IoT Development History and Overview

Foreword

- Internet of Things (IoT) is an important part of the new generation of information technologies and an important development phase in the information era.
- IoT is widely used in network convergence using communications and sensing technologies, such as intelligent sensing, identification, and pervasive computing. Therefore, IoT is called the third wave of global information industry development after computers and the Internet.

Objectives

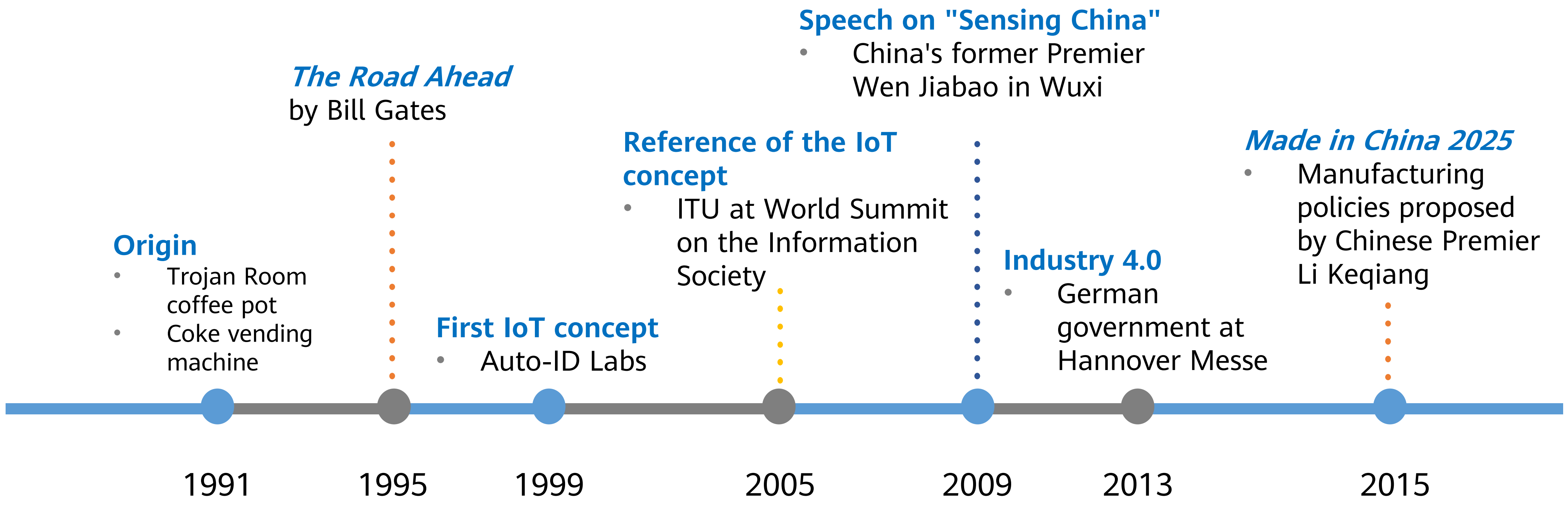
- On completion of this course, you will have an understanding of:
  - IoT development history
  - Basic IoT concepts
  - Layers of the IoT architecture

Contents

Origin of the IoT

- Trojan Room coffee pot in 1991: At the Trojan Room of the Computer Laboratory in Cambridge University, scientists went downstairs to see if the coffee was cooked, but often returned empty-handed.
- To solve this problem, they wrote a set of programs and installed a portable camera next to the coffee pot. The camera was aimed at the coffee pot. Computer image capture technology was used to check at any time whether the coffee was cooked, eliminating the need to go up and down the stairs.

Development of the IoT



IoT Key Events: Evolution of NB-IoT Standards

- The standards of the narrowband cellular IoT (NB-IoT) communications technology NB-IoT were officially initiated in September 2015, and the core standards were frozen in June 2016.

2014	2015	2016	2017		2020
		Rel-13	Rel-14	...	Rel-16
NB- M2M	NB-CIoT	Standards frozen NB-IoT	Enhanced features		Continuous evolution
NB-IoT for LPWA scenarios	Convergence of NB-OFDM and NB-LTE	Deep coverage 10 years battery lifespan Ultra-large capacity	Site location Higher rate Multicast services		Use of NB-IoT in 5G mMTC application scenarios.

After two convergences, NB-M2M evolved to NB-IoT.

IoT Key Events: Commercial Use of 5G

- On October 31, 2019, China Telecom, China Mobile, and China Unicom jointly announced the launch of 5G commercial services and released corresponding packages at the opening ceremony of the China International Information Communication Technology Exhibition. 5G will bring diversified and comprehensive benefits to IoT, and will also promote new solutions and industry chains.

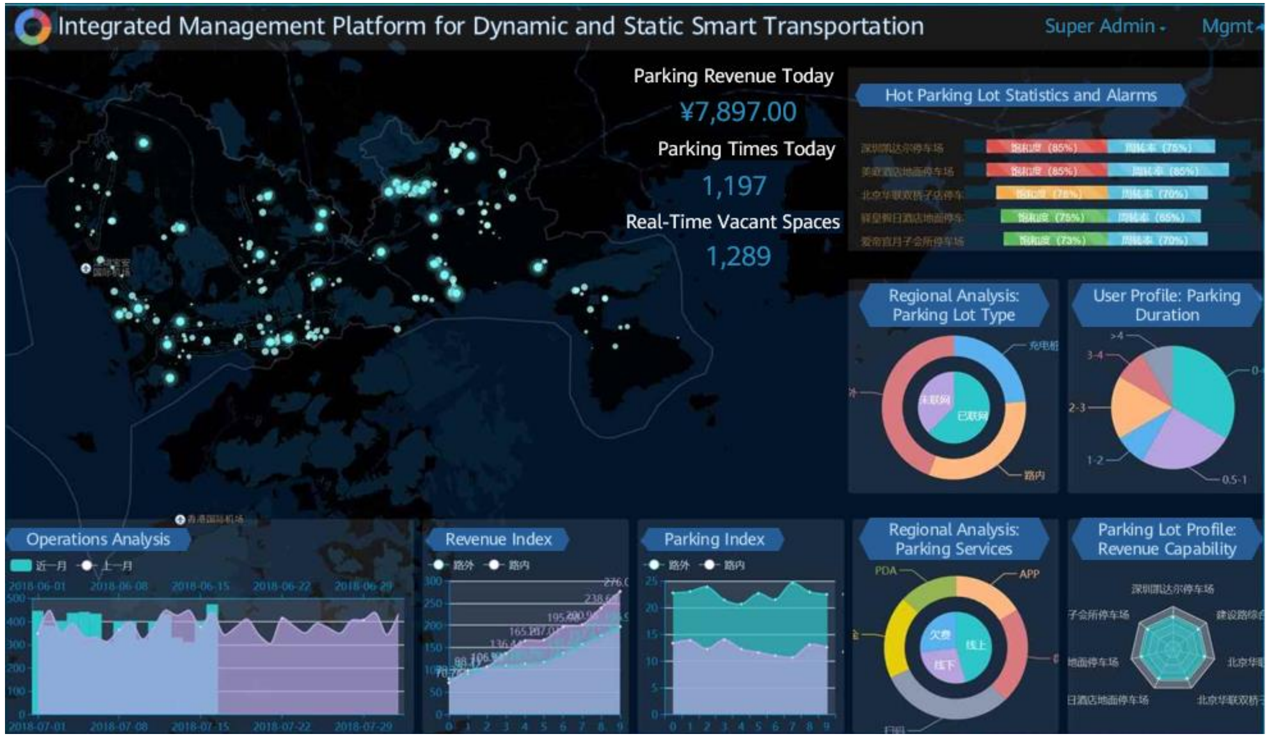
IoT Key Events: SoftBank's Acquisition of Arm

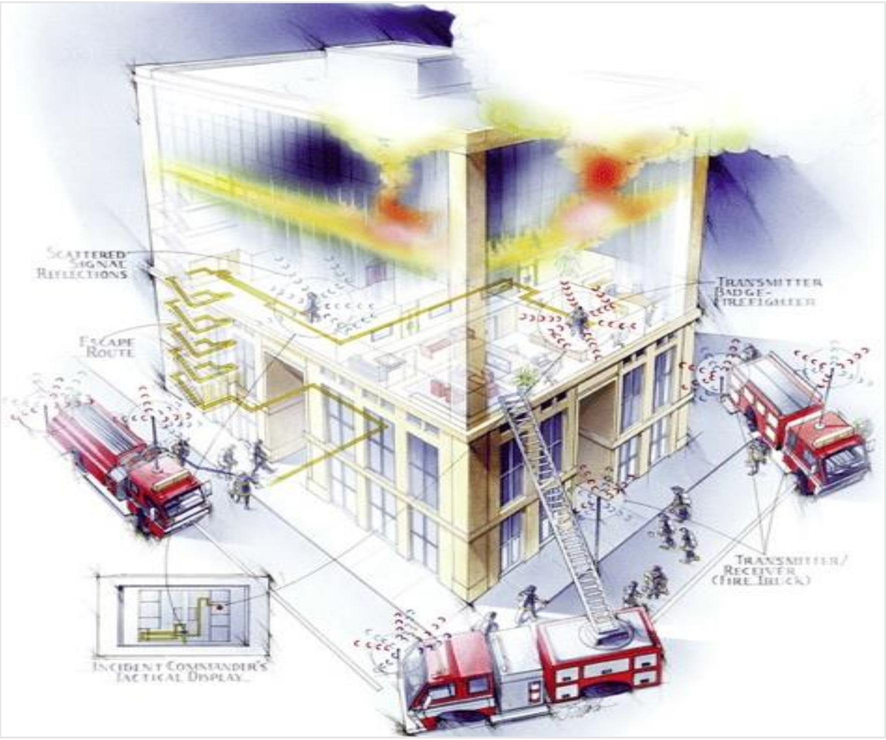
- On July 18, 2016, Japan’s SoftBank and the UK’s Arm announced that they had reached an agreement. SoftBank acquired Arm at GBP 24.3 billion (CNY 202.8 billion, JPY 3.3 trillion).

Development Status of the IoT Industry: Consumption-Driven

- Consumer IoT is directly applied to consumers' IoT products and services. Consumer-related IoT products and services include smart bands, VR and AR glasses, body fat scales, smart locks, smart speakers, shared bicycles and trams, and automated driving vehicles. According to a report released by MarketsandMarkets, the global consumer IoT market scale in 2018 was **$46.8 billion USD**. It is expected to reach **$104.4 billion USD** by 2023 with a compound annual growth rate of 17.39% from 2018 to 2023.

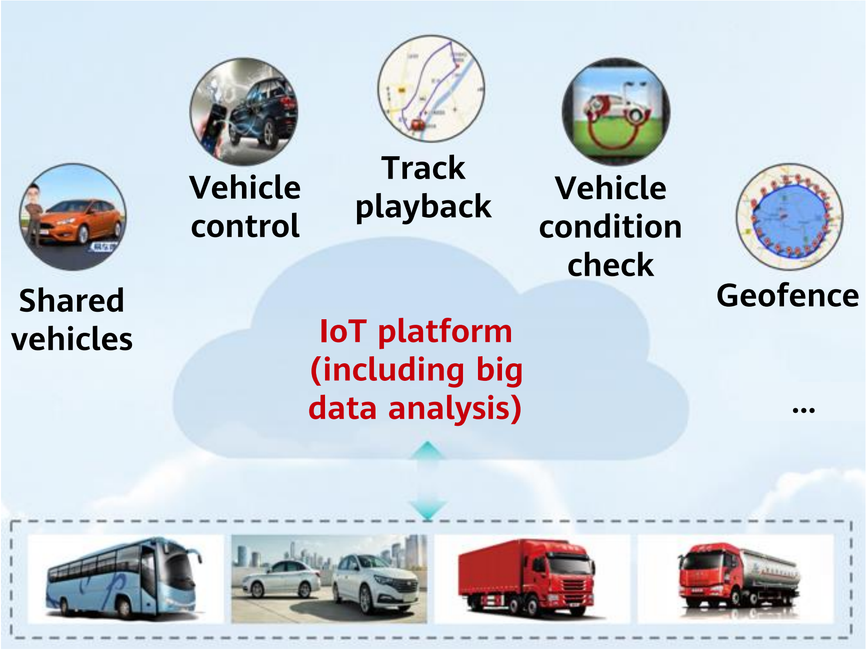
Development Status of the IoT Industry: Policy-Driven





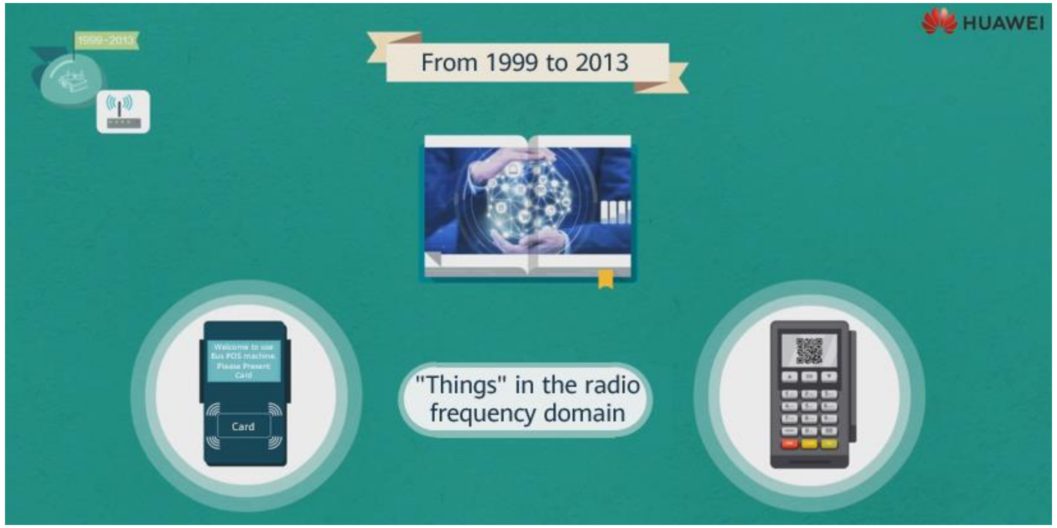
- Policy-driven applications mainly cover city management scenarios, such as firefighting, security, system integration, public utilities, lighting, and parking.

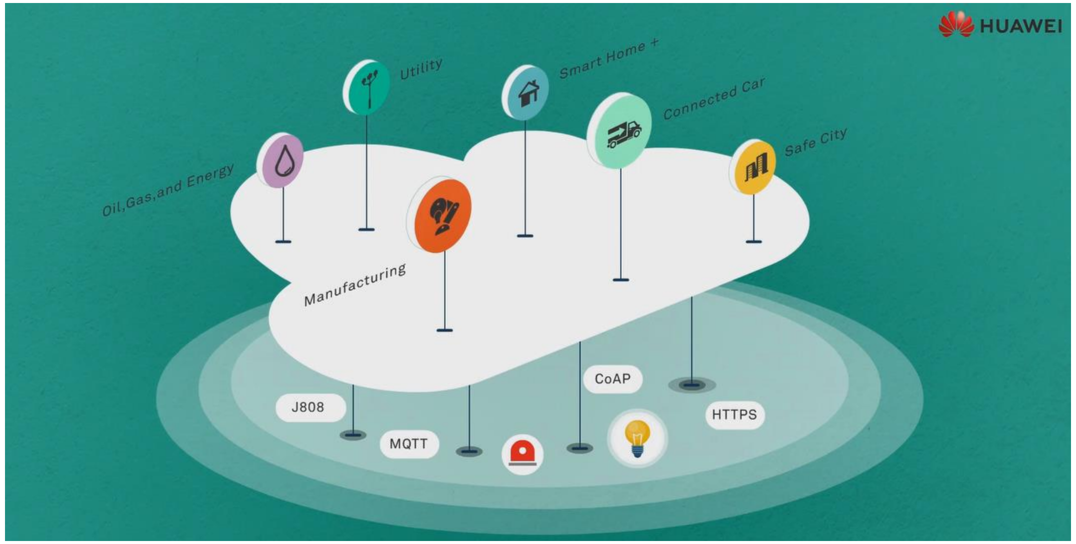
Development Status of the IoT Industry: Industry-Driven



- Industry-driven applications are mainly oriented to business customers. Relevant industries include smart industry, Internet of Vehicles (IoV), smart logistics, and smart agriculture.

Penetration and Development of IoT in Industries





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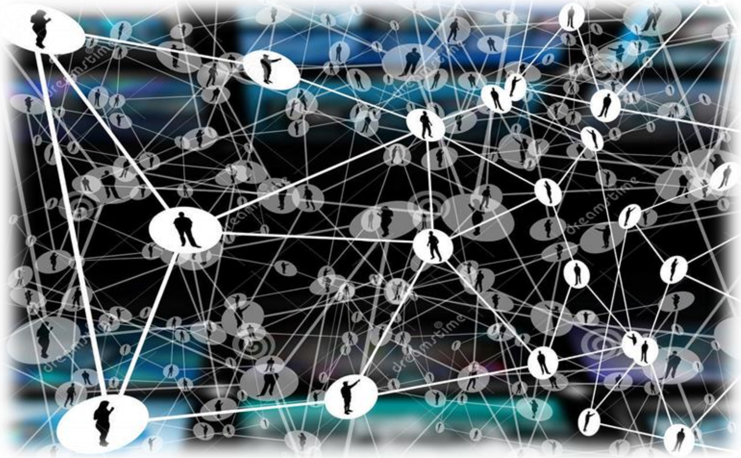
IoT Overview

- The concept of IoT was first proposed by MIT in 1999. The early IoT was a network based on RFID technology and devices. It combined objects with the Internet using the agreed communication protocols to implement intelligent identification and management of objects and realize interconnection and information sharing.
- IoT serves as a network that enables information sensing devices, such as QR code scanners, RFID, infrared sensors, global positioning systems, and laser scanners, to **connect any item with the Internet** for information exchange and communications based on agreed protocols. As such, IoT can facilitate intelligent identification, location, tracking, monitoring, and management (ITU).
- IoT is an Internet **where all things are interconnected**. This sentence has two meanings. First, the core and foundation of the IoT is still the Internet. IoT is an extended network based on the Internet. Second, the IoT connects any thing at the user end for information exchange and communication (Baidu Baike).

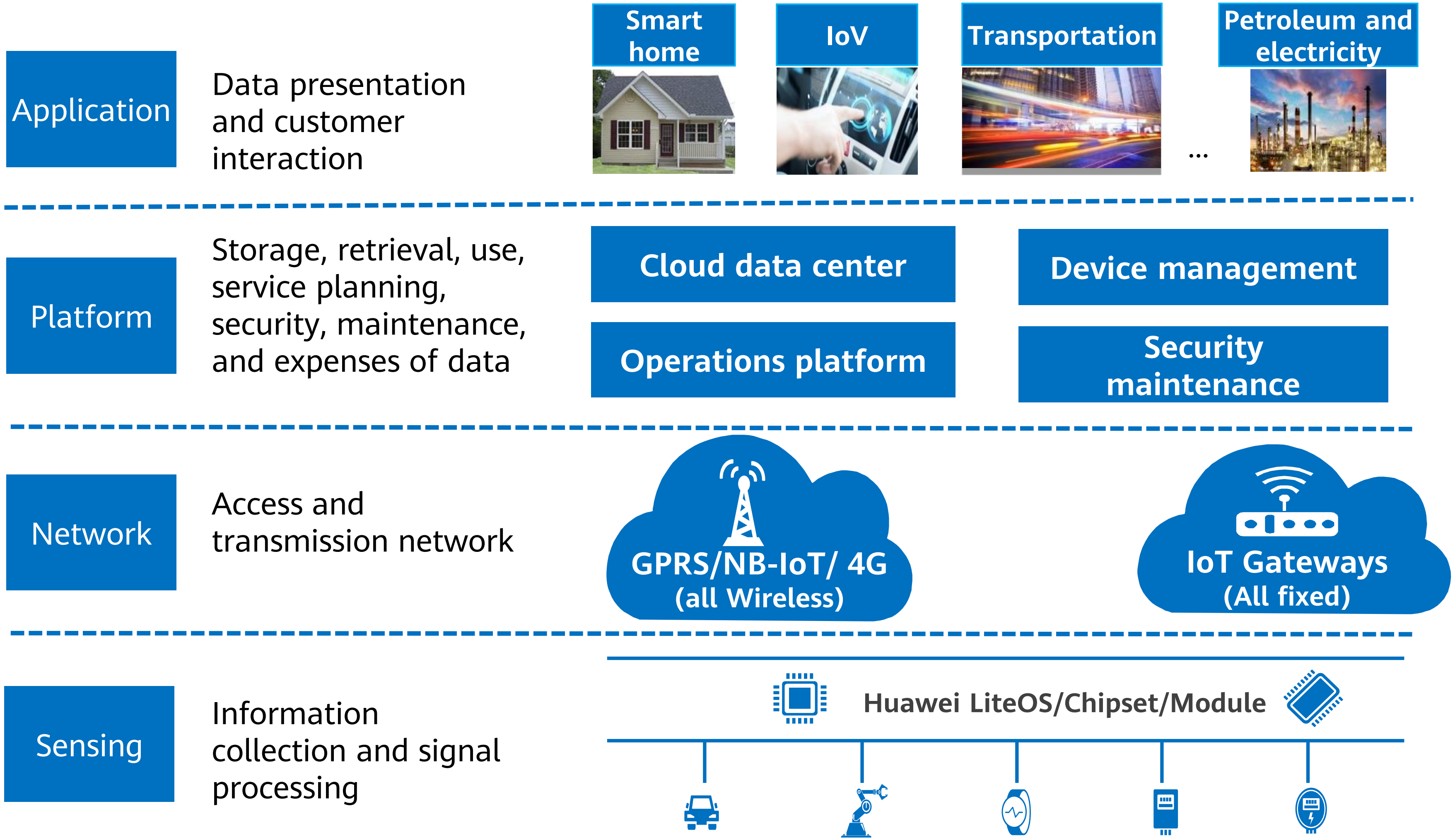
IoT: From Internet of People to Internet of Things

Internet of People



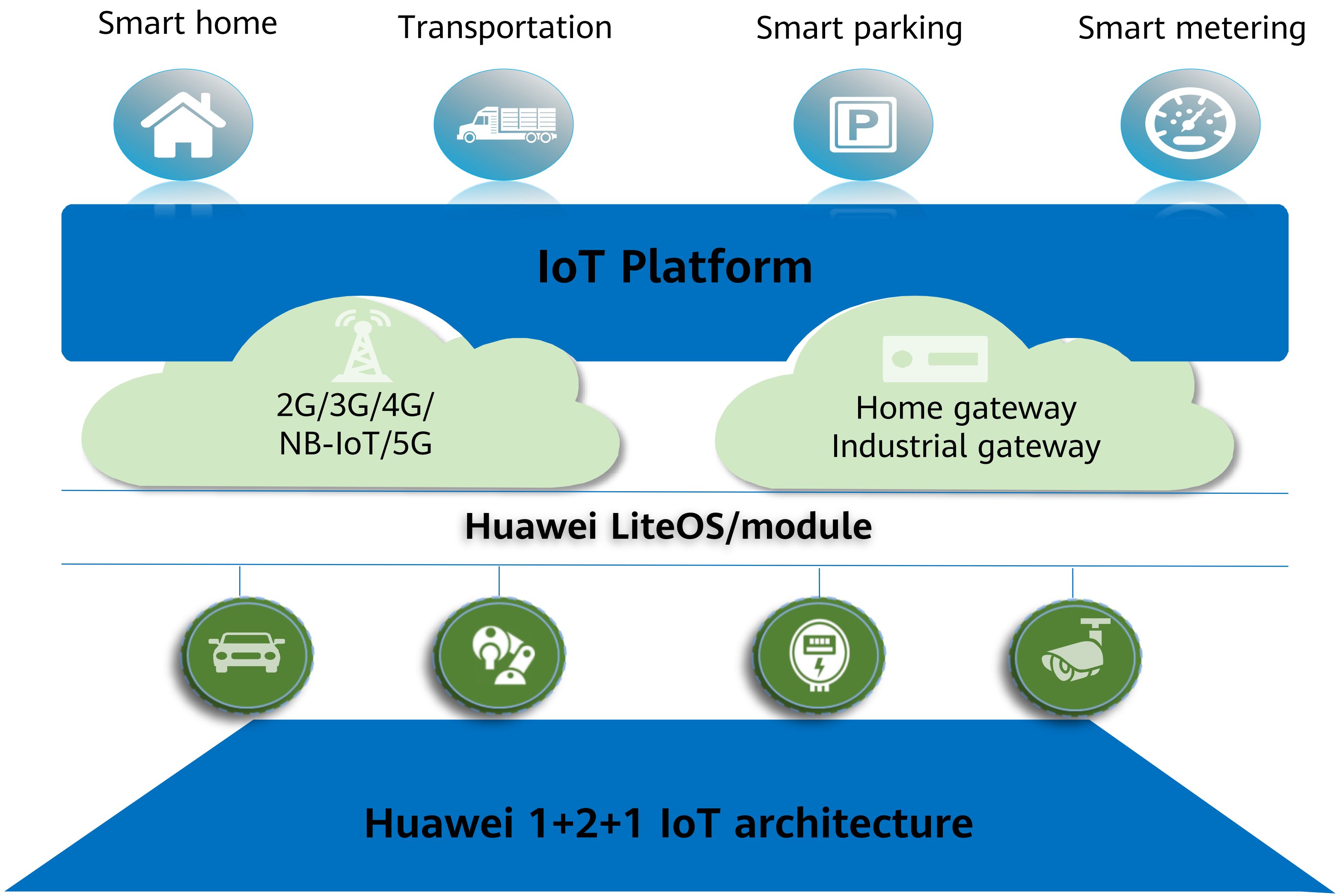
Internet of Things

Layers of the IoT

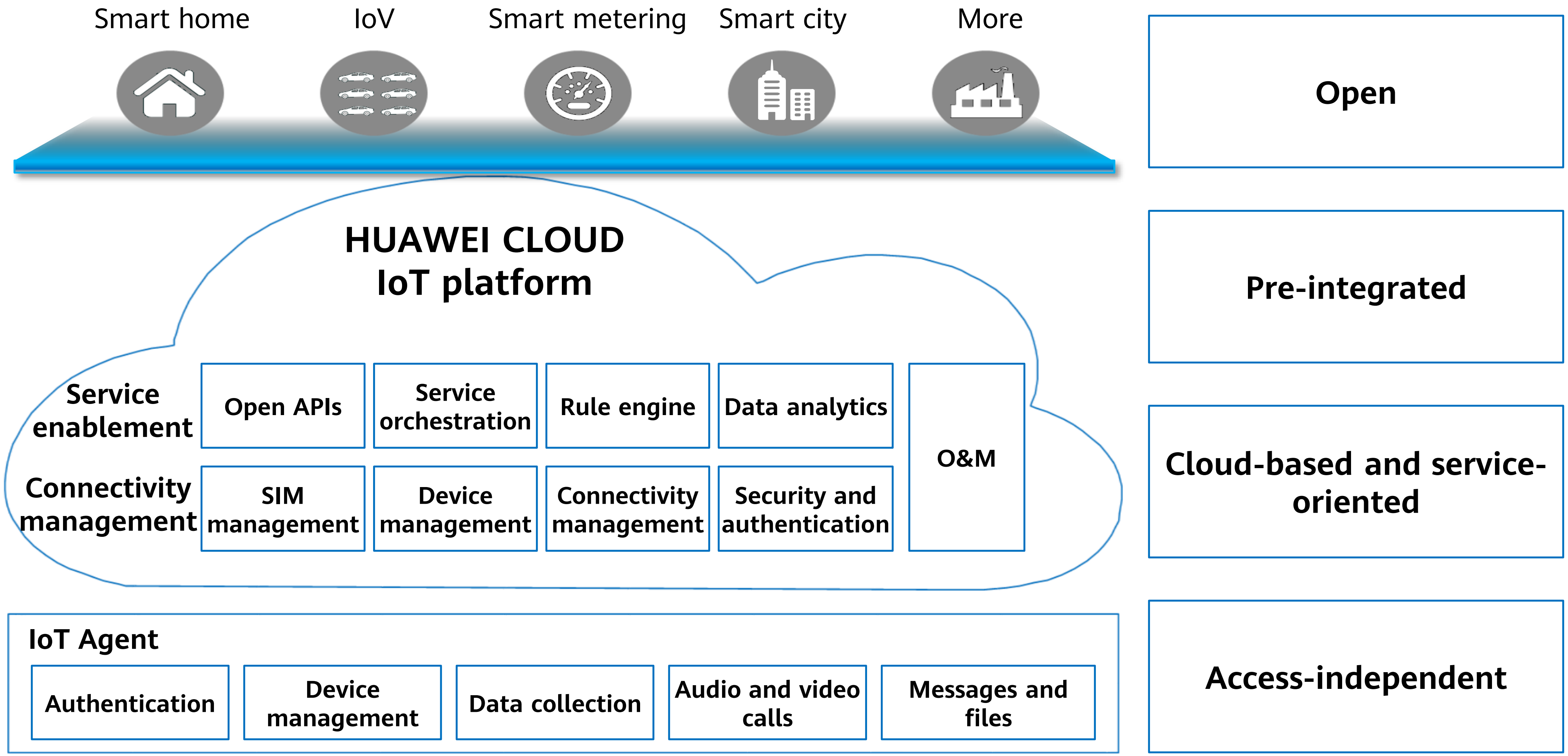


Contents

Huawei 1+2+1 IoT Solution Architecture

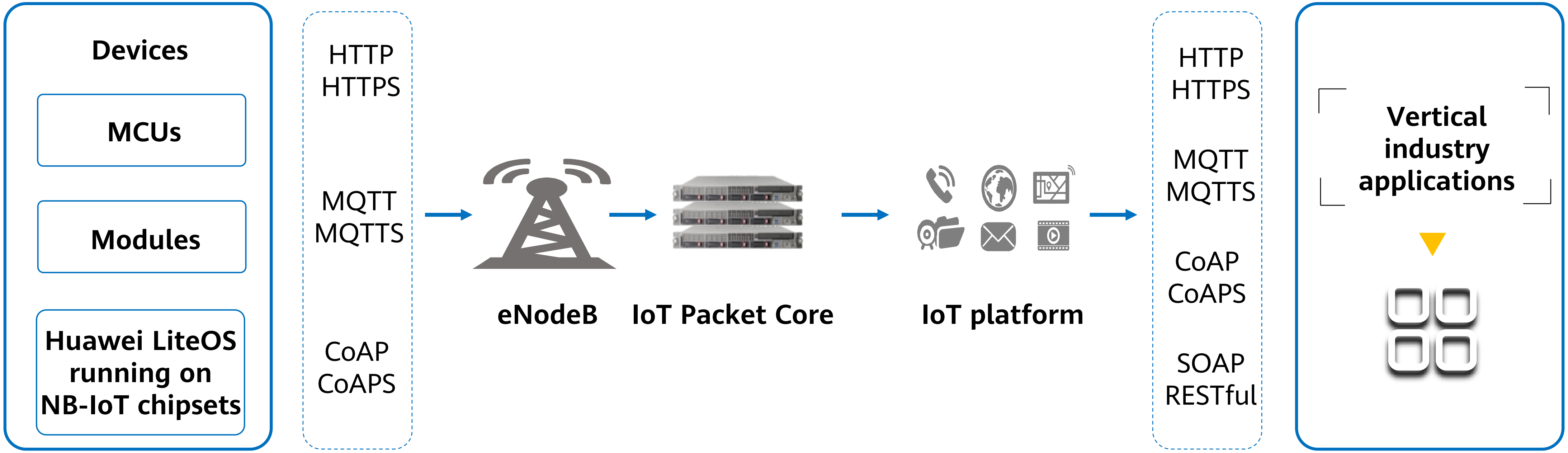


Overall Architecture of HUAWEI CLOUD IoT Platform

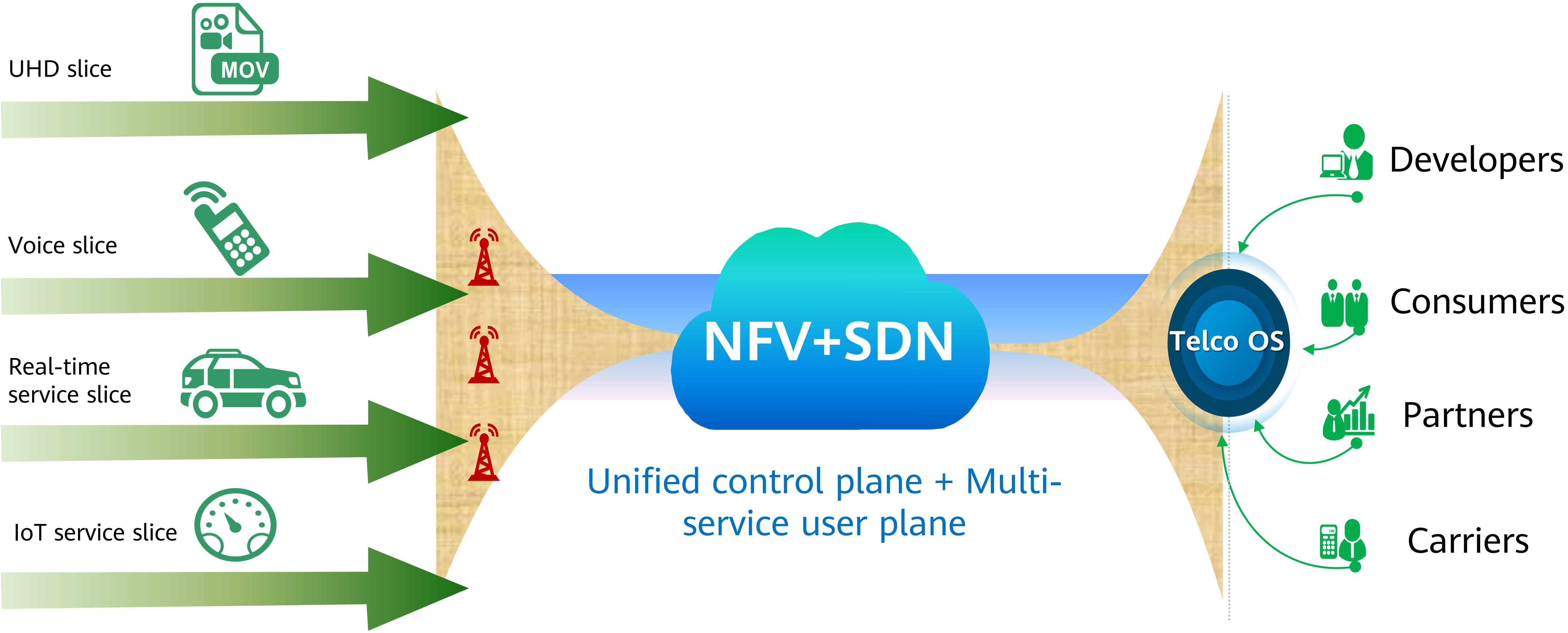


NB-IoT: Connecting Device Fleets Using Cellular Networks

- NB-IoT end-to-end solution



5G Architecture: One Network Supporting Hundreds of Industries



QoS slices defined by industry requirements

Architecture based on cloud and big data

Operations based on Internet architecture

Industrial IoT Gateway

....

Agile AR

Industrial switching/Industrial routing/Built-in computing

Industrial-grade design

Shockproof/Waterproof/Dust proof/Anti-electromagnetic

+

Various interface support

ZigBee/RF/Bluetooth/
RS-485/RS-232/DI/DO/more

+

Complex protocol adaptation

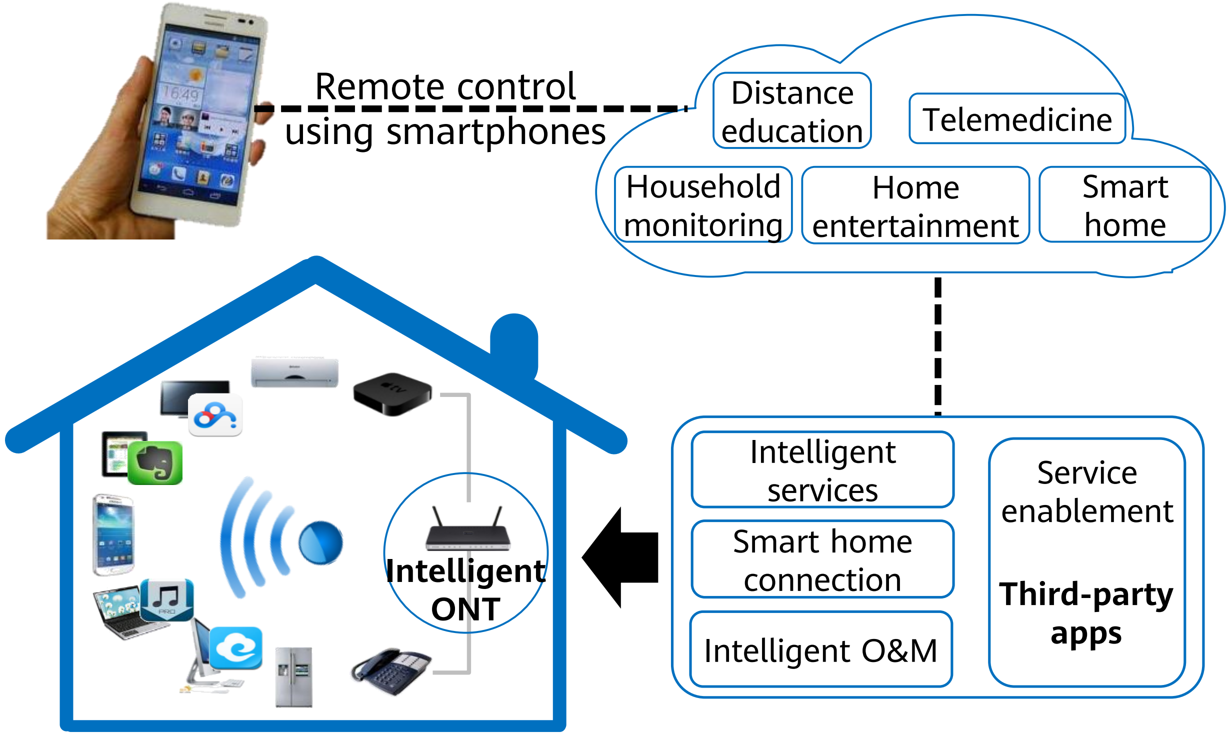
CAN/Modbus/
IEC 62056/IEC 104
/more

+

Local intelligence

Local computing and storage

Fully Open Smart ONT



Intelligent services

FBB, MBB, and digital home services in one bill

Smart connectivity

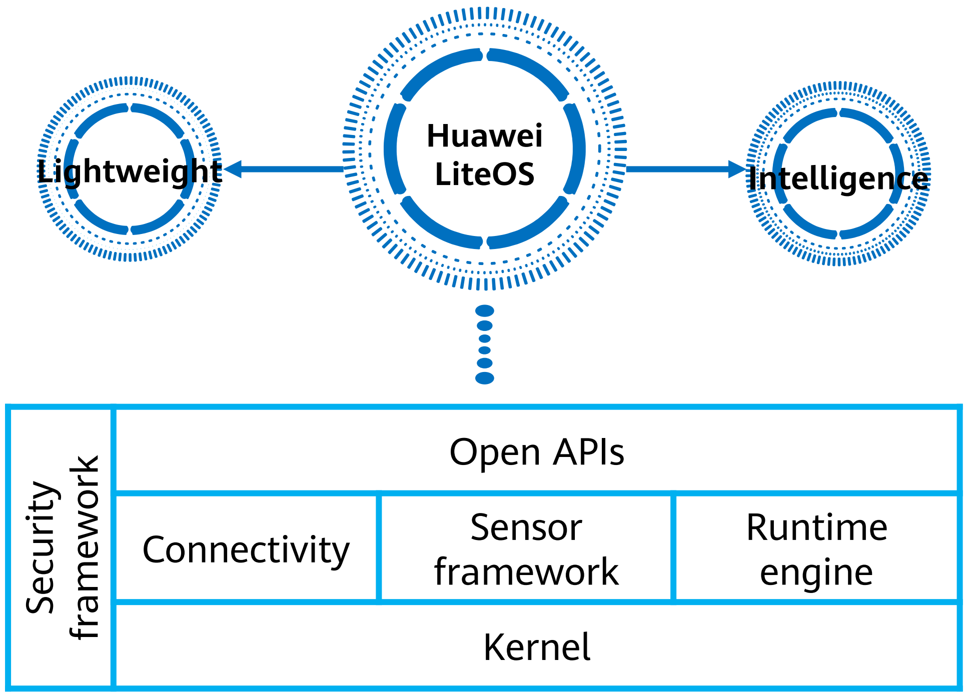
1 Gbit/s full Wi-Fi coverage home solution

Intelligent O&M

Self-service troubleshooting and remote test and diagnosis

- **Mass market:** Wi-Fi coverage, security, energy management, and digital home
- **Entry control point:** The ONT, as the entry point to homes, becomes a value control point.
- **Digital home is coming:** AT&T and PCCW launched smart home security services.

Lightweight, Intelligent Huawei LiteOS



[KB-level kernel]

[Milliwatt-level power consumption]

[Microsecond-level response]

Shorter time-to-market for devices

- Support for connection and device management by industrial protocol stacks
- Support for Huawei and third-party platforms
- Supports HiSilicon and third-party chipsets

[Intelligent sensing]

- Delay reduction
- Accuracy improvement

[Intelligent connection]

- Support for short-distance and long-distance protocols
- Automatic networking

[Intelligent application]

- Chip-level application virtual machine

Quiz

1. (T or F) IoT is an Internet where all things are interconnected. This sentence has three meanings.
2. (Multiple-choice) Which of the following belong to the hierarchical architecture of IoT?
   A. Sensing Layer
   B. Network Layer
   C. Platform Layer
   D. Application Layer

Summary

- In this course, you learned about the origin and history of IoT development and the four-layer architecture of IoT.
- You also learned about Huawei's solutions in the IoT industry based on the four-layer architecture.

Thank you.

把数字世界带入每个人、每个家庭、
每个组织，构建万物互联的智能世界。

Bring digital to every person, home, and organization for a fully connected, intelligent world.

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IoT Network Applications and Solutions

Foreword

- With the development of Internet of Things (IoT) technology, its impact has penetrated into every aspect of society. IoT technology is applied everywhere, from smart home to smart city.
- This slide analyzes existing problems in five IoT industry scenarios: smart city, smart campus, AMI, IoV & DRIS, and industrial Internet. It also describes solutions provided by IoT technologies and success stories. Finally, it introduces the development trends of intelligent connection of everything based on other emerging technologies.

Objectives

- After completing this course, you will be able to understand:
  - Common problems in smart cities and corresponding solution
  - Pain points of smart campus management and corresponding solutions
  - Requirements for reducing the power consumption of the smart grid and corresponding solutions
  - Driving forces of IoV development and the corresponding solutions
  - Requirements and challenges of industrial IoT and the corresponding solution
  - Technologies such as 5IABCDE and the development trends of intelligent connection of everything

Contents

Overview and Objectives

- The following three conditions must be met for IoT to reach the next stage: high population density, strong industrial base, and an integrated national market. Only China meets these three conditions. In November 2008, IBM put forward the concept of Smarter Planet. Later in August 2009, they released the Smarter Planet Wins in China plan, officially unveiling their Smarter Planet strategies in China.
- Smart City is a pilot project inspired by Smarter Planet. It covers a large number of application scenarios and faces many difficulties and challenges. This section describes the challenges encountered by Smart City in different domains and their corresponding solutions.

Common Problems - Traffic Management

Frequent traffic congestion and accidents

Congestion is a pressing issue. Accidents occur frequently due to drivers disregarding traffic laws.

Increased travel time

Heavy traffic significantly increases travel time and lowers commute satisfaction.

Increased pollution

Low driving speeds caused by congestion result in low energy use efficiency, which results in more pollution.

Common Problems - Parking Management

Parking management

Imbalance
- Lack of resource integration and sharing
- Severe tidal effects

Inconvenient charging
- Low labor efficiency and high costs
- Frequent payment evasion

Difficult inspection
- Low efficiency
- Difficulty confirming paid fees

Increasing congestion
- Time wasted locating parking spaces
- Lack of guidance and reservation services

Parking experience

Difficulty finding parking spaces
- Difficulty locating empty parking spaces
- Lack of parking guidance facilities

Difficulty finding vehicles
- Difficulty locating parked vehicles
- Difficulty navigating complex environments

Difficulty entering and leaving parking lots
- Inconvenient parking, card collection and payment
- Congestion at parking lot entrances and exits during peak hours

Outdated payment systems
- Congestion due to manual charging
- Lack of charging modes

Common Problems - Street Lamp Management

Reliable lighting

Provides reliable lighting for urban roads, which is the core responsibility of the Street Lamp Administration.

Emergency lighting

Starts the emergency lighting in bad weather or special weather during daytime.

Simplified O&M

Promptly detects and repairs faulty street lamps. Considers the employment impact when applying advanced technologies.

Asset management

Protects street lamps from being damaged or stolen.

Energy conservation

Turns off lights on time after daybreak. Reduces illumination in the middle of the night. Lowers brightness when there are no pedestrians or vehicles.

Revenue growth

Rents lamp poles to advertisement companies and tower companies for profit. (It is difficult to obtain commercial benefits with current systems.)

Common Problems - Firefighting Management

- Nine small public areas are vulnerable in urban fire safety.
  - Fire risks: chaotic environment, group rentals, random stacking of flammable things, and electricity piracy
  - Weak firefighting facilities: no firefighting facilities or outdated firefighting equipment
  - Delayed fire warning: delayed fire detection and insufficient fire information due to the time-consuming manual inspection

Firefighting facility issues

Flammable material stacking

Old cables

Common Problems - Manhole Cover Management

- Manhole covers are embedded in city streets like screws on giant machines. The manhole covers belong to administrative departments for water, communications, gas, heat, power, and traffic management. Problems of manhole cover management are as follows:
  - Difficult management due to large quantity
  - Disordered identity management due to complex ownership
  - Theft, loss, and shifting
  - Secondary injuries due to security risks




Common Problems - Environmental Sanitation Management

Outdated

Outdated facilities, high O&M costs, low work efficiency, and poor work quality

Low

Outdated management models, limited management methods, lack of basis for decision-making, and serious resource waste

Chaotic

Inconsistent operating standards, random operating status, serious interference caused by human factors, and difficult command and dispatch

Slow

Lack of innovation, slow overall development, slow application of new modes, new devices, and new concepts, low informatization levels, and high management cost

Summary of City Management Issues

Unclear background information

The informatization rate of manhole covers, street lamps, garbage cans, garbage stations, trees, pipelines, dangerous sources, and bridges is low. Manual inspection is heavily relied on.

