LFNETWORKING
Developer & Testing Forum

5G SBP: Enhancing Autonomous Network through Generative AI and Intent-Driven Technologies

China Mobile

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https://lfnetworking.org

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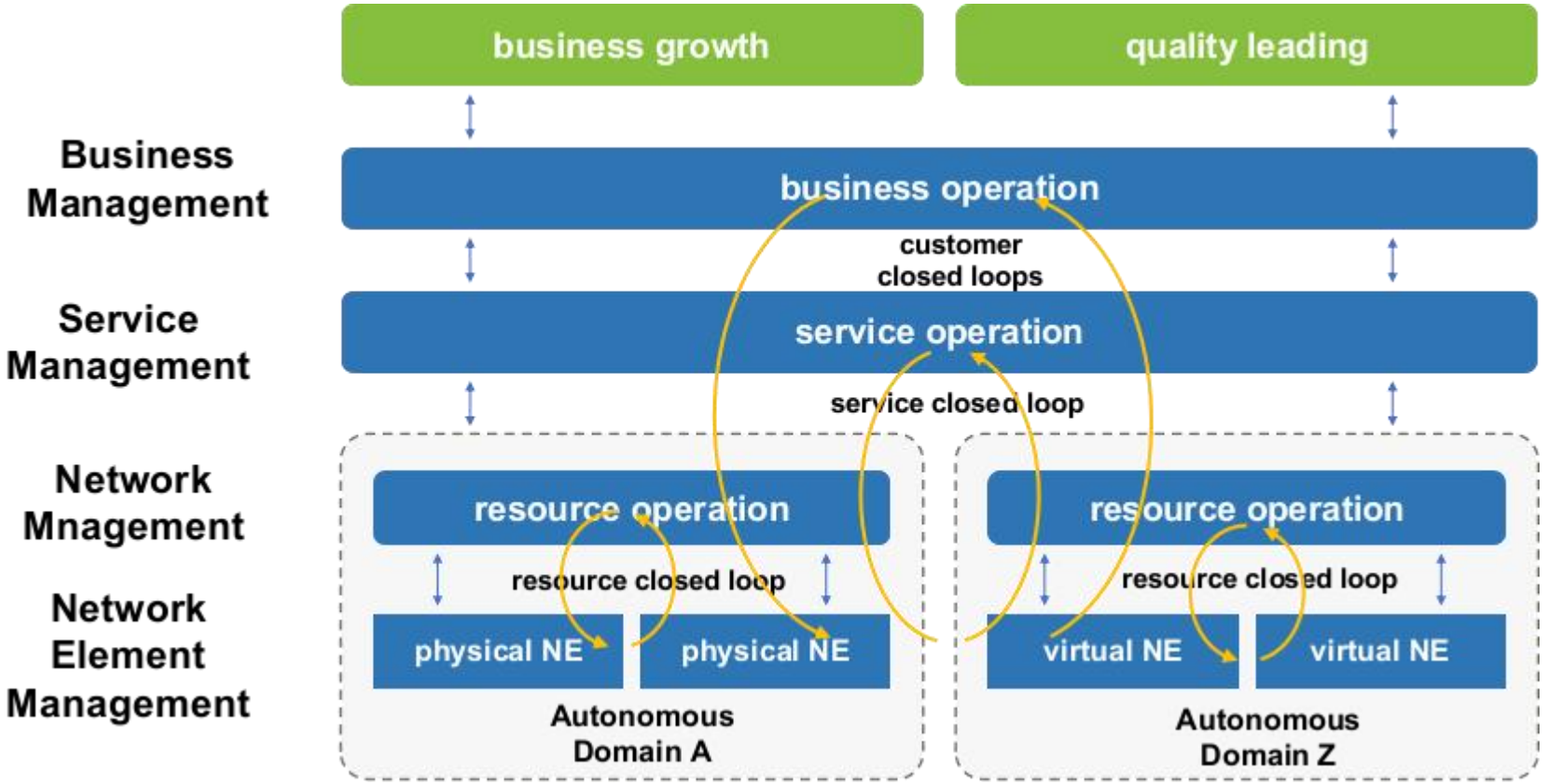
Autonomous Network System Architecture



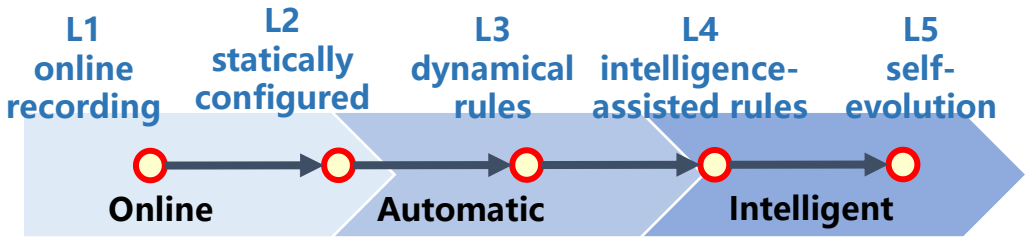
Autonomous network: A network composed of intelligent and automated infrastructure, operational management systems, and business systems.

China Mobile has set the goal of reaching Level 4 advanced autonomous driving by the year 2025 and has initiated a large-scale, comprehensive autonomous network practice across its entire network.

Maturity levels of autonomous networks

Based on TM Forum level table, IT technology maturity levels for core capabilities are defined in detail.

