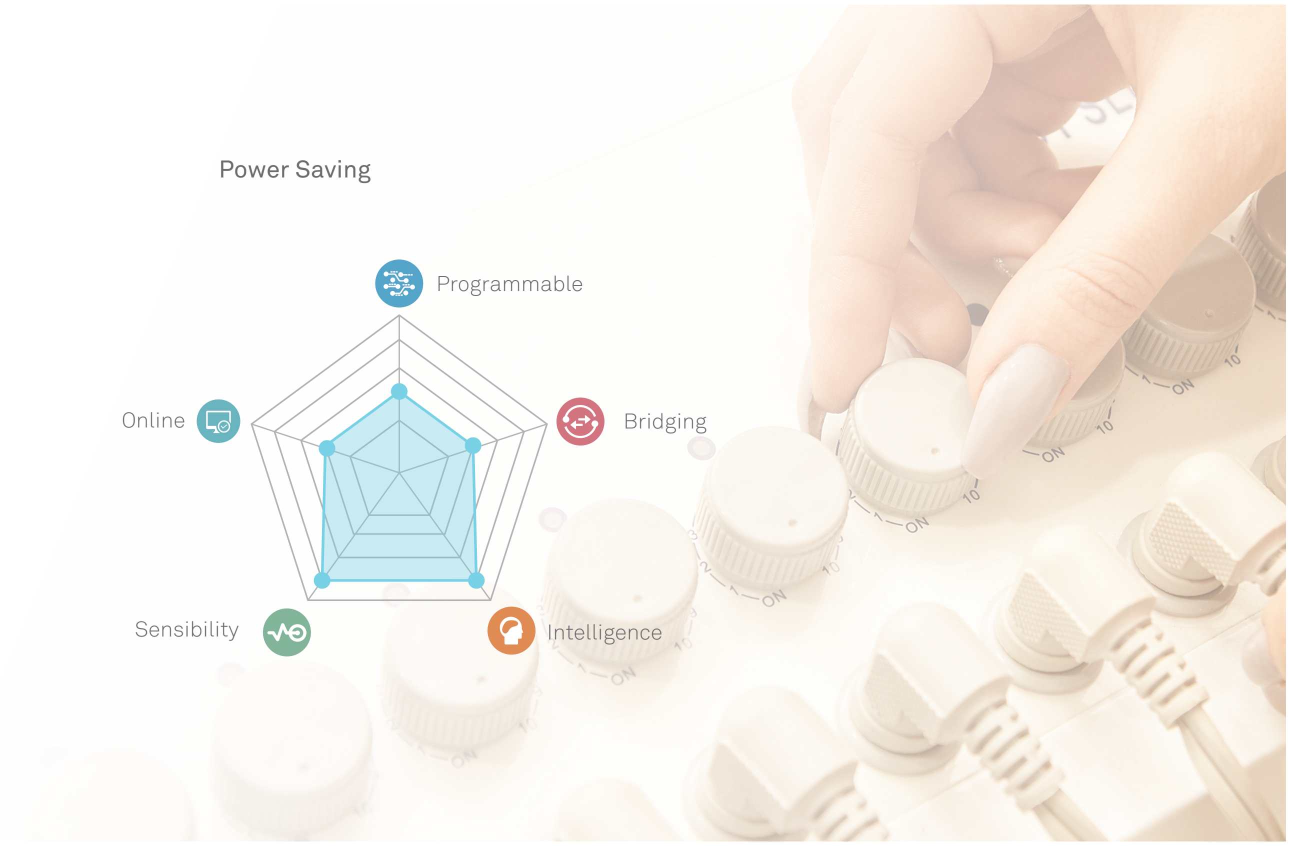
Level 4: Real-time adjustment of power-saving strategies based on traffic prediction. Through integration with third-party space-time platforms, the operator can also add predictive perception of traffic changes, smooth out the user experience, and maximize power-saving.

3) Industry Status

Most current power saving relies on the single mode characteristics launch, and the automation level in the industry is mostly at Level 2.

4) Key Capabilities Required

The key capabilities for power saving are sensibility and intelligence.



- Sensibility:

Power saving mainly depends on the visibility and prediction of real-time traffic patterns to trigger power-off for the RRU (remote radio unit)/carrier and symbol. Therefore, power-saving requires reliable real-time network data, user data, and third-party data to achieve optimal user experience assessment and analysis.

- Intelligence:

This will be enhanced achieve real-time perception of traffic changes, and the ability to predict those, as well as to support collaboration across multi-band and multi-RAT networks, and achieve real-time visibility of business experience.