Untimely issue identification

Issues such as road occupation, facility damage, and garbage overflow cannot be detected on time. As a result, there is little interaction between citizens, and public satisfaction is low.

Difficult collaboration across departments

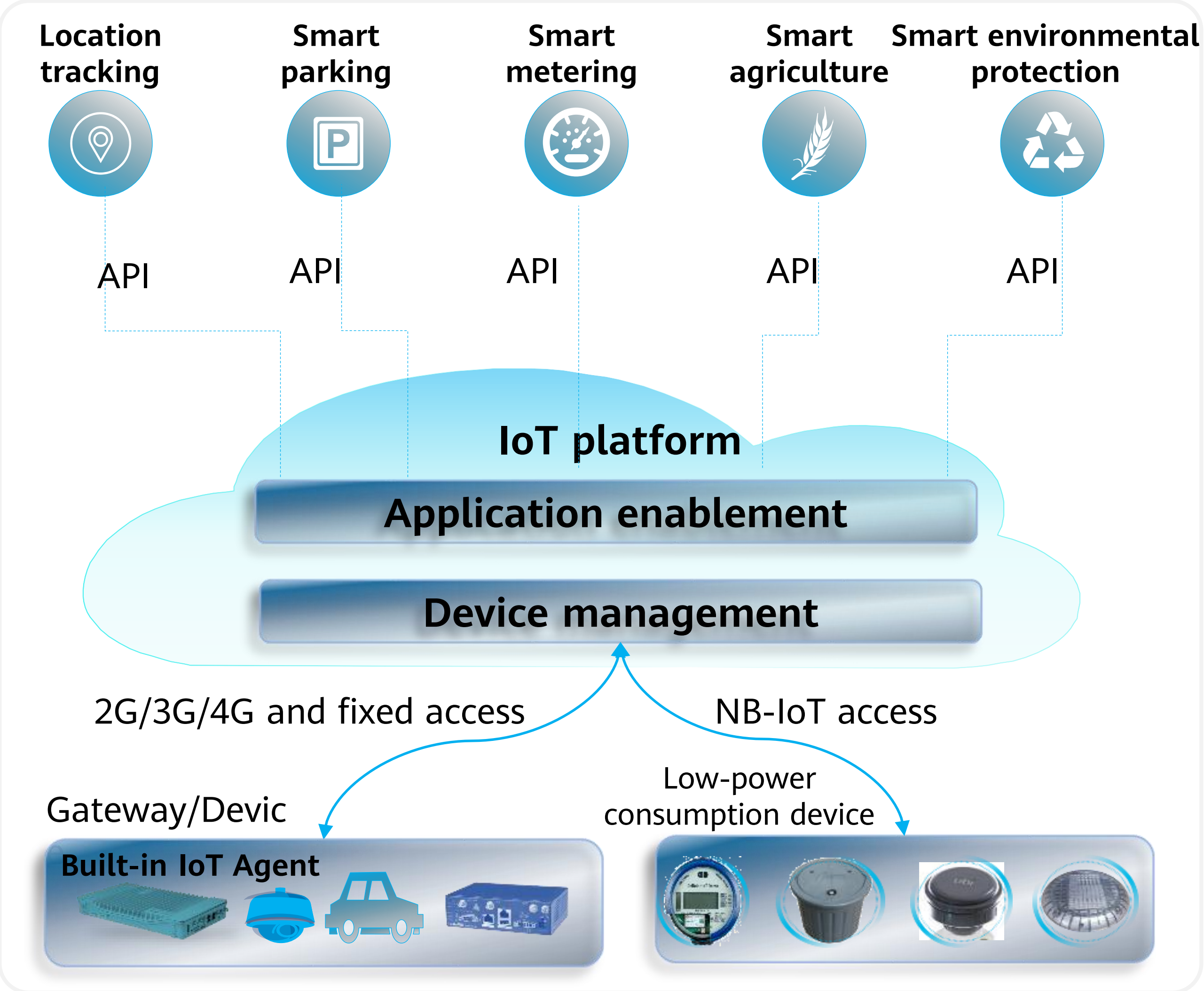
Incidents such as random unloading of slag trucks and water pipe bursts involve multiple departments, such those for sanitation, law enforcement, gardening, city appearance, housing and construction, environmental protection, public security, transportation, and civil affairs. These departments are difficult to coordinate.

Difficult decision-making across isolated systems

Issues include repeated platform construction, isolated systems, difficult data aggregation, lack of a unified data analysis and decision-making systems, and lack of bases for scientific decision-making

How do we use innovative technologies to achieve smart city management?

Smart City Solution

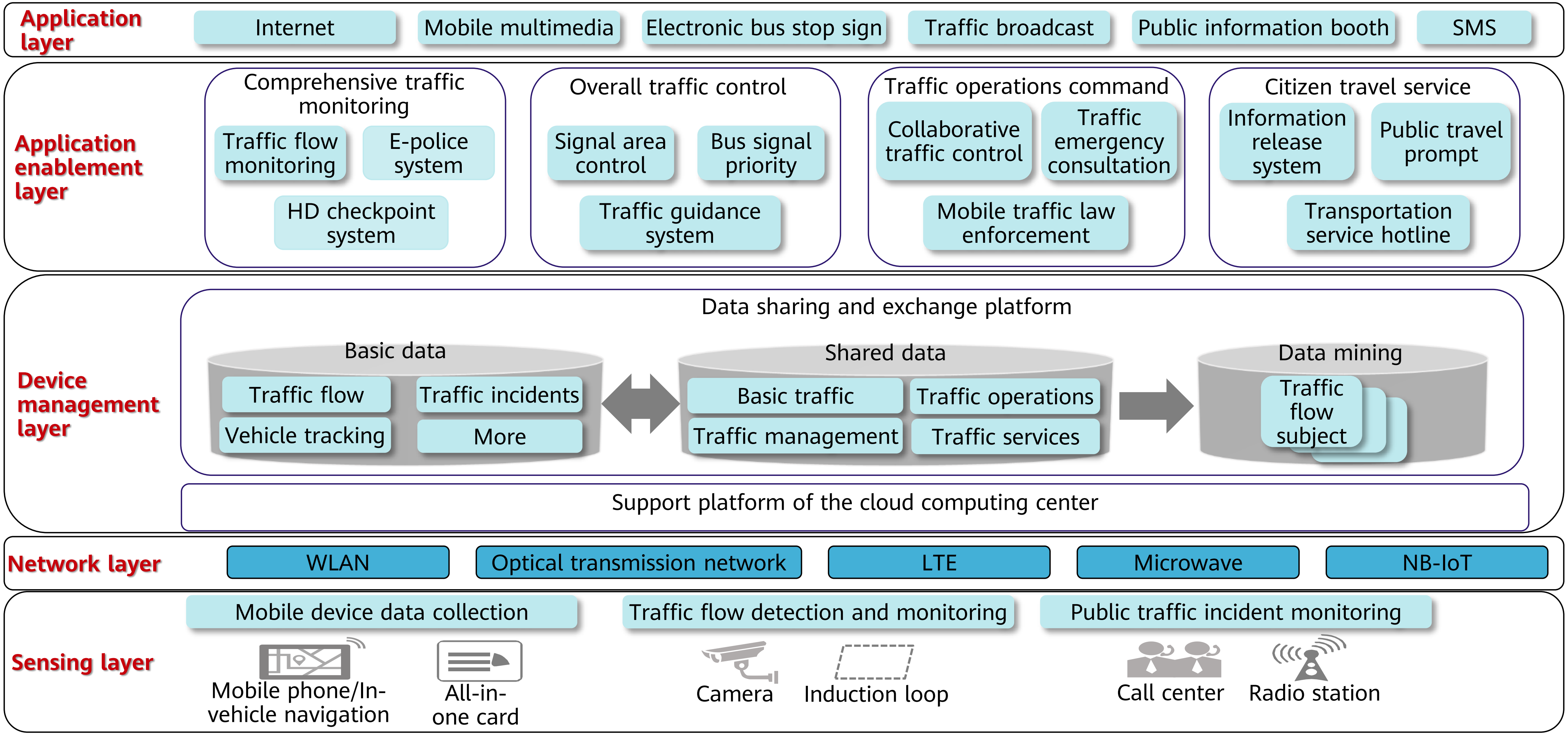


Simplifies development of IoT applications.
Incubates and enables an urban IoT ecosystem.

Aggregates real-time urban IoT data to provide real-time decision-making support for the comprehensive city management system.

Provides unified access standards for IoT applications and devices to prevent fragmented IoT application access.

Smart Transportation Solution (1)



Smart Transportation Solution (2)

Relieve traffic congestion

- Constructs application systems such as e-police, speed detection, signal control, and guidance systems to maximize traffic guidance, reduce traffic accidents, and reduce accidents and property loss.
- Improves road patrol methods and patrol efficiency by displaying road conditions in multiple modes to implement electronic and automatic patrol.
- Uses mobile law enforcement to efficiently and quickly process traffic violation information, vehicle information, and driver information.

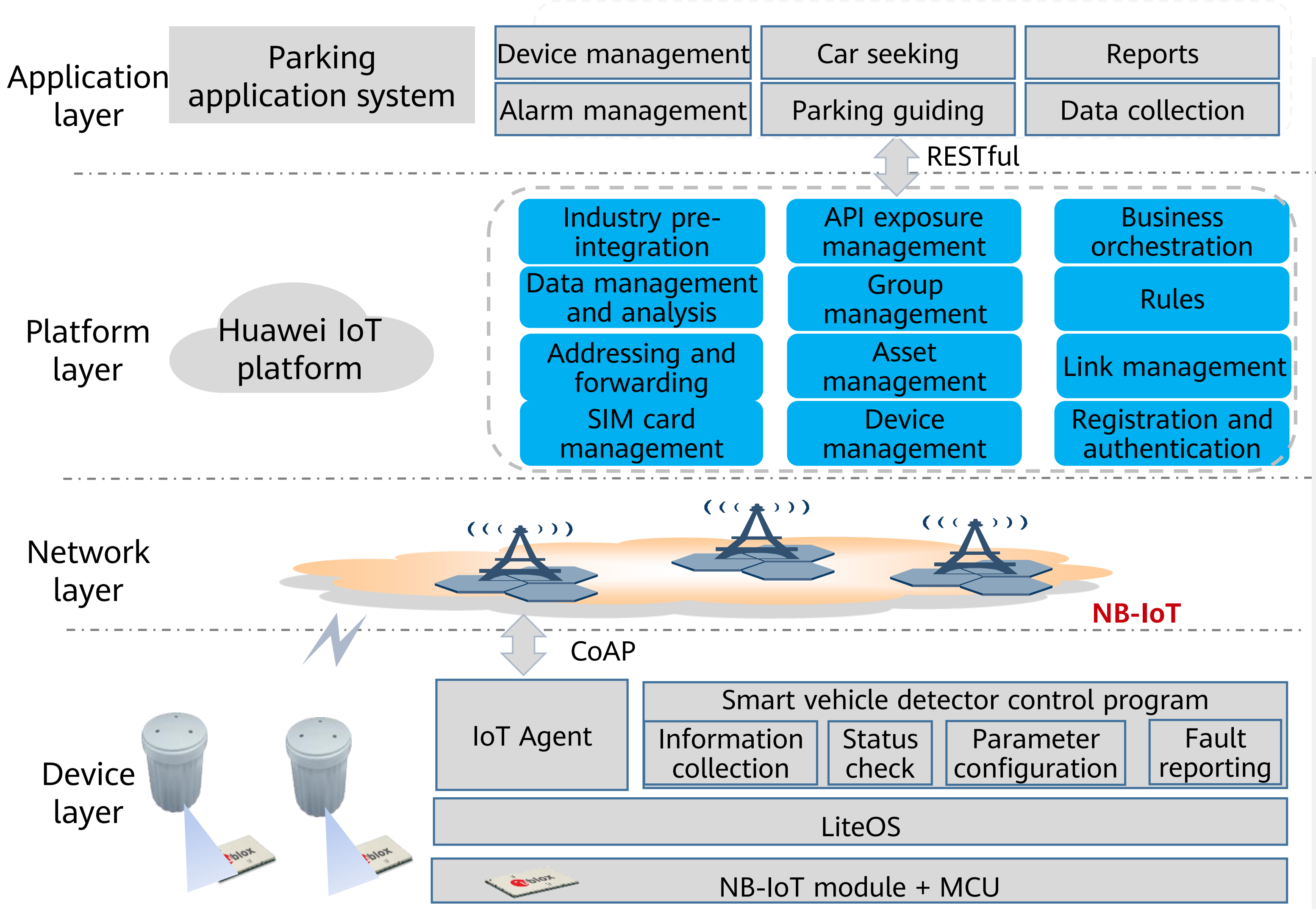
Facilitate citizen travels

- Collects details about rush hour commutes to optimize travel routes and reduce travel times.
- Citizens can obtain real-time traffic details and plan travel routes accordingly.
- Reduced commute times improve citizen satisfaction.

Improve environmental protection

- Smooth traffic improves vehicle speeds and reduces emissions.
- Optimizes public transportation to encourage citizens to choose public transport and reduce exhaust emissions.
- Improves urban environments so that citizens choose eco-friendly travel modes to further reduce emissions.

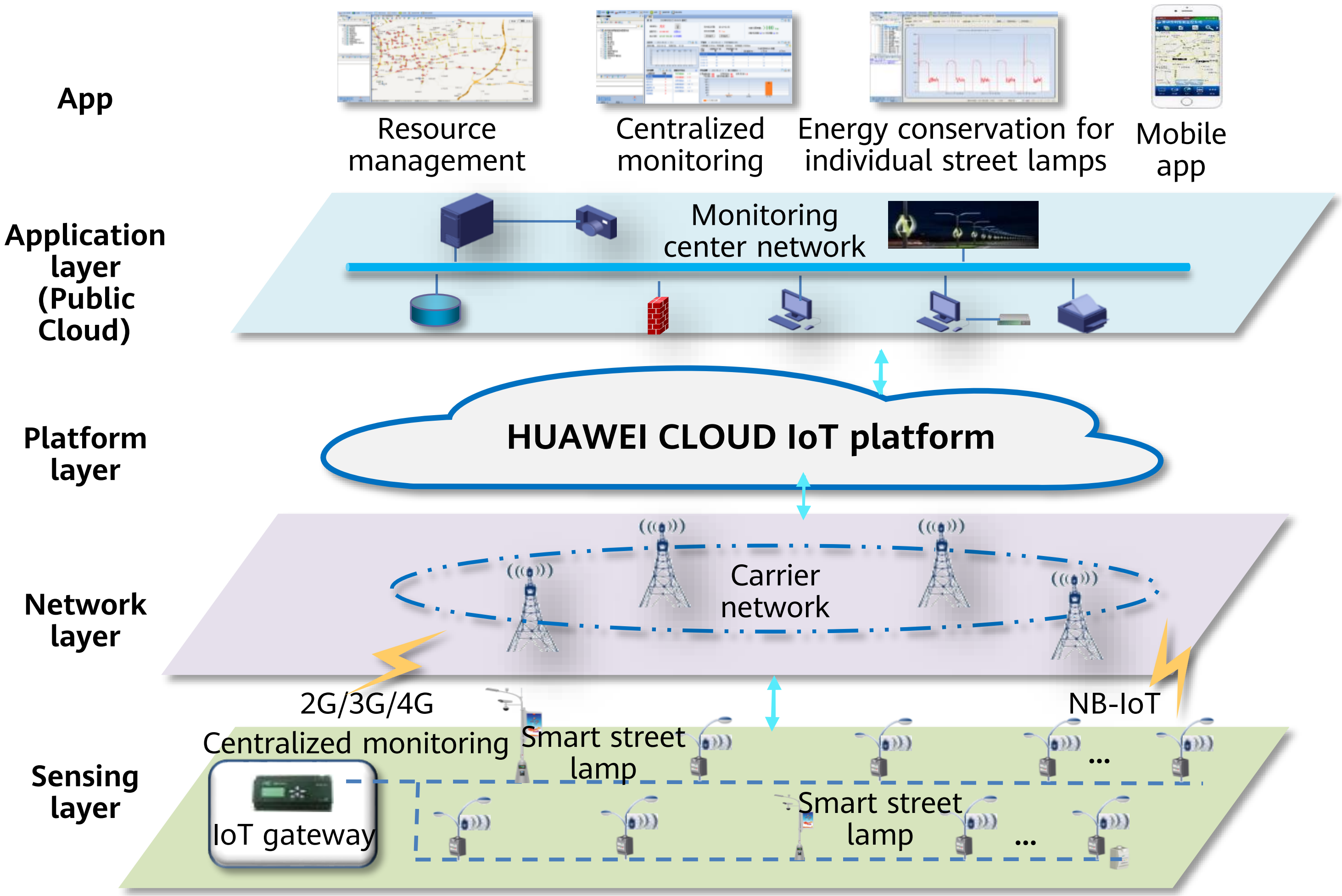
Smart Parking Solution



Highlights

- Platform layer: The IoT platform provides smart parking applications with basic connectivity management, data management, and device management capabilities, enabling flexible and quick deployment through open, standard APIs.
- Network layer: NB-IoT features wide coverage, massive connections, and simplified architecture, satisfying the requirements of discrete parking to reduce operator costs of installation and maintenance.
- Device layer: Integrated NB-IoT modules allow for data parsing on devices to mask access differences.

Smart Street Lamp Solution (1)



Customer Benefits

- **Construction of shared collection devices in cities**: Unified installation of functional facilities in multiple cities, and unified data aggregation and backhaul reduce the construction costs of city infrastructure.
- **Platform-based and unified O&M**: Unified O&M and monitoring of sensors mounted in each bureau improves O&M efficiency and reduces costs.
- **On-demand lighting to reduce consumption and save energy**: Lighting duration is adjusted dynamically, and brightness is adjusted based on the time period. An energy conservation plan is made based on comprehensive analysis of overall lighting power consumption.

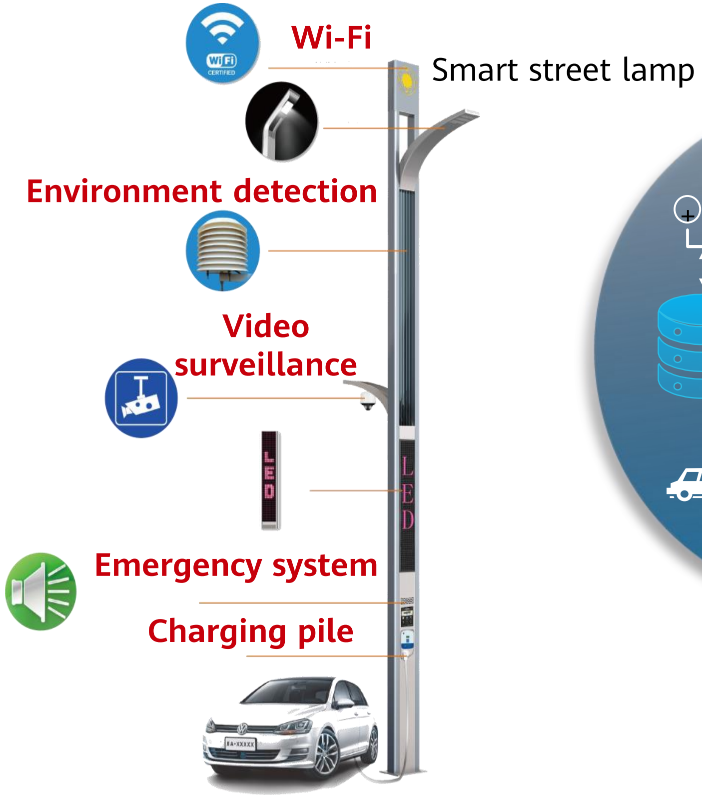
Applicable Scenarios

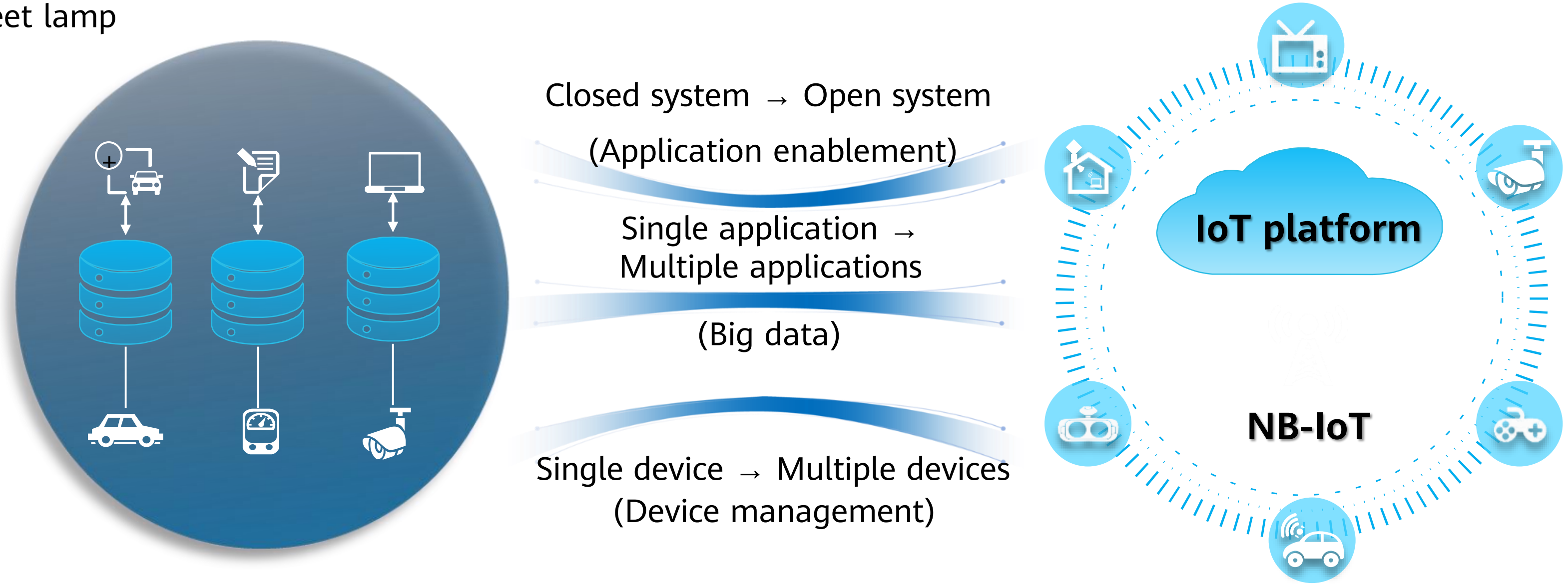
- **Periodic tasks**: enable or disable lamps and adjust brightness during different time segments.
- **Intelligent light adjustment**: automatically detects passing vehicles and adjusts the brightness of lamps based on the actual situation.
- **Automatic O&M**: automatically reports faults to the service system if a street lamp is faulty.

Smart Street Lamp Solution (2)

As natural appendages of smart cities, street lamps are integrating **multiple services**.

As an essential part of smart cities, **the IoT platform** integrates various applications and devices.

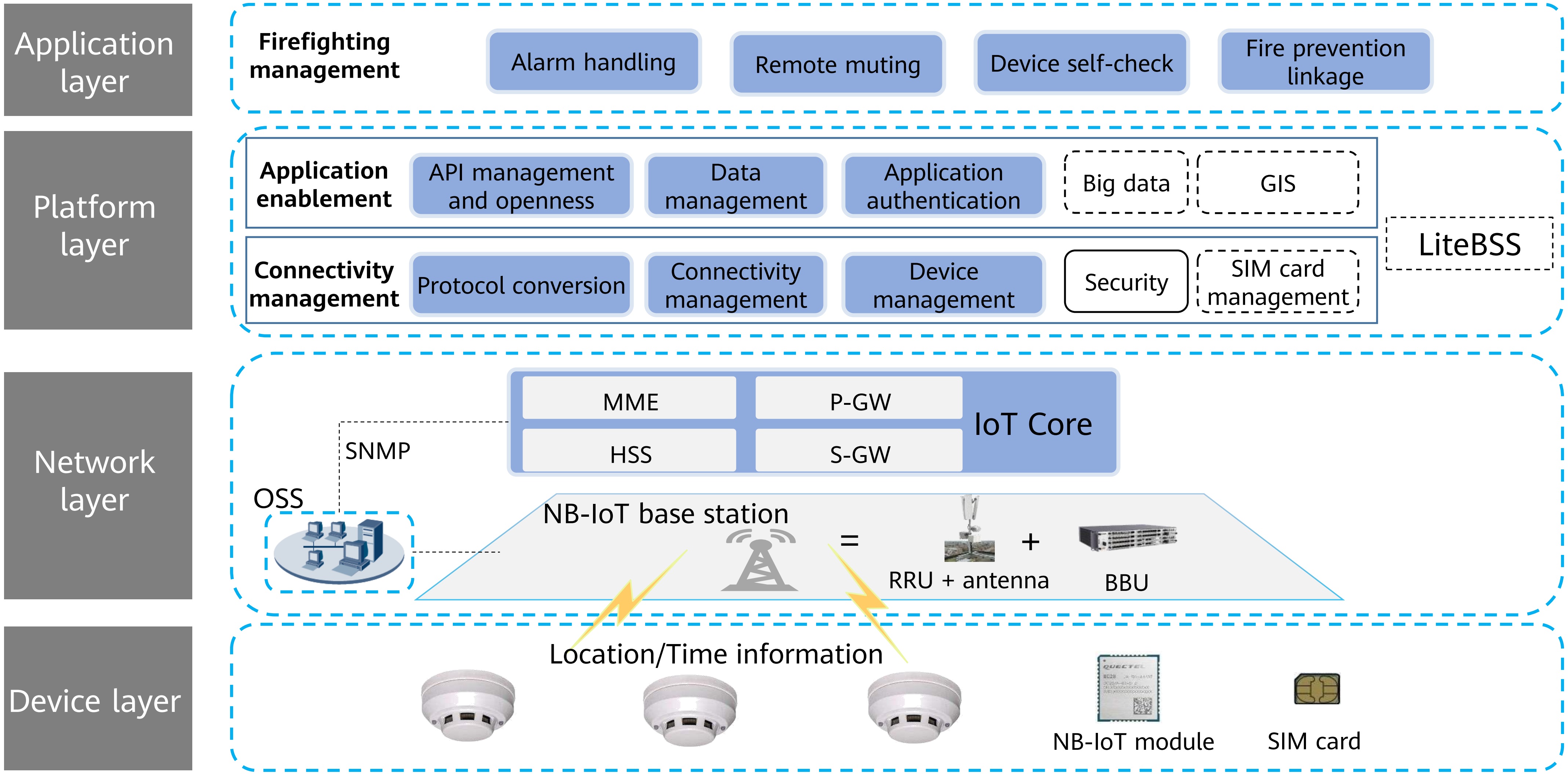




M2M (siloed architecture)

IoT (unified architecture)

Smart Firefighting Solution



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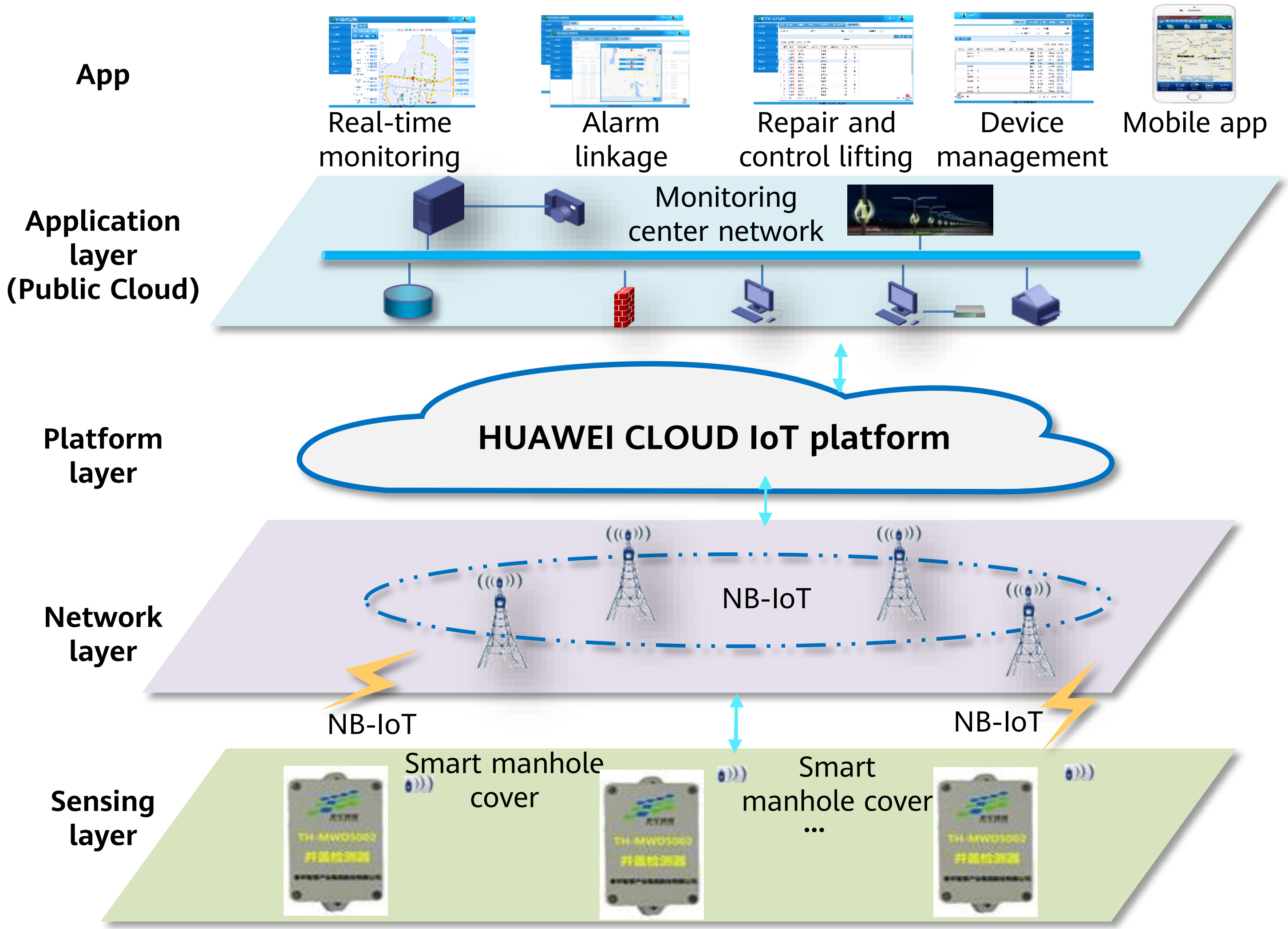
Smart Manhole Cover solution



Customer Benefits

- **Construction of shared collection devices in cities**: Unified installation of functional facilities in multiple cities, and unified data aggregation and backhaul reduce the construction costs of city infrastructure.
- **Platform-based and unified O&M**: Unified O&M and monitoring of sensors mounted in each bureau improves O&M efficiency and reduces costs.
- **Alarm reporting and anti-theft**: By monitoring manhole covers in real time, the system can detect incidents (theft, displacement, and damage), generate alarms, as well as notify construction organizations or policing platforms to take immediate action, eliminating security risks and ensuring city security.

Applicable Scenarios

- **Real-time monitoring**: Manhole covers in a large area are monitored in real time and intelligently maintained.
- **Alarm reporting**: Monitoring manhole covers that are abnormally open helps identify incidents such as theft, displacement, and damage. Alarm reports send the location to the monitoring center and policing platform. Then the monitoring center schedules construction vehicles to maintain these manhole covers and the policing platform dispatches officers to the incident location.

Smart Sanitation Solution

Cleaning | Garbage transit | Garbage disposal

Garbage collection | Garbage transportation | Supervision and assessment

Infrastructure management

Sanitation personnel management

Garbage station management

Vehicle management

Install RFID tags

Read tags when lifting garbage bins.

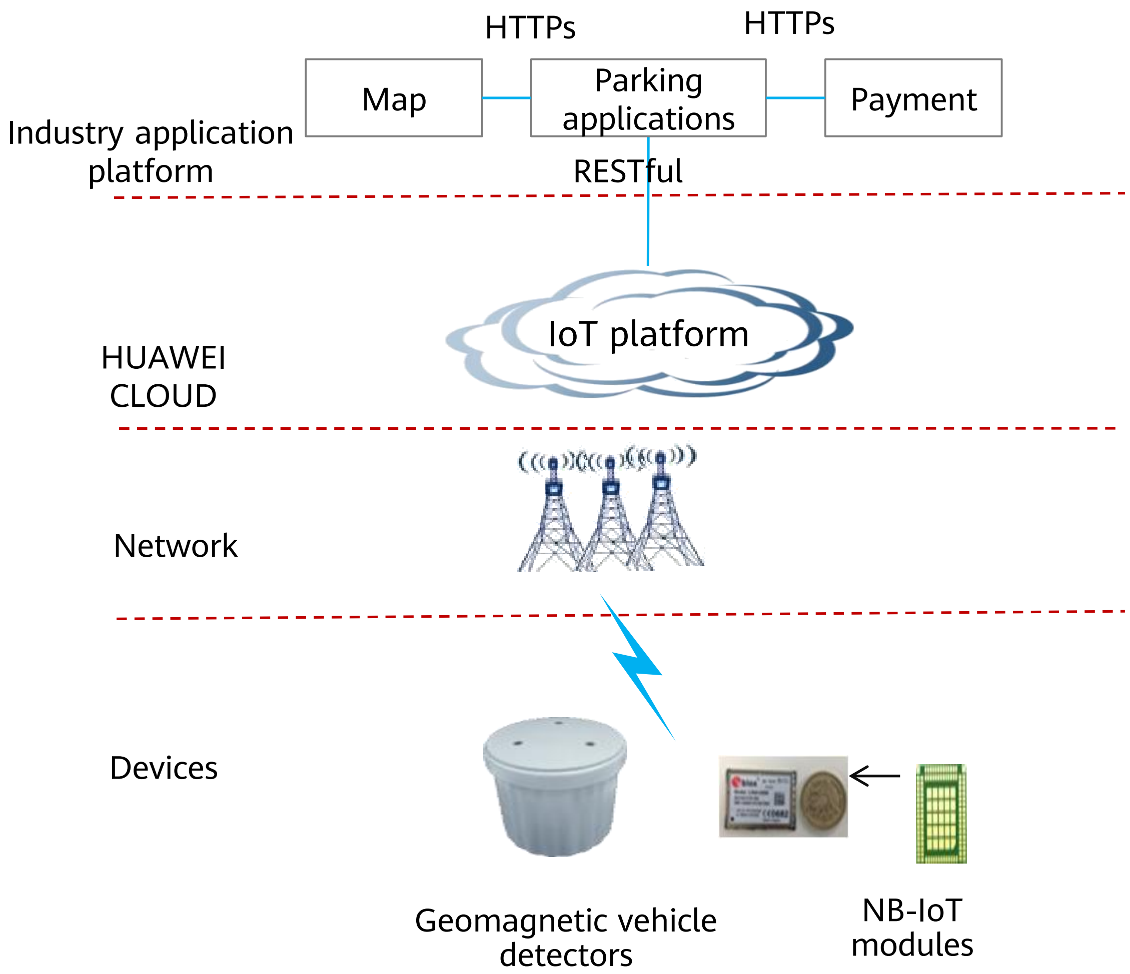
Garbage clearance statistics

4G, 5G, ...

Vehicle track and real-time location

Manages people, vehicles, objects, and events in real time.

Application Cases - Smart Parking Project of Shanghai Disney Resort



Shanghai Disneyland - First Disneyland in Mainland China

- Disneyland is the **largest** theme park in the world.
- In addition to Shanghai, there are **five** Disney other parks, in Los Angeles, Orlando, Tokyo, Paris, and Hong Kong. Their number of annual visitors reaches about **70 million**.
- Shanghai Disneyland is expected to receive **25 million** visitors a year, ranking **first in the world**.

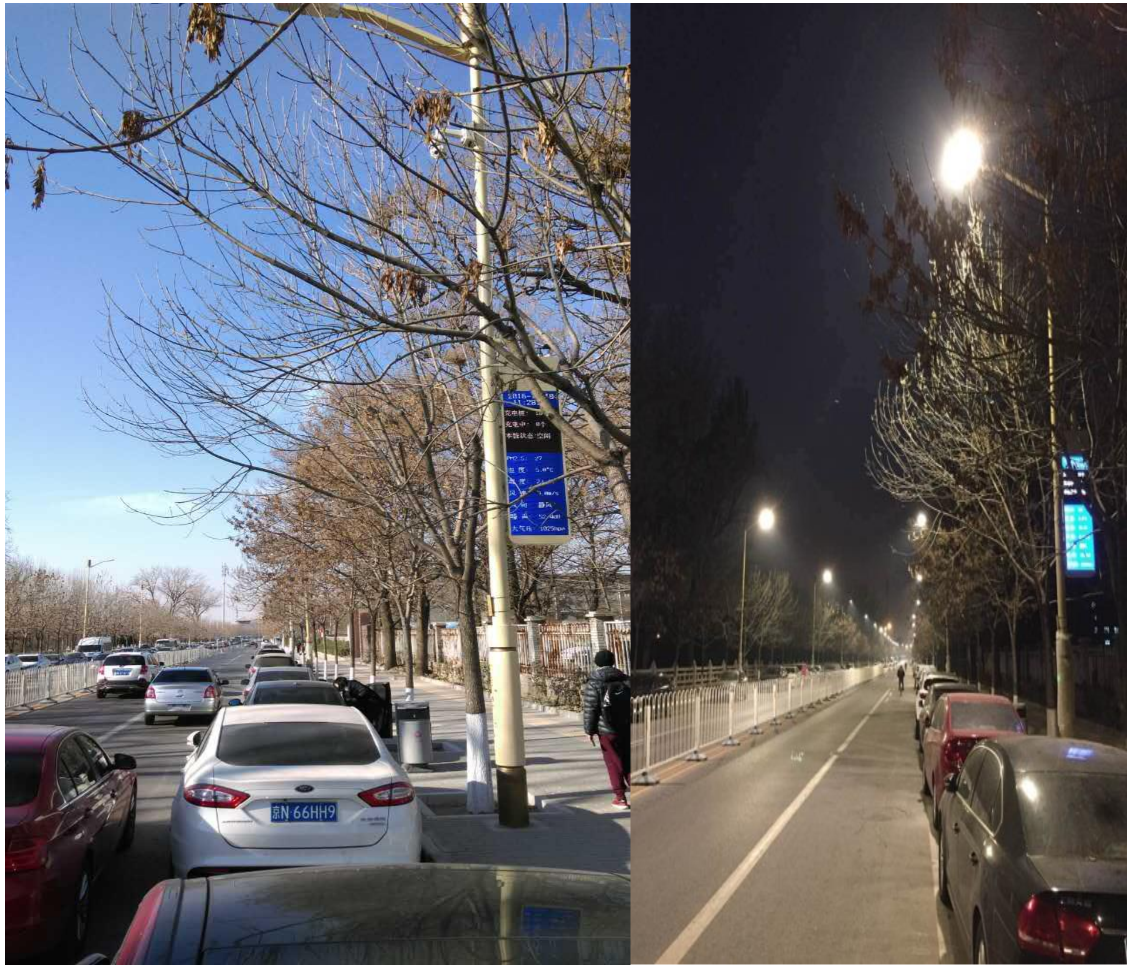
Deploying NB-IoT Networks Through Parking to Build Smart Parks

The NB-IoT solution is used to collect and query parking space information in the park, providing a basis for future smart park construction (such as for vending machines, garbage boxes, smoke sensors, and environment monitoring).

Progress

The Pre NB-IoT version has completed the collection and query of parking space information, and will provide parking guidance and vehicle locating services in the future. **AutoNavi Map and Alipay are being introduced** to provide tourists with better experience in parking and payment.

Application Cases - Smart Street Lamp Project in Zuoanmen, Beijing



Project requirements

- Beijing Lighting Management Center focuses on building smart street lamps and promoting the construction of Beijing Smart City. It integrates Wi-Fi hotspots, wireless carrier networks, environment detection, video surveillance, RFID, and charging pile functions using a wide range of lamp poles, power supplies, and carrier networks. This provides the public and the government with multiple convenient services.
- Due to geographical location, the appearance of the smart pole must comply with the building style of Tiananmen.

Customer benefits

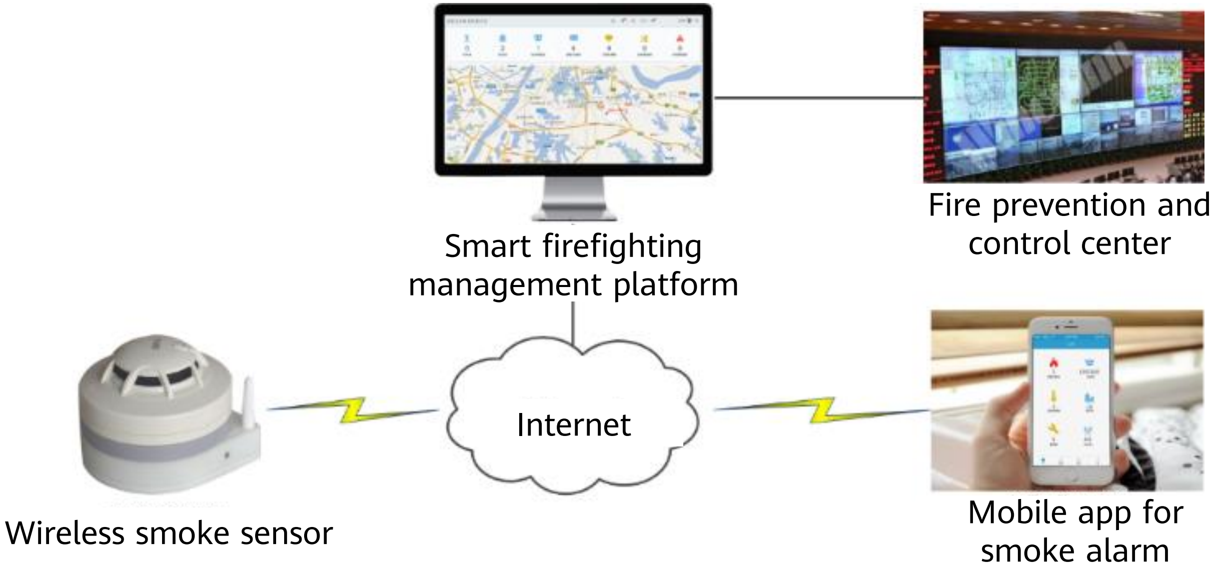
- Helps the government plan the land for charging piles of electric vehicles in cities.
- Helps the government provide services for people's livelihoods and helps people experience smart city scenarios in related areas.

Project achievements

- Built smart street lamps on the existing power distribution and cables.
- Deployed smart street lamp networks in urban areas.
- Connected the management system of smart street lamps to the operation systems of charging piles.

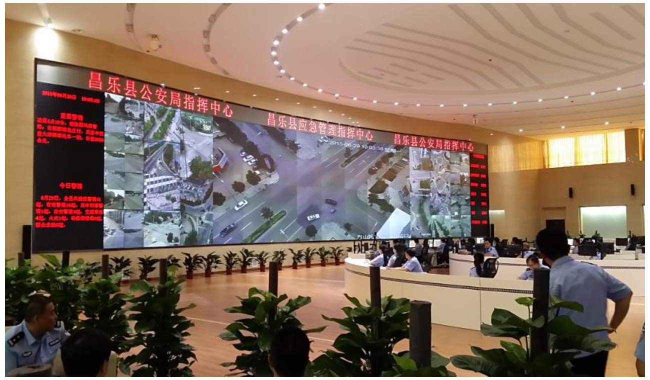
Application Cases - Smart Smoke Detection Project in Zhejiang

- In November 2017, Hangzhou Jianqiao Street used smart smoke detection technology to upgrade applications for the elderly, demolition and resettlement personnel, restricted personnel, and residents in old residential areas. Hangzhou Mobile provided the NB-IoT solution.
- In 2018, the Jianggan District government signed a smoke detection contract with Hangzhou Mobile and installed a smoke detection system after the first phase of the pilot project achieved success.



Application Cases - NB-IoT Smart Manhole Cover Project in Changle

- Bureau of Housing and Urban-Rural Development in Changle, Weifang, are mainly responsible for the county's urban, engineering and town construction. It also manages construction, real estate, gas, heating, and other domains.



Smart monitoring devices were installed on more than 400 manhole covers in the drainage, heat supply, and gas industries of main roads such as Fangshan Road, Hengan Street, Xinchang Road, Baochang Road, Gucheng Street, and Gushan Street in Changle.

Based on the public information platform, the system was built to monitor manhole covers and handle inspection cases using standard workflows. The system realizes real-time monitoring, anti-theft alarms, and alarm reporting for manhole covers.

An app was launched for mobile inspection. Inspectors now carry portable devices installed with the app to share information with the manhole cover monitoring center through a mobile communication network, facilitating alarm reception, handling, and feedback.

Application Cases - Dezhou Smart City Management Project

The Dezhou City Management Project is the first model project in Shandong Province to implement city-county networking. It aims to build a "large-scale city management" system and integrate data of multiple service departments.

Challenges

- A new urban management system to meet the needs of modern urban management needs to be established.
- Linkage of stereoscopic space, the whole process, and social participation is required.
- Information-based process of urban landscape planning and design, construction, management, and maintenance is required.

Solution

- The digital city management system of Dezhou includes subsystems in the following scenarios: digital urban management standards, mobile supervision, city flood prevention, video and audio management, outdoor advertisement management, GPS vehicle positioning, street lamps and landscapes, construction site supervision, law enforcement, 12345 citizen hotline, administrative approval, and city-county networking.