IT Technology Maturity Levels



L2-L5: with higher flexibility, agility, and adaptability to changes

L1 Online recording: Manual implementation, online recording

L2 Statically configured: rules Automatic implementation driven by statically configured rules

L3 Dynamically programmable rules (policies) :Automatic implementation driven by dynamically programmable policies

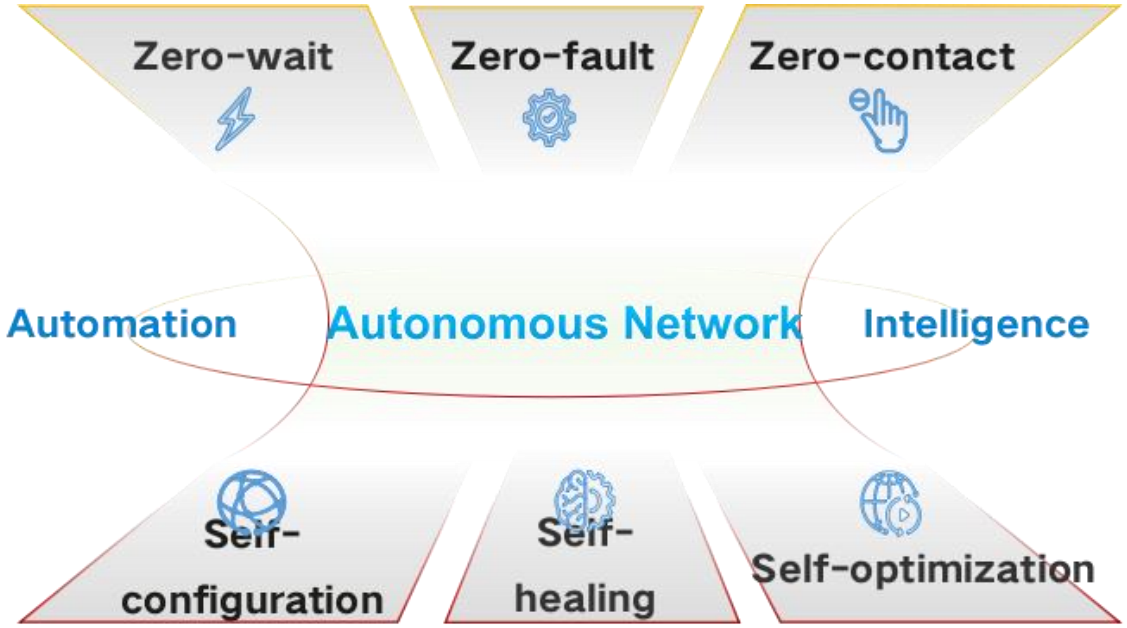
L4 Intelligence assisted auto-generation of rules: Automatic implementation driven by AI assisted (if needed) knowledge, with continuous learning and rapid evolution

L5 Self-evolution: Automatic implementation capable of self-evolution and adapting to change

37 types of Core Capabilities Evolution Direction

Category	Capability	Quantity	Highest level	AI Evolution Direction
Operation	4. Integrated deployment, 6. Opening configuration, 11. Fault handling, 13. Command patrol, 15. Network test, 16.Service test, 20. Quality optimization verification, 24. Effectiveness optimization verification, 26. Resource exploration, 33. Software upgrade, 34. Network data configuration	11	L3	—
Scheduling	25. Provisioning scheduling process, 30. Resource scheduling process	2	L3	—
On site	5. Project acceptance, 14. Site patrol inspection, 32. Hardware execution, 35. Dummy resource collection	4	L4	Sensoring Intelligence
Diagnosis analysis	9. Location and position, 18. Quality problem positioning, 22. Effectivenessy problem positioning, 29. Complaint location, 36. Data correlation, 37. Data verification	6	L4	Diagnosis Intelligence
Prediction analysis	1. Demand prediction, 7. Fault identification, 8. Hidden trouble identification, 12. Scenario monitoring, 17. Quality problem identification, 21. Effectiveness problem identification, 27. Batch complaint warning, 28. User complaint prediction	8	L4	Prediction Intelligence
Schemes	2. Planning scheme, 3. Integration scheme, 10. Processing scheme, 19. Quality optimization scheme, 23. Energy efficiency optimization scheme, 31. Change scheme	6	L4	Control Intelligence

Challenges in the Evolution of Autonomous Network



- There is currently no unified consensus on the technical paths and evolution strategies for advancing towards high-level autonomous networks.
- Key technologies such as network AI large models and generative AI urgently need to accelerate breakthroughs
- How to establish an open and cooperative ecosystem, fostering industry chain synergy to achieve scale advantages, is a critical challenge that telecommunication operators or industry organizations need to focus on during top-level design.