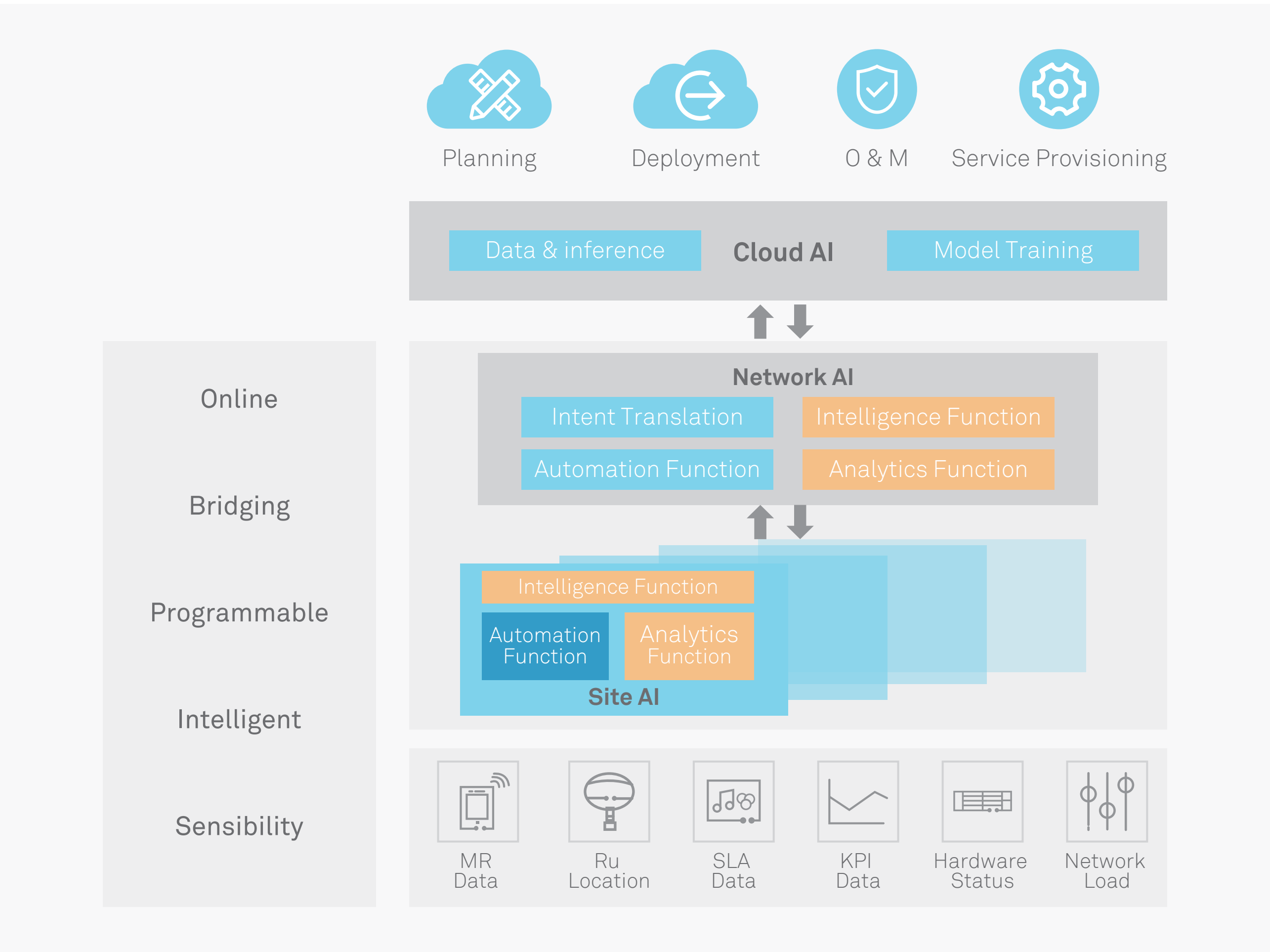
Conclusion

> "Move up the automation levels through architecture innovation."

This paper has illustrated how an operator can start to implement automation strategies now, even before 5G roll-out, and achieve immediate business benefits. They will then be able to move up to higher levels of automation to address emerging network and business requirements, and to accelerate the transition to 5G and a fully digital platform.

However, this is a challenging process. As an operator moves up to higher levels (L3 or above), the scenarios become broader and more general, which means there will be greater degrees of uncertainty than in a specific, well-understood task; To achieve automation across different domains, or even service level automation, requires additional automation capabilities, at all levels, to be supported.

Huawei believe the all-stack AI will be the only way to reach the ultimate goal of full automation. The Intelligence capabilitywill be implemented in each layer: from the site, to the network, to the cloud.



Site AI: deployed in-site, to realize real-time control of radio resource management (RRM) and round-trip time (RTT), to meet very strict requirements for low latency (down to millisecond level).

Network AI: deployed in the area where management and control converge. This translates business intentions to automated actions, in order to achieve non real-time control.

Cloud AI: responsible for the AI training model, enabling control across domains, to achieve a whole-network closed loop.

MBB Automation Engine (MAE), Huawei's mobile network autonomous driving solution, fully inspires the automation potential empower by AI, and enables all-scenario autonomous driving in mobile networks.

Take complexity create simplicity, with intra-layer autonomy

The end result will be an automation loop which works across all the network layers. In networks, that goal is comparable to that of the truly driverless car in the automotive sector. That car may not arrive until the 2030s, though the biggest barrier is not technical, but human – the lack of courage to take a huge leap. The network is different - the value will be unlocked scenario by scenario, level by level. At each stage, operators can enjoy a dividend.

With scenario-based automation and multi-level roadmaps, Huawei believes the industry can accelerate the process of automation and start to take advantage of network AI immediately. Huawei will drive the idea of “take complexity, create simplicity”, to achieve a win-win situation for operators and create a better mobile industry.

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