Customer benefits

- By July 2018, over 520,000 parts and 51 city events of 7 categories and 89 subcategories were surveyed and classified into 5953 unit websites. More than 740,000 city management issues were found, with a handling rate of 95.2%.

Contents

Challenges for Traditional Campuses

Inefficient Operations

Campuses are **mainly managed by humans and management experience cannot be shared effectively**. They do not have comprehensive and E2E IT systems.

More Security Risks

Conventional check in/out management and control systems face many challenges from **increases in the number of people, vehicles, and objects** on campuses. **Security incidents are penetrating campuses**.

Poor Employee Experience

Campuses have poor services, complex management, complicated processes, and manual intervention. As a result, **employees have poor experience and low loyalty**, which affects work efficiency.

Lack of Sensing

There are **few smart applications and devices**. Due to the lack of **effective sensing**, much manpower is required to analyze and process data. Sensors incorrectly report or fail to report alarms, so **real situations cannot be perceived**.

Increasing Operation Costs

Water, electricity, and gas prices keep rising, and campuses waste resources due to extensive management. In addition, labor costs are increasing all over the world, **resulting in high OPEX for campuses**.

Penetration of the Internet Mindset

The Internet mindset is gradually penetrating traditional campuses. **Campuses will not succeed if they continue to stand still.**

Common Problems - Security Management

Pre-event

Human patrol

In-event

Reactive response

In-event

Manual command and dispatch

Post-event

Manual video check

No alarms are triggered when intruders break into access control systems.

No alarms or linkage policies are triggered when thieves burst into campuses.

Air conditioners do not stop working even when a fire occurs. Verification, evacuation, and police reporting are executed manually.

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Common Problems - Visitor Management

Visitors

Visitors need to register and obtain visitor cards.

Visitors are allowed to visit only when accompanied by employees.

Employees

Employees need to swipe their cards at entrances.

Employees need to register when they forget their cards.

- Visitors need to wait about 5 minutes for reception by Huawei employees after arriving at Huawei campuses.
- Huawei employees receive about 600,000 visitors every year, spending a total of 50,000 working hours (6300 working days).
- About 30,000 visitor vehicles access Huawei campuses every year. It takes a vehicle 10 minutes on average to go through procedures and pay fees.

- Huawei employees need to swipe their cards when entering the campus. They forget to swipe their cards about 720,000 times and forget to bring their cards about 30,000 times per year. In the latter scenario, they need to manually record attendance data, which takes 5 minutes each time. That is, a total of 62,500 working hours (7800 working days) are wasted each year.

Common Problems - Power Consumption Management

Lights are always on even during non-office hours.

Curtains are always open where the sun shines.

Air conditioners are always on even during non-office hours.

Facility appliances are always on even in idle conference rooms.

Huawei's campuses in China spend CNY2.45 billion each year on management and services, of which power consumption accounts for 57% (CNY1.39 billion).

Problems

High OPEX

Inefficient IT infrastructures and services; mainly **managed by humans**

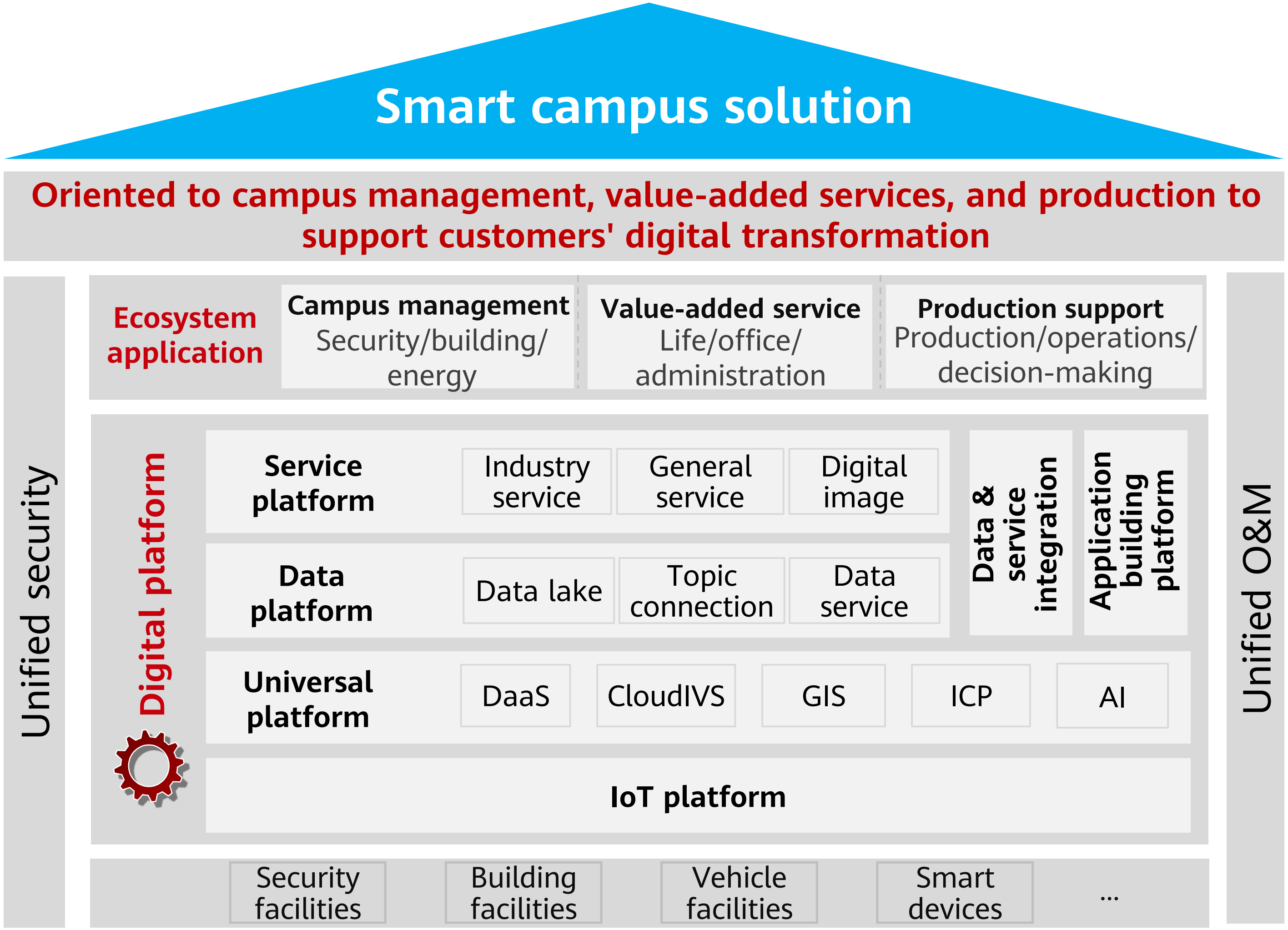
Unsatisfactory services

These systems are isolated from each other, making it hard to achieve unified monitoring, management, and emergency command for governments, and to provide smart services for citizens.

Extensive management

No intelligent security or property management solutions; reactive response to security risks

Solution - Smart Campus (1)



Solution - Smart Campus (2)

Personnel

Buildings

Vehicles

Security

Assets

Electricity meters

Work stations

Conference rooms

All-optical access

One fiber Full-service bearing

10000 Mbit/s Ultra-broadband access

All-scenario Wi-Fi

80,000 persons Online concurrently

100% Seamless coverage

All-scenario IoT

20+ IoT APIs

100% Complex environment adaptation

100% Industrial protocol adaptation

Security Management

Firefighting linkage

Intelligent pre-event warning

In-event system linkage and one-click handling

Post-event intelligent analysis

Perimeter linkage

Video-assisted alarm acknowledgment

System linkage handling

Visitor Management

Visitor reservation portal

Visitors log in to a portal, enter personal information (including name, contact information, and license plate), and download a visitor app.

Parking barrier (license plate recognition)

When visitors arrive at a campus, the gate control system automatically allows them to enter after recognizing their registered license plates.

Campus visitor app

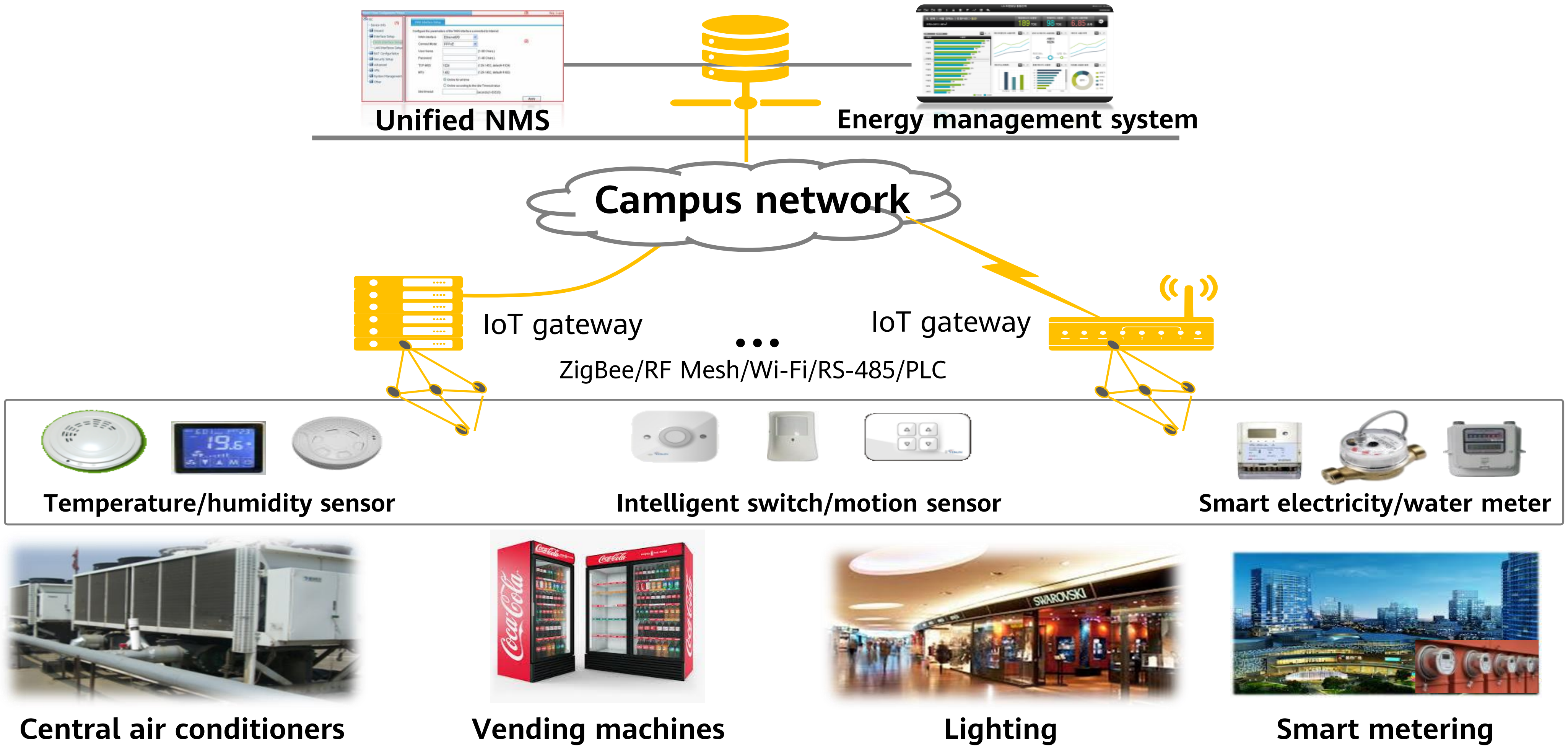
Visitors entering a campus and opening the visitor app:

- 1. Connect to the campus network through Wi-Fi.
- 2. Find the parking garage entrance through navigation services.
- 3. Select one of the following methods to enter an office building:
  - Facial images
  - QR codes

Power Consumption Management (1)

- **Environmental-friendly**, smart PV power generation
- Seamless switchover using standby UPS and stored power, **a special balanced power supply technology**
- **Energy big data platform-based** intelligent analysis and diagnosis models and algorithms, managing and controlling energy comprehensively, improving energy utilization, and reducing O&M costs
- Overall energy saved by **5%–30%;** per-capita O&M efficiency increased by **30%**

Power Consumption Management (2)



Application Cases - Huawei Campuses Around the Globe

Beijing

Langfang

Nanjing

Hangzhou

Shanghai

Chengdu

Shenzhen HQ

Dongguan Southern Factory

India

Democratic Republic of the Congo

Application Cases - Huawei's Southern Factory in Dongguan

- Facial recognition + license plate recognition reduce the number of security personnel needed by 30%.
- Smart PV + energy efficiency prediction and optimization achieve intelligent power generation, distribution, utilization, and management.
- Intelligent supply chain management enables refined control of orders, warehousing, and logistics.
- Visualized production and operations display multi-dimensional factory information in real time.

This factory occupies a total area of about 1 million m^2, and accommodates about 30,000 employees in three districts.

Application Cases - Smart Industrial City in Yanbu, Saudi Arabia

- Effects:
  - Average incident response time < 7 minutes
  - Yearly traffic accidents < 1200
  - Fiber coverage rate in Yanbu's industrial city > 59%
  - Free Wi-Fi coverage rate in public areas > 70%
  - Garbage disposal efficiency: 30% increase
  - Public lighting costs: 30% reduction
  - Road maintenance costs: 20% reduction
- Economic benefits:
  - Investment growth rate: from 3.5% to 16%
  - Industrial talent in the past three years: 22.5% increase

Application Cases - Tian An Cloud Park Phase 1

- Tian An Cloud Park is located to the north of Huawei Industrial Base, Bantian, Shenzhen. It occupies an area of 760,000 m2 and covers a building area of 2.89 million m2. It is a large complex that consists of offices, businesses, residential buildings, and hotels.
- It focuses on leading industries such as cloud computing, mobile Internet, robot, and intelligent devices. It is a base for developing modern and productive services based on these industries.

Tian An Cloud Park Phase 1

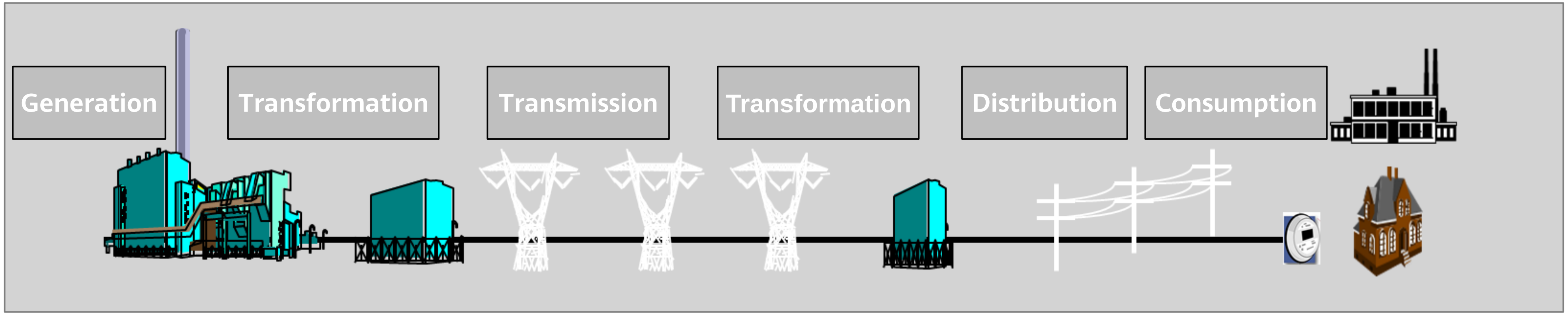
Introduction: Tian An Cloud Park Phase 1 consists of seven 30-floor buildings. Offices are located on the sixth floor or above, businesses on the first to fifth floors, and parking lots on the first and second basements. There are XXX enterprises in this park.

Key ICT requirements: Providing high-speed networks, data centers, and intelligent infrastructures for enterprises and campus operations personnel.

- Use the Cloud Community+ (CC+) campus operations and service platform to provide enterprises with property management, office, and enterprise ICT leasing services.
- Use a local cloud to provide cloud IT and communications services for enterprises, reducing their O&M costs.
- Use a converged network to carry the campus IoT, Wi-Fi, and property management office networks, delivering high Internet access speeds.

Contents

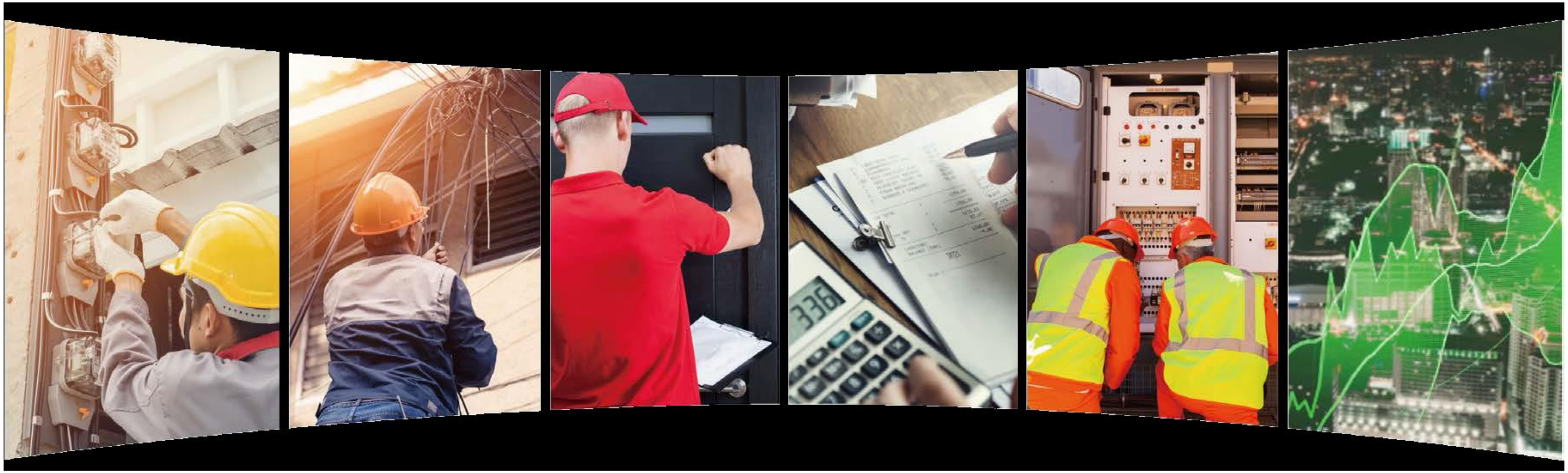
Overview of the Electric Power Supply System



Power generation	Power transformation	Power transmission	Power distribution	Power consumption	Scheduling
• Electric power generation • Source: coal, nuclear, hydro, solar power, and others • Generator outlet voltage: 6 kV to 30 kV • Controlled by a scheduling center with automatic generation control (AGC) and automatic voltage control (AVC)	• Voltage increase or decrease • Higher voltage yields lower transmission loss. • Voltage: 6 kV to 1000 kV • Department involved: scheduling center (responsible for safe operation of the grid)	• Electric power transmission across long distances • Higher voltage yields lower transmission loss. • Voltage: 110 kV to 1000 kV • Department involved: scheduling center (responsible for safe operation of the grid)	• Electric power distribution and sales • Voltage: 110 V to 110 kV • Department involved: power supply bureau/company and marketing/electricity department in the electric power company	• Type: civil, commercial, industrial electricity, and others • Voltage: 110 V to 6 kV • The power dispatching data network carries the production scheduling service. It is one of the core networks of electric power informatization.	• End-to-end electric power system management and monitoring • Hierarchical management • The power dispatching data network carries the production scheduling service. It is one of the core networks of electric power informatization.

Long-Term Pain Points of Electric Power Companies

- High line loss, low efficiency, and high investment are the long-term pain points of low-voltage power distribution network operations in electric power companies.



Characteristics of Traditional Grids





Power generation | **Transmission** | **Expenditure**

Simultaneity

- Power generation, transmission, and consumption are performed at the same time.
- Power generation cannot be interrupted, and electricity cannot be stored during generation.

Randomness

- The grid status changes rapidly.
- Monitoring on the change status and emergencies is required.

Integration

- All parts of the grid are unified.
- If any problem occurs, the entire system is affected.

Security

- Grid security affects national security.
- Power automation and informatization, which can enhance the safety coefficient of the grid, are absent.

Rigid systems

- Access of large-scale intermittent power and distributed power is not supported. The access, exit, and transmission of power supply are not flexible.

Unbalanced power generation and consumption areas

- Power generation is concentrated in the northwest of China.
- Electric power is mainly consumed in the central, eastern, and coastal areas of China, requiring long-distance and high-voltage power transmission.

Challenges of Traditional Grids

Distributed power supply access

- Access of large-scale intermittent power and distributed power is not supported.
- The access, exit, and transmission of power supply are not flexible. As a result, the grid is not dynamic and flexible.

Massive transmission loss

- Massive transmission loss is caused by unbalanced power generation and consumption.

Management mechanism problem

- Inconsistent standards
- Weak security with flooding vulnerabilities and risks
- Single product development and lack of network planning
- Closed system which restricts service development

Unbalanced power supply and demand

- The demand for power consumption increases rapidly.
- The power supply system cannot meet the demand.
- Power use is limited due to insufficient power supply.

Security issues

- Due to the increasing demand for power, power supply equipment is overloaded for a long time. Outdated equipment causes massive loss.
- The security and reliability of the power supply and distribution system are not planned, which creates security risks.

In the face of challenges, electrical grids need to be managed intelligently and delicately. Advanced Metering Infrastructure (AMI) comes into being.

Poor power quality

- Simple user services and one-way information hinder user interaction.
- User power consumption information cannot be obtained immediately, and power quality cannot be ensured.

Difficult information sharing

- The system structure design is flawed. Multiple information silos exist in the system, hindering information sharing.

Lack of power distribution automation

- Fault discovery, isolation, and troubleshooting take a long time due to inefficient methods, requiring informatization means.

Challenges Faced by Electric Power Companies

Insufficient service supervision and serious economic losses

- Transformers are overloaded in high temperatures, and equipment is severely damaged.
- Lack of effective monitoring methods for VIP users
- Power consumption is not analyzed in real time, and electricity theft is a serious issue.

Low operation efficiency and high labor costs

- Line loss cannot be effectively decreased.
- Electricity fees are difficult to collect, collection periods are long, and arrears are significant.
- Power consumption is not transparent and causes many complaints.

Lack of real-time data support for service decision-making

- Power outage management is disorganized.
- Power line reconstruction is unfeasible.
- Household electricity relationships are complicated.

Different Grid Requirements in Different Countries and Regions

Prepayment option (Africa and Latin America)

- Collect electricity fees on time using prepayment options and gradually implement tiered electricity billing.

Line loss reduction (Africa and Latin America)

- Reduce non-technical line loss caused by electricity theft, which is equivalent to directly increasing revenue.
- Send alarms when electricity theft is detected and locate the area the theft occurred.

Customer satisfaction improvement (all regions)

- Provide detailed bills to customers for confirmation of detailed electricity usage and billing results.
- Provide power saving suggestions based on intelligent analysis and guide users to save power.

Safe grid operations (China, Europe, and America)

- Reduce power failures and quickly locate and rectify faults.
- Limit power consumption during peak hours.
- Balance renewable and non-renewable energy yield.

Balance between supply and demand (China, Europe, and America)

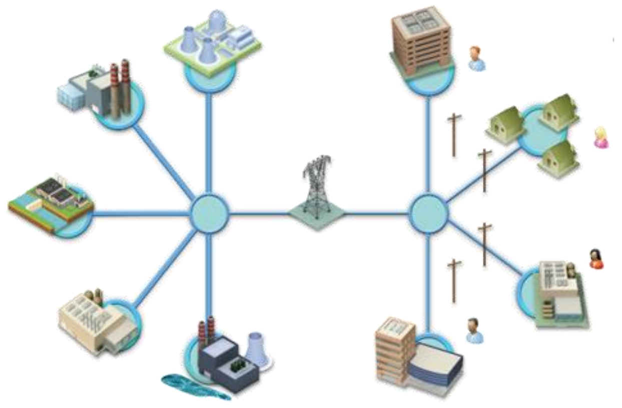
- Balance between supply and demand can reduce waste caused by extra power generation and ensure the security of the grid.

New value-added services (China, Europe, and America)

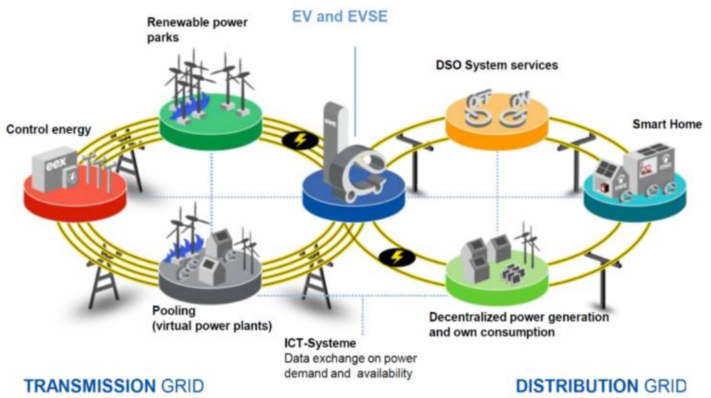
- AMI is the foundation of smart grids.
- Based on AMI, new technologies such as requirement response, distributed energy management, CVR, and new services can be applied to further improve the profitability of electric power companies.

Grid Evolution Trends

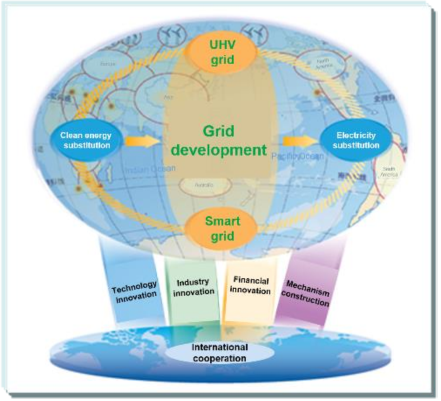
Traditional grids



Smart grids



Energy Internet Industry Group



Continuous access to new energy and services

- Solar and wind energy
- Charging piles, smart homes, and smart street lamps

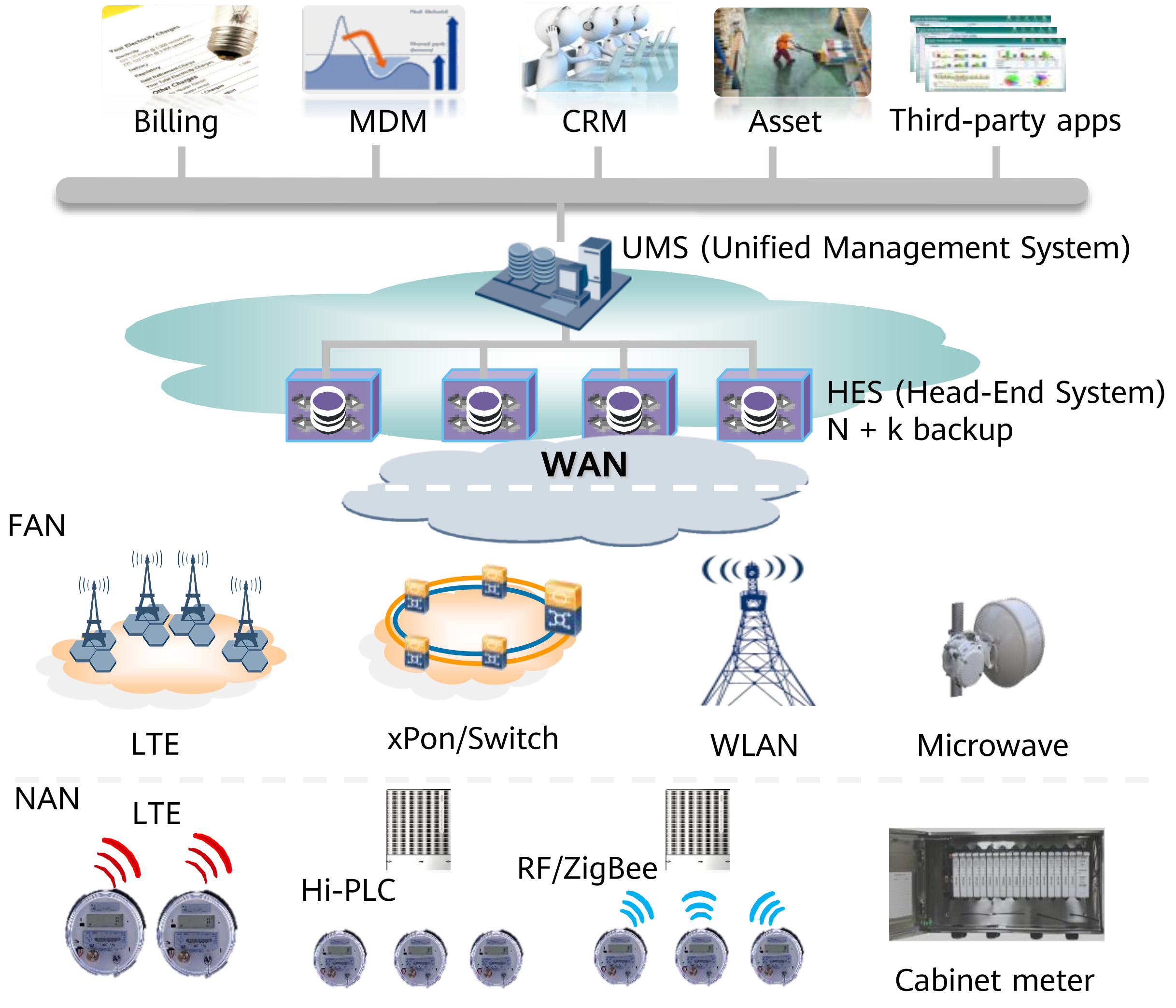
Control extension

- Expansion from transmission and transformation control to distribution networks, distributed power supply, and the user side
- Number of control points: from 100,000-level to million-level. Controller latency: from quasi-real-time to real-time. Control frequency: from low to high.

Explosive growth of information collection requirements

- Increasing collection points and collection volume
- Higher collection frequency and real-time performance

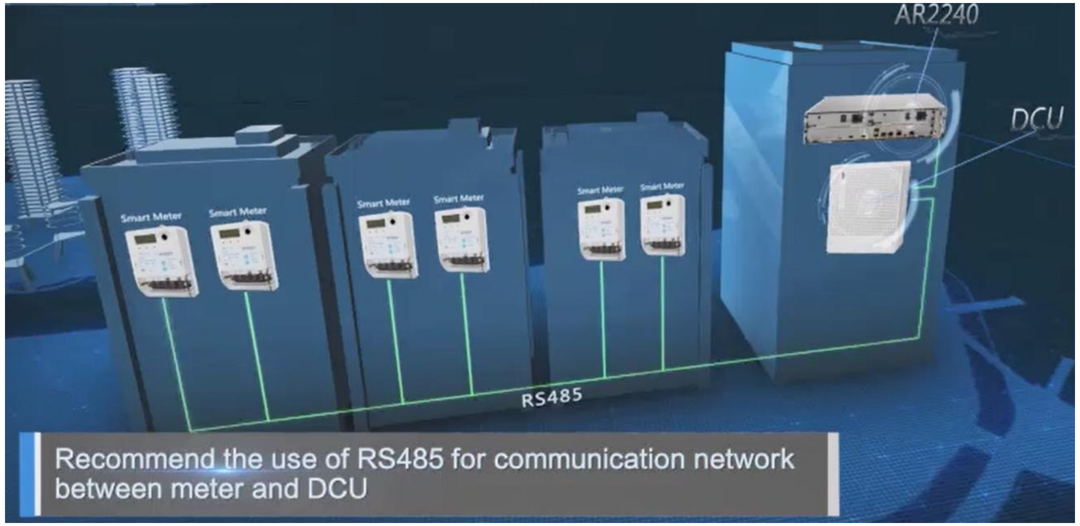
AMI Solution (1)

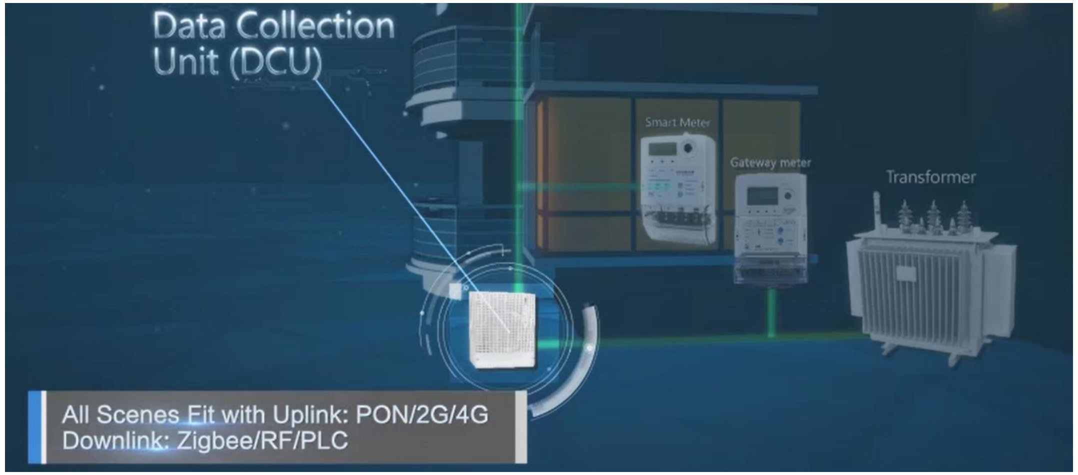


- AMI is **a complete system** that includes smart electricity meters, advanced communications networks, collectors, concentrators, and back-end software. It can use a **bidirectional communications** system to record user load details, and periodically and instantly obtain various metering values from users. It supports remote setting, power connection or disconnection, two-way metering, and scheduled or random meter reading. It connects and provides users with visibility within the grid to establish close contact with them.
- An AMI system consists of hardware devices, software, communications networks, user interfaces, DCP, UMS, and systems at the application layer. The system can **share part of the manual response mechanism** and automatically collect information from users and send information to them. The system changes the normal consumption mode of users and **displays power consumption information transparently**. Users can **plan appropriate consumption** according to the information to avoid waste. For suppliers, consumption based on pricing plans can limit increasing power use during peak hours and **balance power supply**.
- AMI components contain upper-layer application systems, collection systems, devices, and communications networks.

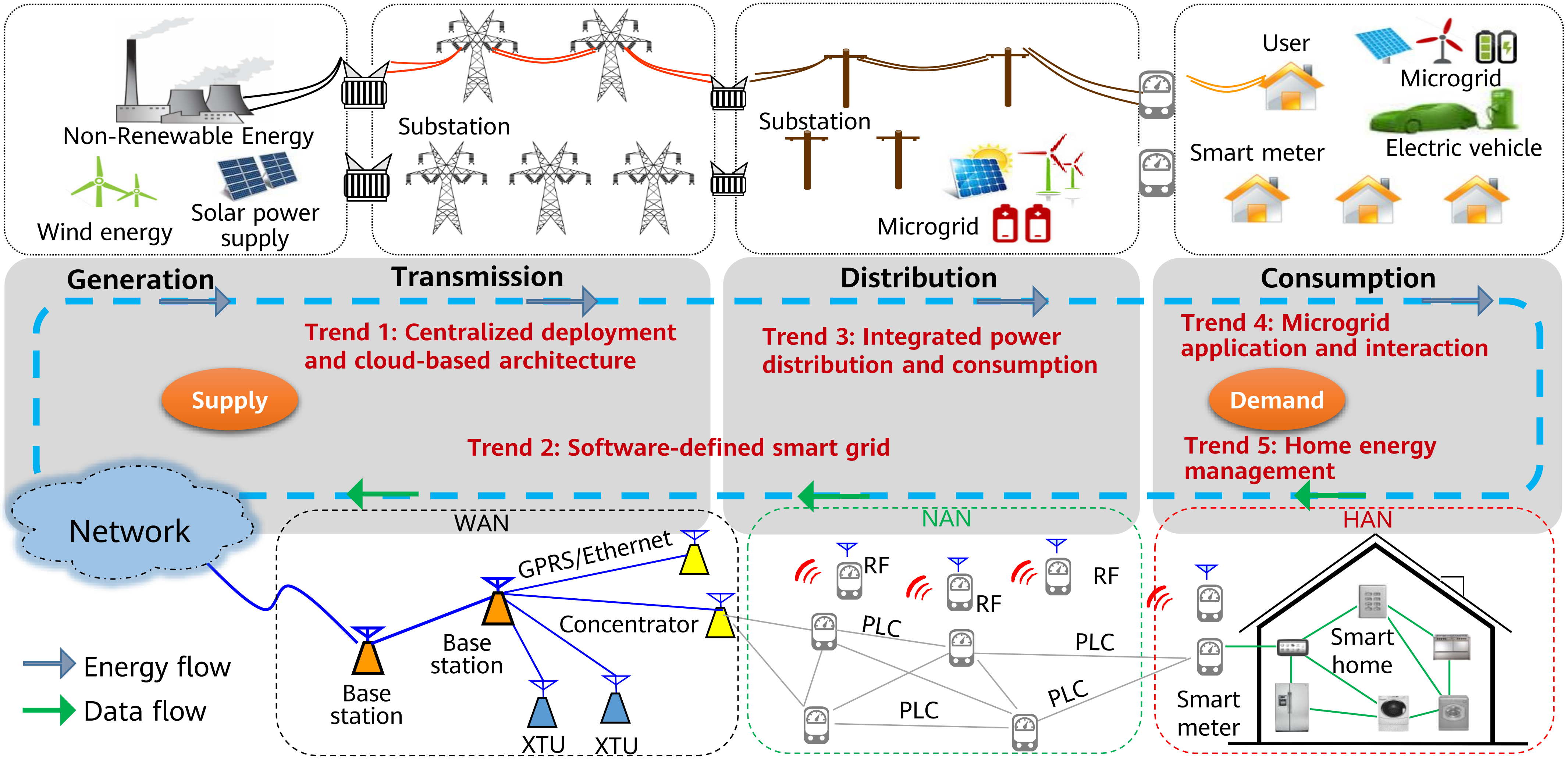
AMI Solution (2)

- Huawei provides an end-to-end smart metering solution for electric power companies to implement a full upgrade from meters to applications.
  - **Smart electricity meters:** Traditional mechanical electricity meters are replaced with prepaid smart electricity meters with a communications function. Multiple electricity theft detection methods are provided, such as open cover alarms, reverse wiring alarms, and strong magnetic field alarms. The PLC-IoT technology is used to report information such as current, voltage, power, and power consumption in real time.
  - **A meter reading network:** Concentrators communicate with electricity meters through communications methods such as power line carriers, converge data to the industrial gateways, and then send the data back to the main control center through the carrier's public network. This achieves a 100% meter reading success rate.
  - **An application system deployed on the IoT platform:** Huawei provides the IoT platform to manage data, connection, and devices, and pre-integrates partners' powerful application systems for billing, prepayment, and payment. The IoT platform provides advanced functions, such as data statistics analysis, real-time line loss analysis, and electricity theft behavior analysis, to help customers operate services effectively.





AMI Solution: Fully-Connected Grid (1)



AMI Solution: Fully-Connected Grid (2)

Power generation	More new energy access and power generation devices are becoming distributed.
Power transmission	Transmission lines are gradually monitored in real time. WAN connections are required.
Power distribution	Distribution network control is gradually shifting from 10 kV to 0.4 kV, connecting tens of millions of nodes.
Power consumption	High frequency and high-precision meter reading of 450 million meters requires new access technologies.

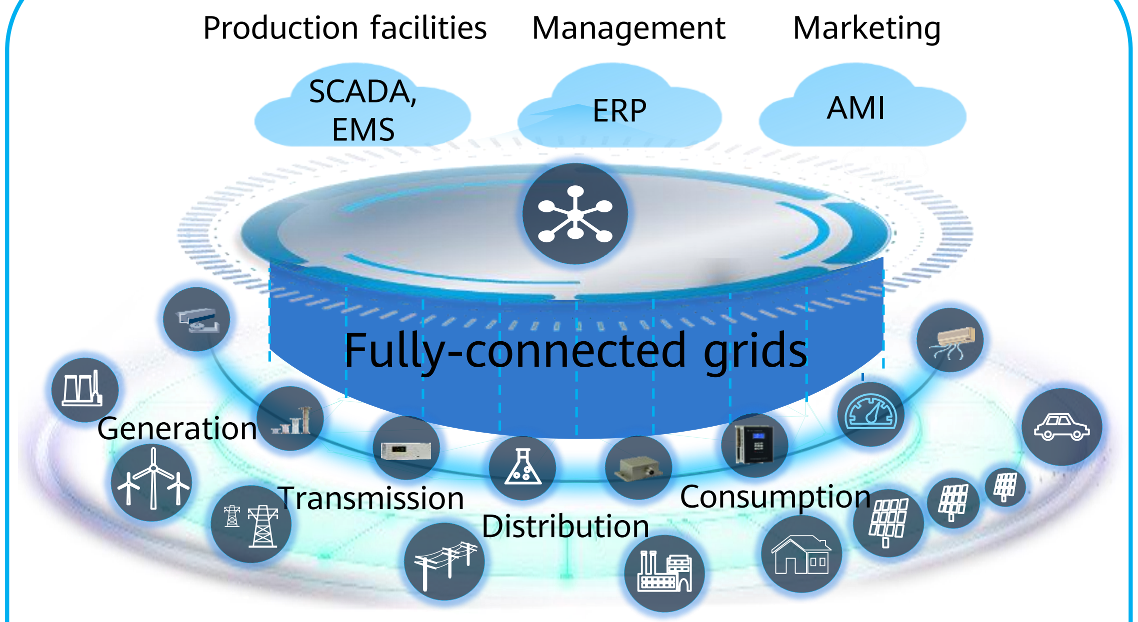
High Security scenarios

Low Latency

Magnitude Coverage

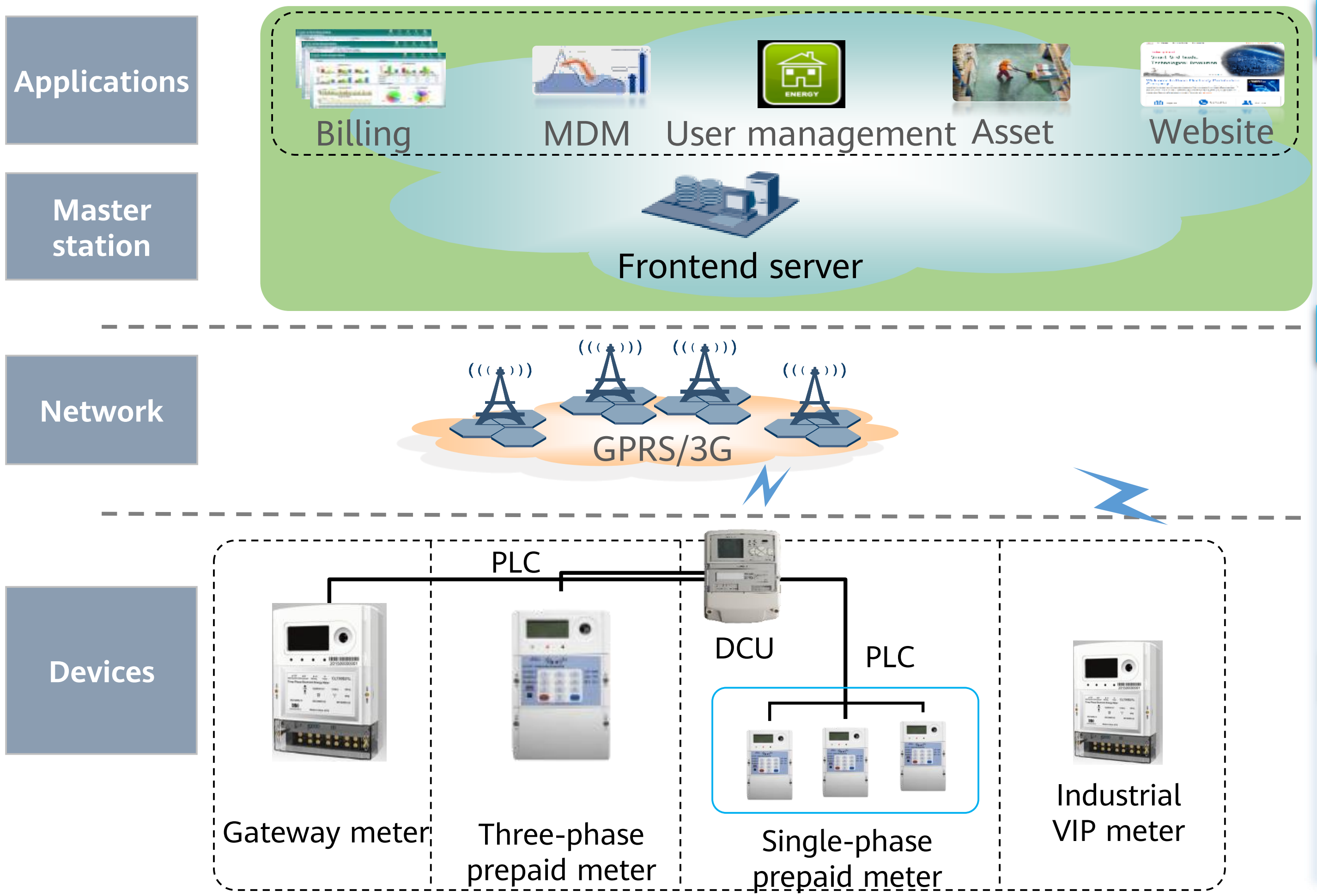
Low Power consumption

Massive connections



Connections increase from tens of thousands to hundreds of millions and go from covering backbone lines to full grids. Wireless is the key.

Application Cases - Electric Power Company of Togo (CEET)



Background

- High line loss of 17.88% in 2014
- The peak load increases rapidly. The peak load in 2013 was 181.76 MW. If the peak load can be reduced by 10% after consumption analysis, it will be reduced by about 18.176 MW.

Huawei Case

- Number of residential meters: XX0,000
- Number of meters for VIP users: XX
- Number of meters in power distribution station: XX
- An end-to-end AMI solution, involving meters, concentrators, master station systems, and marketing systems, is provided.