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Key Enabling Technology

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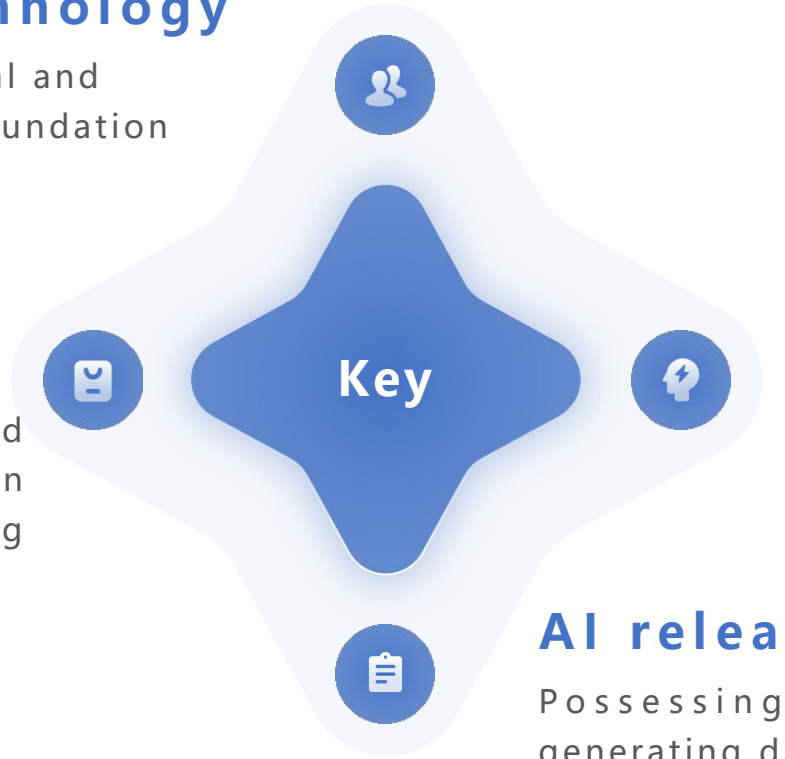
To achieve the goal of reaching Level 4 advanced autonomous networks by 2025, there is a need to focus on exploring the applications of key technologies such as network convergence awareness, network digital twins, intent-driven, generative AI, and others. Through technological innovation, to realize a significant leap in application value.

Network Convergence Awareness Technology

The integration and perception of internal and external network environments are the foundation for achieving autonomous network.

Network Digital Twin Technology

Deliver comprehensive, customizable, and iterative business pre-validation capabilities with network-wide monitoring



Intent-Driven

Key to Enhancing Network Intelligence

AI releated technology

Possessing general understanding capabilities, generating diversity, and featuring boundless knowledge, it serves industry-specific applications.

Relationship between intent and autonomous network

- Intent is the formal specification of all expectations including requirements, goals, and constraints given to a technical system(TMF IG1253)
- Intent can directly originate from humans. e.g. customers expect the system to utilize the underlying infrastructure.
- Intent also arises within the autonomous system, used between subsystems.

A must for autonomous Networks

Based on user specified goals, combined with AI technology to achieve automatic closed-loop, autonomous evolution

Evolution of autonomous domain interface

Interface between autonomous domains has evolved from rule-based/policy based to intent based.

Defines what an autonomous domain is expected to achieve

Leave the details of how to design and operate the network to the internal operations of the autonomous domain.

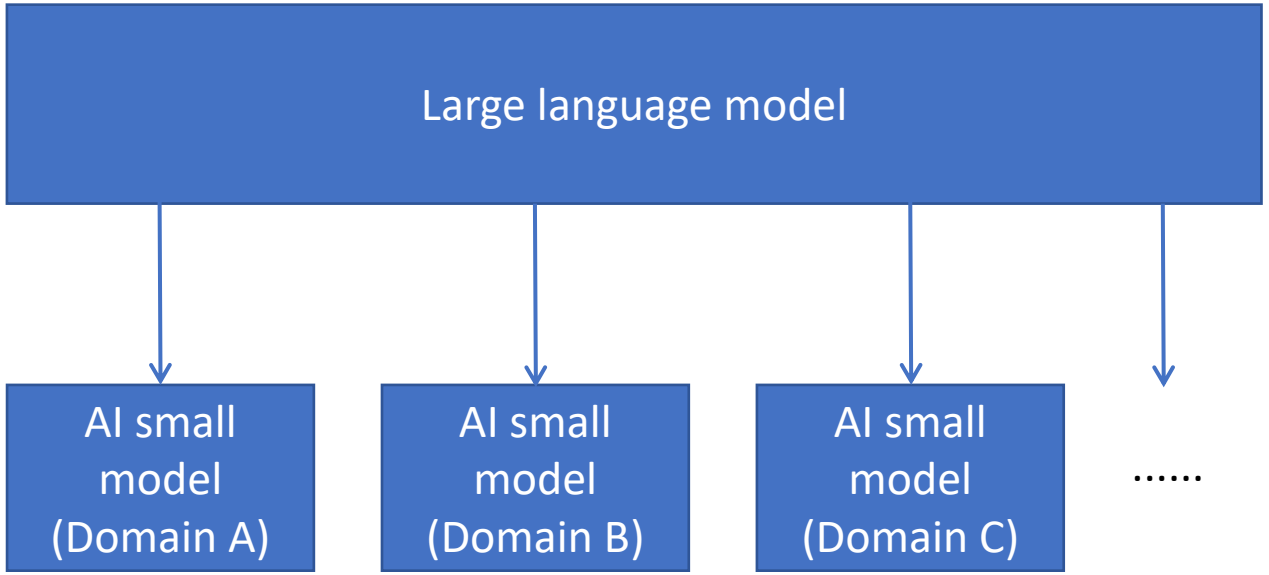
Key Technologies of Closed Loop Management

Closed loop achieves and maintains intent goals through perception, analysis, decision-making, and execution.

Autonomous network

AI introduces entirely new capabilities

By harnessing the unique advantages of new technologies such as generative AI, including 'network panoramic knowledge cognition,' 'emergence of new scenario capabilities,' and 'intent-driven interactions,' it will drive the evolution of traditional networks towards 'intent-driven' networks, bringing a completely new impetus to the digital transformation and upgrading of networks.