Customer benefits

- Line loss reduction by 11% to 17.88%
- Peak load reduction
- User experience improvement
- Accelerated cash return

Application Cases - State Grid Jiangsu Electric Power Co., Ltd.

Load control

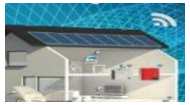
Substation video surveillance

Distributed energy

Consumption data collection

Automated power distribution

Switching station monitoring



Smart home

Inspection of the transformer district

- **Large scale and biggest services**: **50+** 1.8 GHz wireless communications sites, **5,000+** devices, and **10+** services are operating in three cities.
- **100%** device online rate: The network performance test results meet the service requirements of the state grid of China.
- **First application of an end-to-end physical security isolation solution**: One network bears three types of services: power distribution, precise control, and procurement.
- **First application of the public and private integration modules**: Service availability is improved and the cost of converting from public to private networks is reduced.

Contents

Common Problems for IoV

Safety

- Delayed detection of vehicle status faults
- Impact of faulty vehicles on safety of other vehicles
- Influence of natural weather changes on safe driving

Efficiency

- Traffic citations for speeding
- Traffic congestion caused by road repairs
- Inconvenient use of in-vehicle multimedia devices
- Inefficient traffic lights

Added Value

- No obvious differentiation of insurance rates
- Private use of company vehicles
- Difficult fleet management
- ETC, parking fee recharging, etc.

Requirements and Driving Forces of Development

National mandatory requirements

- **Ministry of Transport of the People's Republic of China (MOT)**: Since August 1, 2011, a satellite positioning device that meets the requirements of *GNSS System for Operating Vehicles-Technical Specification for Vehicle Terminals* must be installed on key commercial vehicles in China. Since the end of 2015, MOT requires that in-vehicle devices be installed on vehicles before delivery.
- The scope includes coach buses, shuttle buses, dangerous goods transportation vehicles, heavy cargo vehicles, and semi-trailer towing vehicles.
- **Mandatory technical standards**: JT/T/794, JT/T/796, JT/T 808, and JT/T 809

Customer operations requirements

- **Cost control for fuel consumption**: Fuel costs are up to 50% of the operating cost. If a truck costs more than CNY300,000 on fuel consumption, CNY30,000 can be saved per year by using IoV.
- **Improving punctuality of maintenance**: IoV detects component wear status, intelligently arranges preventive maintenance, and maintains good vehicle conditions and rescue maintenance.
- Real-time data collection and online driving behavior analysis optimize fleet operations and reduce the accident rates.

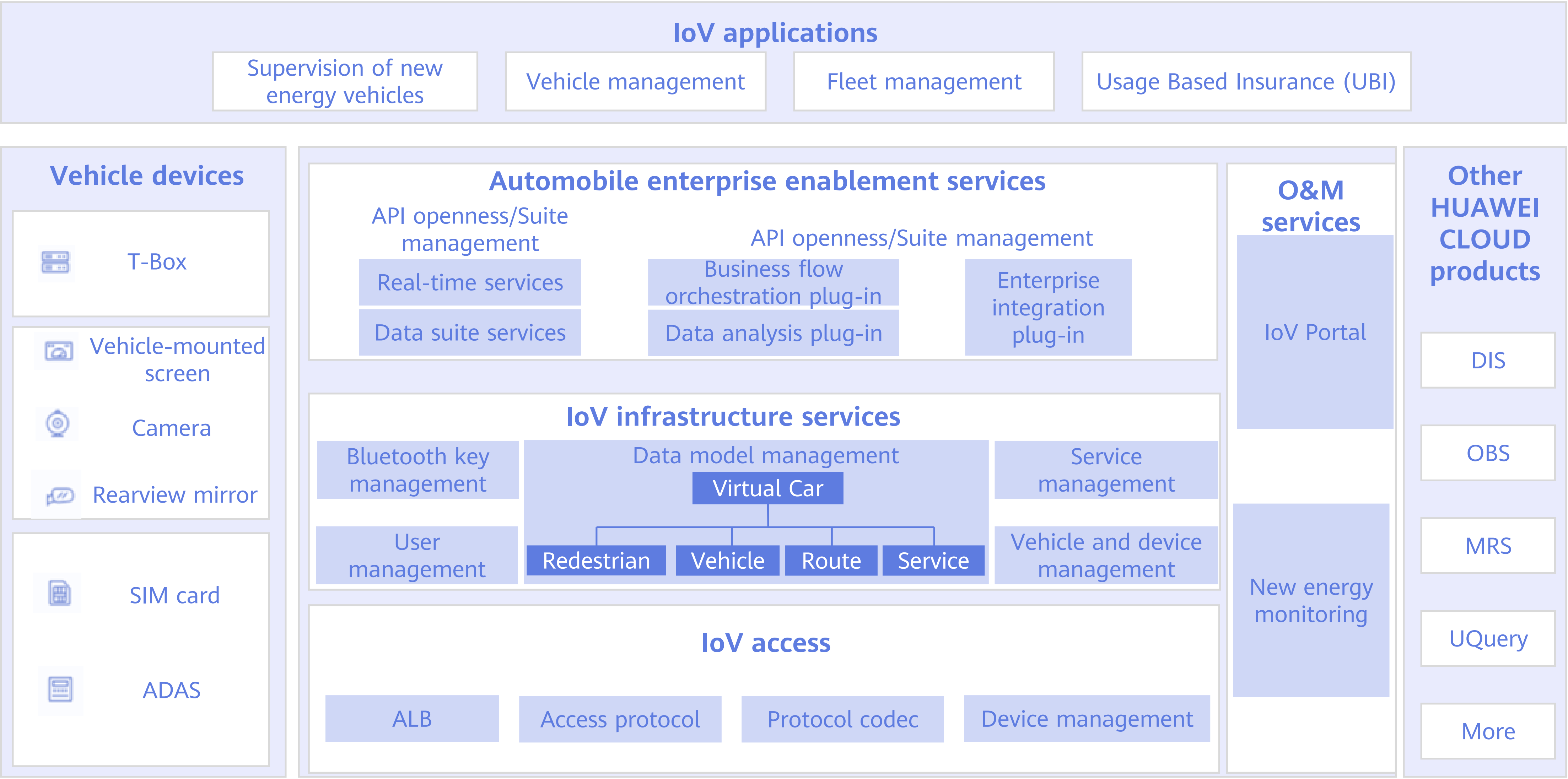
Insurance industry requirements

- **Improving profitability of vehicle insurance companies**: In 2013, after more than 10 years of operations in China's vehicle insurance market, all of the 46 companies were losing money, except for the three listed companies: PICC, Ping An Insurance, Pacific Insurance. The main reason for this was high compensation.
- **Reform of vehicle insurance premium rates**: In February 2015, the China Insurance Regulatory Commission (CIRC) released the *Work Plan for Deepening the Pilot System Reform of the Administration of the Commercial Motor Vehicle Insurance Clauses and Premium Rates*. According to this work plan, driving behavior and other factors affect vehicle insurance pricing, and good driving behavior has lower premiums.
- **Automatic collection of driving behavior**: Safe drivers (evaluated based on the driving behavior data automatically collected by the IoV system) enjoy lower premiums, which helps insurance companies reduce compensation risks and increase profits.

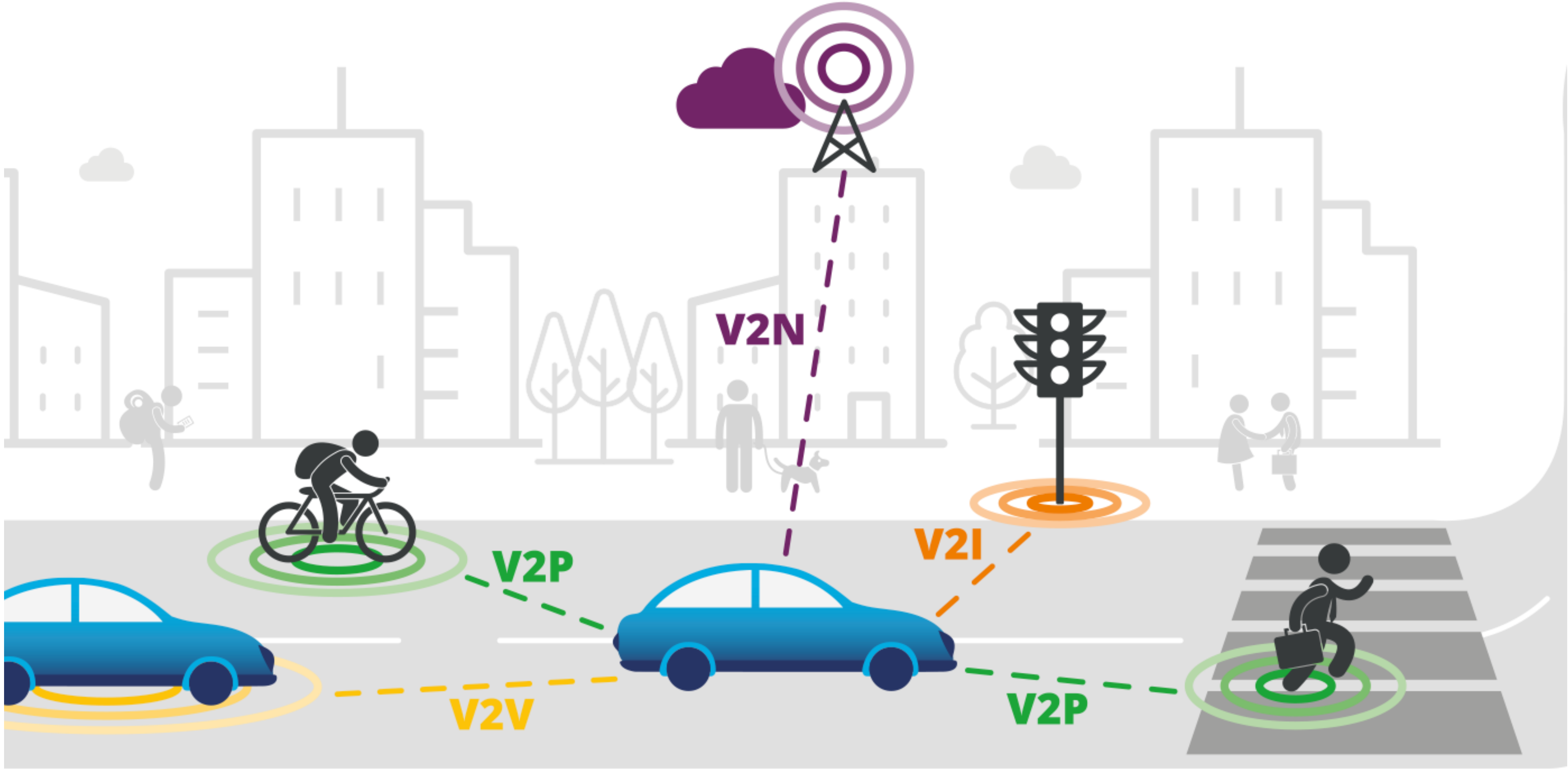
What is IoV?

- Internet of Vehicles (IoV) means that **in-vehicle devices** on vehicles use **wireless communication technologies** to make full use of all dynamic vehicle information on **the information network platform** and **provide various functions** and services during vehicle running.
- IoV **has the following characteristics**:
  - It provides assurance of the distance between vehicles to reduce vehicle collisions.
  - It provides real-time navigation for drivers and communicates with other drivers and network systems to improve traffic efficiency.

IoV Solution



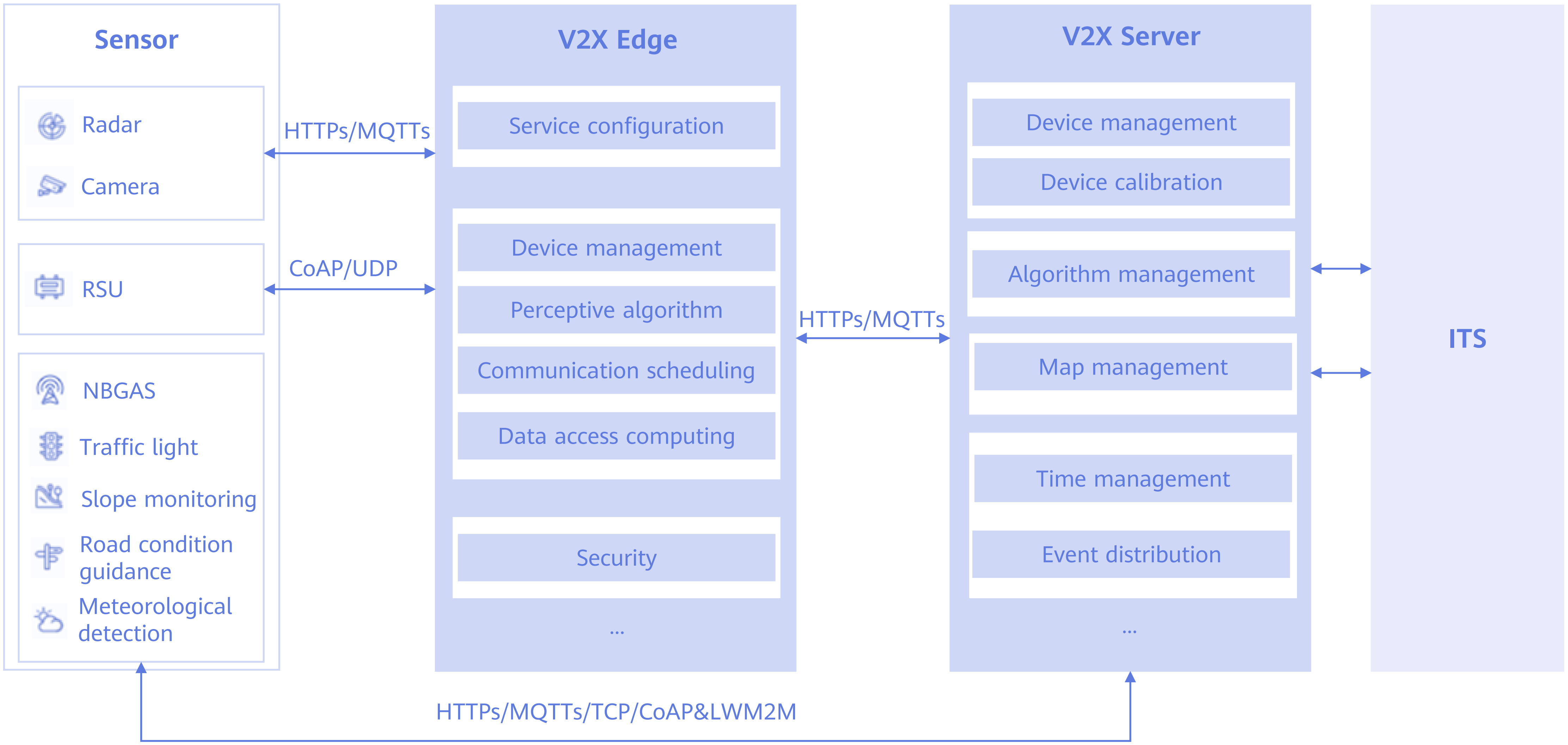
V2X



DRIS Solution

- Digital Road Infrastructure Service (DRIS) implements digital information exchange among people, vehicles, roads, and networks, improves driving safety and road traffic efficiency. This facilitates large-scale commercial use of automated driving.
- DRIS consists of **V2X Server** and **V2X Edge**.
  - V2X Server provides digital road infrastructure services and edge-cloud synergy services such as data analysis and roadside computing unit management.
  - V2X Edge provides real-time service processing capabilities at the edge such as roadside sensor data access, DRIS event identification, and communication forwarding.
- The goal of DRIS is to connect multiple roadside sensors to implement digital perception of roads and provide information for traffic participants to facilitate traffic operation.

DRIS Architecture



IoV Service Development (1)

Road information collection and communications

Improve the efficiency of partial roads with the traffic control and monitoring system of a single-point or partial roads as a core.

Partial traffic control

Wired and wireless roadside equipment communication

Telematics

Vehicle-to-network WAN communication implements online navigation, remote diagnosis and control, infotainment, and vehicle alarm through in-vehicle communication modules and cellular communication.

Online navigation/IVI

2G/3G/4G

ITS - BSA

V2V or V2I short-distance communication implements reminding or even controls the potential collision risks of vehicles, improving vehicle safety and traffic efficiency (basic application set).

ADAS

802.11p/LTE-V

ITS - ESA

Realize automatic control and automated driving without accidents for real convergence of pedestrians, vehicles, roads, and environments. It is the future ITS.

Automated driving

Future technologies

1990s' 2005s' 2015s' 2020s' 2025s' 2030s'

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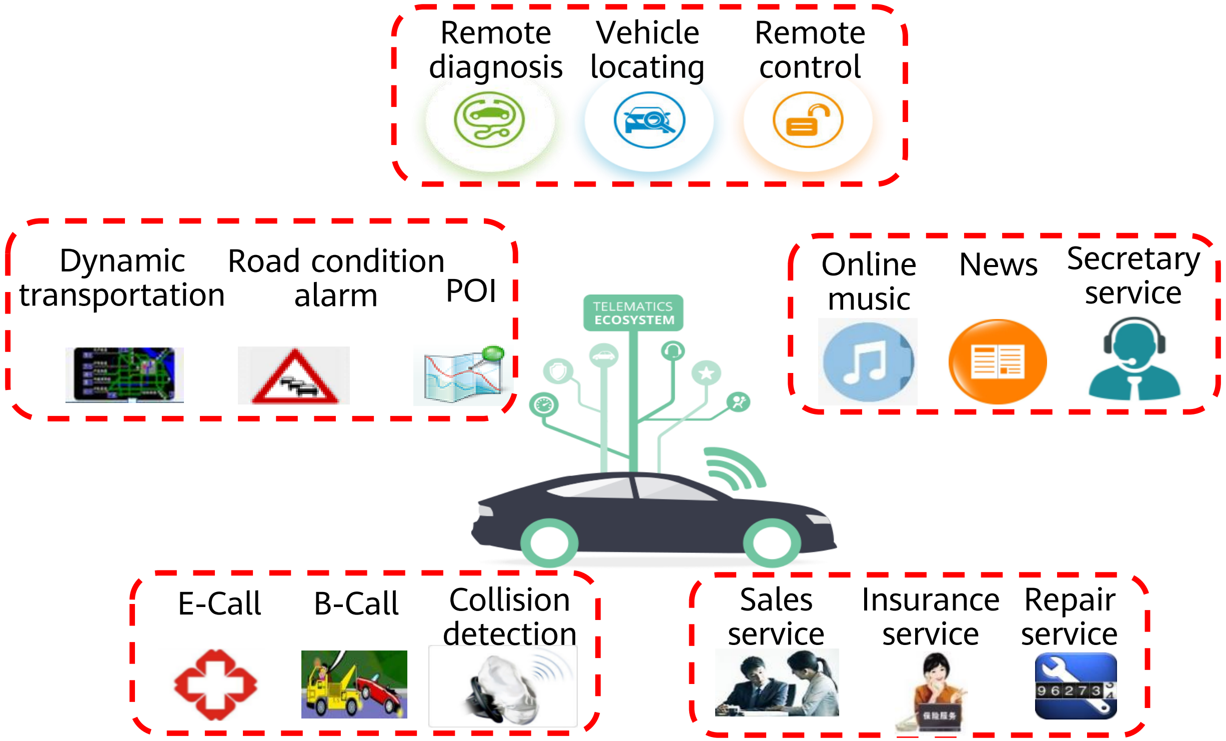
IoV Service Development (2)

Phase 1: Entertainment and navigation functions	Phase 2: Attached ecosystem and O2O of the IoV represented by OBD/T-Box	Phase 3: Automated driving and ADAS replace the existing HU
• Entertainment: In the past, in-vehicle infotainment (IVI) used cassettes, CDs, and MP3 downloaded using USB drives. Now, drivers can listen to music online through IoV. • Navigation: Real-time online map navigation replaces offline map navigation stored on SD cards.	• Connect to the Electronic Control Unit (ECU) to obtain more vehicle information, such as mileage, fuel consumption, fault, and location, for subsequent services. • Provide sufficient map information points, and even directly complete O2O consumption. This is not only an IoV function, but also an O2O consumption entry.	• Integrate the sensing capability of sensors, judgment capability of processors, and control capability of electric controllers. • The core of automated driving is processor judgment. The hardware and software of this processor are highly artificial intelligence. Once the automated driving function is implemented, both the ECU and HU will be replaced.

IoV Development Status

- IoV is evolving from IVI services to intelligent transportation. It is mainly classified into OEM and aftermarket modes. The OEM mode focuses on internal services of OEMs, vehicle data collection, and personal entertainment services. The aftermarket mode focuses on industry applications, supplemented by personal IVI information services.

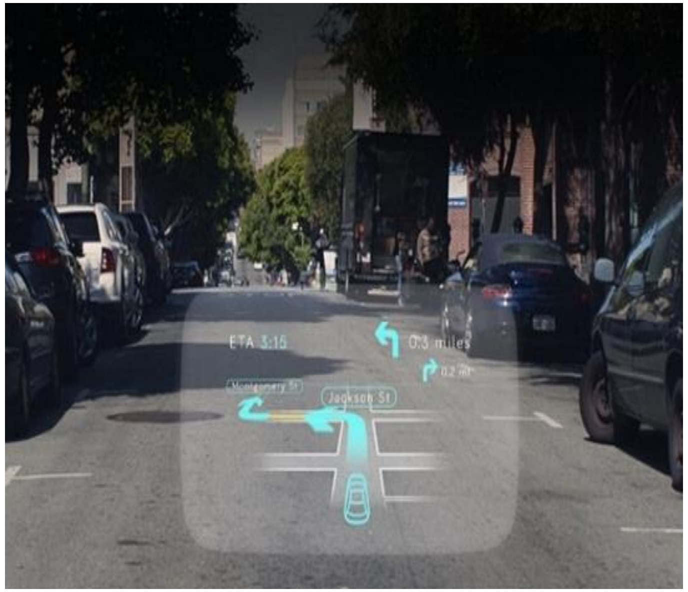
OEM IoV



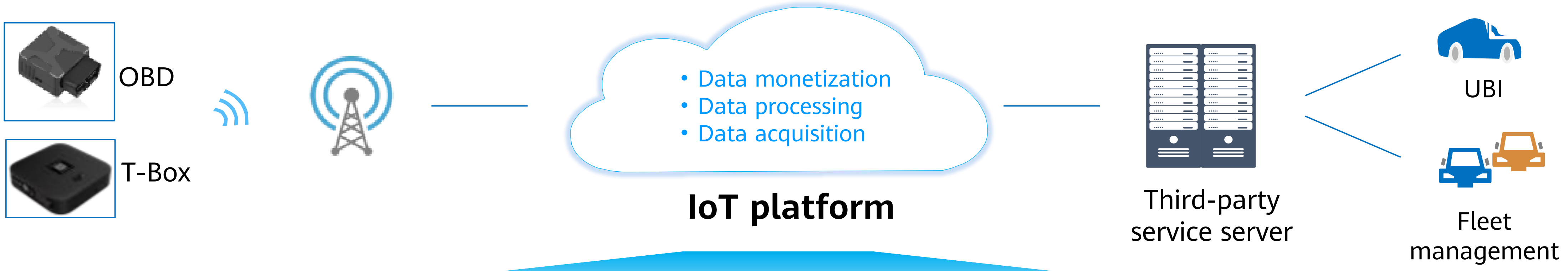
Aftermarket IoV

HUD

- Driving safety is the purpose of Heads Up Display (HUD). With the HUD, drivers do not need to shift their attention to the dashboard or touch the head unit while driving. Most of the information displayed on the HUD is vehicle indicators such as speed and fuel volume, which are displayed on the dashboard.
- In addition, the HUD provides functions such as navigation, SMS, phone, email, and even provides simple interactions to make vehicles more intelligent.



OBD/T-BOX



Shortened commercial use time for services

- 20 device partners worldwide
- Multi-device policy that covers over 90% of vehicle models
- Pre-integration of partners' applications

Elimination of privacy leakage risks

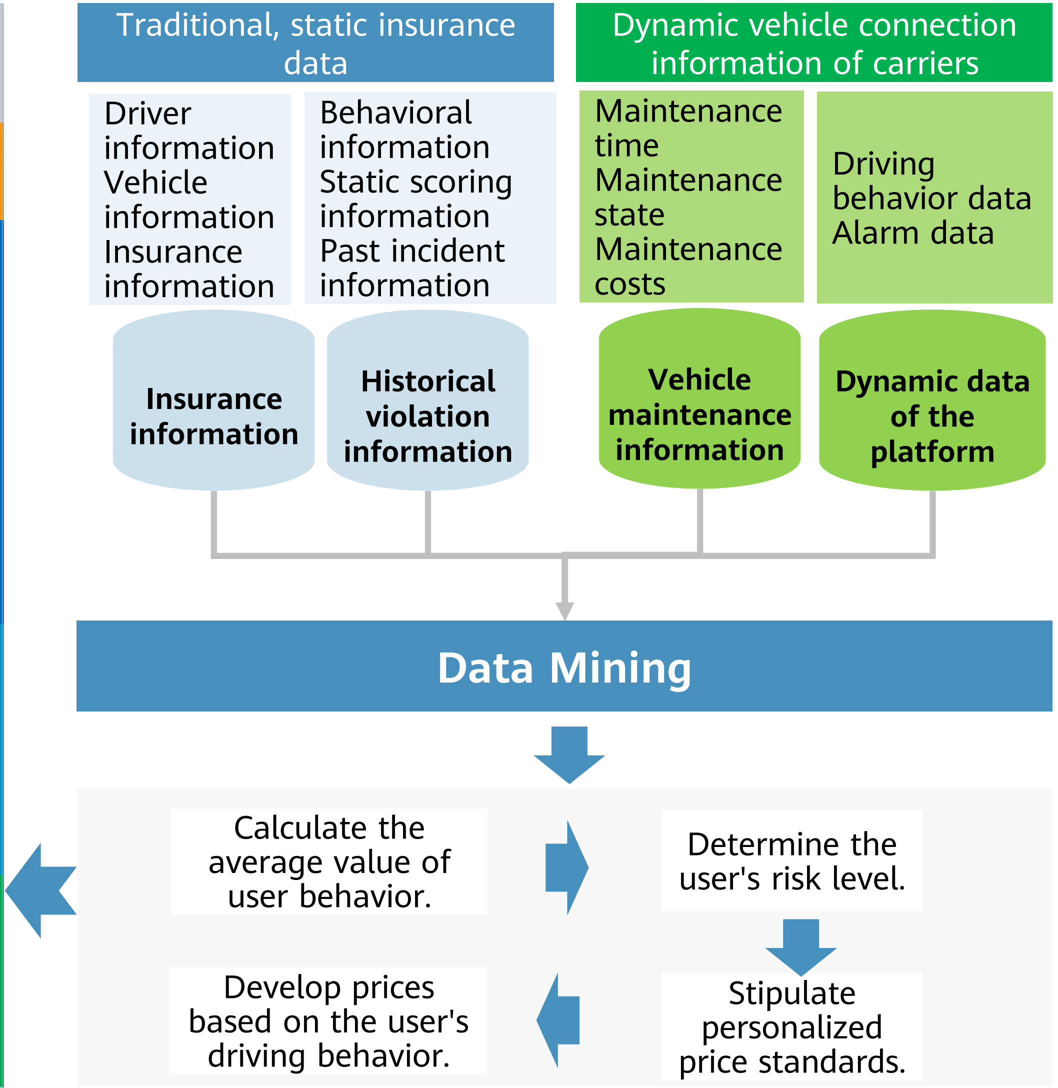
- Data storage encryption
- Network intrusion prevention
- Data communication encryption through the IoT Agent

Carrier-class high performance assurance

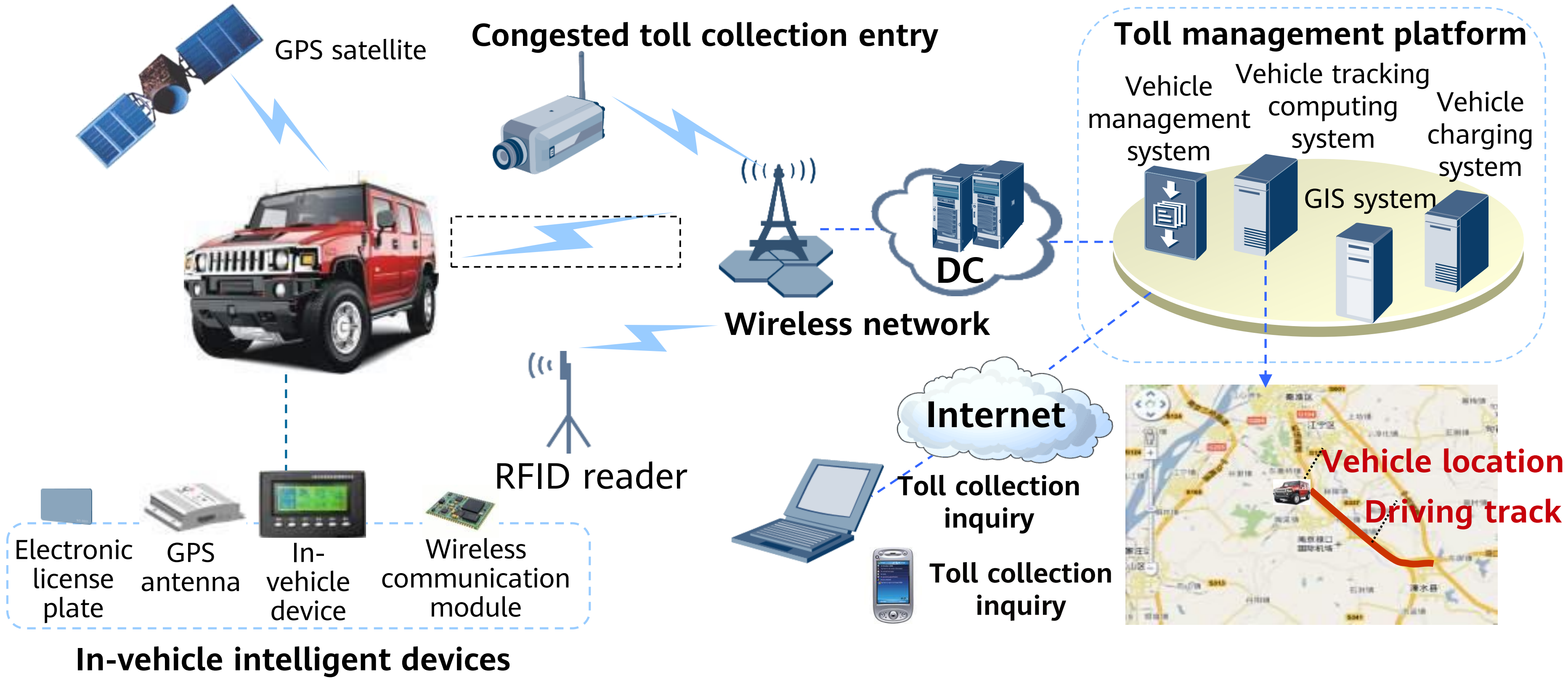
- Millions of concurrent connections
- Carrier-class 99.999% reliability
- Support for multiple tenants in the public cloud

UBI

Customer Category	Service Strategy
High-risk customers	• Do not provide the insurance service.
Customers with poor behavior	• Provide daily driving behavior scoring reminders and driving behavior suggestions. • Regularly communicate with customers about their driving behavior through the call center. • Encourage customers to improve their driving behavior through discounts.
Customers with neutral behavior	• Provide daily driving behavior scoring reminders and driving behavior suggestions. • Encourage customers to improve their driving behavior through discounts.
High-value customers	• Provide additional services to retain customers. • Perform regular surveys through the call center to increase customer loyalty.

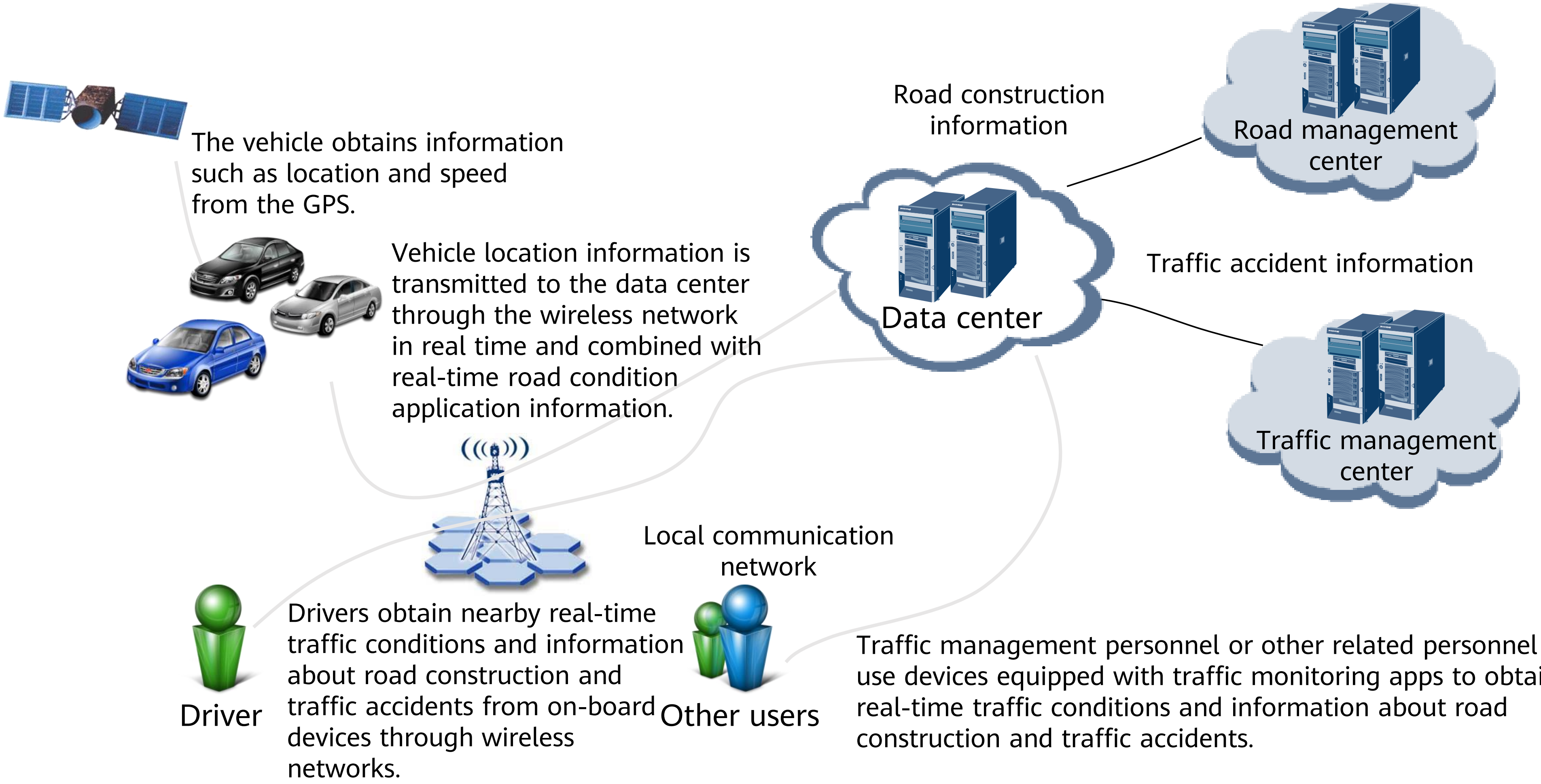


Automatic Toll Collection and Vehicle Tracking



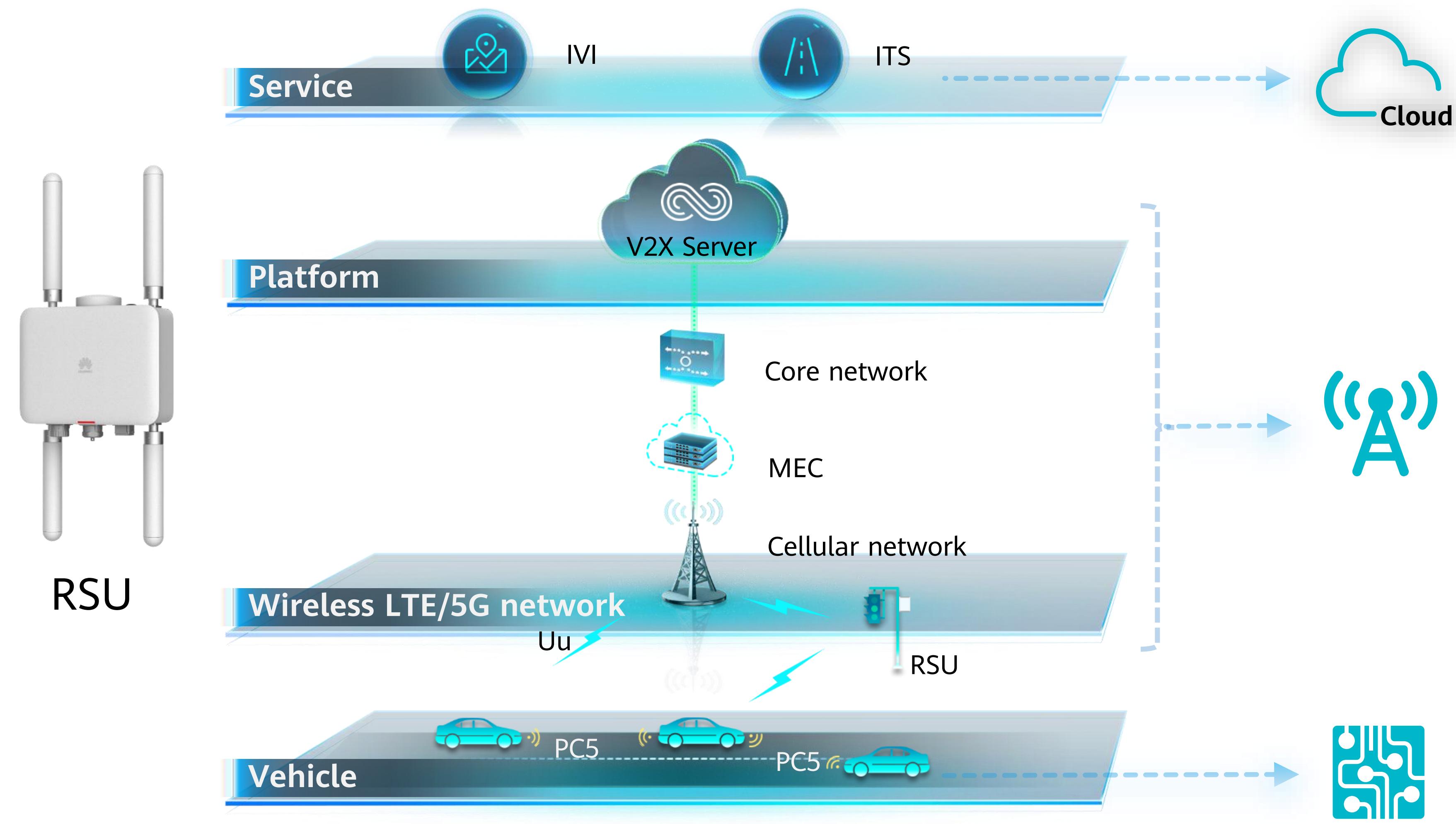
- A front-end video device is deployed at a congested tollhouse to identify license plates. The RFID reader reads electronic license plate information and reports it to the toll management platform through the wireless network.
- The in-vehicle intelligent devices report GPS location information of vehicles in real time through the wireless network. The GPS location information is used to determine the driving track of the vehicles.
- The solution supports toll collection by time or by distance and time. The time segment and range of toll collection can be set flexibly.
- The in-vehicle intelligent devices use the GPS to determine vehicle location, report the vehicle location to the toll management platform in real time through the wireless network, and determine the driving track of vehicles based on the GIS system for automatic toll collection.

Intelligent Transportation



The intelligent transportation system can effectively divert traffic based on accurate and real-time traffic information to avoid traffic congestion.

Application Cases - Wuxi LTE-V2X End-to-End Commercial Solution (1)



HUAWEI CLOUD
Maintenance service, interconnection service, fleet service, security service, data service, and mobility service

C-V2X end-to-end solution
Platform, base station, and core network

First dual-mode RSU commercial product
Uu + PC-5

C-V2X commercial in-vehicle chip/device
Balong 765
T-Box

Application Cases - Wuxi LTE-V2X End-to-End Commercial Solution (2)

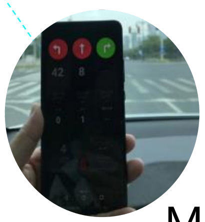
Smart camera
- Reminder for pedestrians on the crosswark
- Reminder for vehicles from the on ramp

Traffic light
- Speed guidance for traffic lights
- Red light warning
- Traffic light control

RSU

On-board device

Rear view mirror



Mobile app

Road status detection and notification

Roadside signs
- Speed limit notification
- Reversible lane notification

Application Cases - Integrated Test Base for Intelligent Transportation

One-button ride hailing

- Vehicle-road synergy and convergent perception
- Collaborative HD positioning
- Lane-level path planning

Improves user experience by transforming from "people looking for vehicles" to "vehicles looking for people"

Dynamic platooning

- Low-latency, reliable C-V2X connections
- Convergent sensing of vehicles and roads
- Centralized, coordinated scheduling

Reduces manpower costs and improves transportation efficiency by providing low-latency and simultaneous movement.

Reminder of entrance to bus lanes

- Cellular assisted high-precision positioning
- High-precision electronic fence technology
- Cloud AI behavior identification algorithm

Prevents traffic violations and ensures smooth public transportation.

Road condition perception beyond visual range

- Warning about pedestrian crossings in blind spots
- Traffic video backhaul at intersections

Detects road conditions in advance to improve driving safety and optimize paths.

In contrast to traditional driving, the C-V2X technology achieves the preceding differentiated scenarios and helps improve traffic in terms of safety, efficiency, cost, and experience.

Contents

We Are At a Critical Stage of a New Industrial Revolution

Mechanization > > > Electrification > > > Automation > > > Intelligence

- After three industrial revolutions (mechanization, electrification, and automation), we are witnessing the fourth revolution represented by intelligent technologies. Intelligent technologies are used in all the interconnected things and service processes.
- ICT technologies, such as big data analysis, cloud computing, mobility, and the IoT, are the foundation of this intelligent industrial revolution.

Developing More Efficient and Refined Manufacturing

Focus only on the automation of production and manufacturing

Gap: more efficient and refined smart manufacturing

Fully connect human, data, and machines, and combine big data analystics to develop more efficient and refined manufacturing.

Industry chain information silos

Invisible production data

Vertical integration of production information

- Dynamic awareness and intelligent O&M
- Dynamic production control
- 3D virtual factory

Horizontal integration of the industry chain

- Crowdsourcing and collaborative R&D
- E-commerce of marketing procurement
- IoV

Production IoT

Industrial cloud and intelligent big data analytics

Mobility, real-time grasp of production information

Industrial IoT Development Plans of Difference Countries

	2014-2017	2020-2022 Industrial IoT	2025
Germany	✓ Implemented Industry 4.0.	✓ Complete manufacturing connection **communications standardization**.	✓ **Unify EU Industry 4.0 standards.**
China	✓ Released "Made in China 2025".	✓ Establish a **standards system** for intelligent manufacturing communications equipment. ✓ Domestic industrial robots reach 50% of the market share. ✓ Large-scale application of the industrial wireless network with a bandwidth of **500 Mbit/s**	✓ Breakthroughs in **10** fields, such as automotive, healthcare, and energy ✓ Large-scale application of an industrial wireless communication network with a bandwidth of **2 Gbit/s**
US	✓ Signed into law the Revitalize American Manufacturing and Innovation Act.	✓ Complete flexible production line assembly within 24 hours.	✓ Invest US$1.9 billion to build **45** innovation organizations. ✓ Complete flexible production line assembly within 8 hours.
Japan	✓ Launched new robots and IoT strategies. ✓ Established Industrial Value Chain Initiative (IVI).	✓ Complete **international standardization** of manufacturing robots. ✓ Transform from manufacturing to large-scale commercial use of service robots.	✓ Increase the manufacturing informatization level from 30% to **50%.**
South Korea	✓ Proposed Manufacturing Industry Innovation 3.0.	✓ Develop IoT/smart manufacturing technology, transform **30% of existing factories** into intelligent ones, and develop 10,000 intelligent production lines.	✓ Invest US$23 billion in **13** industries, such as unmanned aerial vehicles, smart vehicles, and healthcare. Surpass Japan in the export volume.

National Policy Drive

On November 27, 2017, with the approval of Premier Li Keqiang, the State Council released the Guiding Opinions on Deepening the Development of the Industrial Internet with "Internet + Advanced Manufacturing" (referred to as "Guiding Opinions"), which is a **programmatic document** that regulates and guides the development of China's Industrial Internet.

1

Guideline
Build **three functional systems** by centering on how to promote the in-depth integration of the Internet and real economy to fully support building of national strength in manufacturing and networks.

2

Objectives
By 2020, an infrastructure and industrial system with international competitiveness will have taken shape.
By 2035, internationally leading fields will be established.
By the middle of this century, comprehensive strength will leading in the world.

3

Major Tasks

- **Consolidating network foundation**
- **Building a platform system**
- **Enhancing security**

- Strengthening industry support
- Promoting converged applications
- Improving the industry ecosystem
- Accelerating openness and collaboration

4

Assurance support
Establishing and perfecting laws and regulations to create a good environment for development
Increasing financial and tax support and innovating service modes
Strengthening professional talent support and improving organization implementation mechanisms

ICT-based Production System of Smart Manufacturing Enterprises

Intelligent sensing

- Dumb terminals to be intelligent
- Diverse access protocols
  - Zigbee, PLC, RS485, Modbus, Profibus, HART, Wi-Fi, LTE, etc.
- Device interconnection

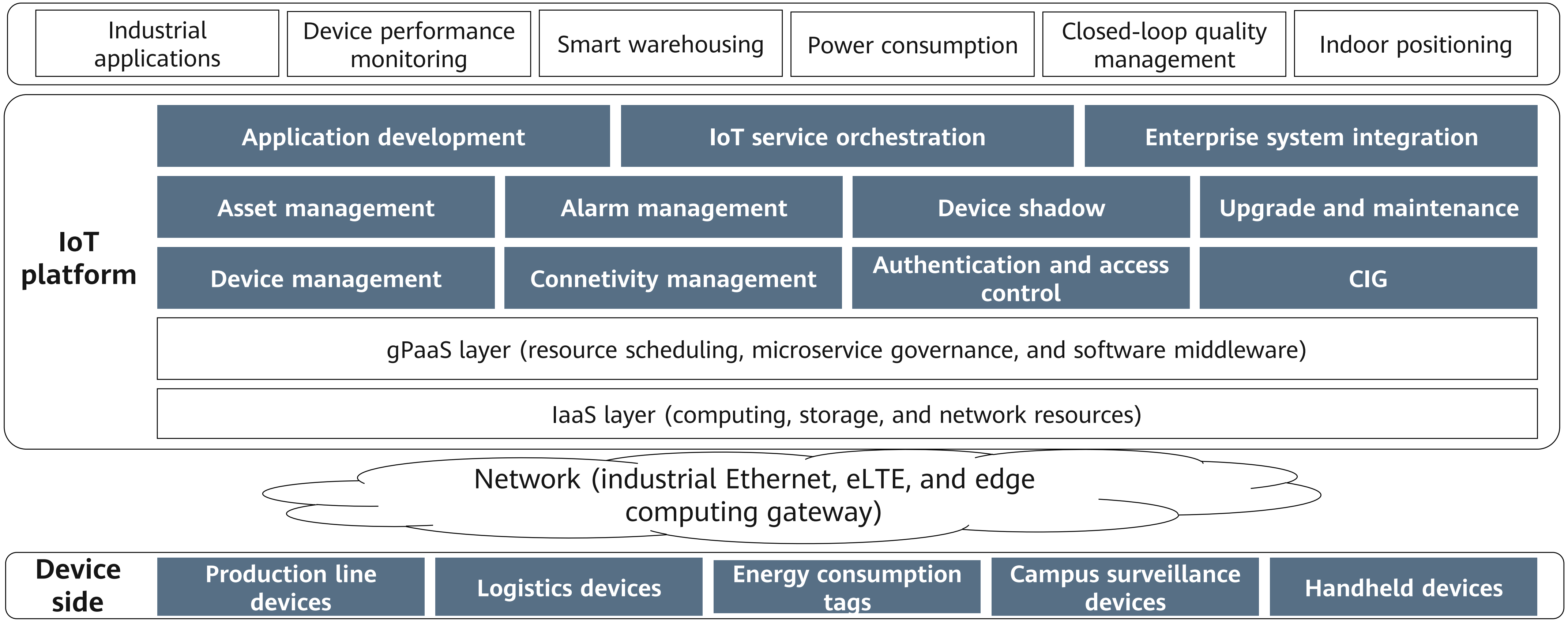
Ubiquitous connections

- Numerous connections
- Meeting requirements in different scenarios
  - Latency and reliability: industrial control
  - Bandwidth: video surveillance
  - Low costs and rates: metering

Data value creation

- Industrial knowledge
- Data sharing
- Security and privacy

Technical Architecture of the Huawei Industrial IoT Solution



As a key component of the industrial PaaS, the IoT platform provides capabilities such as device access, connectivity management, device management, and device data processing. It also provides open capabilities to upper-layer applications.

Digital Production in the Factory and Digital Products Outside the Factory

Huawei | Ecosystem

Industry applications: Oil & gas | Manufacturing | Electricity | Transportation

Digital production


Production visualization


Asset locating and tracking


Production line energy consumption management


Smart logistics in factories

Industrial IoT

Digital products

IoV


Internet of Elevators


Internet of Containers


AMI (meters)


HUAWEI CLOUD IoT platform + Network (NB-IoT/eLTE-IoT/EC-IoT) + Cloud (Fusion Cloud + HUAWEI Cloud)

Industrial terminals: Oil & gas | Manufacturing | Electricity | Transportation

Necessity and Benefits of Production Visualization System Construction

Converting data into visualized production management execution processes and decision-making basis

Industry Necessity

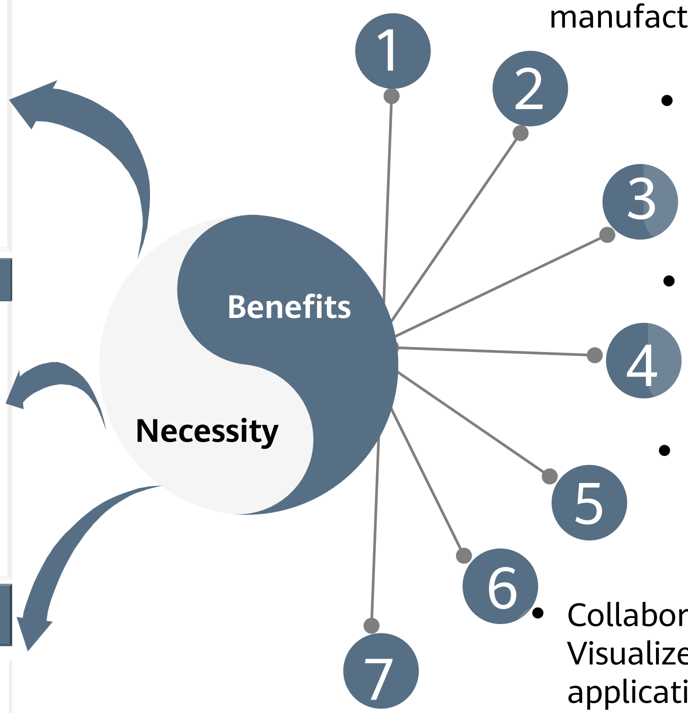
Improve production reliability, comprehensive equipment efficiency, and management efficiency, and help automotive OEMs maintain long-term competitiveness.
Improve supervision, management, and control capabilities of the production process to ensure quality, promote branding and reputation, and reduce costs.
Provide valuable experience for product updates, iteration, and upgrades.

Development Necessity

Provide comprehensive information and decision-making methods for managers and decision-makers.
Integrate intelligence with management and automation with efficiency to support automated, intelligent, and efficient applications and comprehensive personnel management in the future automotive industry.

Data Application Necessity

Control the running time of assets, predict energy consumption, and improve the profitability of enterprises.
Leverage smart data to make smarter decisions quickly and effectively.



- Enhance management, reduce costs, and increase efficiency.
- Control quality precisely, optimize integrated manufacturing costs, and improve profitability.
- Implement efficient management and flexible production, perform situation analysis and release results, and accelerate analysis and decision-making.
- Improve efficiency management of personnel, equipment, and production lines, enhance surveillance and management efficiency, and promote comprehensive productivity control.
- Support implementation of indicators and management concepts with indicator-based surveillance and real-time data tracking and surveillance.
- Collaboration between management and production: Visualized, data-based, graphical, and mobile applications are used to resolve risks and silos in production management.
- The surveillance, management, control, and inspection of the visualization system will directly improve coordination of human, machine, and material factors.

Production Visualization Sub-scenarios

Visualized technological process simulation

Dynamic simulation overview of the entire workshop

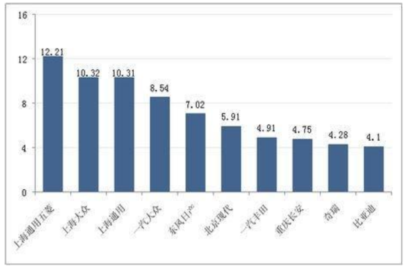
Technological process running analysis

PLC running data display

Energy efficiency of the technological process

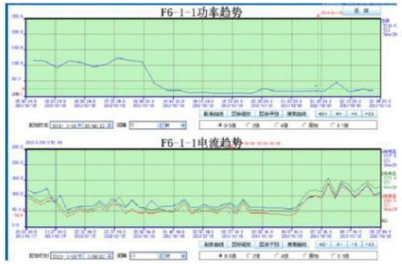
Energy consumption of each production stage

Production data integration



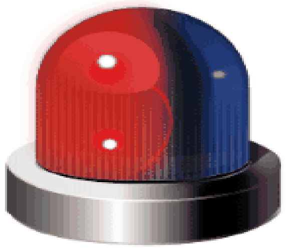
Integration of workshop production data

Historical running status of equipment



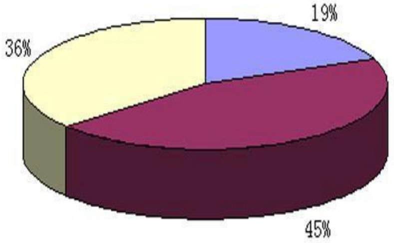
Production line equipment and PLC control Historical running status

Real-time alarms of production lines



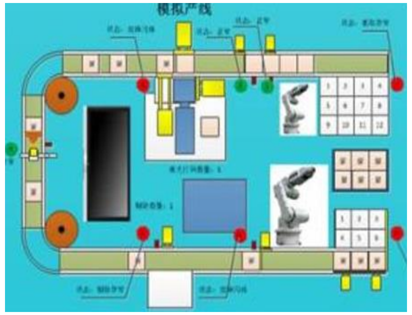
Alarms for product line abnormalities, with preset warning thresholds

Production line productivity analysis



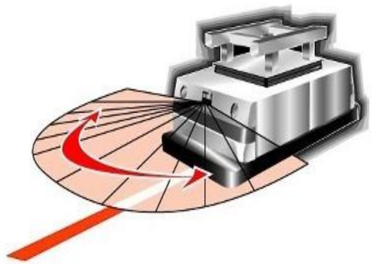
Percentage line equipment Achievement rate of planned productivity

Dynamic simulation of production lines



PLC-based data collection and simulation of dynamic production

Automated Guided Vehicle (AGV) visualized surveillance



Interconnection with the AGV management system to obtain running data and dispatch data of the AGV

Interconnection with Andon system and data display

Interconnection with the Andon system to push Andon system information

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Integrated Intelligent Factory Production Management Platform

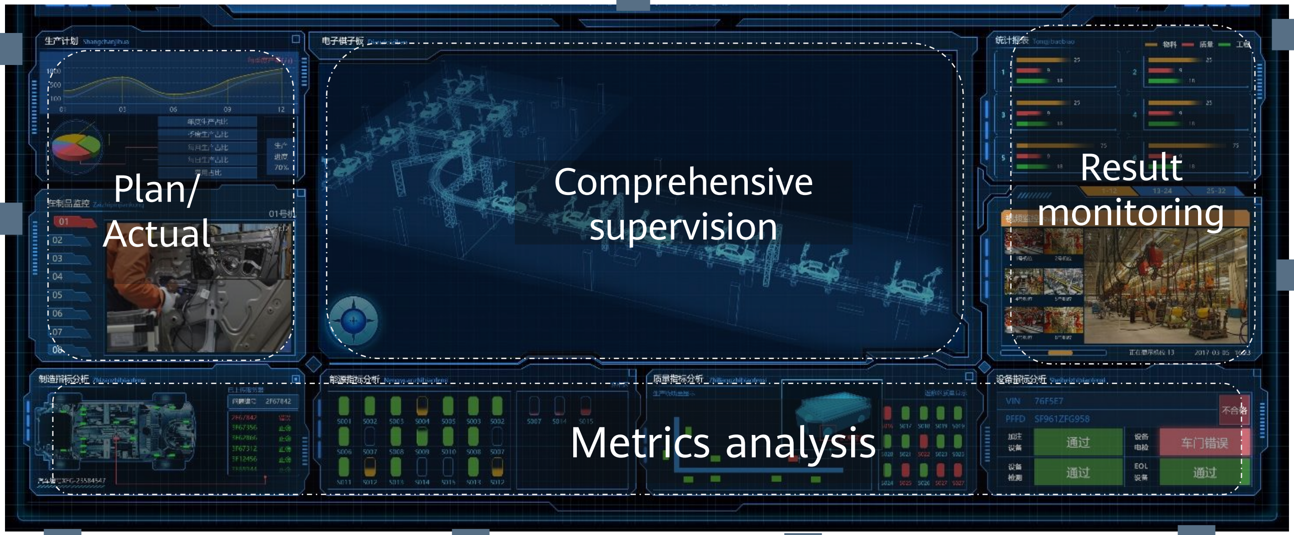
Factory overview based on a 3D design

Graphical production plan application

Innovative WIP supervision application

Data report exporting based on big data

Structural, online video surveillance system



Manufacturing operations metrics

Energy metrics

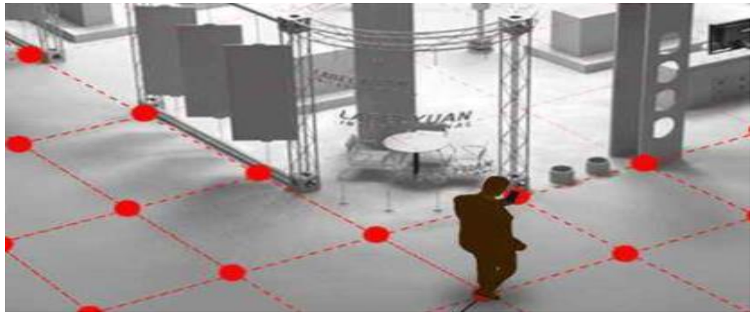
Comprehensive and sub-item quality metrics

Device running metrics

Asset Locating and Tracking Requirements

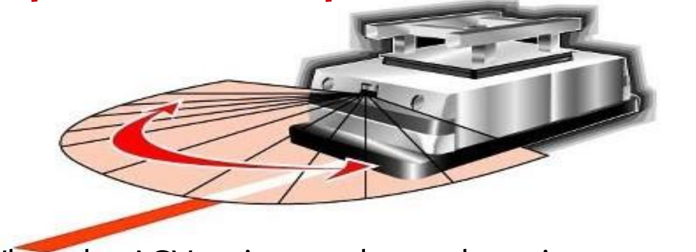
Location query

Displays the locations of people, vehicles, devices, and tools in a workshop in real time.



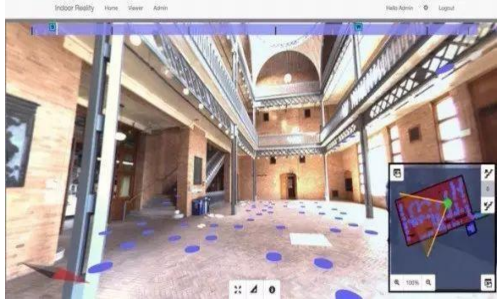
By entering information on the management platform, we can quickly find the exact location of the target and plan the arrival route.

Bidirectional transmission of production dispatch instructions

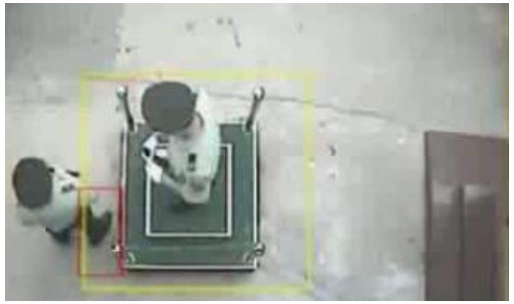


When the AGV arrives at the work station, information transmission is automatically triggered. The LED displays the task instruction and product attributes. The operator confirms the operation and sends back the instruction.

Intelligent judgment



Determines whether the forklift truck or material is sent to the correct position, facilitating overall management and allocation.



When an employee enters a non-designated work station, an audio and visual alarm is generated to remind the employee. The system records the event to prevent the employee from visiting other areas during working time.

Area division

User-defined area division enables regional alarm reporting.

The system automatically generates alarms when production tools and materials in the specified area are removed.

The system automatically sends alarms to the surveillance center when an unauthorized person, object, or vehicle enters the area.

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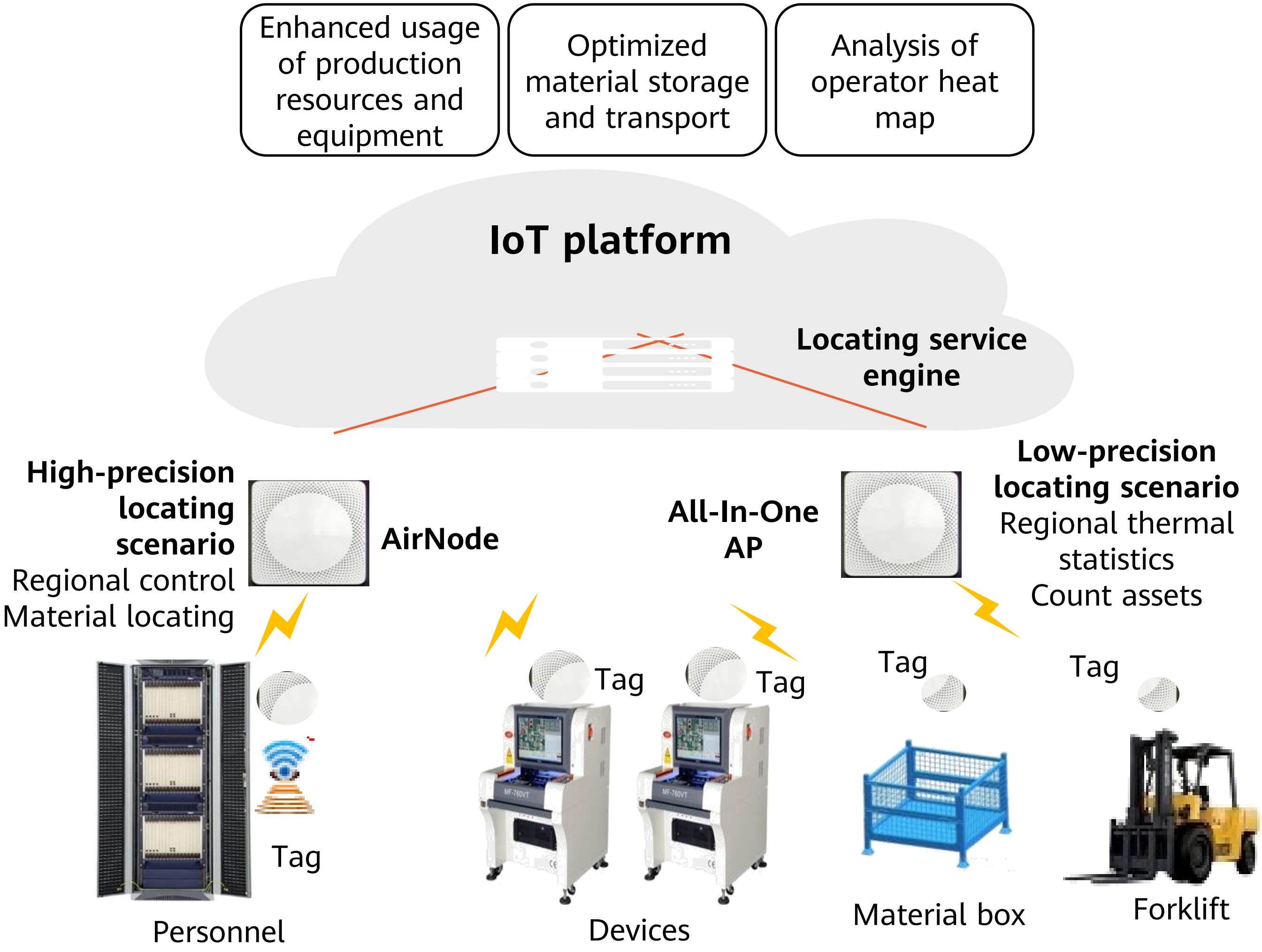
Asset Locating and Tracking Solution



Platform and application system

The IoT platform synchronizes the locating data submitted by the Airnode/all-in-one AP and performs location calculation in the locating service engine.
Using the coordinates provided by the locating engine, the application system platform matches the indoor map and provides heat map analysis, foolproof operation alarms, and personnel tracking and route optimization based on services.

Network locating layer

The positioning base station (Airnode/All-in-one AP) receives the beacon signal sent by the positioning tag and sends the beacon signal to the upper-layer IoT platform to parse the positioning information.
The high-precision positioning is precise to 30 cm, and the low-precision positioning is precise to 3 m to 5 m.

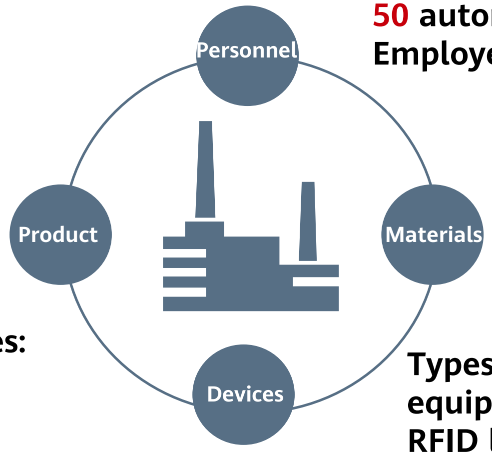
Location data collection

A key node at this layer is a location information collection tag that periodically reports a location information beacon.
The tag uses a chip with ultra-low power consumption, which lasts for more than three months.
(The specific time is adjusted based on the data reporting frequency.)

Application Cases - Songshan Lake Smart Factory (1)

Huawei Songshan Lake South Factory uses technologies such as IoT, wireless communications, cloud computing, and big data to seamlessly collect production resource data based on the transparent factory concept. It builds digital applications from workshop scheduling to resource scheduling, and from device operation monitoring to transparent operations management. In this way, vertical streamlining is implemented among factory IoT sensing, network connections, a big data platform, and applications.

More than 80% of key resources connected



50 automated production lines
Employees: 15,000

Mobile phone materials: tens of thousands
Pan-network materials: tens of thousands

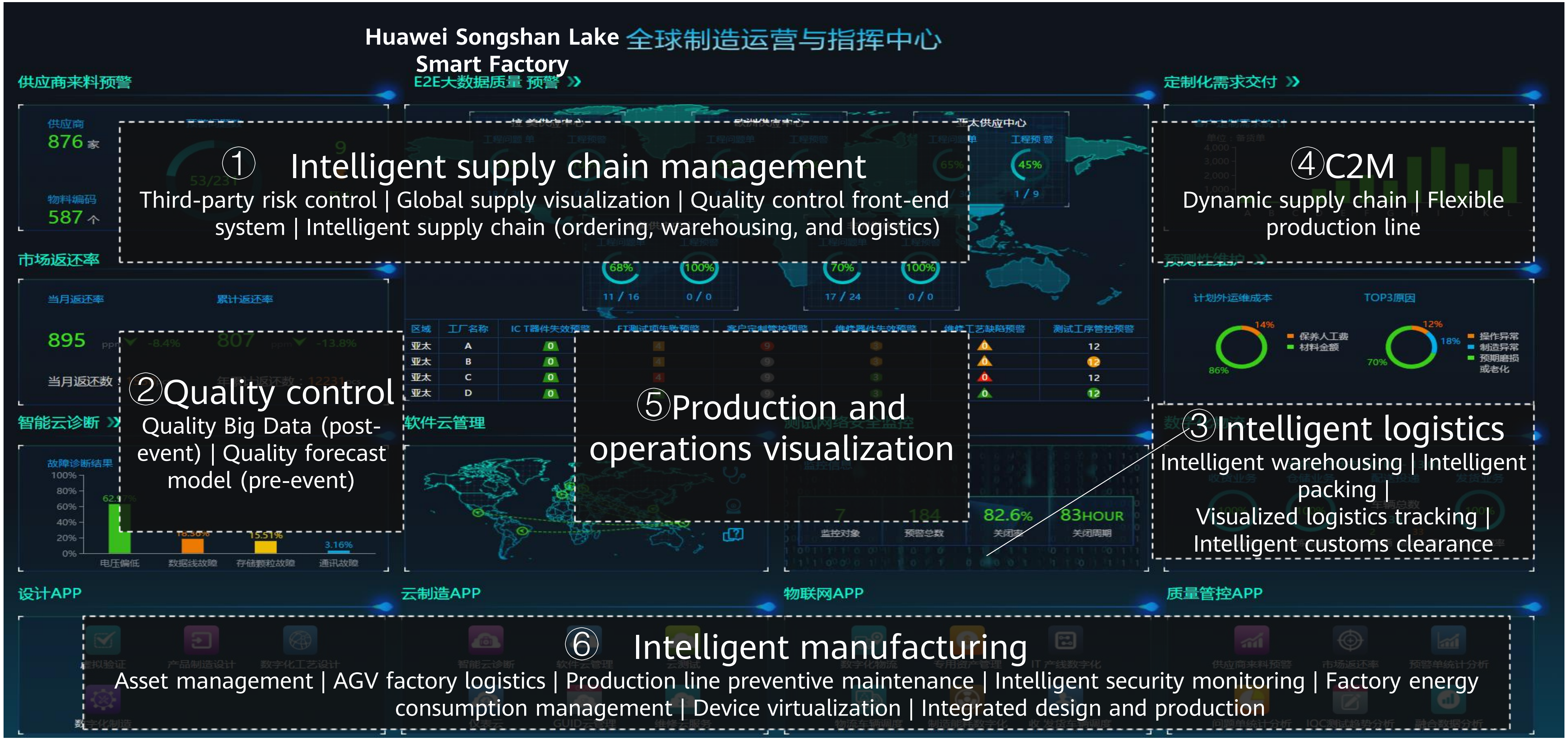
Mobile phone types: 50+
Types of pan-network devices: 5,000+

Types of production equipment: 4,000+
RFID logistics boxes: 13,000+
AGVs: 100+

Visualized operations for higher efficiency and lower costs

Real-time production warnings: 6,000+
The product manufacturing cycle is optimized, and the production efficiency is improved by 20%.
In the wireless benchmark production workshop, the equipment failure rate is reduced by 23.2%, and the inventory cycle is reduced by 20%.
286 fewer persons are required in logistics, and a site with 38,000 square meters is saved.
Mobile phone production line: 29 persons -> 20 persons; IT production line: 27 persons -> 13 persons; Wireless production line: 15 persons -> 10 persons

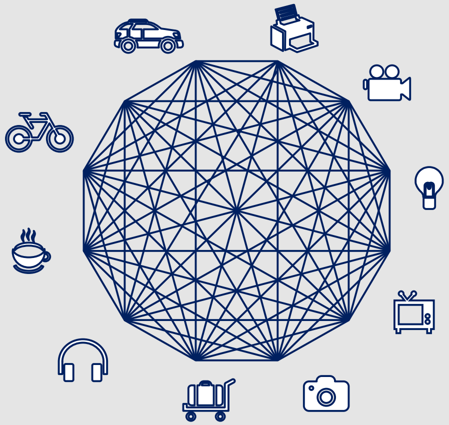
Application Cases - Songshan Lake Smart Factory (2)



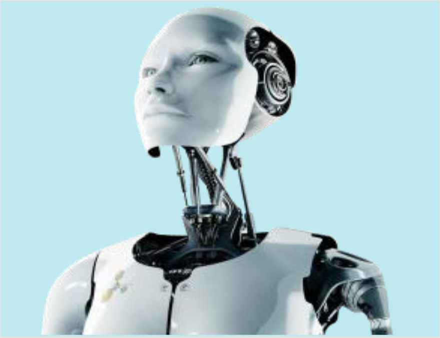
Contents

Seven Emerging Technologies: 5IABCDE

5G

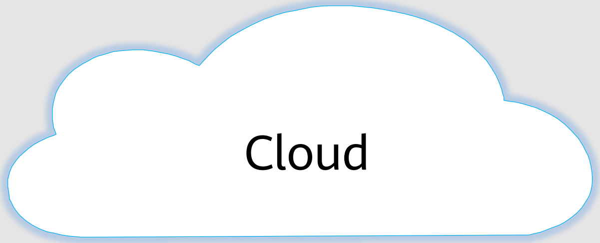


IoT



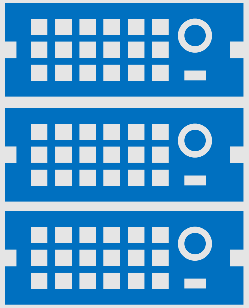
AI

Blockchain



Cloud computing

Big data



Edge computing

5G and Edge Computing Empower Low-Latency Services

- The uRLLC scenario empowered by edge computing and 5G communications technologies provides users with ultra-high reliability and ultra-low latency, allowing services with high real-time requirements to respond to emergencies:
  - In the V2X scenario, services such as ADAS and automated driving have low latency requirements.
  - In remote surgery scenarios, low-latency HD video transmission improves surgery success rates.
  - In industrial manufacturing scenarios, low latency facilitates remote control of high-precision instruments.

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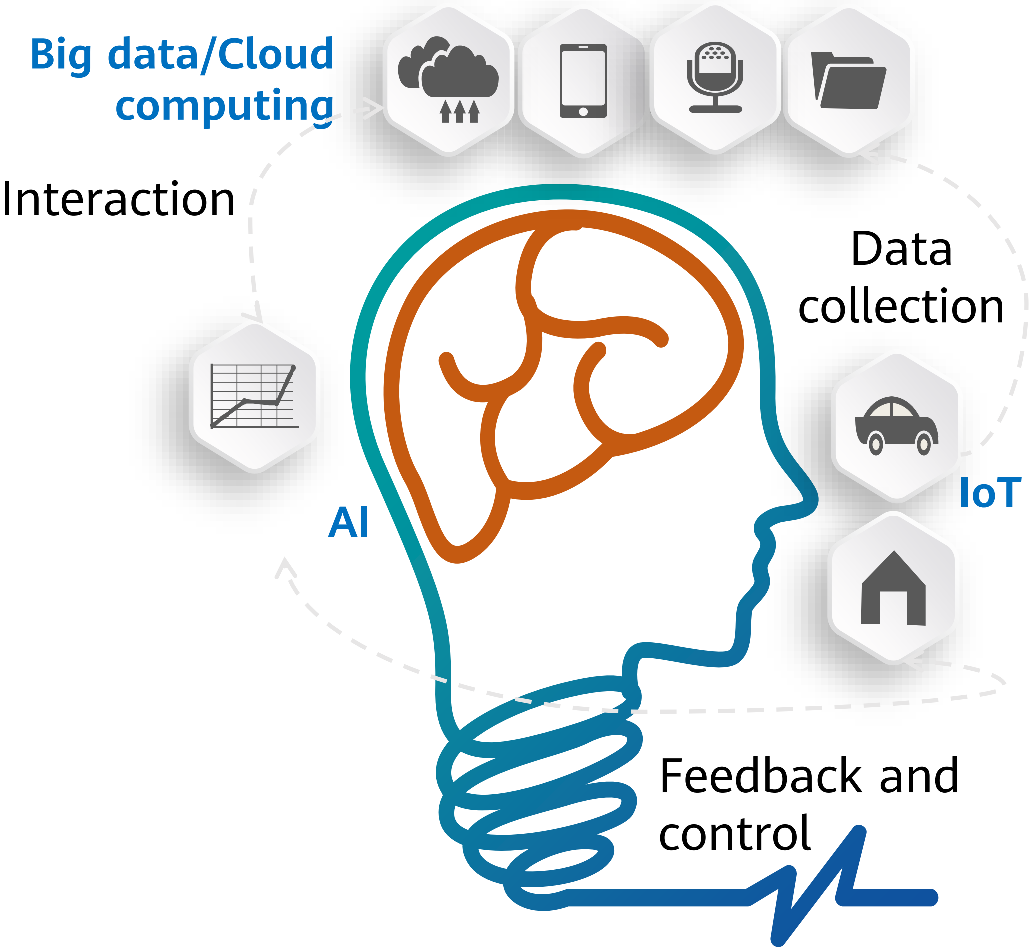
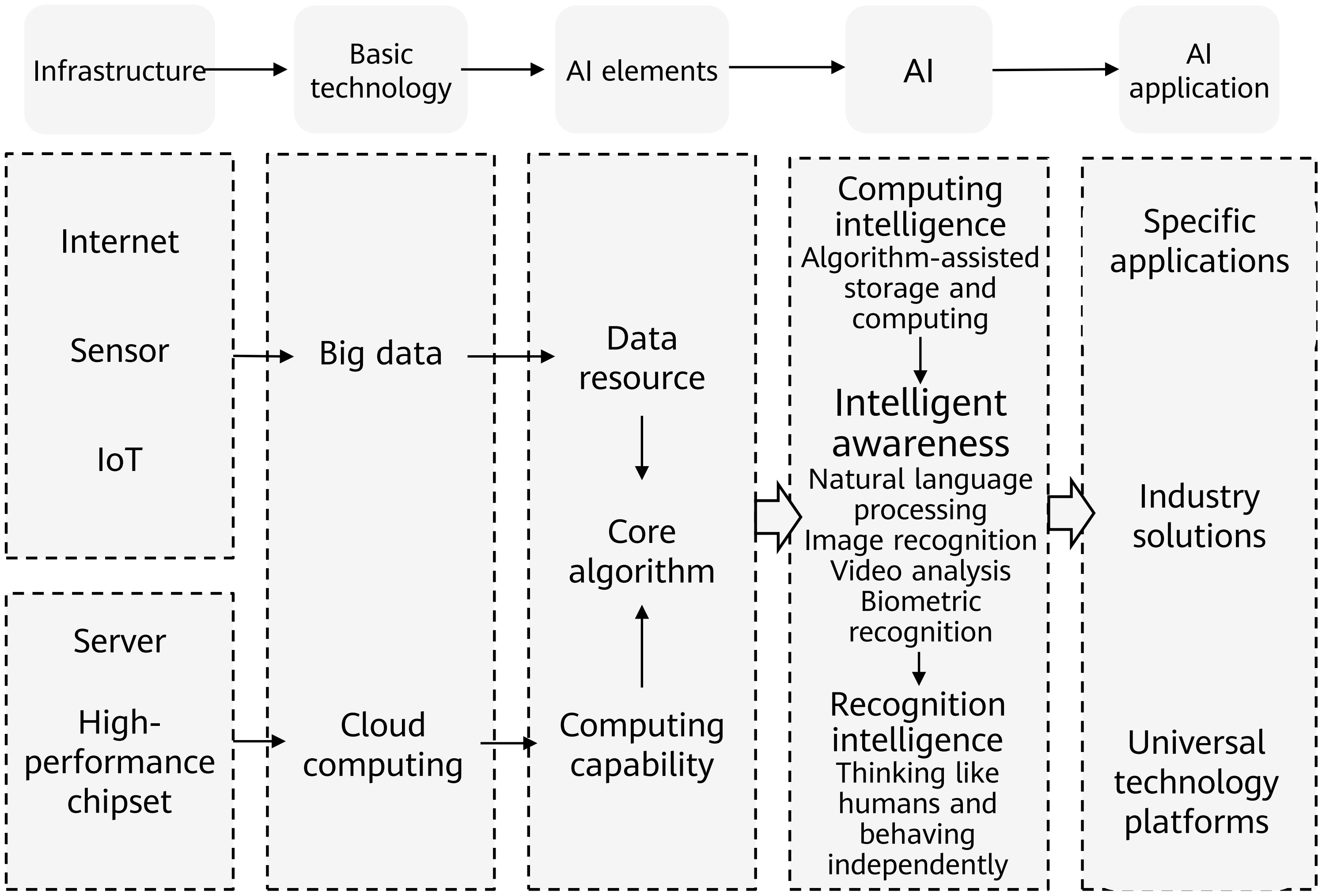
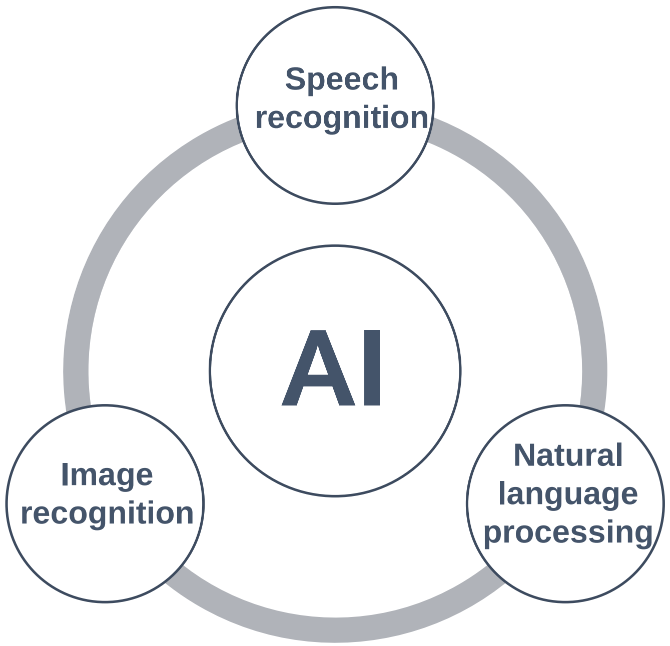
Relationship Between Big Data, Cloud Computing, IoT, and AI



The IoT has multiple eyes, noses, tongues, ears, and skins for sensing. Big data is sensory information obtained by various sensing organs. Cloud computing provides memory and storage. AI is cognition and decision-making. The essence of information technology (IT) and data technology (DT) development is personalization and intelligence. The intelligent era is inevitable.

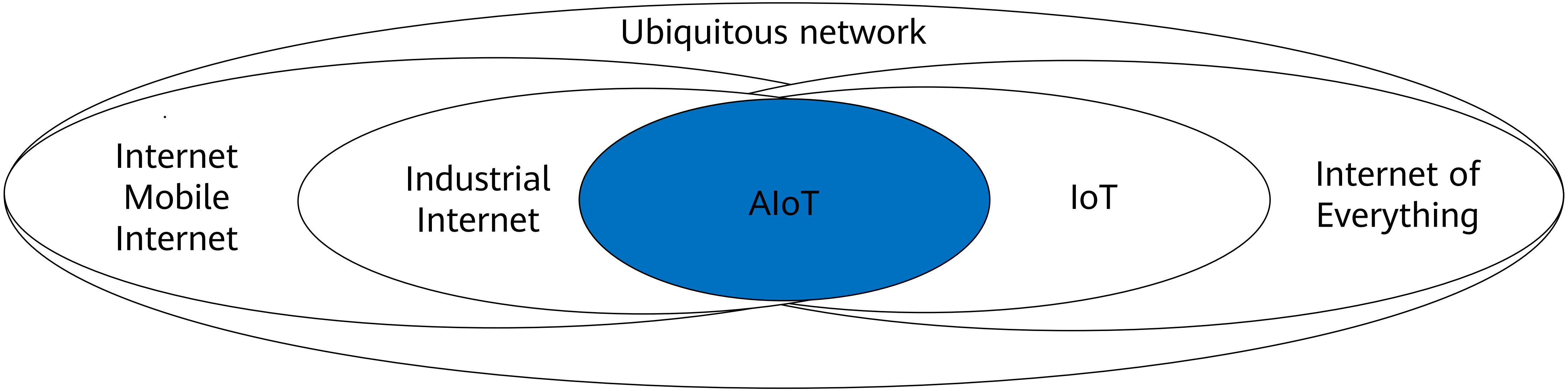
AI Industry Ecosystem and Application Direction



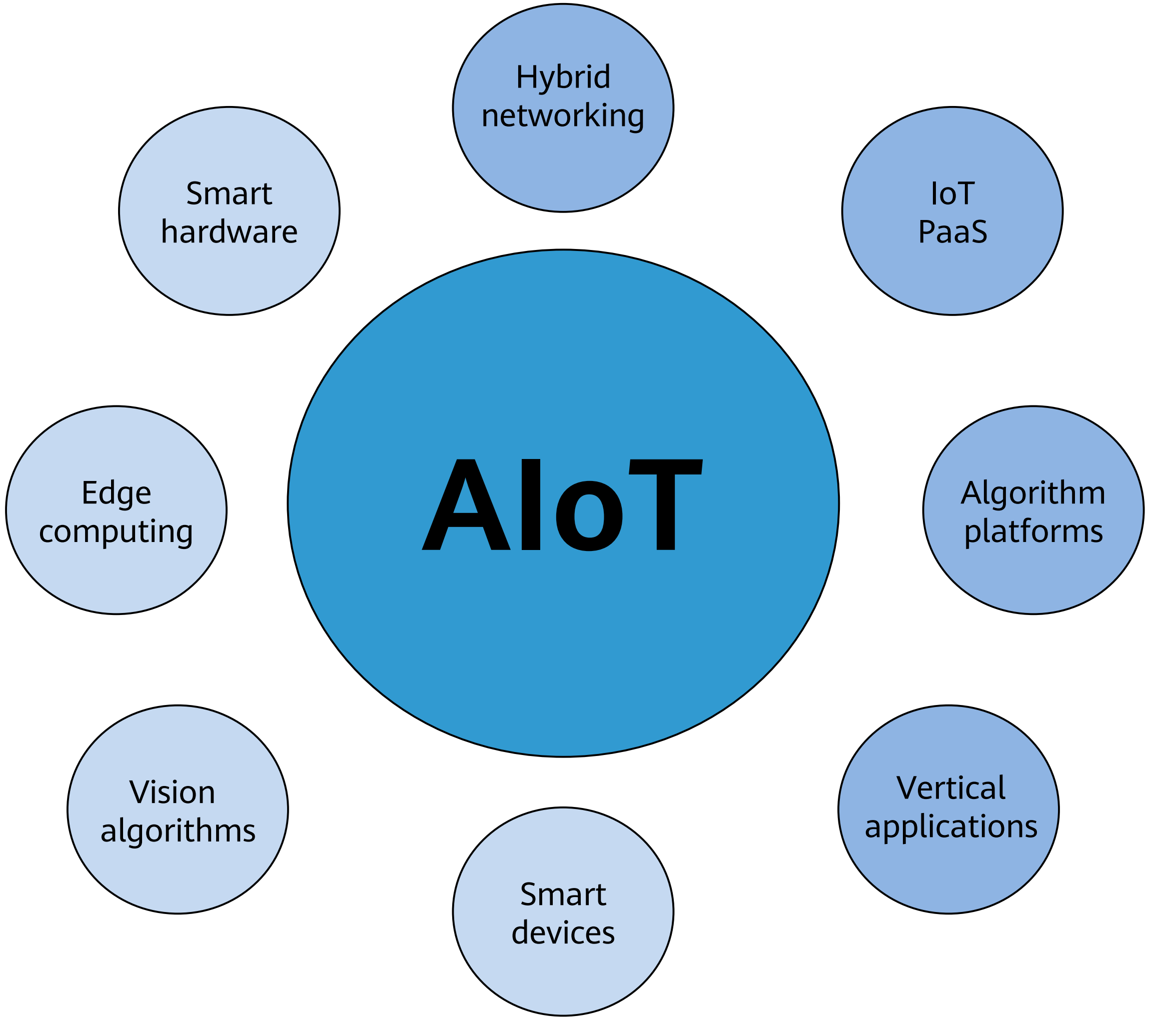


From IoT to AIoT

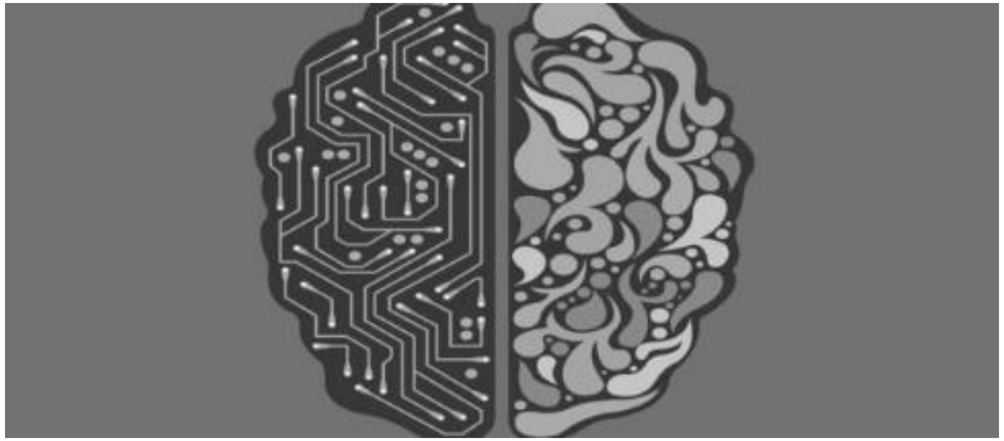
- AIoT = AI + IoT. IoT integrates AI to promote the intelligent connection of everything.
- IoT standards focus on data transmission technologies, whereas AIoT focuses on new IoT application forms, especially services and IoT-oriented backend processing and applications.
- AI and IoT complement each other. IoT provides huge amounts of data for deep learning, and scenario-based interconnection of IoT provides a basis for fast implementation of AI. AI converts data into value through analysis and decision-making.



AIoT System Drives Smart Connectivity of Everything



- The market research firm Gartner predicts that the number of global IoT devices will reach 26 billion by 2020, and the market scale led by IoT will reach $11.2 trillion USD by 2025.
- For example, remote voice control of home appliances and backend systems in factories can automatically collect and process data sent from sensors and generate diagnosis reports, and cities can go smart. It can be said that the development of AIoT is inevitable. The emergence of AIoT implements substantial AI enablement and intelligent connectivity of everything.