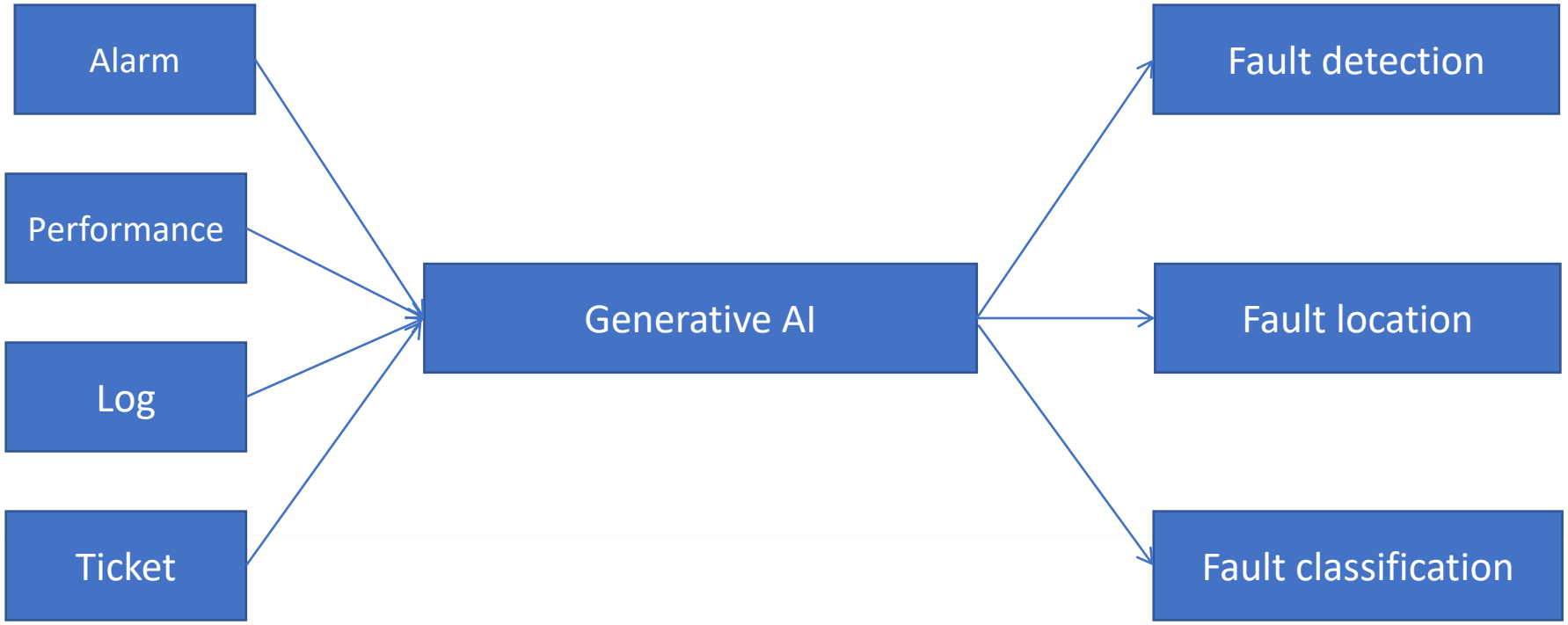


- The AI small models and API capabilities, functioning as a collective, are encapsulated with a large language model serving as an orchestration scheduler at the outer layer.
- These AI capabilities span various areas, including core networks, wireless, government-enterprise solutions, and home broadband, covering a diverse range of scenarios such as perception, diagnosis, control, and prediction.
- Based on user input, the large language model, through understanding user intent, invokes corresponding AI small models and APIs or their combinations.
- Leveraging the capabilities of a multitude of AI small models and APIs, it enhances operational efficiency, with the large language model serving as an interface to provide unified services internally and externally.

AI introduces entirely new capabilities

- The AI releated technology such as generative AI is employed in scenarios such as intelligent diagnosis of networks and intelligent business forecasting, enabling precise analysis of network faults, complaints, vulnerabilities, and quality issues, also facilitates trend predictions for business usage and business quality.

- Through extensive pre-training on structured data and adaptation to various upstream inputs and downstream tasks, this model possesses a versatile analytical capability for different professional network scenarios. When encountering new task scenarios, only a small amount of fine-tuning is required to achieve strong generalization capabilities.