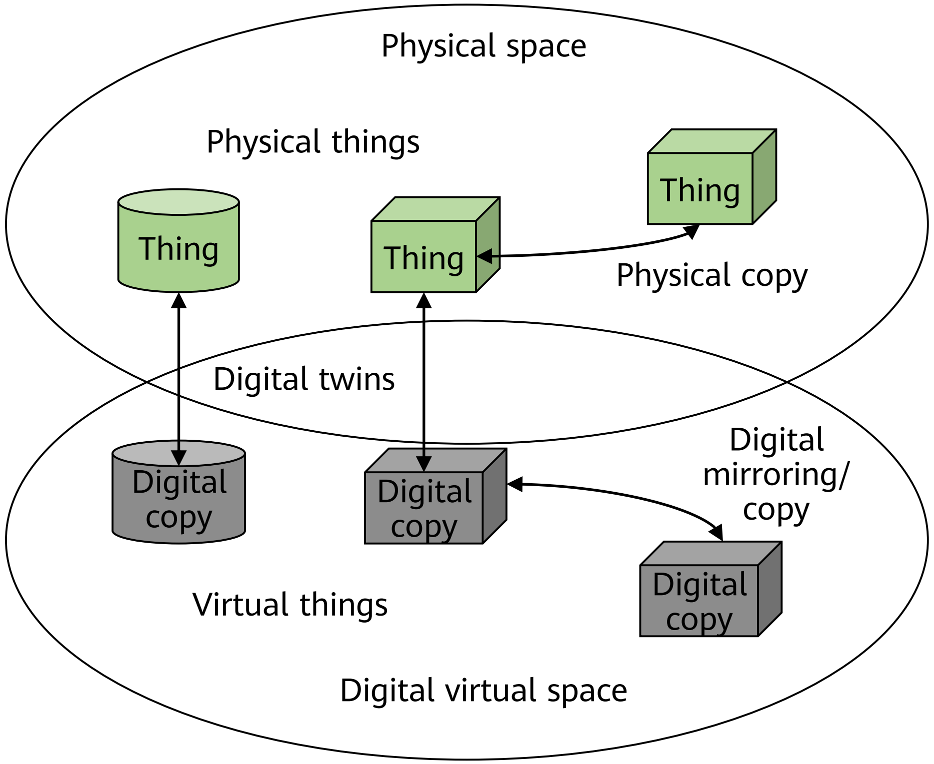


Future Trend - Quantum Computing Releases Infinite Computing Power

- Quantum computing is especially addressed to problems that cannot be effectively solved by traditional computing (such as integer decomposition, database search, extremum optimization, structural analysis of complex molecules, large sample simulation, and machine learning).
- Quantum algorithms will evolve from efficient computing for a number of specific problems to computing for more general problems.
- The capability of traditional computing individuals will be enhanced by the overall computing capability of the cloud. The expansion of quantum computing power will also depend on the distributed parallel computing of the network.
- However, quantum computing will not be able to surpass traditional computing over a long time, and for many purposes, quantum computing cannot replace traditional computing.

Digital Twin Facilitates Device O&M

- The term Digital Twin was first proposed by Michael Grieves, a professor at the University of Michigan, in a course on product lifecycle management in 2003. It is defined as a three-dimensional model that includes physical products, virtual products, and the connection between them.
- Digital twins are empowering technologies and means for practicing advanced concepts such as smart manufacturing, Industry 4.0, industrial Internet, and smart city. Digital twins are used to build multi-dimensional models for applications in 10 fields covering manufacturing and service industries, containing space communications networks, ships, vehicles, power generation, aircraft manufacturing and flight, complex electromechanical equipment, stereoscopic warehouses, healthcare, manufacturing workshops, and smart cities.



Summary (1): New Infrastructure Plays an Important Role in the IoT Industry with Slow Development

- Over the past decade, the IoT has been a slow-developing industry. Many well-known research institutions have released IoT prediction data, and almost all of them predicted that the IoT would generate tens of billions of connections and the IoT market would be worth hundreds of billions of dollars by 2020. However, these results did not come into fruition.
- New infrastructure may not necessarily be physical facilities with large-scale investment. For example, infrastructure that can penetrate into every corner of production and operations in different industries. It can directly generate multiplier output for production and operations. Innovative IoT elements, such as widely used lightweight IoT device operating systems and AI algorithms that can be applied to a large number of scenarios, can increase output by several times. In the next decade, the role of new IoT infrastructure will be clear. The scale of the IoT industry will be worth paying attention to. Changes in various industries after the IoT transformation are even more worth paying attention to.

Summary (2): IoT Brings New Industry Reshuffling Opportunities

- The IoT brings great impact and more changes to traditional enterprises than those in PC Internet and mobile Internet eras. No enterprise can ignore the IoT. Similarly, the IoT brings reshuffling opportunities for enterprises in the world.
- According to an IDC survey report, nearly **90%** of Chinese enterprises believe that IoT is of strategic significance for driving digital transformation. In the next four years, China's IoT platform will maintain a compound annual growth rate (CAGR) of **13.0%**. By 2021, China's IoT platform will create value worth **$6.22 billion USD**, accounting for more than **30%** of the world's total.
- According to a report released by the Bureau of Radio Regulation of the Ministry of Industry and Information Technology (the State Radio Office), China's IoT business revenue in 2018 increased by **72.9%** compared with the previous year. Overall development is very rapid.
- With the official commercial use of 5G in China this year, the IoT will take off. Driven by 5G technologies, intelligent connection of everything will become possible, and IoT application scenarios will become more and more extensive. In particular, the in-depth integration of the IoT with unmanned driving, smart homes, smart manufacturing, and remote healthcare will create huge growth space for all industries.

Summary (3): Self-Innovation in Traditional Industries Is Becoming More and More Obvious

- Thanks to the spread of concepts such as the digital economy and industrial Internet, traditional industries have started to explore various innovation methods to fulfill their own transformation and upgrade requirements. The IoT is an important tool for innovation. Driven by self-innovation of many industries, the IoT will become more and more popular in these industries.
- A typical case is the proposal by the State Grid Corporation of China (SGCC) to construct ubiquitous electric power IoT in early 2019. This plan is not intended to partially apply IoT, but to transform SGCC through IoT and related technologies. As an enterprise with a large production volume and a significant impact on all aspects of the national economy, SGCC has embraced the IoT and has started the large-scale application of vertical industries, which has demonstrable influence.

Quiz

1. (True or False) Wi-Fi technology is commonly used for parking, fire fighting, and manhole cover management in smart cities.
2. (Multiple-choice question) What are the common problems encountered in campus management?

   A. High OPEX

   B. Unsatisfactory services

   C. Coarse-grained management

   D. Proactive response
3. (True or False) The entire process of the power system is as follows: power generation, transformation, transmission, transformation, distribution, and power consumption.
4. (Single-answer question) Among the seven emerging technologies of "5IABCDE", what does "C" refer to?

   A. Blockchain

   B. Cloud computing

   C. Big data

   D. IoT

Summary

- This section describes several common IoT application scenarios at the application layer, such as Smart City, Smart Campus, AMI, IoV, and industrial IoT. Among the Smart City application scenarios, there are several small application scenarios. This section describes the challenges faced by various industries and the changes that digital solutions can bring to them.
- You can also learn seven emerging technologies: 5IABCDE, how these technologies should be integrated in the IoT, and their development trends.

Thank you.

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IoT Security Technologies

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Foreword

- In today's human-centered network era, security has become the biggest concern for network development. It also will be a more trending topic in the coming Internet of Things (IoT) era where everything can be connected.
- IoT security involves four layers: application, platform, network, and device. A comprehensive security protection mechanism must be designed to ensure collaborative protection at each layer.

Objectives

- Upon completion of this course, you will have an understanding of:
  - Problems faced by IoT
  - Huawei IoT security technologies
  - Typical Huawei IoT security cases

Contents

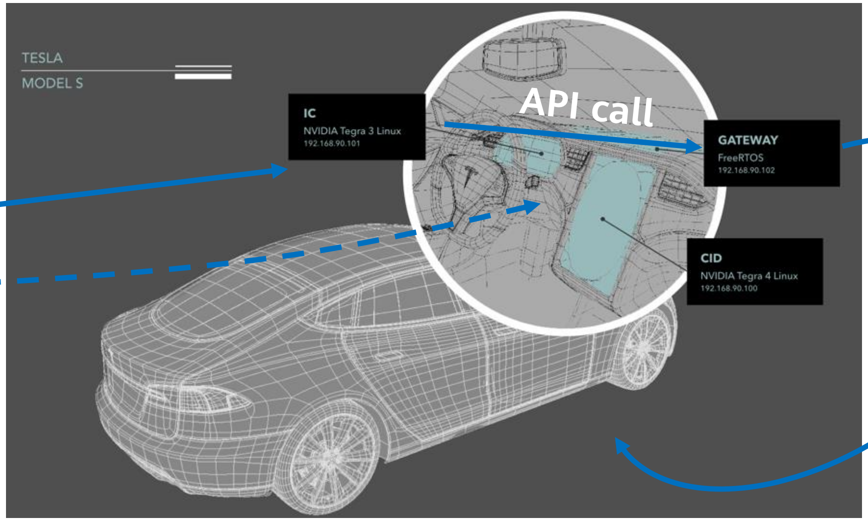
Tesla Incident

- The in-vehicle system is intruded, causing a vehicle to be remotely started or stopped.

② Forge a connection to communicate with the background and obtain the password for the in-vehicle system.

Attacks can cut off power during the driving process.

③ Log in to the system and deliver commands to the CAN bus through the gateway.



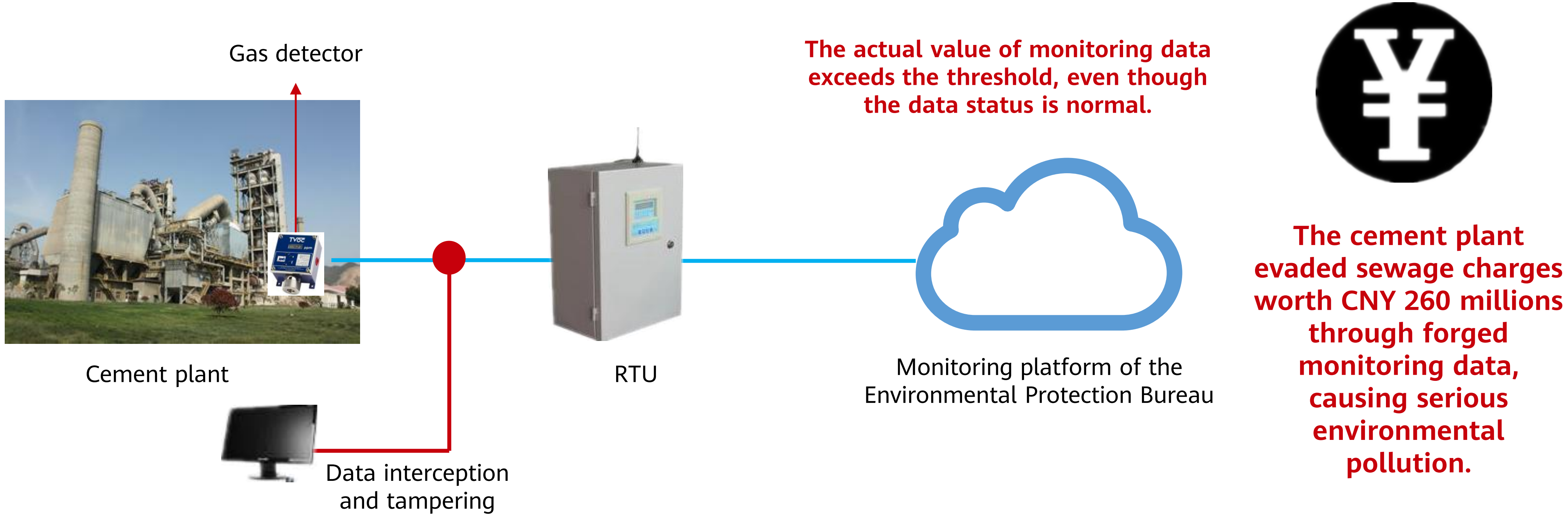
④ Deliver commands to the CAN bus to control the vehicle's behavior, including vehicle startup and shutdown, as well as door opening and closing.

① Analyze the hardware and find the removable storage card that contains the background remote communication certificate and password stored in plaintext.

- No protection measures are taken for local key information causes this incident.

Nanjing Environmental Protection Bureau Incident

- The local network was intruded, and environmental monitoring data was tampered with.



- Encryption and integrity protection are not carried out during data transmission, which allows the violation to be possible.

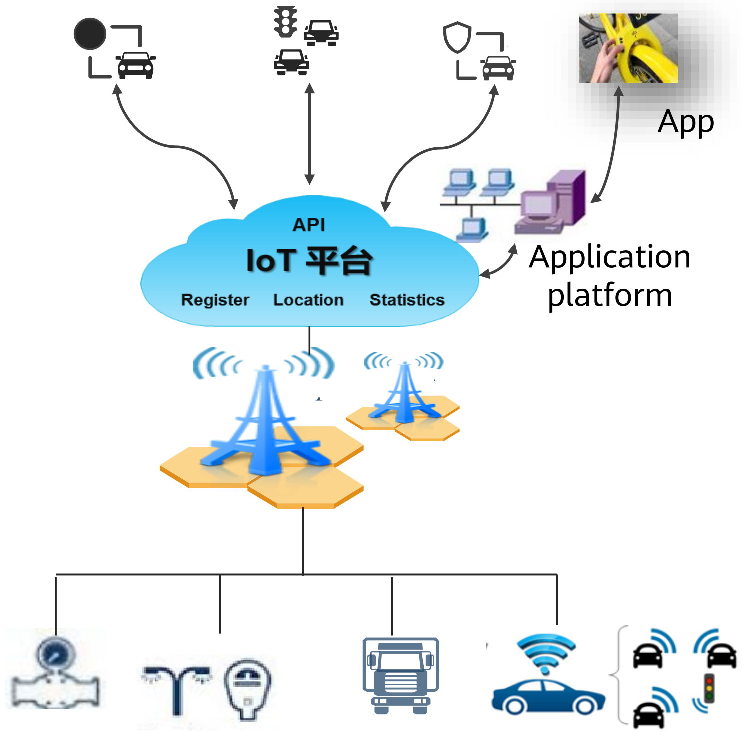
DDoS Attack on Network Cameras in the U.S.

- The large-scale DDoS (Distributed Denial of Service) attack was launched by botnets composed of IoT devices that were infected with Mirai malware.
- "Zombies" refer to network cameras, digital video recorders and intelligent routers.
- Mirai botnets infected millions of devices, and only one tenth of them were involved in this DDoS attack.

From 11:00 to 17:00 (UTC time) on October 21, 2016, Internet services were unavailable in several cities in the U.S., and **nearly half of the network was disconnected**.

Summary of Threats in Key IoT Security Fields

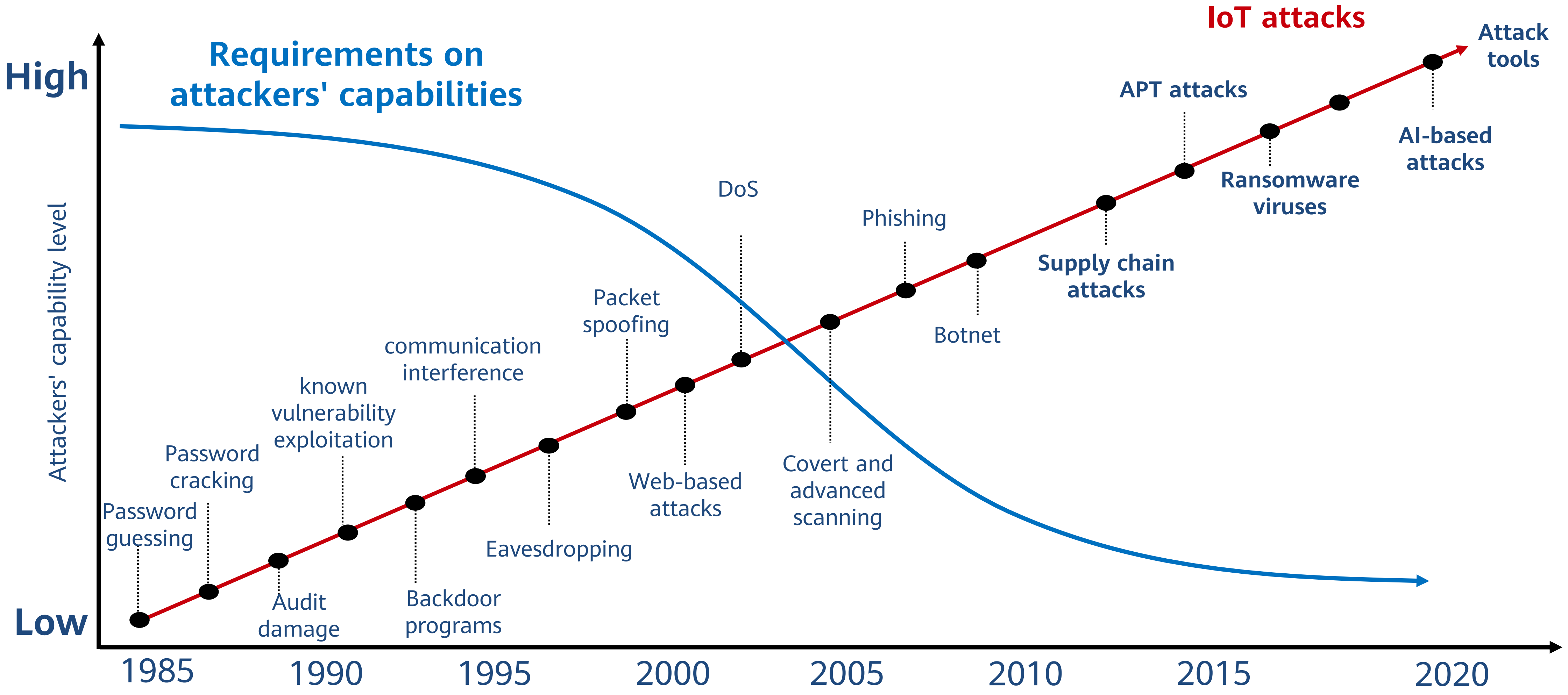
- The threats cover device, communications, cloud/platform and lifecycle management.



Category	LPWA Security Threat	IoV Security Threat
Application	• Sensitive information leakage • Invalid security access control • Incorrect security configurations	• Bluetooth vulnerabilities • Malicious in-vehicle infotainment (IVI) apps • API attacks
Cloud/ Platform	• Unauthorized access • Tenant intrusion • Data leakage and hijacking	• Trajectory privacy leakage • Data tampering and audit • No awareness of abnormal vehicle behavior
Pipe	• DDoS attacks/signaling storms • Gateway vulnerability or improper configurations • Improper identity authentication measures • Unencrypted transmission	• Identity spoofing • Protocol attacks • PKI/CA certificate spoofing
Device	• Device identity simulation • Trust key attacks • Software and firmware interference • Remote security management • Checking of damaged devices • Brute-force device breakdown	• CAN bus authentication and encryption • T-Box communication security threats • OBU/RSU vulnerability threats • Vehicle-mounted certificate security

- IoT security threats are in the negative triangle model, and most of them are from devices. Pipe detection, cloud-cloud synergy, and trusted device authentication are effective means to resolve threats.

Trend of Network Attack Technologies



Contents

"3T+1M" Framework of the Huawei IoT Security Solution

"3T+1M" framework

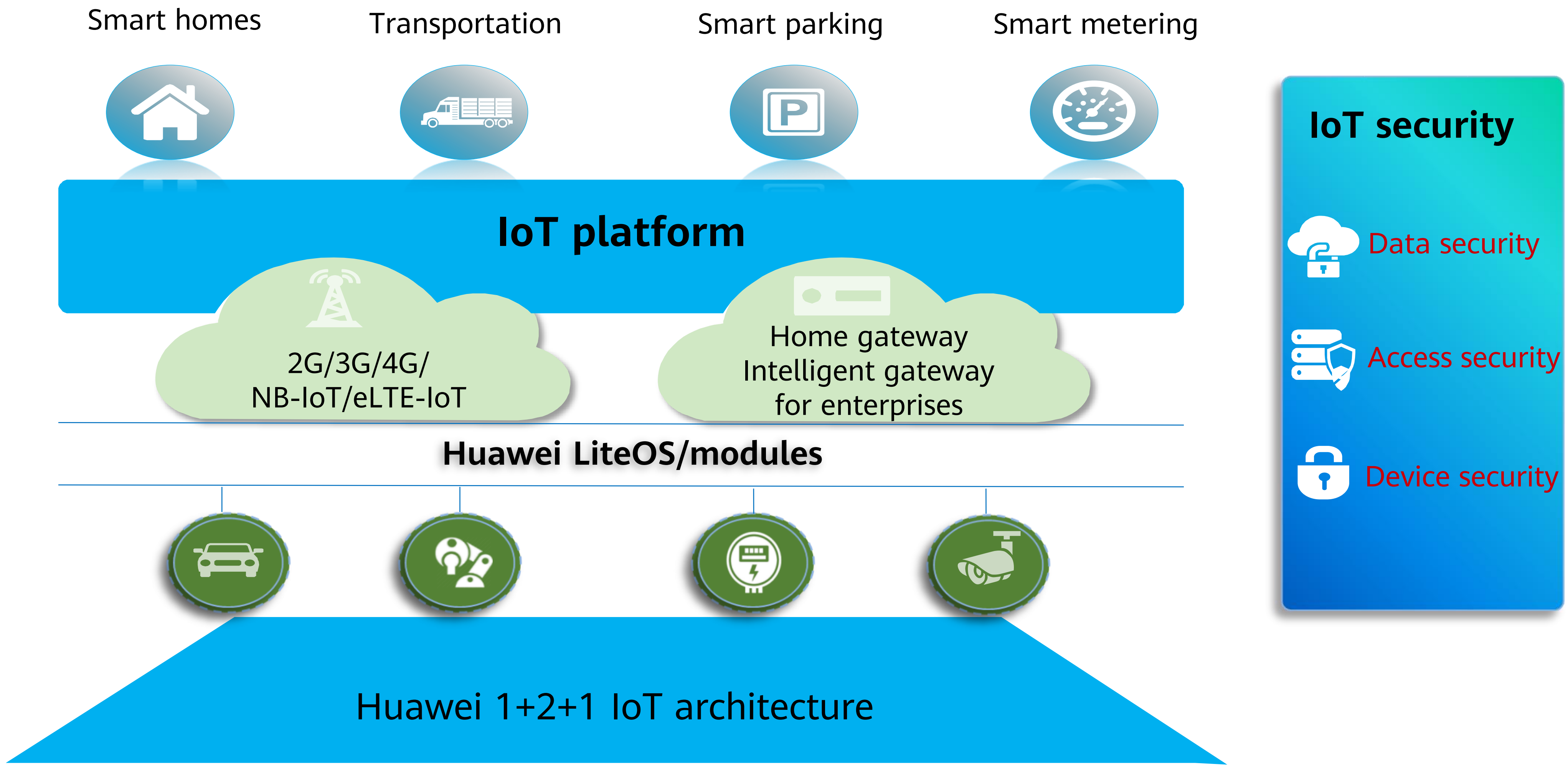
Security scenarios
- Smart water/gas
- Traffic spoofing
- Signaling storms
- IoV privacy
- Vehicle communication security
- Industrial control vulnerability threats
- More

	LPWA IoT	**Vehicle IoT**	***Extended domains***
Cloud /Platform **(T)**	Big data analytics and ML intelligent threat detection; IoT asset security situational awareness	IoV threat intelligence libraries; IoV data security and privacy protection	Security policy, privacy protection, device-cloud synergy, etc.
Pipe **(T)**	Detection and isolation for malicious devices; Anti-DDoS/Signaling storm monitoring; L2TP/IPSec security pipe	Behavior exception awareness and detection; OBU/RSU security certificate authentication	Security risk monitoring and analysis, communication security, etc.
Device (including chips/OS) **(T)**	Device Identifier Composition Engine (DICE); DTLS/DTLS+; Bidirectional authentication; FOTA upgrade; Secure boot; LiteOS security	Security certificate management; Bus intrusion detection; IDPS detection; Bus encryption and authentication; T-Box secure boot, storage, and upgrade	Border and device protection, etc.

(M) Security O&M and management
- Security strategy configuration
- Security policy management
- Security policy orchestration
- Handling policy delivery
- Security behavior models
- More

Compliance
- Compliance with national/regional laws and regulations (e.g. General Data Protection Regulation of Europe and Cyber Security Law of China)
- Security standards for important industries (IETF/3GPP/ISO-JTC1/IEEE1609/OWASP)
- Compliance with enterprise standards and security specifications (DT, China Telecom, China Mobile, TLF)

Huawei IoT Security System - Cloud-Pipe-Device (1)



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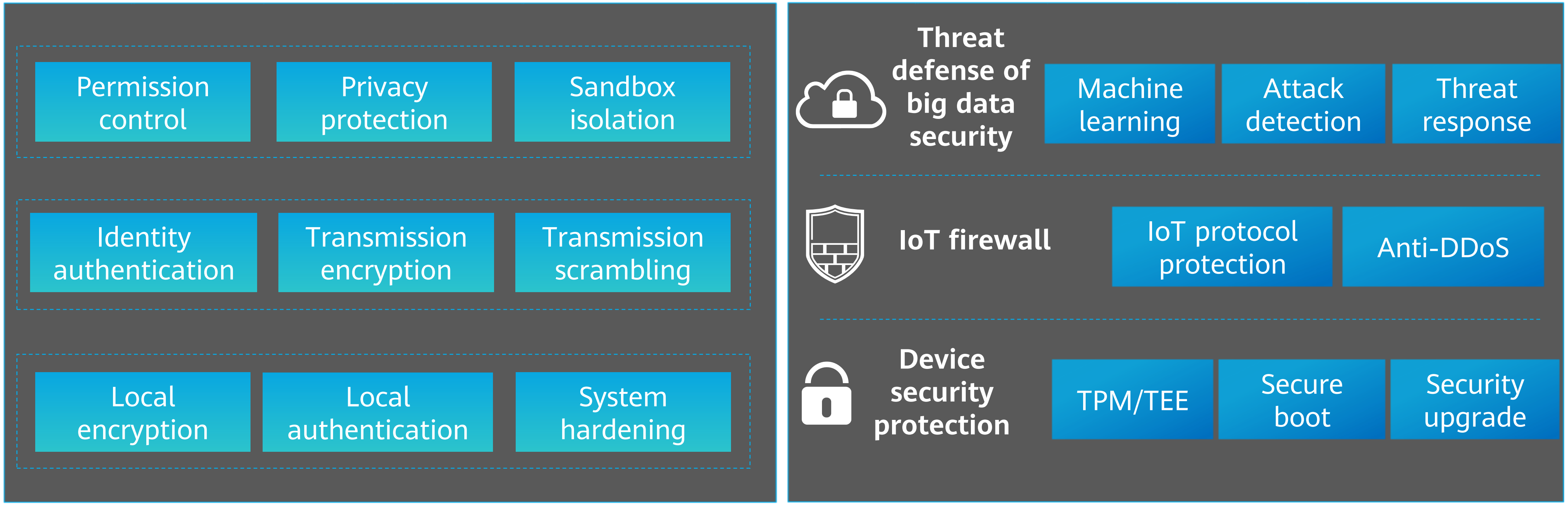
Huawei IoT Security System - Cloud-Pipe-Device (2)

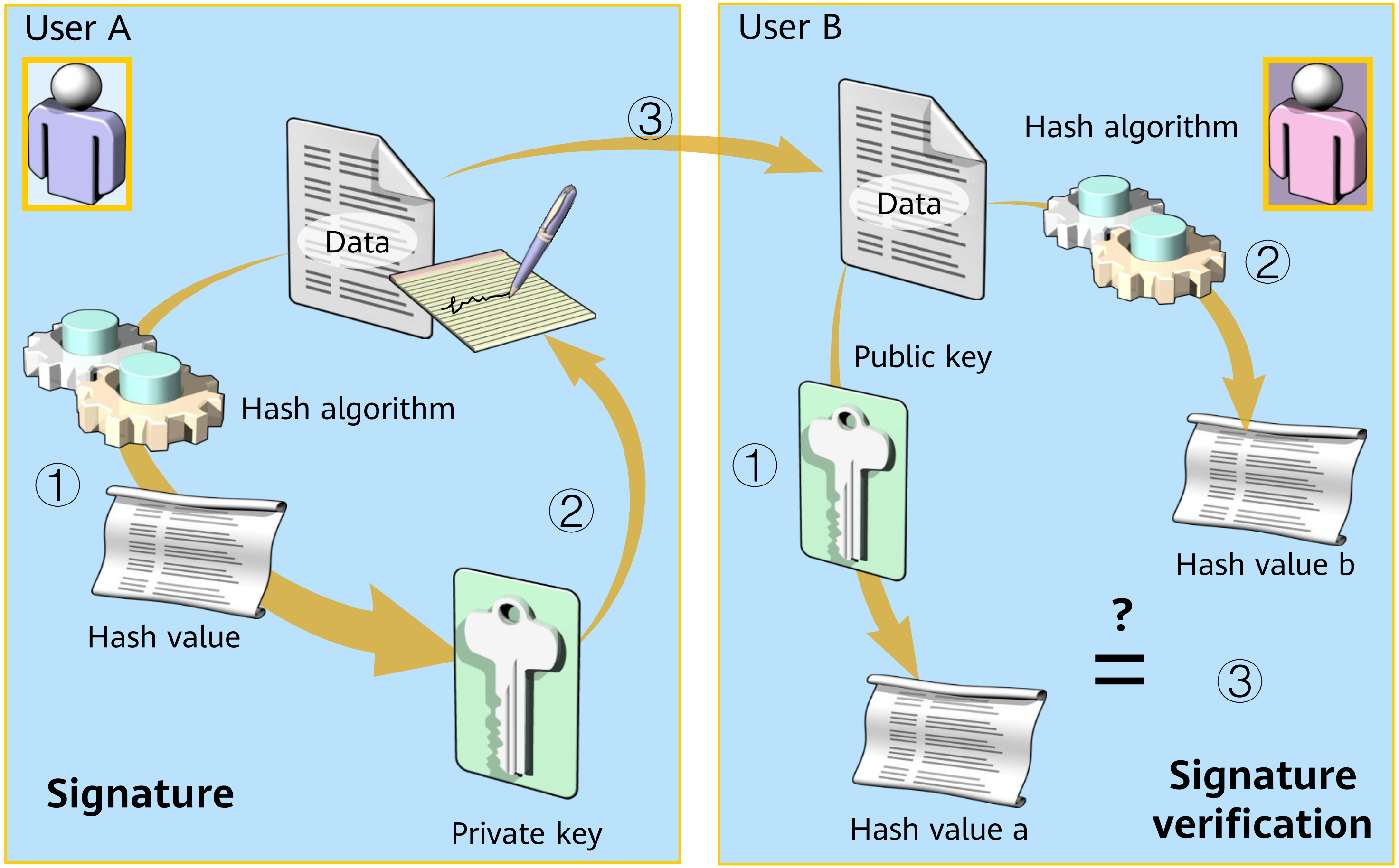
- Leveraging extensive experience in security technologies, Huawei launched a comprehensive IoT security solution.

IoT Product Security **IoT Security Products**

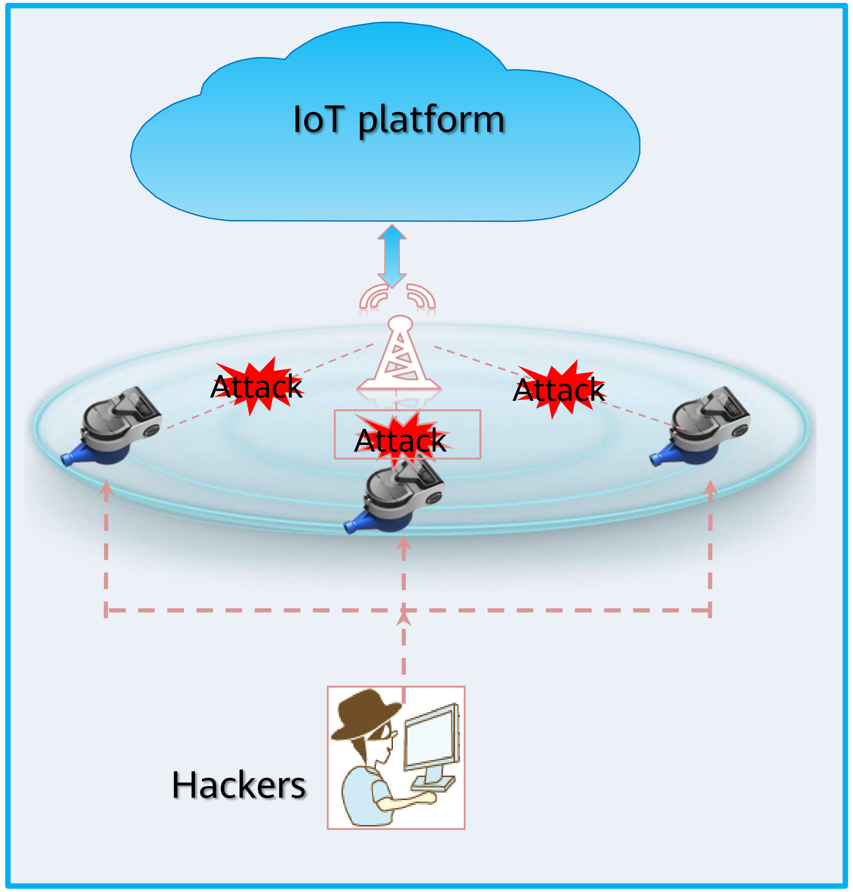


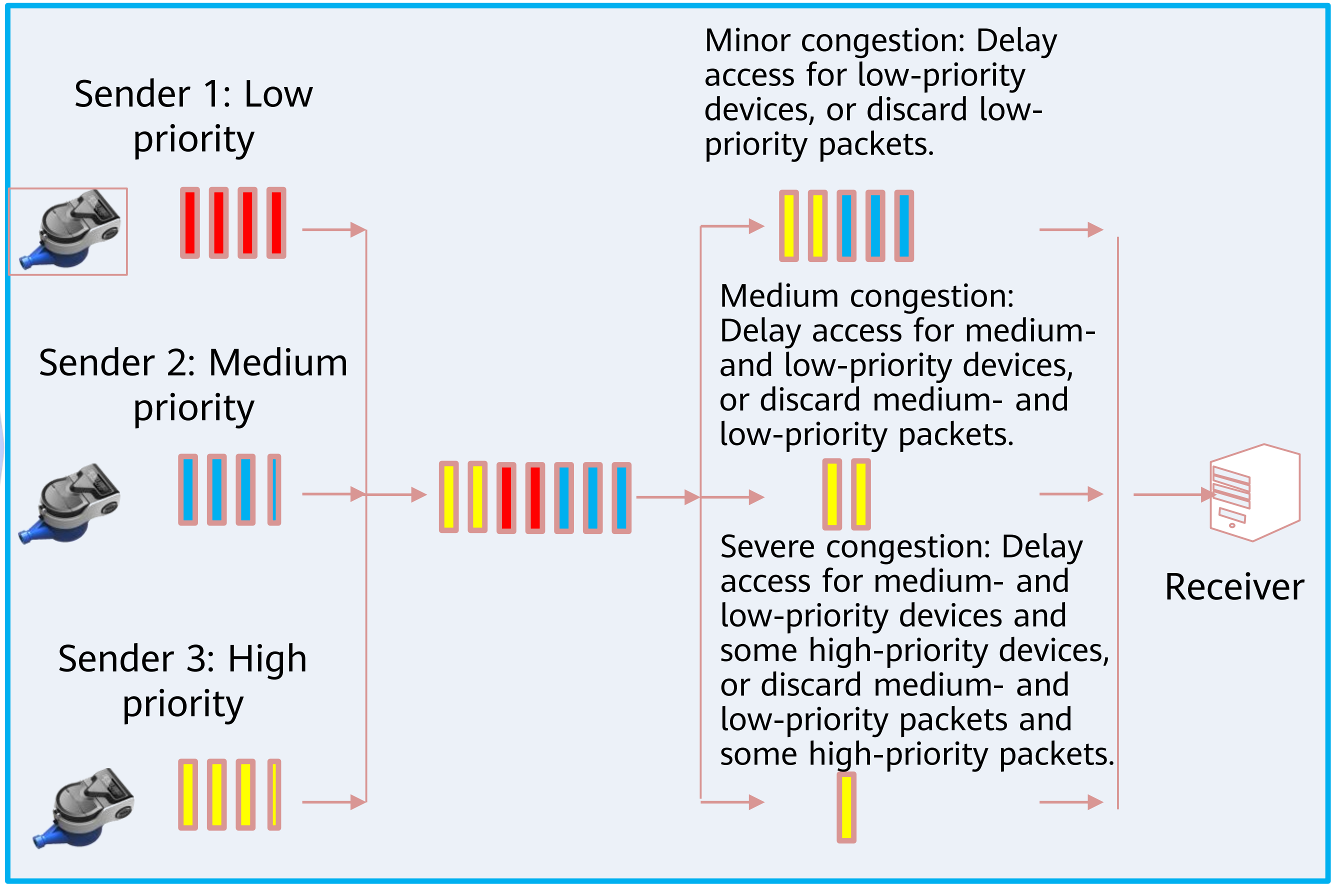
Device Security: Firmware Validity and Integrity Achieved by the FOTA Digital Signature

- Benefits: Integrity check is performed on the upgrade package (downloaded in the flash memory of the device) to ensure that the current firmware is valid and complete (not tampered with).
- Implementation: RSA2048 + SHA256
- Algorithm
  - Generation of public and private keys
  - Signature (encryption on the device)
  - Signature verification (decryption) – provided by Huawei

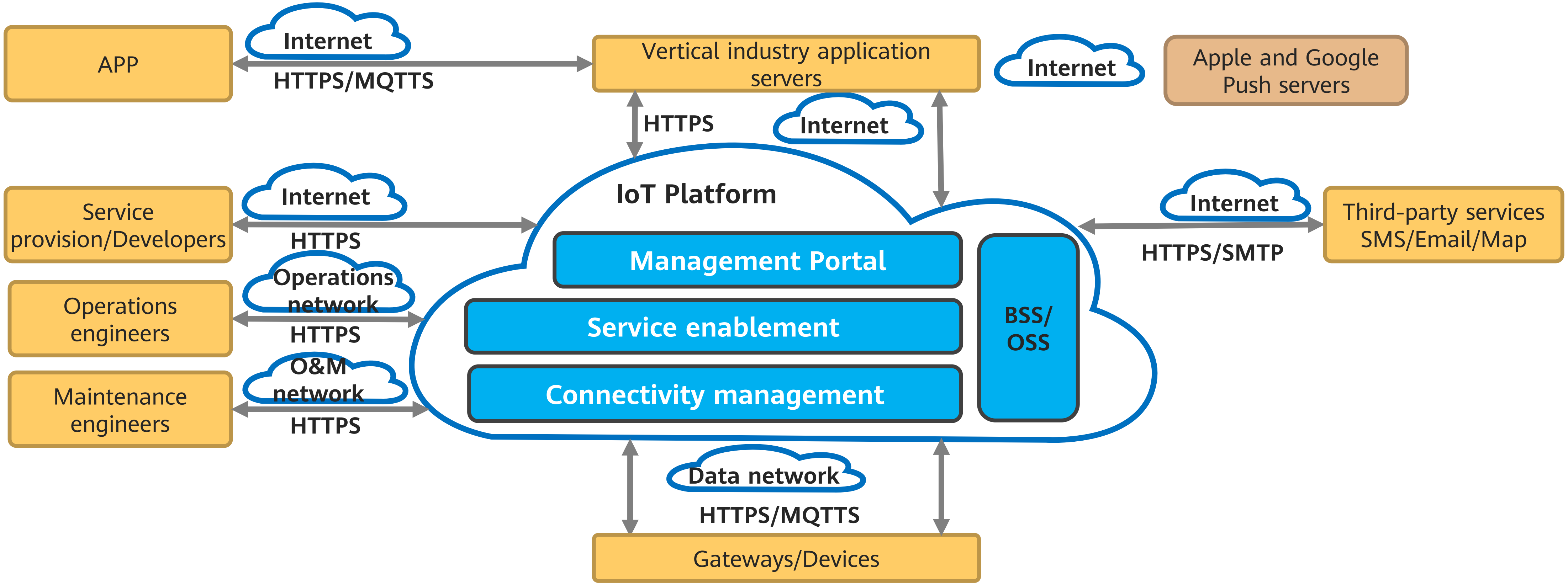


Pipe Security: Anti-DDoS and Signaling Storms





Cloud Security: E2E Authentication, Access, and Transmission Security on the IoT Platform



The IoT security solution provides secure transmission channels and trusted access. It also provides two-factor authentication (certificate + password or SMS + password) for key interfaces to ensure communication security. E2E security authentication management ensures transmission security of APIs.

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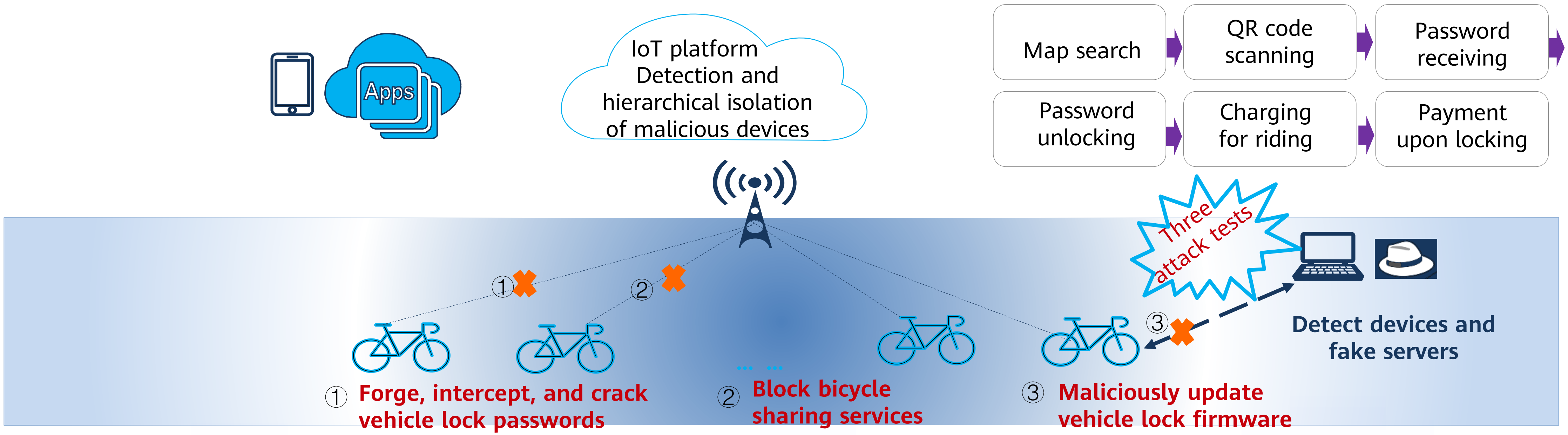
Typical Use Cases of "3T+1M" in IoT Security - Bicycle Sharing



- No authentication or one-way authentication, causes password forging and cracking.
- DTLS consumes high power, failing to meet the requirements of battery power supply.
- DTLS+ with dual authentication and encrypted transmission is used to reduce the power consumption of vehicle locks.

- Non-device-cloud synergy makes malicious operations invisible, for example, blocking or forging bicycle sharing services or consumption.
- Malicious behavior (for example, abnormal connections) can be detected and isolated on the IoT platform.

- Devices are untrusted, and vehicle lock firmware can be maliciously updated after these devices are attacked.
- DICE is used for locks to prevent inauthentic firmware upgrade and password change.

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Quiz

1. (Single choice) In the Tesla incident, at which layer of the Huawei IoT architecture does the security issue occur?
   A. Application layer
   B. Platform layer
   C. Network layer
   D. Sensor layer

Summary

- This course describes typical IoT security cases and problems. It also describes the architecture and typical cases of the Huawei IoT security solution.

Thank you.

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Overview of Common IoT Communications Technologies

Foreword

- Communications technologies are the foundation of not only the Internet of Things (IoT), but also a fully connected world. If the IoT is a logistics system of information, then communications technologies are the various means of transportation. However, regardless of the technology adopted, the ultimate goal is to connect devices to the cloud-based applications.
- Common communications technologies can be classified into two types: wired and wireless communications technologies. In terms of their applications and technical features, the specifications of wired and wireless technologies vary considerably.

Objectives

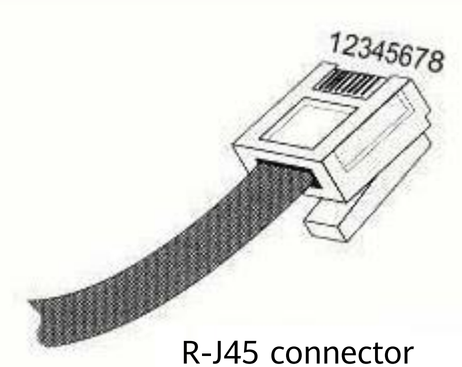
At the end of this course, you will have knowledge of:

- Common IoT wired communication technologies.
- The technical standards, features, and differences between various short-range wireless communications technologies.
- The characteristics and developing trends of cellular mobile communication technologies.
- The characteristics of Low Power Wide Area (LPWA) communications technologies and distinguish between their different types.

Contents

Ethernet

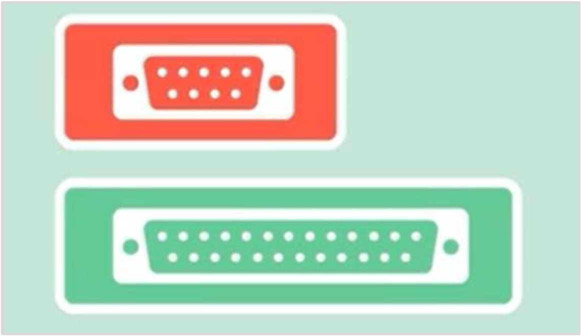
- Ethernet is the main LAN technology of TCP/IP and is named after the medium Ether, which transmits electromagnetic waves.
- A base station can use one ETH port, two FE/GE ports, or two SFP ports. ETH indicates it is a standard Ethernet, which transmits data at the rate of 10 Mbit/s. FE is short for fast Ethernet, which provides a tenfold increased transmission rate of 100 Mbit/s, and GE is short for Gigabit Ethernet, which provides a transmission rate of 1000 Mbit/s. SFP ports are gigabit optical ports, which transmit data over optical fibers. FE/GE enable autonegotiation of transmission rate with the peer switch.
- Carrier sense multiple access with collision detection (CSMA/CD) is the core Ethernet technology. "carrier sense" indicates the detection before transmission, "multi-access" indicates that data sent from one sender is received by multiple receivers, and " collision detection" indicates the detection during transmission.

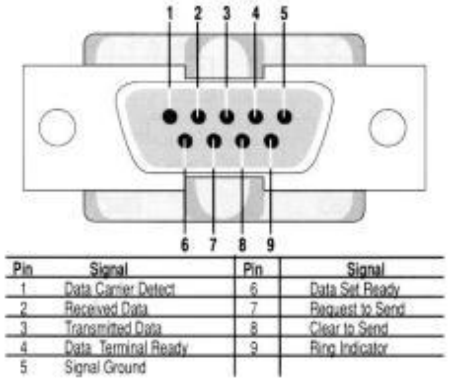


R-J45 connector

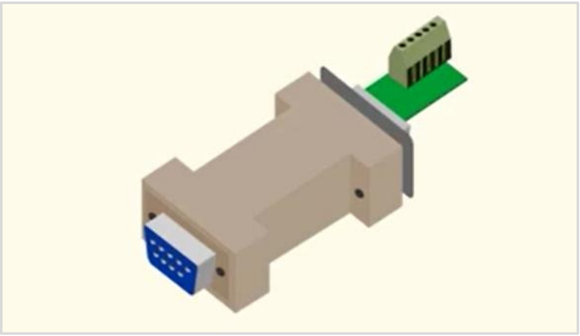
Introduction and Comparison Between RS-232 and RS-485

Item	RS-232	RS-485
Communication distance	Less than 20 m	1200 m theoretically; 300–500 m in reality
Transmission mode	Unbalanced transmission mode; single-end communications	Balanced transmission; differential transmission
Number of transceivers	One-to-one communications	A maximum of 128 transceivers on the bus
Transmission rate	38.4 Kbit/s	10 Mbit/s



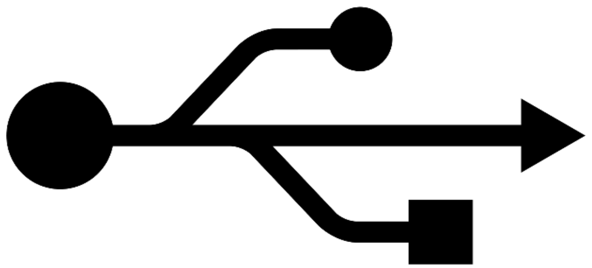


Pin	Signal	Pin	Signal
1	Data Carrier Detect	6	Data Set Ready
2	Received Data	7	Request to Send
3	Transmitted Data	8	Clear to Send
4	Data Terminal Ready	9	Ring Indicator
5	Signal Ground		



USB

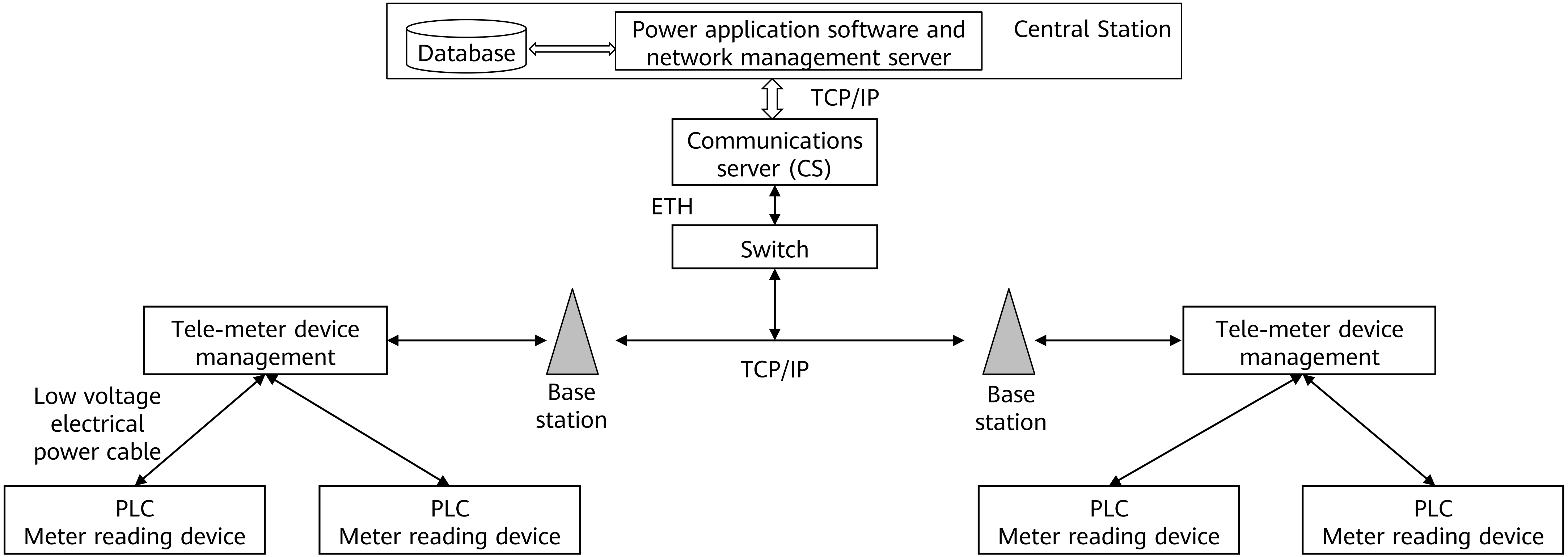
- USB, short for Universal Serial Bus, is a serial bus standard for connecting computer systems and devices. It is also a technical specification for input and output interfaces. It is widely used with information communications products such as personal computers and mobile devices, and its use has been extended to related fields such as photography equipment, digital TVs (set-top boxes), and game consoles.
- Before USB was developed, the scalability of computer interfaces was inadequate with limited rates due to devices (such as the keyboard, mouse, modem, printer, and scanner) needing to be connected to different interfaces (such as serial/parallel interfaces), making it impossible for a computer to provide sufficient interfaces for connections. USB is designed for high speed, scalability, and ease-of-use.
- The latest-generation USB is USB 4, with a transmission rate of 40 Gbit/s.



M-Bus

- M-Bus, short for Meter Bus, is a data bus designed for information transmission of consumption measuring instruments and counters. M-Bus has been widely applied in business and collection of data on industrial energy consumption.
- The maximum transmission distance of the M-Bus is 1000 m. As the M-Bus can supply power to onsite devices, no power cable needs to be connected. The power supply capability of the bus is 5 A, and the current of each node needs to be less than 0.65 mA.
- The M-Bus not only fulfills the need for the networking and remote reading of utility meters but also meets the specific requirements of the remote or battery power supply system. The bus topology of the M-Bus serial communications meets the requirements of the utility meters for reliable and cost-effective networking. Hundreds of backup devices can also be connected within a distance of several kilometers.

Power Line Communication



- Power line communication (PLC) refers to a mode of communication in which data and media signals are transmitted on an electrical power cable. With PLC, high frequency signals containing information are loaded onto the current, and the adapter receives the information over the cable, separates the high-frequency signals from current, and then sends the signals to a computer or telephone.

Comparison of Wired Communications Technologies

Communication Mode	Characteristics	Application Scenario
ETH	Comprehensive protocol, universal, cost-effective	Intelligent terminal, video surveillance
RS-232	One-to-one communications, cost-effective, short transmission distance	A few instruments, industrial control
RS-485	Bus topology, cost-effective, strong anti-interference capability	Industrial instruments, meter reading
USB	One-to-one communications, universal, fast transmission	Smart home, office, mobile devices
M-Bus	Designed for meter reading, common twisted-pair cables, strong anti-interference capability	Industrial energy consumption data collection
PLC	For power line communication, wide coverage, easy installation	Power grid transmission, electricity meter

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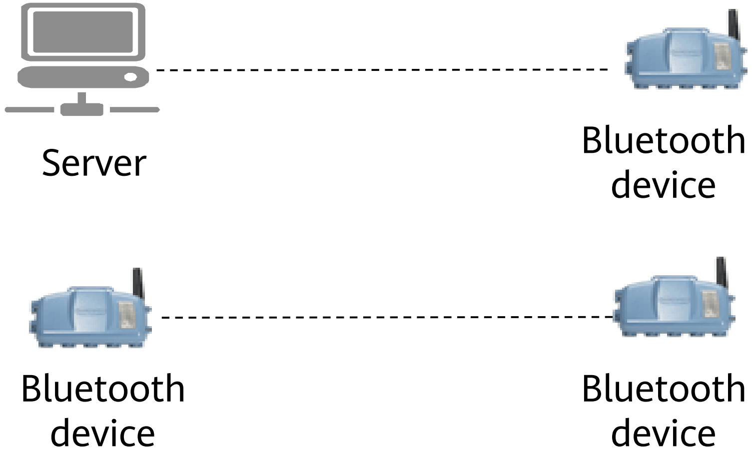
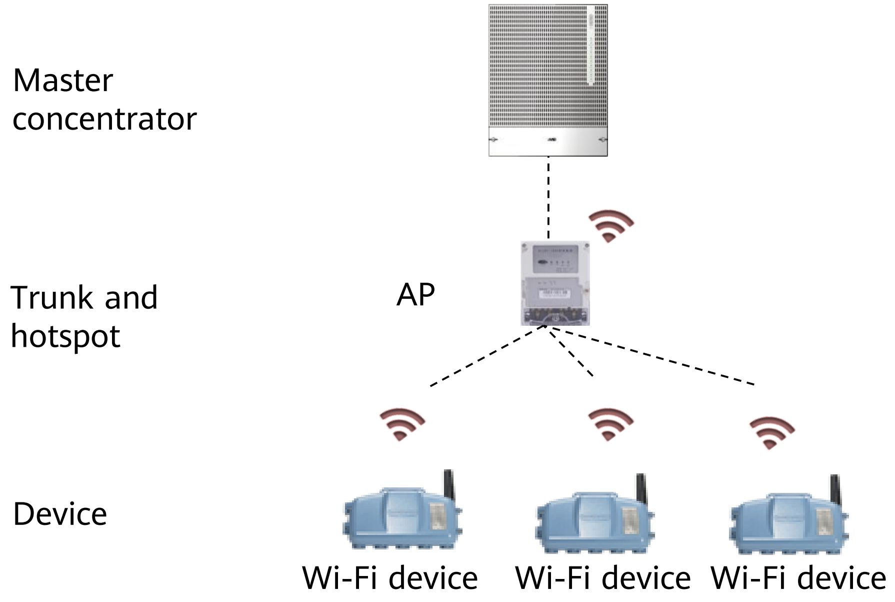
Short-Range Wireless Communications Technology: Bluetooth



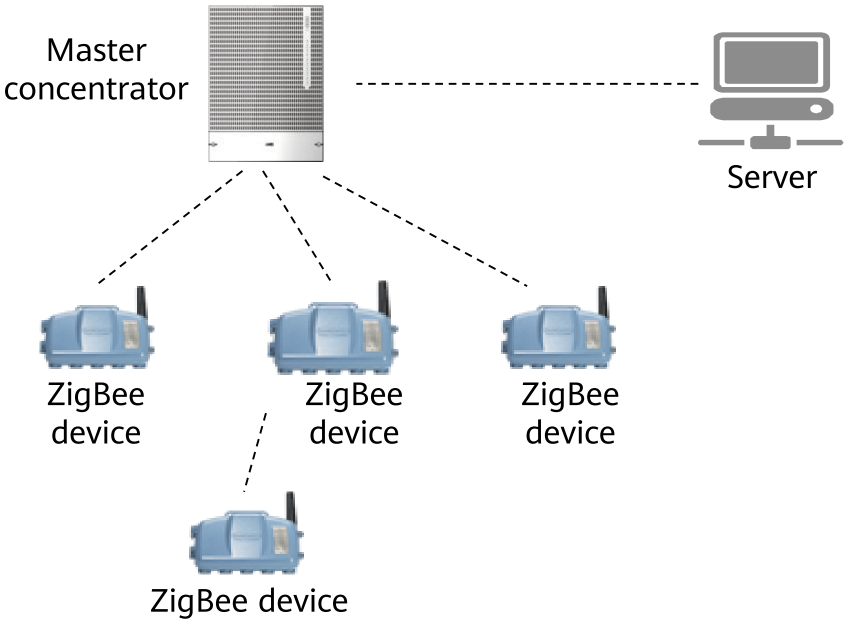
- Bluetooth is a large-capacity wireless digital communications technology standard for exchanging data over short distances. The latest Bluetooth 5.0 supports a maximum transmission rate of 3 Mbit/s and a transmission distance of about 300 meters. The technology has been divided into two types: Bluetooth Basic Rate/Enhanced Data Rate (BR/EDR) and Bluetooth low energy (BLE). The BR/EDR type supports only point-to-point (one-to-one) communications, whereas the BLE type supports point-to-point, broadcast (one-to-many), mesh (many-to-many), and other modes of communications. The BLE type is mainly used in the IoT field to provide services with higher performance that consume little power for smart home appliances.
- Advantages: high rates, high security, and low power consumption
- Disadvantages: The EDR type, with few network nodes, is not suitable for multi-point deployment.

Short-Range Wireless Communications Technology: Wi-Fi



- Wi-Fi enables an electronic device to connect to a wireless local area network (WLAN) using the 2.4 GHz UHF or 5 GHz SHF ISM radio frequency band. The latest Wi-Fi 6 supports a transmission rate of 9.6 Gbit/s and a latency of 20 ms.
- Advantages: wide coverage, fast data transmission rate
- Disadvantages: low transmission security, low stability, high power consumption, poor networking capability

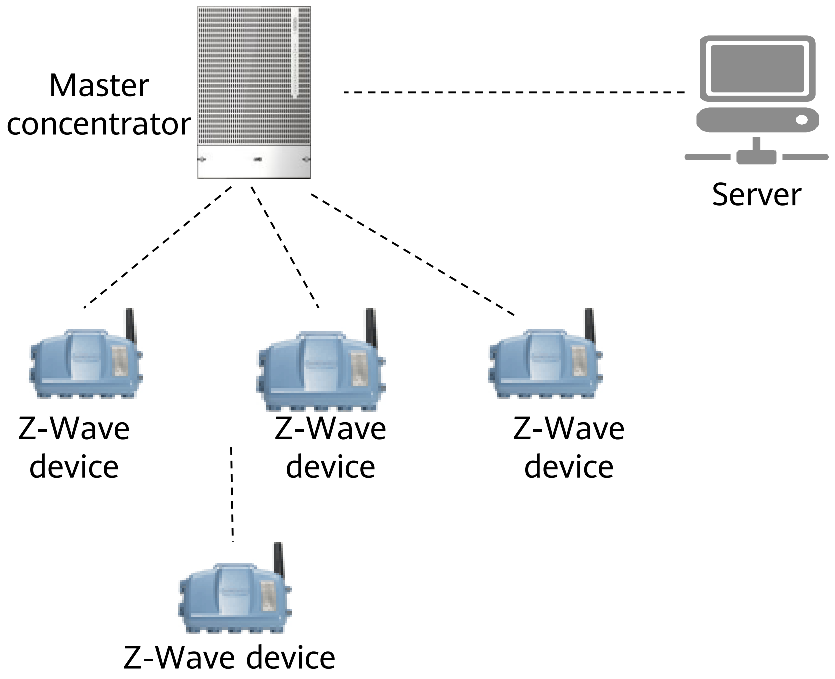
Short-Range Wireless Communications Technology - ZigBee



- ZigBee is a short-range wireless communications technology featuring low power consumption.
- Characteristics: short transmission distance, low complexity, self-organization, low power consumption, and low data rate.
  Widely used in industrial and smart home fields.

ZigBee	
Low power consumption	Two batteries can support the device for 6–24 months.
Low cost	No patent fee is required and the cost is about US$2.
Low rate	20–250 Kbit/s
Short distance	10–100 m
Low latency	15–30 ms
Large capacity	The number of nodes theoretically is 254.
High security	Three security levels
Grant free	915 MHz, 868 MHz, 2.4 GHz
Easy networking	Mesh networking, ad hoc networking
Low compatibility	The compatibility of different chips is low.
Difficult maintenance	Difficult to maintain due to high networking flexibility

Short-Range Wireless Communications Technology - Z-Wave



- Z-Wave is an emerging RF-based wireless communications technology with a short transmission distance and high reliability at low costs and little power consumption.
- Advantages: simple structure, high reliability, low rates, low power consumption, low costs
- Disadvantages: The standard is not open. The chip can only be obtained from Sigma Designs.

Comparison of Short-Range Wireless Communications Technologies

	Bluetooth	Wi-Fi	ZigBee	Z-Wave
Frequency band	2.4 GHz	2.4 GHz 5 GHz	868 MHz/915 MHz 2.4 GHz	868.42 MHz (Europe) 908.42 MHz (USA)
Transmission rate	1–3 Mbit/s (24 Mbit/s over 802.11 links)	802.11b: 11 Mbit/s 802.11g: 54 Mbit/s 802.11n: 600 Mbit/s 802.11ac: 1 Gbit/s 802.11ax: 9.6 Gbit/s	868 MHz: 20 kbit/s 915 MHz: 40 kbit/s 2.4 GHz: 250 kbit/s	9.6 kbit/s or 40 kbit/s
Typical distance	1–300 m	50–100 m	2.4 GHz band: 10–100 m	30 m (indoor) to 100 m (outdoor)
Typical application	Data exchange between nearby nodes such as a mouse, wireless headset, mobile device, and computer	WLAN, high-speed Internet access at home and other indoor areas	Home automation, building automation, and remote control	Smart home appliance, monitoring and control

Contents

Cellular Mobile Networks - 2G

- Global System for Mobile Communications (GSM) is the second-generation mobile communications technology. It is a standard developed by the European Committee for Standardization in 1992. It incorporates digital communications technologies and a unified network standard, which ensures the quality of communications and enables it to develop various new services. The data rate of GSM is 9.6 kbit/s.
- General Packet Radio Service (GPRS) is a mobile data service available to GSM mobile phone users. It is a data transmission technology of the second-generation mobile communications and an extension of GSM. GPRS provides data rates of 56–114 kbit/s.

Cellular Mobile Networks - 3G

- 3G is the third generation mobile communications technology. It supports high-speed data transmission and can transmit voice and data simultaneously with a rate of several-hundred kbit/s. 3G is a mobile communication system that integrates wireless communications and multimedia communications such as the Internet. Currently, 3G has three standards: CDMA2000, WCDMA, and TD-SCDMA. The latest WCDMA technology HSPA+ supports a downlink rate of up to 42 Mbit/s.

Cellular Mobile Networks - 4G

- 4G is the fourth-generation mobile communications technology. It includes two modes: LTE TDD and LTE FDD.
- Integrating 3G and WLAN, 4G can transmit data, high-quality audio, video, and images at a high speed. The download rate of 4G can exceed 100 Mbit/s, which is 25 times the speed of ADSL (4 Mbit/s), meeting almost all users' requirements on wireless services. In addition, 4G can be deployed in areas where the digital subscriber line (DSL) and cable television modem are not covered, and then expanded to the entire region. 4G has shown notable advantages.

LTE UE Categories

- The LTE UE category indicates the UE access capability level, in other words, the transmission rate level supported by a UE. For example, LTE category 4 indicates that the LTE network access capability level of the UE is 4.

Level	Downlink Rate (Mbit/s)	DL-MIMO	Uplink Rate (Mbit/s)
1	10	1	5
2	50	2	25
3	100	2	50
4	150	2	50
5	300	4	75
6	300	2 or 4	50
7	300	2 or 4	150
8	1200	8	600
9	450	2 or 4	50
10	450	2 or 4	100

LTE UE Category 1

- UE category 1 supports a downlink rate of up to 10 Mbit/s, enabling IoT devices with lower power consumption and costs to connect to LTE networks. LTE operators around the world deploy LTE networks based on 3GPP Release 8 or later. As such, operators can simply reconfigure parameters to permit the access of UE category 1 without needing to upgrade the networks.
- Although higher rates are supported for UE category 4 or later, the costs are relatively high for the IoT industry. Therefore, using UE category 1 is most cost-effective.

Cellular Mobile Networks - 5G

- The fifth-generation mobile communications network, 5G's theoretical maximum transmission rate can reach 10 Gbit/s, which is 100-fold improvement over 4G. With 5G, a 1 GB movie can be downloaded in eight seconds.
- ITU Radiocommunication Sector (ITU-R) defined three major 5G application scenarios in June 2015: enhanced Mobile Broadband (eMBB), Massive Machine-Type Communications (mMTC), and ultra-reliable low-latency communication (URLLC), as well as eight capability specifications, including the throughput, latency, connection density, and spectral efficiency.
- On June 6, 2019, the Ministry of Industry and Information Technology (MIIT) officially issued 5G commercial licenses to China Telecom, China Mobile, China Unicom, and China Broadcast & Television, and announced the start of 5G commercialization on October 31, 2019.

Comparison of Cellular Mobile Network Technologies

	2G	3G	4G	5G
Frequency band	Authorized frequency band (mainly 900 MHz)	Authorized frequency band (mainly 900 MHz and 1800 MHz)	Authorized frequency band (1800–2600 MHz)	Authorized frequency band: C-band, mmWave
Transmission rate	GSM: 9.6 kbit/s GPRS: 56–114 kbit/s	TD-SCDMA: 2.8 Mbit/s CDMA2000: 3.1 Mbit/s WCDMA: 14.4 Mbit/s	Downlink Category 6/7: 300 Mbit/s Category 9/10: 450 Mbit/s	10 Gbit/s (Balong 5000 chips support a downlink rate of 4.6 Gbit/s and an uplink rate of 2.5 Gbit/s)
Typical application	POS and smart wearable devices	Vending machines, smart home appliances	Mobile terminals, video surveillance	AR, VR, assisted driving, automated driving, and telemedicine

Contents

LPWA - SigFox

- The SigFox network uses Ultra Narrow Band (UNB) technology. Its transmission power consumption is low and the data connection is stable. Its radio link uses the unlicensed ISM radio frequency band. Frequency usage varies according to national laws and regulations. The 868 MHz frequency band is widely used in Europe, and the 915 MHz frequency band is used in the United States.
- The network adopts ultra narrow-band modulation technology. A single base station can transmit network messages over a distance of over 1000 km. Each base station supports a maximum of one million IoT devices.
- SigFox is preferred for IoT connections as it uses free frequency bands, devices that consume little power, and a simplified network architecture.

LPWA - LoRa

- The Long Range (LoRa) is a physical-layer-based technology that implements data communications over networks. It is maintained and managed by the LoRa Alliance. The technology supports bidirectional data transmission and complies with a series of open source standards. The specific solution for network implementation is called LoRaWAN, which is developed by Semtech and supported by IBM. The application of LoRa includes automatic meter reading, smart home appliance, building automation, wireless warning and security systems, industrial monitoring and control, and remote irrigation systems.
- LoRa uses unlicensed spectrum.

LoRa Alliance
Wide Area Networks for IoT

LPWA - NB-IoT

- NB-IoT is a cellular based narrowband IoT. It is built on a cellular network and requires a bandwidth of only 180 kHz. It can be directly deployed on legacy GSM, UMTS, and LTE networks to reduce deployment costs and implement smooth upgrades.
- NB-IoT is an emerging technology widely used for LPWA IoT markets. It features enhanced coverage and wide connections with low rates, costs, power consumption, and the optimal architecture.
- According to 3GPP Release 14, NB-IoT supports base station positioning and mobility scenarios with a speed less than 80 km/h.

LPWA - eMTC

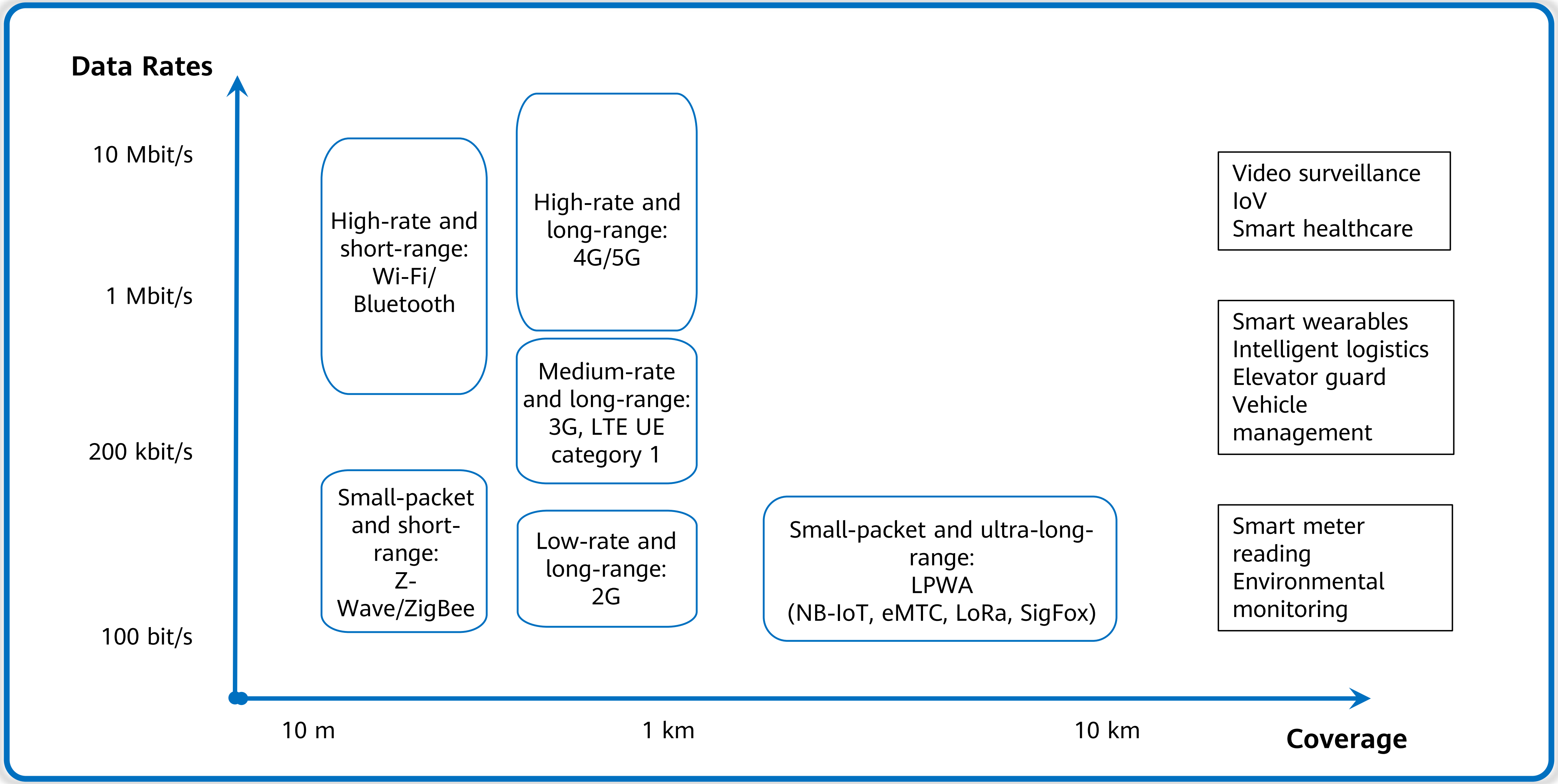
- eMTC is a wireless IoT solution proposed by Ericsson. The solution designs the soft features of the wireless IoT network based on LTE access technology. It is mainly used in IoT scenarios that require low rates, deep coverage, low power consumption, and a considerable number of connections.
- eMTC features a higher rate (up to 1 Mbit/s) and power consumption and smaller coverage and capacity than NB-IoT. eMTC also supports voice communications.

Comparison of LPWA Technologies

	SigFox	LoRa	NB-IoT	eMTC
Frequency band	Sub-GHz unlicensed frequency band	Sub-GHz unlicensed frequency band	Mainly sub-GHz licensed frequency band	Sub-GHz licensed frequency band
Transmission rate	100 bit/s	0.3–5 kbit/s	< 250 kbit/s	< 1 Mbit/s
Typical distance	1–50 km	1–20 km	1–20 km	2 km
Typical application	Smart home appliances, smart electricity meter, mobile healthcare, remote monitoring, and retail	Smart agriculture, intelligent building, and logistics tracking	Water meter, parking, pet tracking, garbage disposal, smoke alarm, and retail devices	Shared bicycle, pet collar, POS, and smart elevator

Contents

Comparison of Wireless Communications Technologies



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Quiz

1. (Single-Choice) Which of the following communications technologies is a wired communications technology?
   A. 5G
   B. NB-IoT
   C. PLC
   D. ZigBee
2. (True or False) All NB-IoT networks are deployed on sub-GHz licensed bands.

Summary

- This document described common IoT communications technologies, which are divided into wired and wireless ones. Wireless communications technologies are further classified into three types: short-range wireless, cellular mobile, and LPWA communications technologies. This document also provided the characteristics and application scenarios of these communications technologies in various aspects.

Thank you.

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NB-IoT Communication Technologies and Solutions

Foreword

- Unlike the traditional Internet, the Internet of Things (IoT) works in diverse and complex communications scenarios. Different wireless communications scenarios vary in their requirements. We summarize the communications scenarios in which small packets are occasionally transmitted through passive devices as low-power wide-area (LPWA) scenarios.
- In LPWA scenarios, NB-IoT is one of the most widely used technologies. This technology complies with the 3GPP specifications, deployed on authorized frequency bands of operators, and provides a public network for IoT devices, encouraging the development of IoT public utilities.

Objectives

At the end of this course, you will have knowledge of:

- The evolution of the NB-IoT standards and the development of the NB-IoT industry
- Key technologies of NB-IoT
- NB-IoT application scenarios and solutions

Contents

Evolution of NB-IoT Standards

2016 R13 → **2017 R14** → **2018 R15** → **2020 R16** → **R17 (initiated)**

2016 R13	2017 R14	2018 R15	2020 R16	R17 (initiated)
LPWA basic version --20 dB coverage --Massive connections --Low power consumption --Low cost --Cat-NB1	**Increased data rate and capacity, more functions** --Data rate > 100 kbit/s --Multi-carrier transmission --Locating/Mobility: 80 km/h --Cat-NB2	**Improved performance, more scenarios** --Power consumption: 80%↓ --Latency: 20% ↓ --Cell radius: 100 km --QoS management	**Improved efficiency, connection to 5GC** --5G NR coexistence --Access to 5G CN --Multimode --Interoperability	**NB-IoT enhancement project initiated** --16QAM (M) --Mobility optimization --Carrier service differentiation

Technologies Defined by 3GPP Will Evolve to 5G

- On July 7, 2019, 3GPP and the 5G Promotion Group of MIIT put forward the NR and NB-IoT proposals to the ITU.
  - 3GPP Release 15: NB-IoT and NR can coexist. Existing UEs are not affected.
  - 3GPP Release 16: Technical standards meeting 5G requirements are officially accepted as a 5G technical standards.

The industry recognizes NB-IoT evolution and agrees to incorporate NB-IoT into the overall 5G plan.

Company	Proposal
China Mobile	✓ Jointly promot NB-IoT access to 5G devices and the core network based on R16.
DT	✓ No requirement on developing NR-based LPWA solutions. NB-IoT can meet IMT-2020 requirements.
E	✓ In the 5G era, continue using NB-IoT and LTE-M to meet LPWA service requirements.
Q	✓ NB-IoT/eMTC is 5G mMTC.

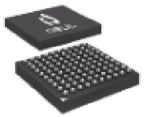
LPWA Technologies Adopted by Global Operators

NB-IoT first + eMTC	vodafone, China unicom 中国联通, kt, KDDI, EE, etisalat, SoftBank, STC, AIS, Bell, NOS, TDC, TeliaSonera, Telefónica, Safaricom, telenor, 中国电信, U+, 中国移动 China Mobile, TELE2, Ростелеком, true move, ...
eMTC first + NB-IoT	verizon, at&t, TELUS
LoRA first + eMTC	orange, SK telecom, swisscom

NB-IoT Spectrum Selections of Global Operators

APT 700 MHz	Telefónica (Latin America), etisalat
800 MHz	vodafone, Telefónica (Germany), T (Hungary)
850 MHz	U+, 中国电信, TELUS, Bell, KDDI
900 MHz	T (Germany, Holland, Poland, Austria), Telefónica (Germany), 中国移动 China Mobile, China unicom 中国联通, SoftBank, etisalat, kt, AIS, true move
1800 MHz	China unicom 中国联通, kt, EE, STC

Huawei Releases World's First Commercial-use NB-IoT Chip and Network Version



2016.Q4	2017.Q1	2017.Q2	2017.Q4	2018.Q2
Boudica 120 Sample	**Boudica 120** Trial commercial use	**Boudica 120** Commercial use	**Boudica 150** Trial commercial use	**Boudica 150** Commercial use (including Rel14)

World's most integrated NB-IoT chip

- SOC: BB +RF +PMU + AP/SP/CP + eFlash + SRAM
- Three ARM Cores: AP+CP+SP

Boudica 120 (3GPP R13)

- Features: PSM/eDRX
- Coverage level selection
- Paging
- 20 dB coverage enhancement
- Supporting IP and non-IP
- Single tone
- Integration of third-party applications
- Supported protocols: CoAP/FOTA/LWM2M/DTLS/TCP/eSIM

Boudica 150 (3GPP R13&R14)

- Supported frequency bands: 5/8/20/28
- Downlink: 21.2 Kbps; Uplink: 15.6 Kbps
- Positioning (OTDOA)
- Multicast (SC-PTM)
- Data transmission at the user layer
- Supporting both single-tone and multi-tone transmission
- Third-party application development

Single RAN versions

SRAN12.0

SRAN12.1

Global commercial use

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NB-IoT Ecosystem Partner List

1000+ Industry Partners and 40+ Industries

Smart water

Smart gas

Smart streetlight

Smart parking

Asset tracking

Smart agriculture

Smart meters

Smoke detection

Air quality monitoring

Children/Pet tracking

Bicycle sharing

White goods

Healthcare

Solution integration

Seven NB-IoT Open Labs

Mature development environment and test tools

Contents

NB-IoT Physical Layer

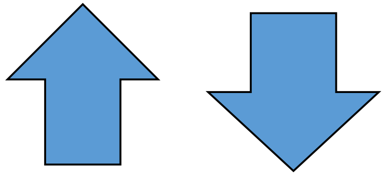
Physical layer design

- System bandwidth: 180 kHz
- Downlink technology: OFDMA; SCS 15 kHz; 12 subcarriers
- Uplink technology: SC-FDMA

Physical channels and physical signals

- To simplify implementation, NB-IoT removes unnecessary physical channels, leaving only three types of physical channels and two types of reference signals in the downlink and two types of physical channels and one type of reference signal in the uplink.

- Two types of uplink physical channels:
  - NPUSCH
  - NPRACH
- One type of uplink physical signal:
  - NDMRS

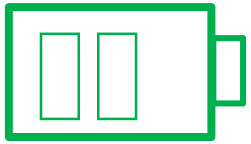


- Three types of downlink physical channels:
  - NPBCH
  - NPDCCH
  - NPDSCH
- Two types of downlink physical signals:
  - NRS
  - NSS

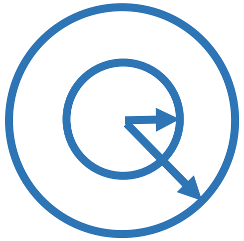
- Through a smaller target rate, repeated transmission, and lower-order modulation, **NB-IoT** physical channels achieve **wider coverage, lower costs, and lower power consumption**.

Key NB-IoT Features

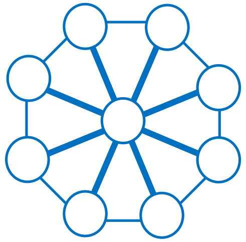
Ultra-low cost



Ultra-low power consumption



Ultra-wide coverage

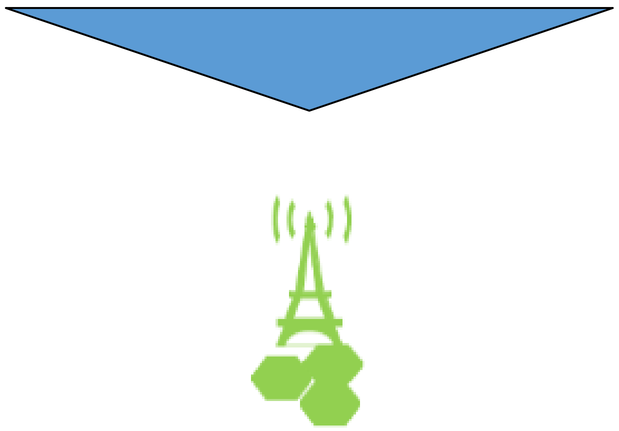


Massive connections

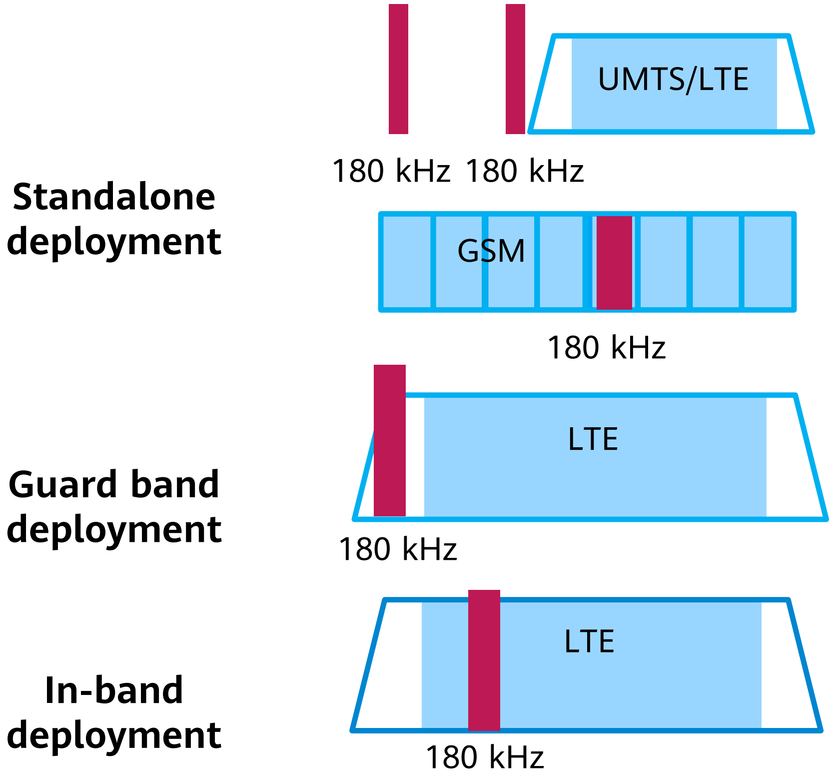
NB-IoT Deployment Modes

- The NB-IoT supports LTE-based smooth evolution and flexible frequency band deployment to meet different requirements of operators, reducing network deployment and maintenance costs.

LTE-based evolution

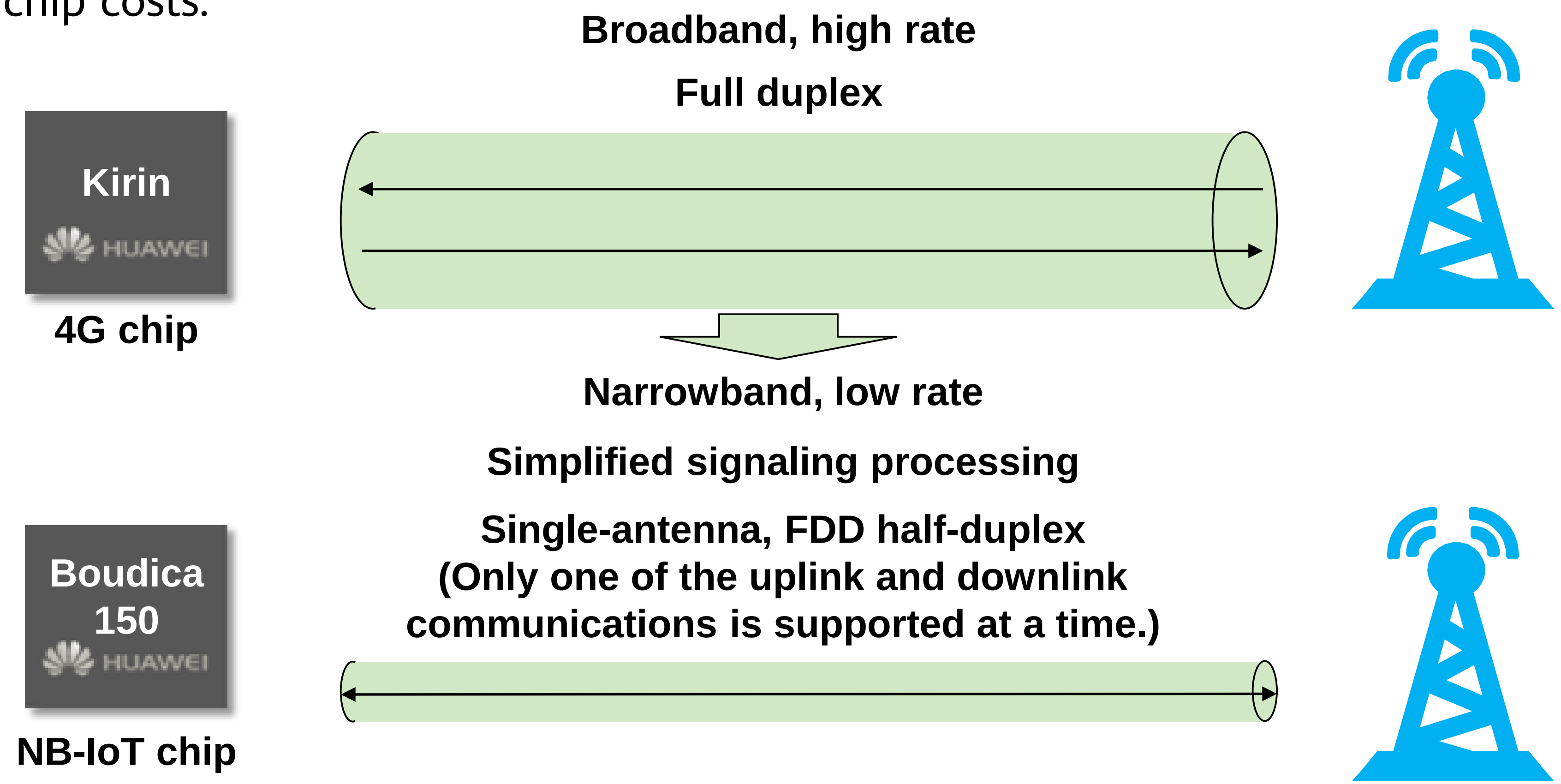


Supporting smooth evolution of SingleRAN

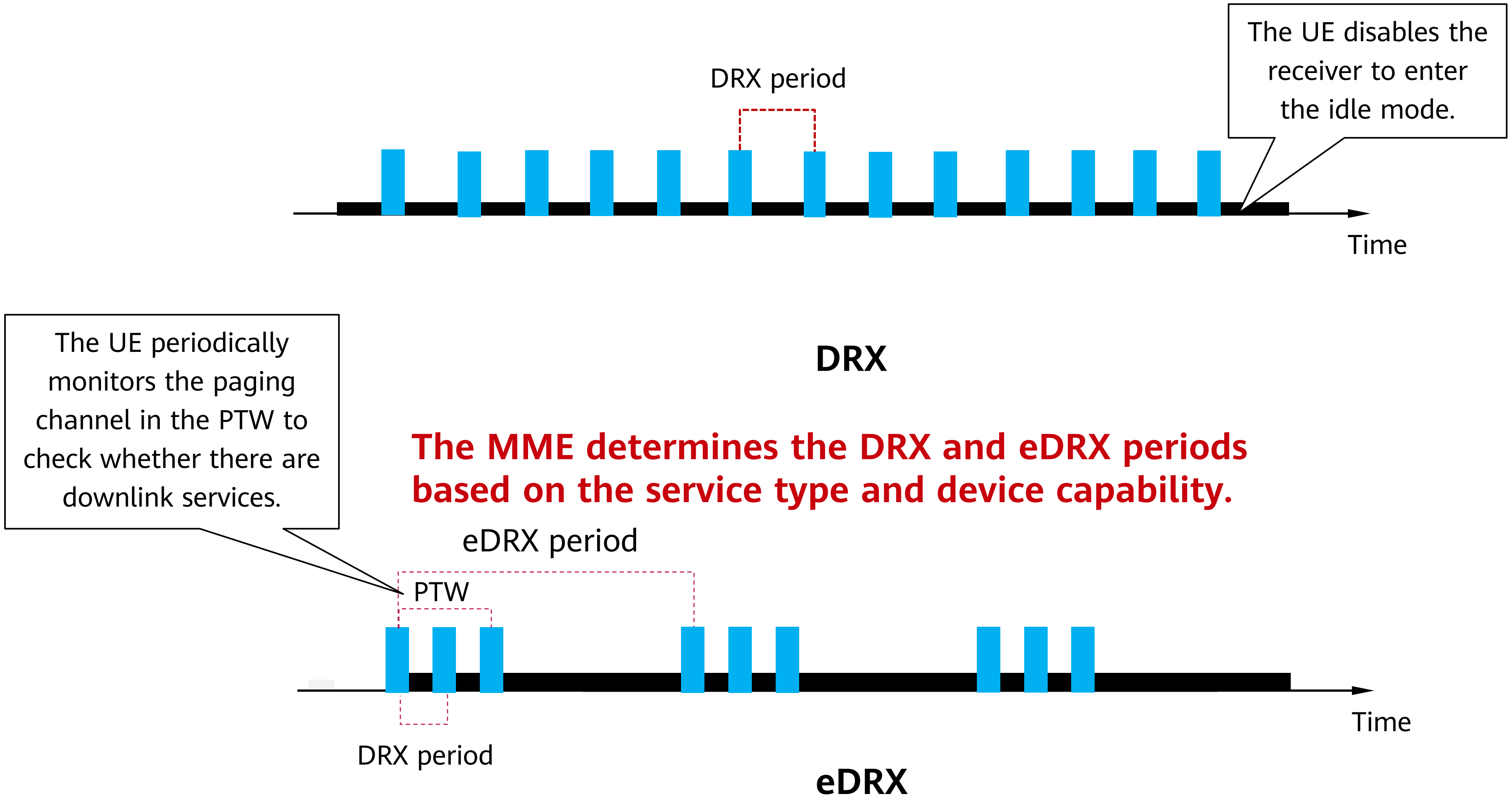


Ultra-low Cost: Communication Chips Specially Designed for IoT

- Non-essential physical hardware modules are tailored using simplified functions and algorithms, reducing chip costs.