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Intent-Based 5G Blueprint

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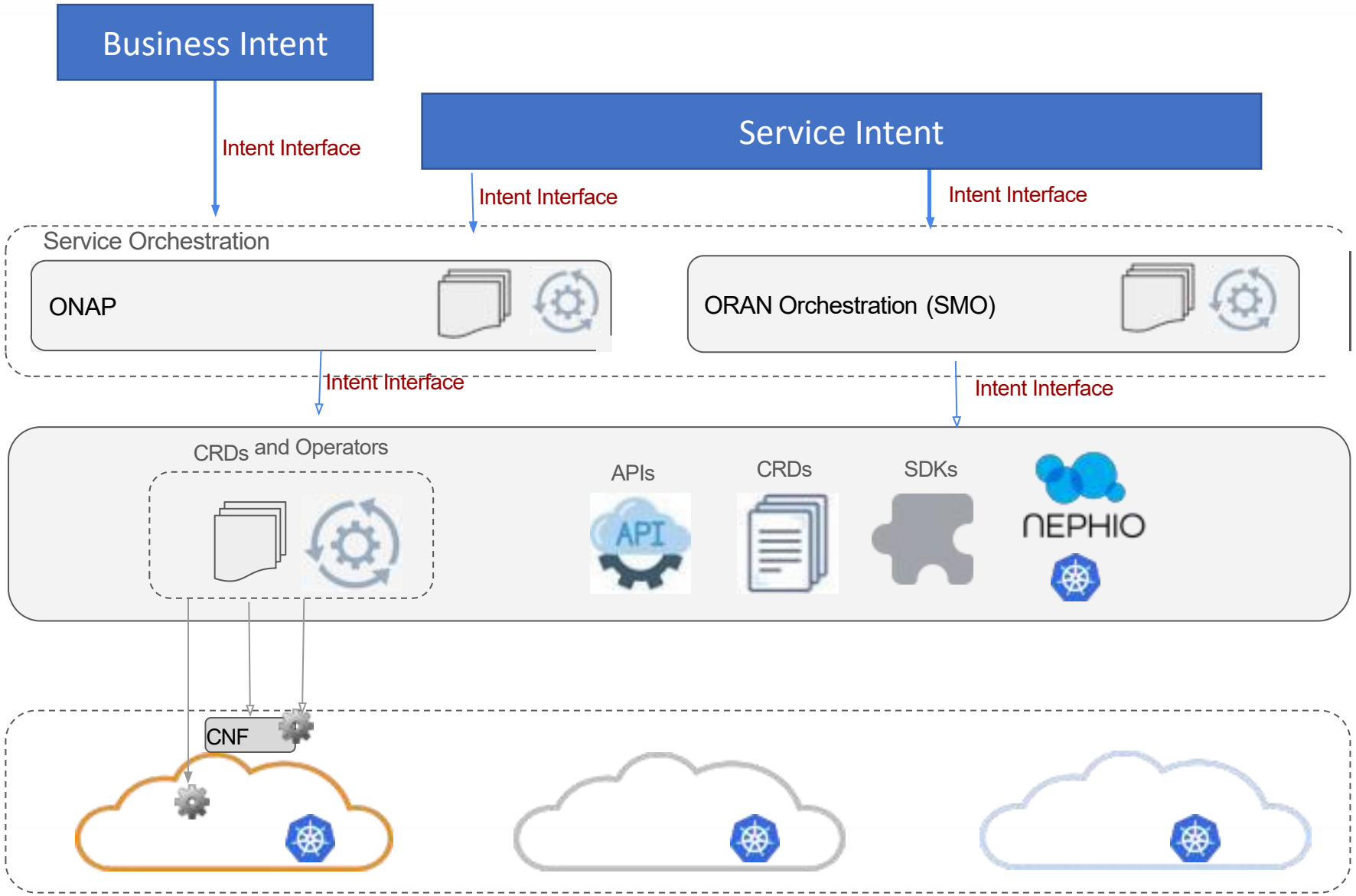

- We hope to handle Business intent, Service intent, and Resource intent.
- The intent interface enabling intent interactions across different layers .
- By incorporating generative AI and other AI releated technologies, the capability for intent processing is enhanced.

Day 0 - Enhancing Customer Experience

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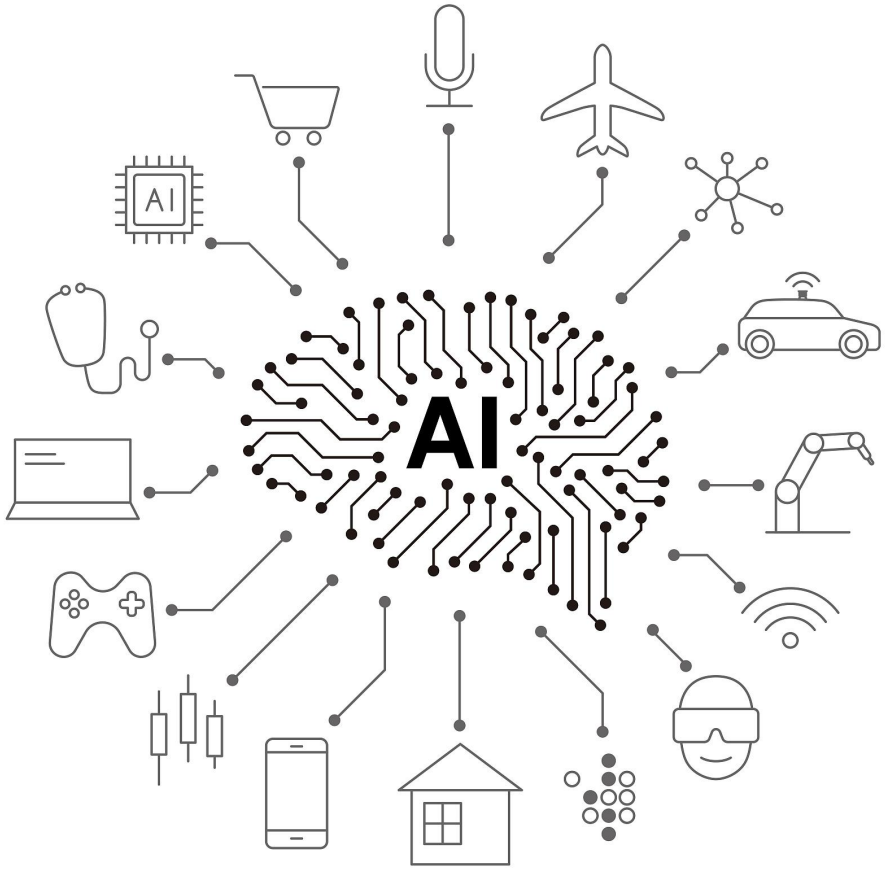
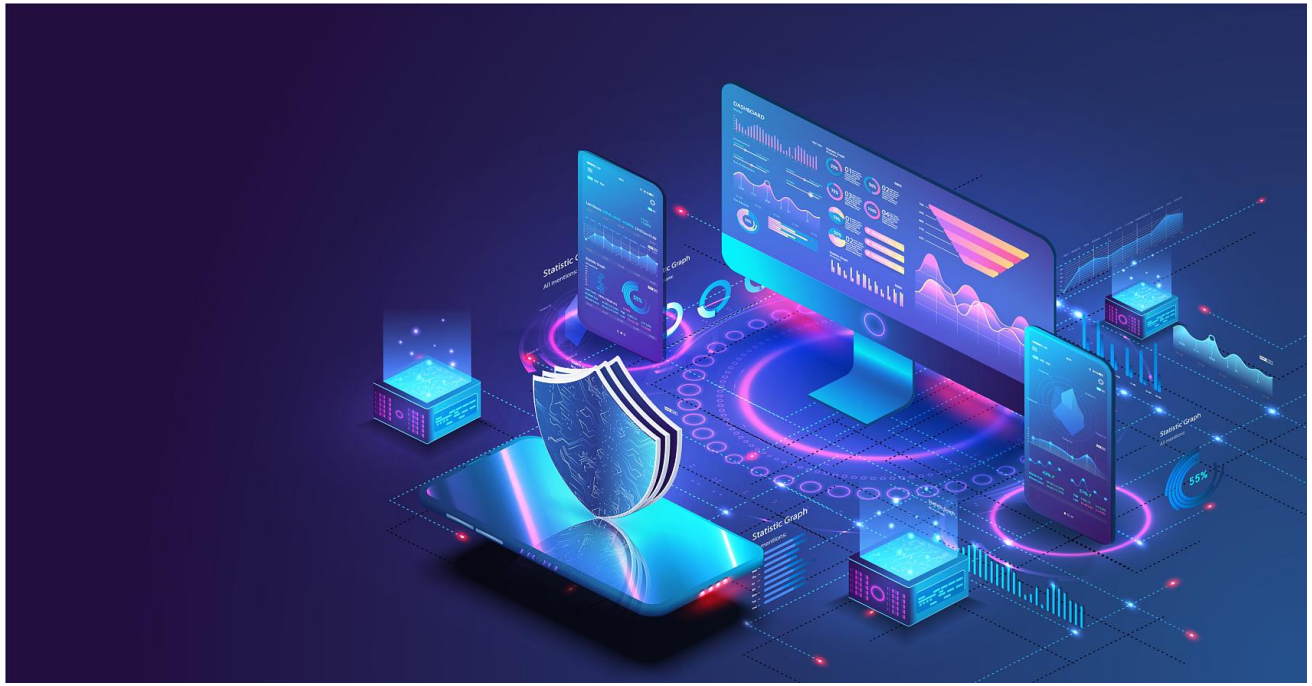


- Generative AI can assists customers in addressing queries and issues, and can even create personalized services based on individual preferences and behavior.
- AI releated technology can assists operations personnel in achieving efficient knowledge and data query applications, simplifying daily operations.
- Generative AI can optimize network planning by predicting requirement and identifying areas that require capacity expansion. This helps telecommunications operators plan and build networks more efficiently, reducing costs and improving network performance.

Day 1 - Enhancing Intent Processing Capability

- Automatically achieve end-to-end intent processing.
  Service Intent ---> ONAP/ORAN ---> Nephio
- Through the code generation capability provided by generative AI, it becomes convenient to add new functionalities, such as implementing network isolation or enhancing security measures.
- Adding the intent for new workflows involves automatically updating the existing business logic to accomplish network changes.

Day2-Provide intelligent assurance



- Network Optimization: AI releated technology can analyze data in network incidents and automatically identify patterns indicative of issues such as network congestion or signal interference. This information can then be used to optimize network performance.
- Predictive Maintenance: AI releated technology can analyze historical and current data to predict potential equipment failures or network interruptions. Predictive maintenance helps telecommunications companies plan maintenance tasks and minimize downtime by identifying patterns and trends.
- Quality of Service: AI can predict where network congestion may occur and allocate additional resources to those areas before congestion occurs.

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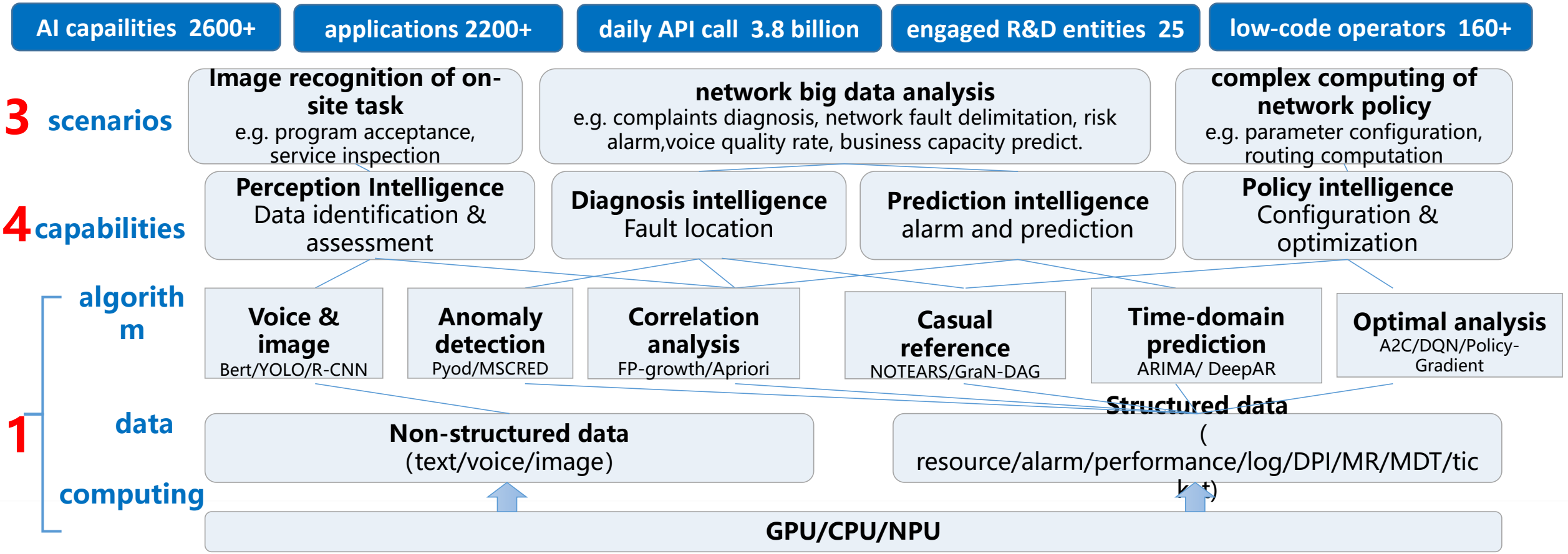
Intelligent network O&M framework

Massive on-site tasks exist in mobile network O&M that requires manual operation, together with the highly complexity of network control policy. strategy. China Mobile innovatively built the "143" framework of intelligent network O&M. Based on self-developped "JIUTIAN" centralized AI platform, we built four categories of AI capabilities of perception intelligence, diagnosis intelligence, prediction intelligence and policy intelligence, and promoted the leap of intelligent network capabilities around 3 scenarios of image recognition, complex computing and big data analysis.



Case 1： Intelligent Identification of Transport Dumb Resources

The equipments of transport dumb resources(such as OLT, light container delivery, etc.) have many features, such as wide range of points and areas, complex network structure, buried underground or overhead, and it is quite difficult to manage. Introducing target detection, image feature retrieval, OCR and other technologies into the lifecycle management of dumb resources can improve the efficiency of resource management, improve the accuracy of resource data, and save resource management costs.

The whole process of dumb resource management

Resource Access

Workflow

- Network planning
- Intelligent planning issuing
- Construction acceptance (AI)
- Intelligent identification of construction standardization
- Resource warehousing (AI)
- Automatically generate resource warehousing information

Resource Scheduling

Workflow

- Before cut-over
- Upload resource panel photo
- After cut-over
- Upload resource panel photo
- Construction order acceptance (AI)
- Automatic comparison of differences before and after construction
- Resource warehousing (AI)
- Automatically generate resource warehousing information

Resource Check

Workflow

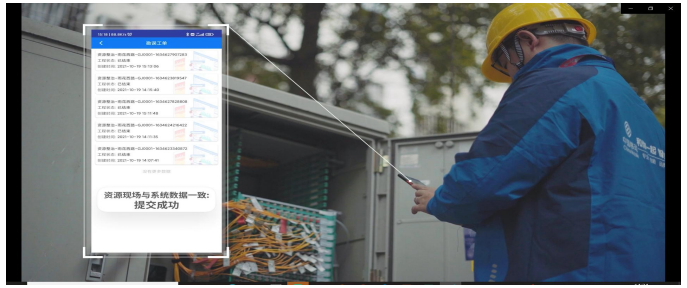
- Periodic check (AI)
- Intelligent check
- Revision process
- Actively initiate resource governance order
- Revision acceptance (AI)
- Automatic quality inspection after resource governance
- Resource warehousing (AI)
- Automatically generate resource warehousing information

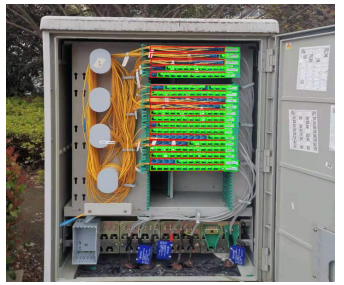
Resource Release

Workflow

- Before withdrawal
- Intelligent trigger judgment
- Ater Withdrawal
- Archiving
- Withdrawal acceptance (AI)
- Automatically compare the differences before and after construction to confirm the resource clearance and connection cancellation
- Resource warehousing (AI)
- Automatically generate resource warehousing information

Example of landing application





Intelligent identification of idle ports
(Statistics of idle quantity)

Intelligent identification of tube well risks
(missing, warped, damaged)

Effect

- After the deployment and introduction of AI, the accuracy of key dumb resource data has been improved by 15%, and processing efficiency improved by more than 90%. The number of problems identified per thousand kilometers has increased by 10% (where maual inspection has been inefficient)

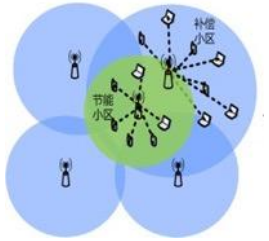
Case 2： Intelligent Energy-saving of Base Station

This case excavates the energy saving time and energy saving sites according to different coverage scenarios and business characteristics, refine the types of cells, and formulate different energy saving strategies to maximize the energy saving effect. At the same time, it introduces a security mechanism to intelligently detect the changes in network perception and user perception, and ensure that user perceive has zero impact.

Space Expansion

Excavate more energy saving cells

Ensure the accuracy of energy-saving and compensation cells



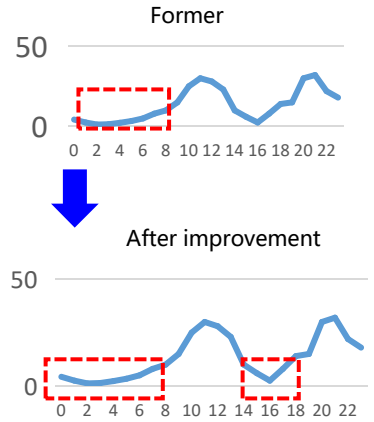
- Add MR/MDT data to supplement and correct the common coverage area
- 4G/5G multi-network cooperation, 5G power-saving shutdown

Time Expansion

Long-term forecast of business trends

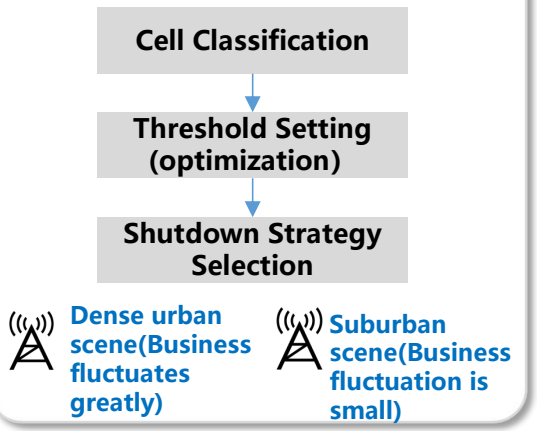
Dig more energy saving time

Expand more from the current 0-6 o'clock



One Policy per Cluster

According to the network coverage, user behavior characteristics, business characteristics and other factors of different scenarios, formulate energy saving schemes for different space-time scenarios



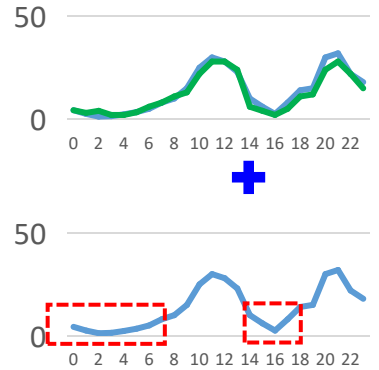
Security Ensurance

Short-term forecast of business trends

Real-time monitoring and query business volume

Network degradation sensitive area filtering

Ensure that the shutdown command is safe and correct



Effect

- After the deployment of the whole network, and the introduction of automation and intelligent means, the power saving ratio is 10%, and the annual saving of the whole network is 3.5 billion kilowatt-hours.

Future plans

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Continuously conducting IBN research

Accurately understand user intents

End-to-end intent closed-loop assurance

LLM

Verification

AI

Domain expansion

Standard Collaboration

Standard and open source

Accurate

Closed loop

General solution

Improve Intent Interaction

Intent Use Cases

Collaborating with other SDOs

SDOs

Target Architecture+
General Technology

tmforum

AN Working Group

ITU

Network AI

3GPP

SA5

ETSI

AN-OCG

ENI

ZSM

NFV

F5G

Industry-AI for Good

Standard-SG13

Intent Model Domain Extension

Domain Model+
Domain Interface

1st Workshop on iNtent drivEn autonomouS neTwORks (NESTOR)

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Upcoming Important Events: The workshop aims to bring together researchers from both academia and industry to investigate challenging aspects in intent-driven management for the 5G and the future 6G systems, as well as to identify future research directions.

Website link: https://www.icin-conference.org/nestor/

Important Dates

- Paper submission deadline: December 21, 2023
- Acceptance notification: January 15, 2024
- Camera-ready paper submission: January 22, 2024
- Workshop: March 11, 2024, Paris, France

Topic:

- Standardization of intent-based management for the telco cloud
- Orchestration frameworks and intent-based management methodologies
- Intent-driven management for the virtualised RAN
- Intent-based management approaches in 5G and towards 6G communications
- Application of intent-based management architectures and frameworks in telecom networks
- Human-to-system intent interpretation through Natural Language Processing (NLP)
- Machine-to-machine intent expression
- Automated intent translation and policy generation
- Automated intent/policy conflict detection and resolution
- Automated intent monitoring and assurance
- Knowledge-driven intent/policy management
- AI-driven intent/policy management
- Intent test and verification before activation
- AI asset management for intent-driven autonomous networks
- Emerging standards, technologies and advances on intent-driven management
- Intent-driven management for real-time and deterministic communications

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Thanks!