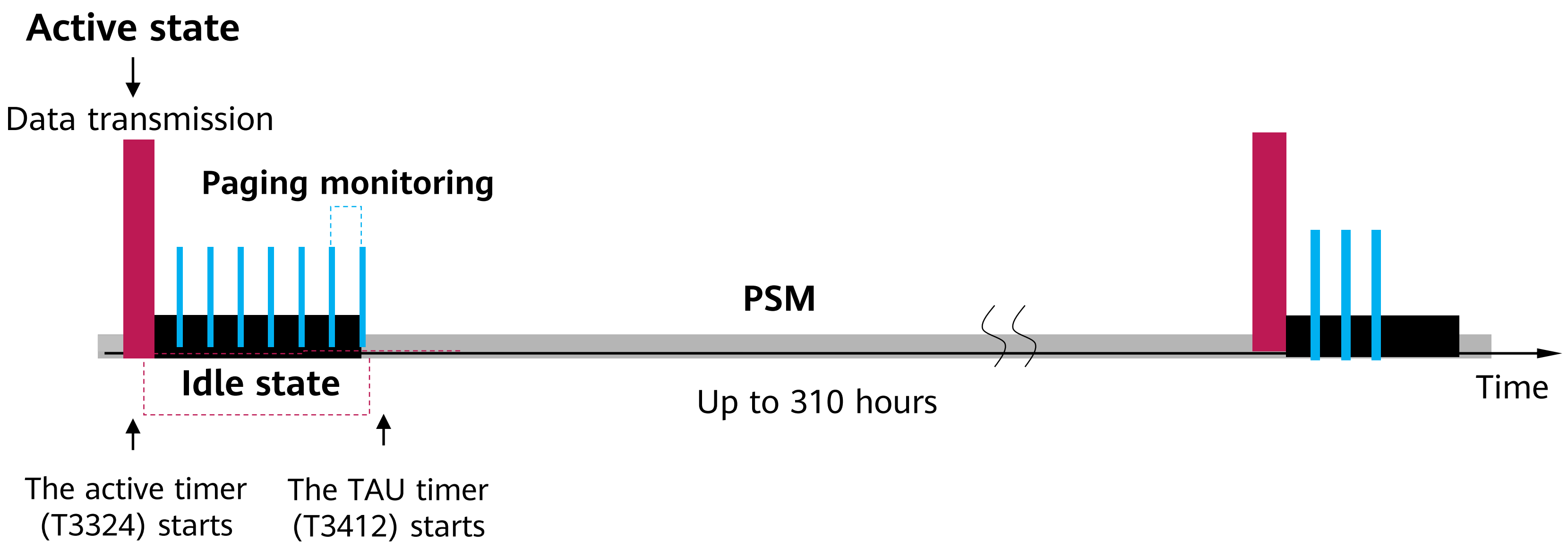


Ultra-Low Power Consumption: DRX and eDRX



The MME determines the DRX and eDRX periods based on the service type and device capability.

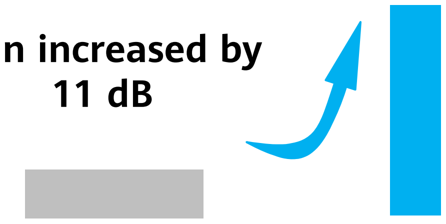
Ultra-Low Power Consumption: PSM



Ultra-Wide Coverage: Increased Power Spectral Density, Time-Domain Retransmission

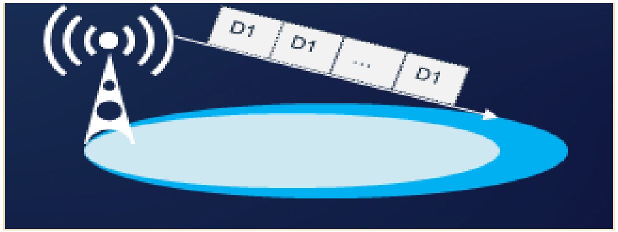
Deep coverage solution

Increased power spectral density

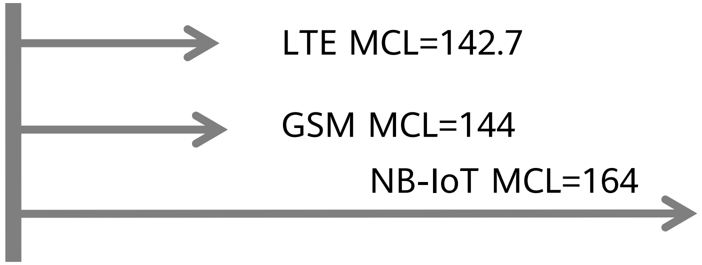


Repeated transmission

Downlink gain increased by 9 dB
Uplink gain increased by 12 dB

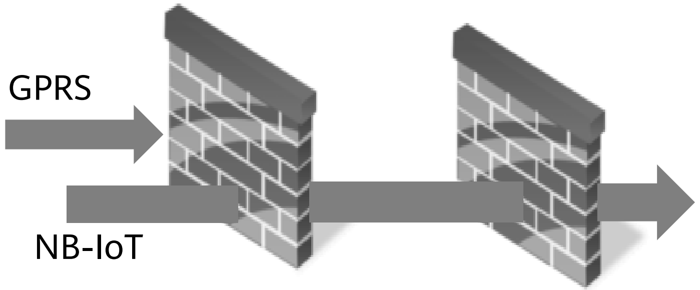


20 dB more maximum coupling loss (MCL) than GPRS



Coverage comparison

The coverage distance of NB-IoT is three times that of GPRS.



NB-IoT signals can penetrate through two more walls than GPRS signals.

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Massive Connections: Reduced Air Interface Signaling Consumption and Resource Usage

A capacity of over 50,000 users

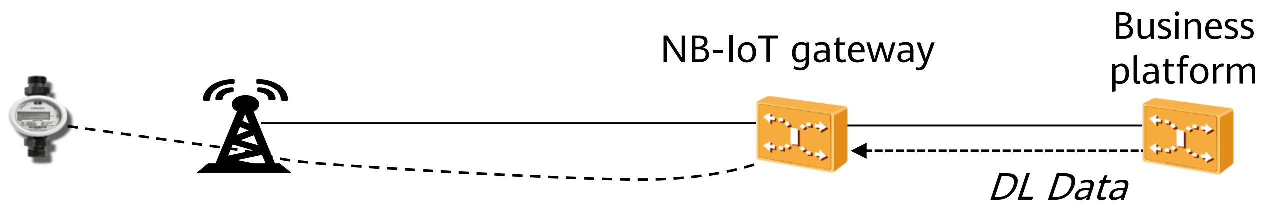
xx byte

50,000 devices per cell

Delay-insensitive

Traffic model

Key technology 1:
Small uplink service scheduling unit: 15 kHz in NB-IoT **VS.**180 kHz in LTE



Key technology 2: air interface signaling overhead reduction

Key technology 3:

PSM and eDRX reduce the resource usage of each device.

Key technology 4: base station optimization

- Independent admission and congestion control
- UE context storage

Key technology 5: core network optimization

- UE context storage
- Downlink data cache

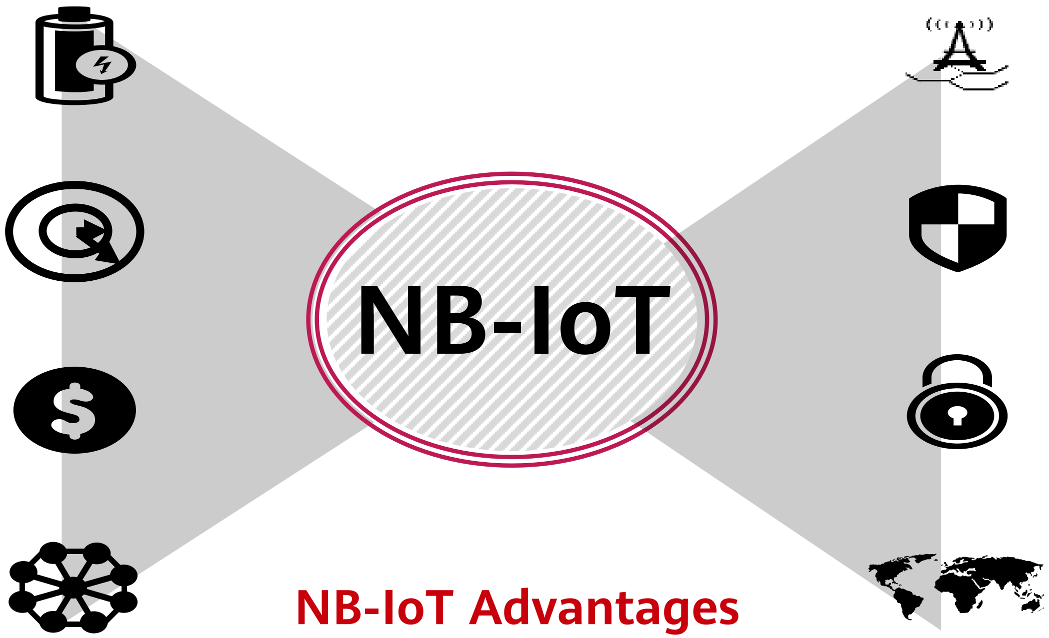
Summary of Key NB-IoT Features

10 years
Battery life

20 dB
Coverage gain

5 USD
Module price

50,000
Number of connections per cell



NB-IoT Advantages

Evolution based on the live network

Operator-level reliability

High security

Global roaming

Low Cost
$5 module cost
- Simplified RF hardware
- Simplified protocols to reduce costs
- Reduced baseband complexity

Low Power Consumption
10-year battery life
- Simplified protocols and lower chip power consumption
- High PA efficiency
- Short TX/RX duration

Wide Coverage
20 dB gain
- Increased narrowband PSD
- Retransmission times: 16
- Coding gains

Massive Connections
50,000 connections per cell
- High spectral efficiency
- Small-packet data transmission
- Low device activation ratio

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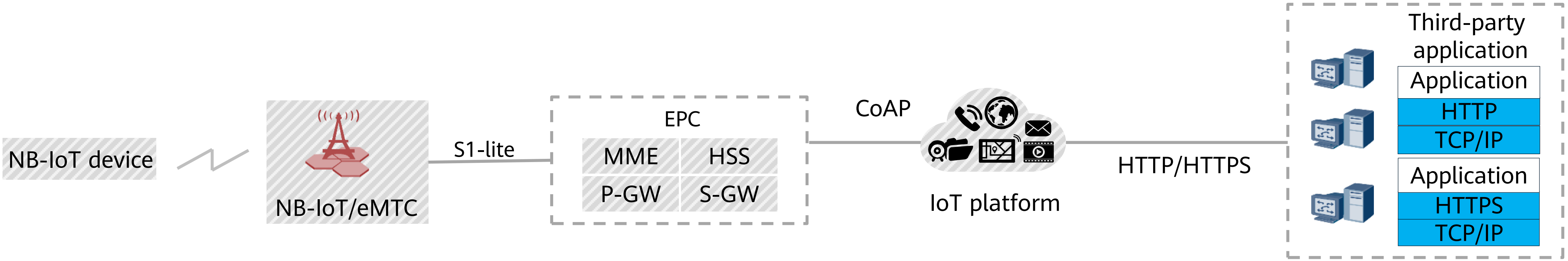
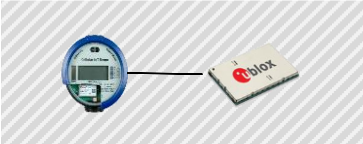
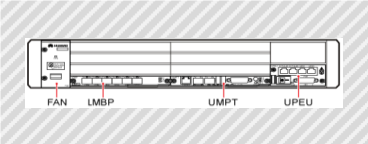
NB-IoT Solution Architecture





NB-IoT device

- Wireless connection
- Virtual SIM card
- Sensor port
- Application residence
- Support for NAS data

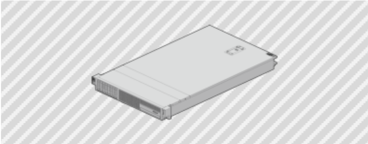


NB-IoT eNodeB

- Low-cost site solution
- Supporting large-capacity connections with new air interface

IoT core network

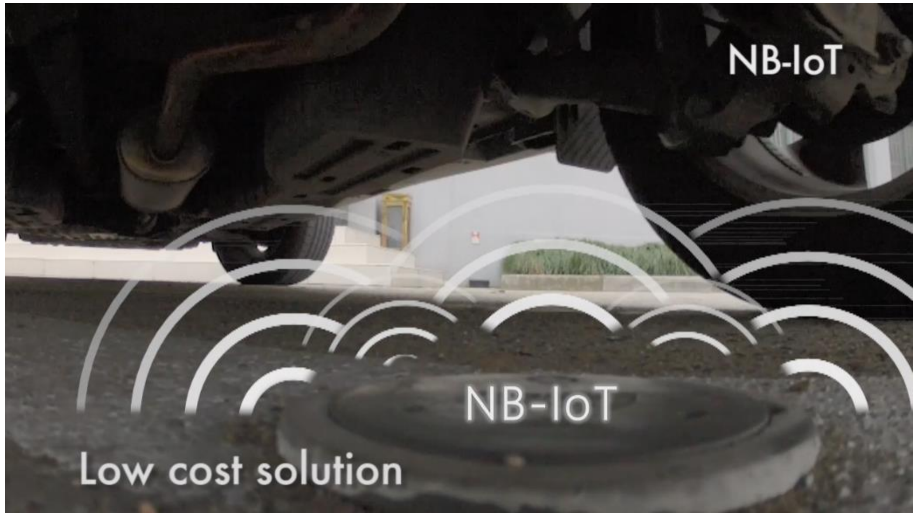
- Mobility, security, and connection management
- Secure access for devices without SIM cards
- UE energy saving
- Congestion control and traffic scheduling
- Billing
- Support for NAS data



IoT platform

- Compatible with application-layer protocol stacks
- Device/SIM OTA
- Device and event subscription management
- Open APIs (to the industry and developers)
- OSS/BSS (for self-help subscriber creation and billing)
- Big data analysis

NB-IoT Application Cases



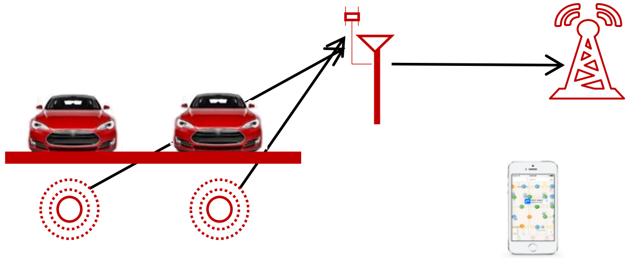
NB-IoT Solution: Smart Parking

Challenges to Current Smart Parking

Street line

Indoor

Data collection (wireless or wired) through gateway and data uploading to the base station



Deploying sensors in each parking space

Parking space query using the app

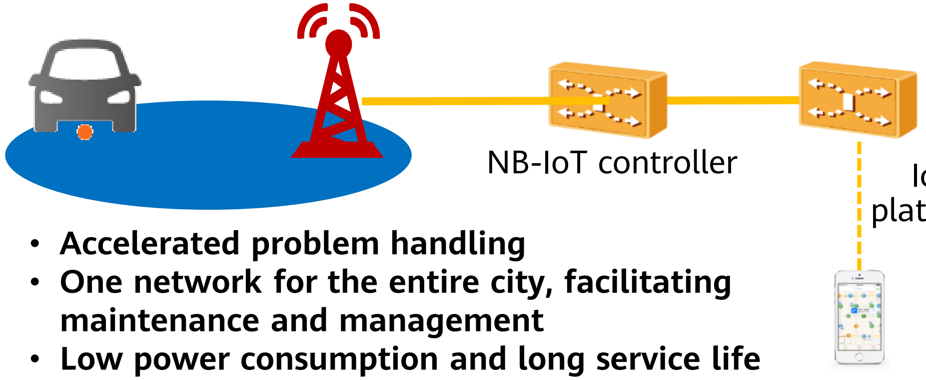
Difficult fault locating

High cost (extra devices and space)

High power consumption

Multi-level network

NB-IoT Provides More Efficient Smart Parking Services



- **Accelerated problem handling**
- **One network for the entire city, facilitating maintenance and management**
- **Low power consumption and long service life**
- **Separated from the real estates, facilitating site selection and installation**
- **Enterprises do not need to maintain networks, reducing operation costs.**

创泰科技 InnoTek

neul

ublox

Smart parking-based vehicle detector

Operating temperature: –40° C to +70° C
Diameter: 90 mm; Height: 80 mm
Material: aluminum

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NB-IoT Solution: Shared Bikes

Map search → Bicycle positioning → QR code scanning → Remote unlocking → Billing → Payment upon locking

Mechanical Lock

- Static passwords: A bicycle can be used by any one who knows the password, eliminating bicycle usage fees.
- Lack of positioning, raising risks of bicycle theft

GPRS Electronic Lock

- High-cost
- The first-generation bicycle uses a motor. The first 30 minutes or 5 km of cycling is not smooth, resulting in poor user experience.
- The second-generation (Lite) uses a solar panel, which is easily affected by external factors (weather and blockage).

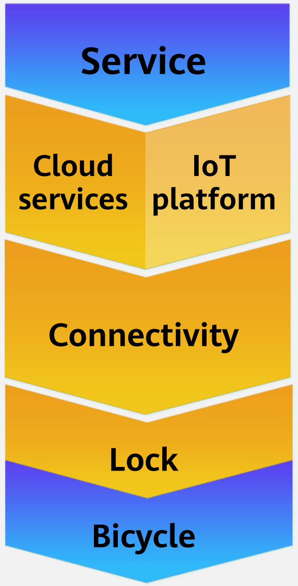
NB-IoT Lock

- Built-in 13000 mAh battery providing two years of power supply
- The 20 dB coverage gain ensures the communication of services such as remote unlocking and positioning.

Innovation of Shared Bikes

Station-free | Positioning | Remote unlocking | Mobile payment | Power supply

Operators' Business Models



Capability openness: For example, identity authentication and deposit are not required for postpaid users.
Cloud services: industry cloud application deployment and data storage
IoT platform: tens of millions of concurrent services; lock management

Guarantee for unlocking success rate and battery life

NB-IoT modules

NB-IoT Solution: Smart Street Lamp

High energy bill

30-50% of the public mains is used for power street lamps.

Large manpower

Time required to install 50 street lamps: 20 persons, 2 days

Legal litigation and public safety joint liability


NORTHJERSEY.COM : NEWS

Broken streetlight to be cited in suit in Ridgewood pedestrian's death

JANUARY 6, 2014

BY CHRIS HARRIS


Remote power on/off

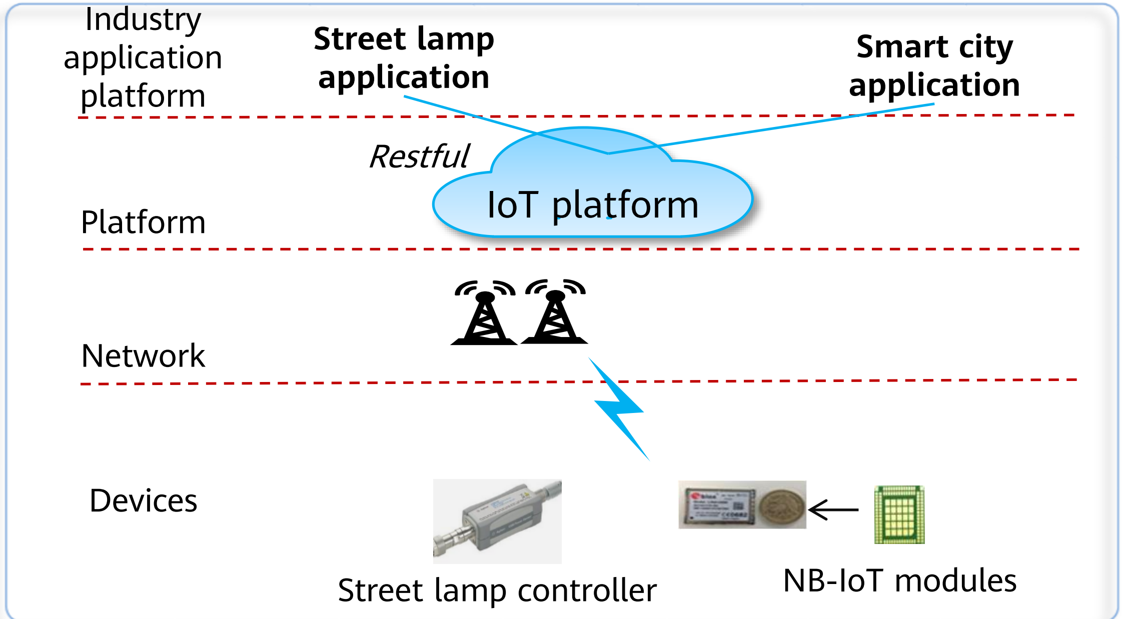

Remote switch timer configuration


Real-time status obtainment

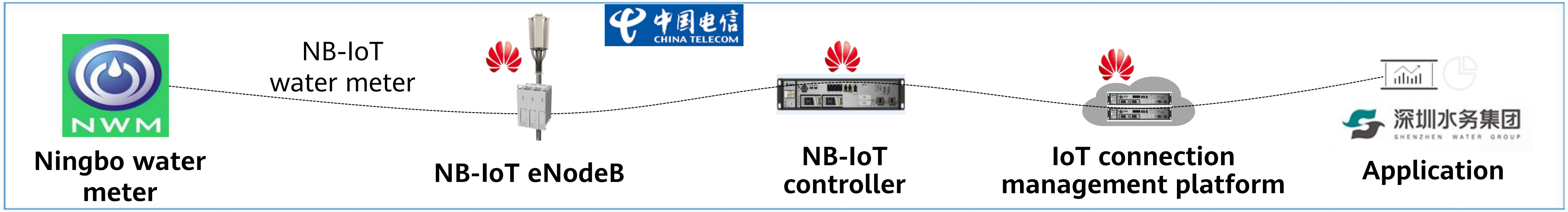

Remote troubleshooting

Remote upgrade

Each street lamp saves 2 USD per month.
Real-time fault reporting, zero-wait maintenance



NB-IoT Solution: Smart Meter Reading



Internet+ smart water meter

IoT Platform Values

- Device management (LwM2M/PSM message caching)
- Asset management
- SIM card management
- Device status monitoring
- Alarm management

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Quiz

1. (Single answer) Which one of the following is not a key feature of NB-IoT?
   A. Wide coverage
   B. Low power consumption
   C. Massive connections
   D. High bandwidth
2. (Single answer) Which mode can help the NB-IoT save most power?
   A. DRX
   B. eDRX
   C. PSM
   D. Idle
3. (True or False) All NB-IoT networks are deployed on the licensed sub-GHz frequency bands.

Summary

- In this course, you have learned NB-IoT technologies in LPWA scenarios, including NB-IoT evolution, the development of NB-IoT in the industry, and key NB-IoT technologies and solutions.

Thank you.

Bring digital to every person, home, and organization for a fully connected, intelligent world.

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5G Communications Technologies and Solutions

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Foreword

- During the World Radiocommunication Conference 2015 held in Geneva, Switzerland from October 26 to 30, ITU Radiocommunication Sector (ITU-R) officially approved the resolution on promoting future 5G research and formally decided on "IMT-2020" as the official name of 5G.
- 5G is a new-generation communications technology. Its standards evolution and industry development have attracted much attention and will be promoted by multiple parties. In addition, for mobile Internet and IoT scenarios, 5G brings new technologies and transformations.

Objectives

Upon completion of this course, you will be able to:

- Understand 5G standards evolution and industry development.
- Master key technologies and points for 5G communications.
- Distinguish between three 5G scenarios and their supported applications.
- Be familiar with 5G business solutions and know the key to the success of operators'.

Contents

Vision 2025: Towards an Intelligent World

All Things Sensing

All Things Connected

All Things Intelligent

1
Live with Robots

Smart home robot usage: 14%

2
Super Vision

Enterprise AR/VR usage: 10%

3
Smart Assistance

Personal smart assistant usage: 90%

4
Smooth Navigation

IoV penetration rate: 15%

5
Work with Robots

Man-machine ratio in the manufacturing industry: 103/10,000

6
Enhanced Creativity

AI usage by large enterprises: 97%

7
Seamless Communication

Enterprise data usage efficiency: 86%

8
Connected Economy

Commercial applications on the cloud: 85%

9
Rapid 5G Coverage

5G coverage rate: 58%

10
Global Digital Governance

Global data volume generated per year: 180 ZB

Evolution of 5G Communications Technical Standards

2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021

On December 21, 2017, the first 5G NR standard that can be commercially used was formulated.

- Release 15
- Release 16
- Release 17
- Commercial use of IMT-2020
- LTE air interface evolution

R15

NR technical framework

- ✓ New waveform
- ✓ Numerology, frame structure
- ✓ Coding, modulation, & channel
- ✓ M-MIMO
- ✓ Flexible duplex

Network architecture: ready

- ✓ UL and DL decoupling
- ✓ CU-DU high-layer split
- ✓ NSA/SA

Industry application basic design

- ✓ URLLC

R16

Function enhancement

- ✓ 2-step RACH
- ✓ IAB
- ✓ Mobility enhancement
- ✓ Enhanced dual connectivity (DC) and carrier aggregation (CA)
- ✓ MIMO enhancement
- ✓ UE power saving

Vertical industry exploration

- ✓ URLLC enhancement
- ✓ 5G+TSN
- ✓ NPN
- ✓ 5G LAN
- ✓ 5G V2X
- ✓ NR-U
- ✓ NR positioning

3GPP Release 15: New 5G Technology Standards

These include:

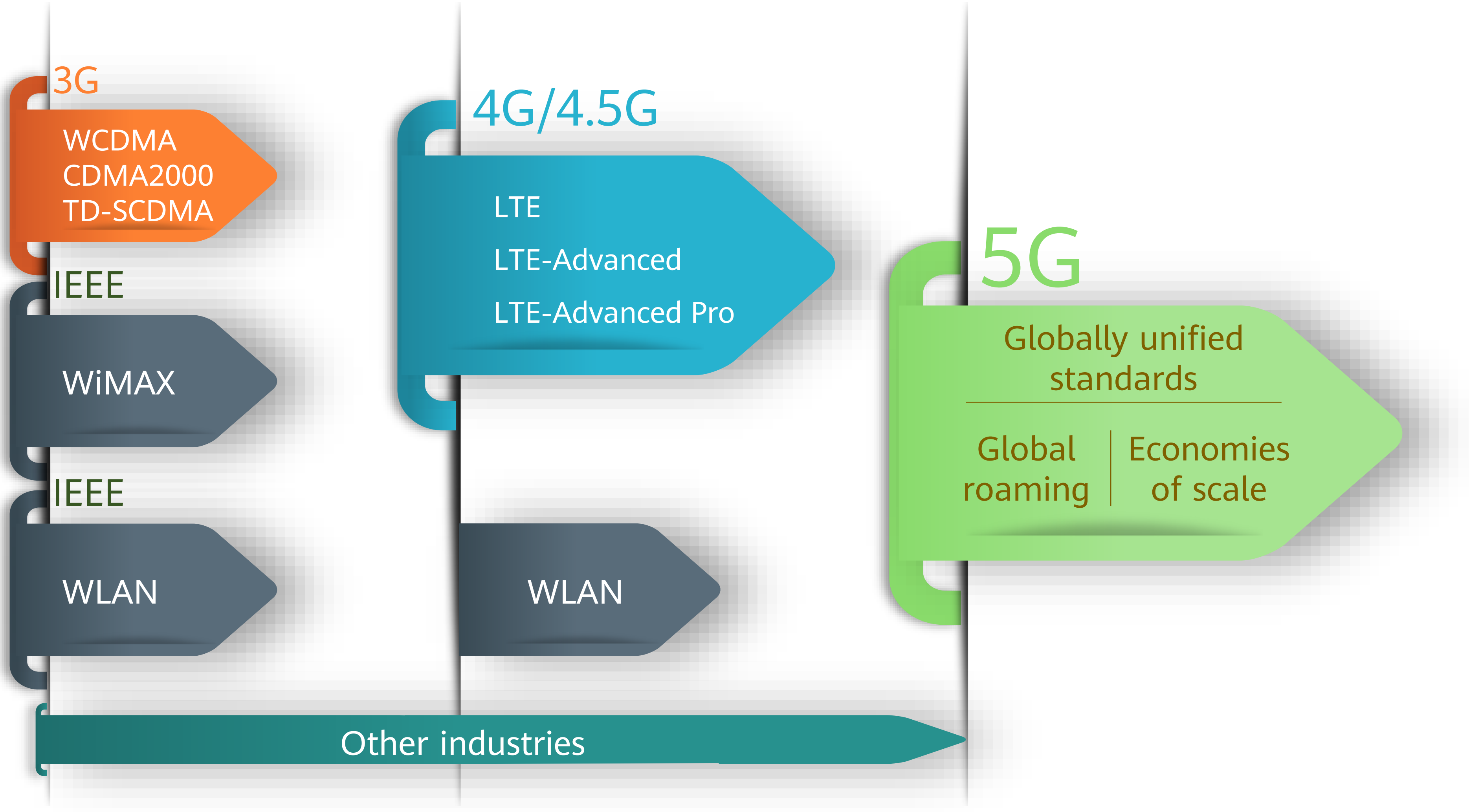
New radio

LTE Advanced Pro evolution

Next generation core (NGC)

EPC evolution

5G Unified Standards



More Countries Value 5G & AI as Key to National Digitization

170+ countries released digital strategies

ICT **20%** ↑ -> GDP **1%** ↑

5G plays an important role in the national digital strategy.

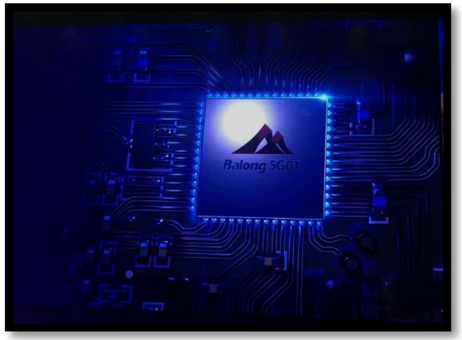
- South Korea: 5G+strategy: Build global top strategic products based on 5G by 2026.
- US: National security strategy: 5G creates a new market of US$250 billion
- China: Three ministries in China established the IMT-2020 (5G) Promotion Group in February 2013
- Germany: Build a high-performance 5G network by 2025. 5G is the basis for digital value creation.
- UK: Leading 5G, building a world-leading digital economy
- Japan: 5G is the foundation of economic, social, and national life.

20+ countries released national AI strategies.

- US: US AI Plan
- China: Next Generation Artificial Intelligence Development Plan
- Canada: Pan-Canadian Artificial Intelligence Strategy
- Singapore: Smart Nation 2025
- UK: Industrial Strategy: AI Sector Deal
- Russia: National AI Strategy 2030
- UAE: National Artificial Intelligence Strategy 2031
- India: National Artificial Intelligence Strategy

Widespread Proliferation of 5G Product Types

- On the eve of the 2018 Mobile World Congress, Huawei announced Balong 5G01, the world's first commercially available 5G chipset compliant with 3GPP specifications. It supports global mainstream 5G frequency bands, including the low ones (sub-6 GHz) and high ones (mmWave). Theoretically, the data download rate can be up to 2.3 Gbps.
- Huawei also launched the first 3GPP-compliant 5G commercial terminal: HUAWEI 5G CPE. There are two types of CPEs, one for low frequency bands (sub-6 GHz) and the other for high frequency bands (mmWave). The tested peak downlink rate can reach 2 Gbps.
- In addition, Huawei unveiled its first 5G foldable phone, HUAWEI Mate X.
- On March 26, 2020, Huawei launched the 5G mobile phones Huawei P40 and P40 Pro globally.



Balong 5G 01

5G CPE

Mate X

P40 Pro

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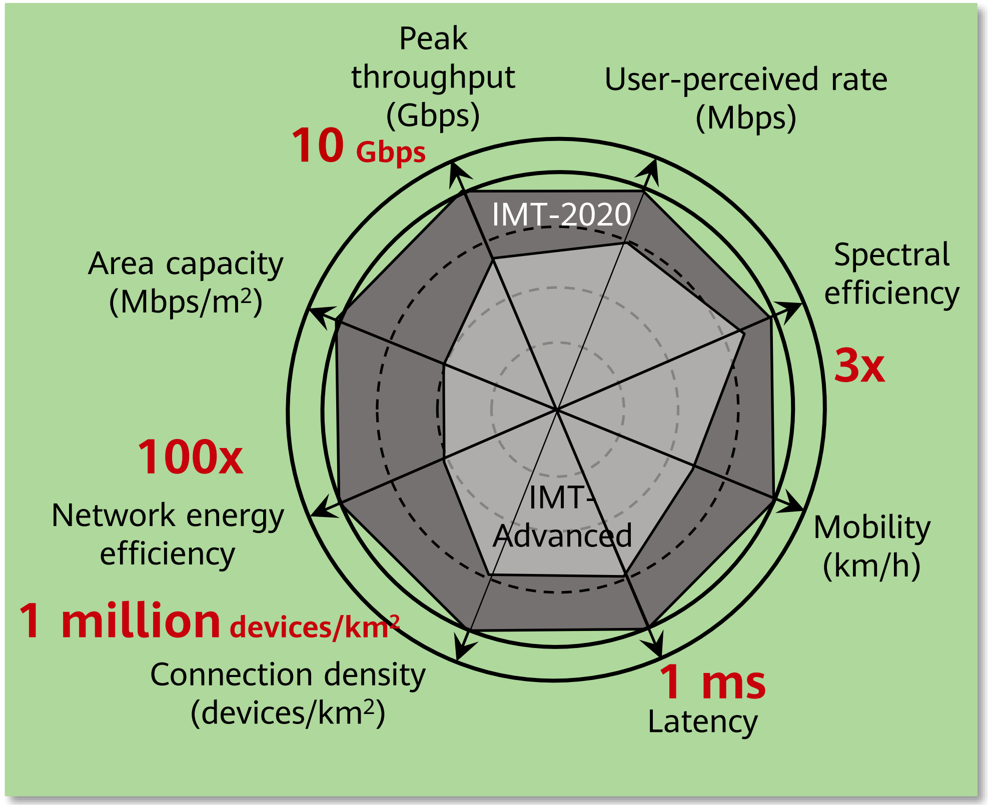
Contents

5G Key Performance Indicators

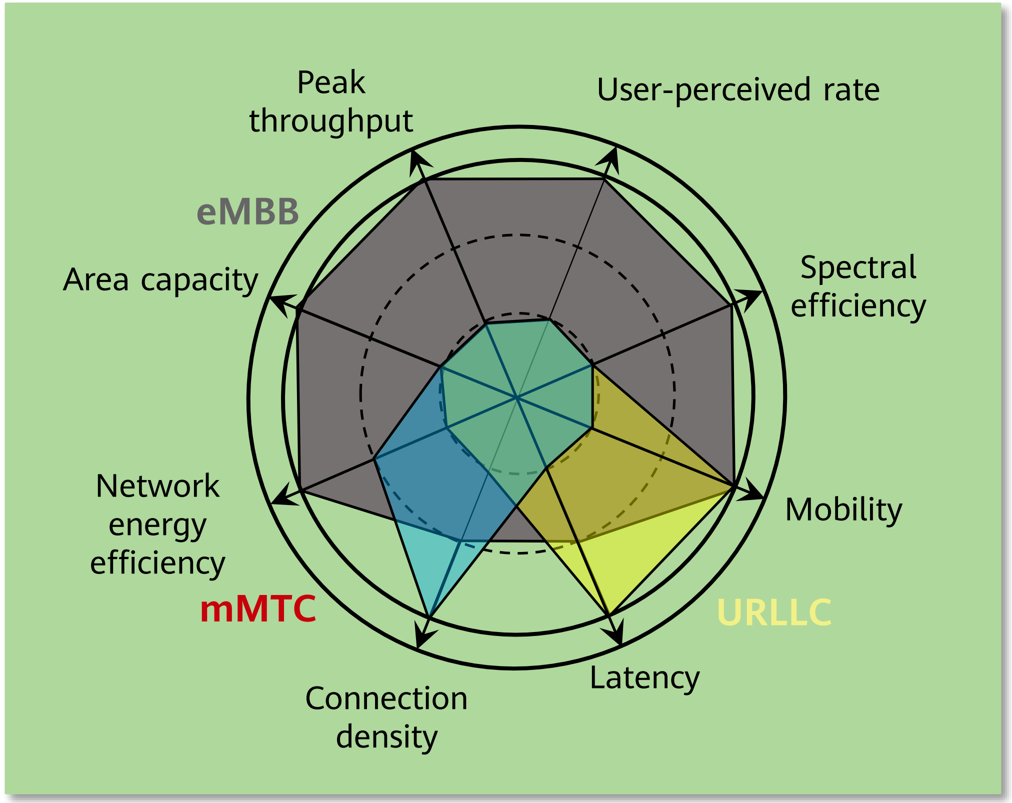
	Latency	Throughput	Connections	Network Architecture
5G	**1 ms** E2E latency	**10 Gbps** per connection	**1 million** per km^2	**Slicing** capability requirements
	30 to 50x	100x	100x	NFV/SDN
LTE	30 to 50 ms	100 Mbps	10,000	Flexibility

5G Key Capability Requirements

Key capability requirements (IMT-2020 vs. IMT-Advanced)

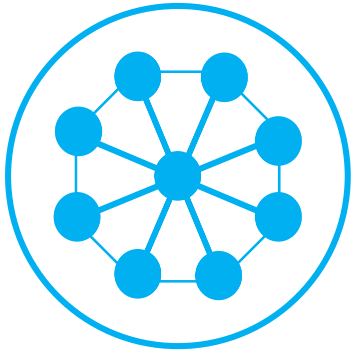


Different application scenarios have different requirements on 5G network capabilities.



Three Key 5G Innovations

New Architecture

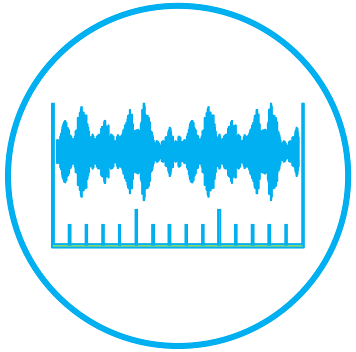


Using both low and high frequency bands for new experience

New Radio

One physical network for hundreds of industries

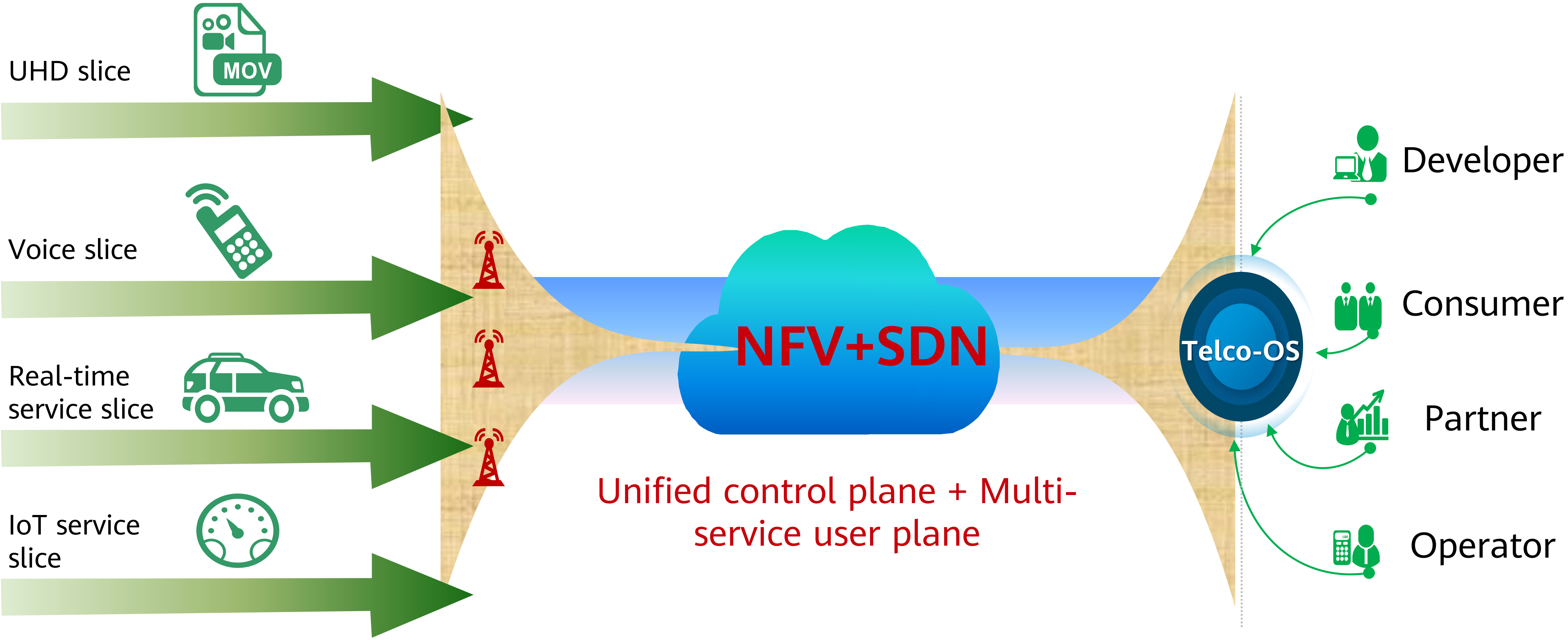
Full Spectrum



Flexible adaptation to various services

Improved spectral efficiency

5G New Architecture - One Network for Hundreds of Industries



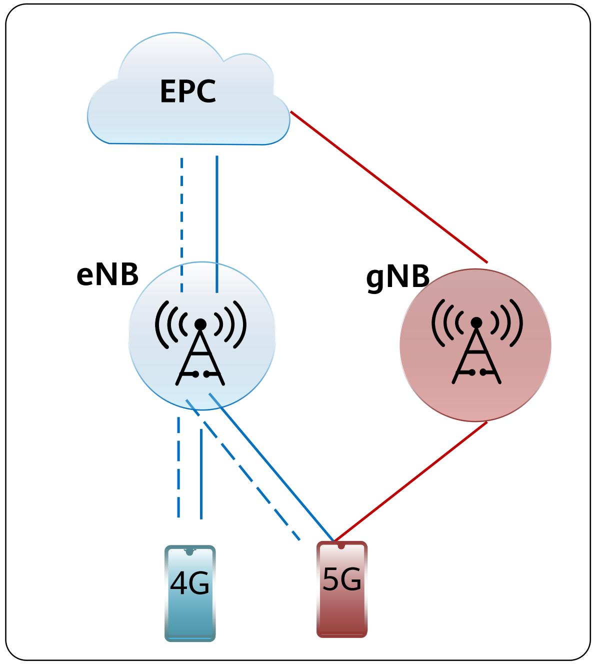
Slice QoS defined by industry requirements

Architecture based on cloud and big data

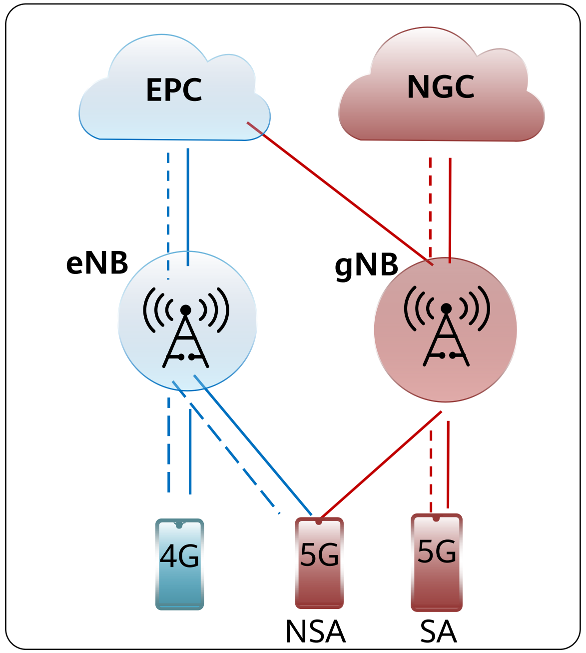
Operations based on Internet architecture

5G Networking Mode

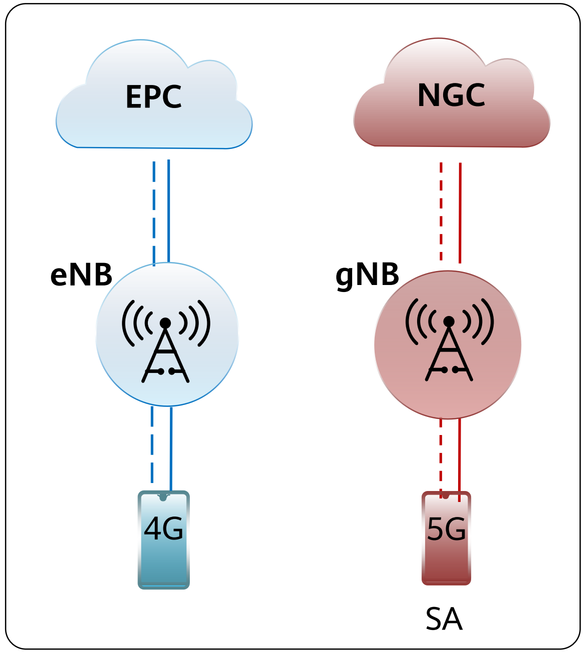
2019
NSA Option 3x



2020 to 2023
Long-term coexistence of NSA and SA



2023+
SA as the target architecture



Enabling eMBB services:
- Quick deployment in the early stage
- LTE as the anchor point
- LTE&NR DC

Enabling 5G 2B services:
- One network adapts to both NSA and SA networking.
- Uplink enhancement (such as super uplink and NR uplink CA)

Fully enabling vertical services:
- NR carrier aggregation

Operators Will Begin Deploying SA Networks in 2020

	Service	User Experience	Deployment Complexity	Ecosystem Maturity
NSA 	• **eMBB and FWA: supported** • URLLC and network slicing: not supported	• **EN-DC**: enhancing uplink coverage • EN-DC: improving user experience	• LTE base station software upgrade to support NSA • EPC software upgrade	• Mature in 2019
SA 	• All-scenario services are supported • **Vertical industries** enabled by network slicing and high uplink bandwidth	• Limited uplink coverage (for C-band) • Ultra-large uplink or **sub-3G NR**: Mandatory	• Super uplink or sub-3G NR • **NGC**: mandatory	• Driven by Chinese and American markets • **Mature in 2020**

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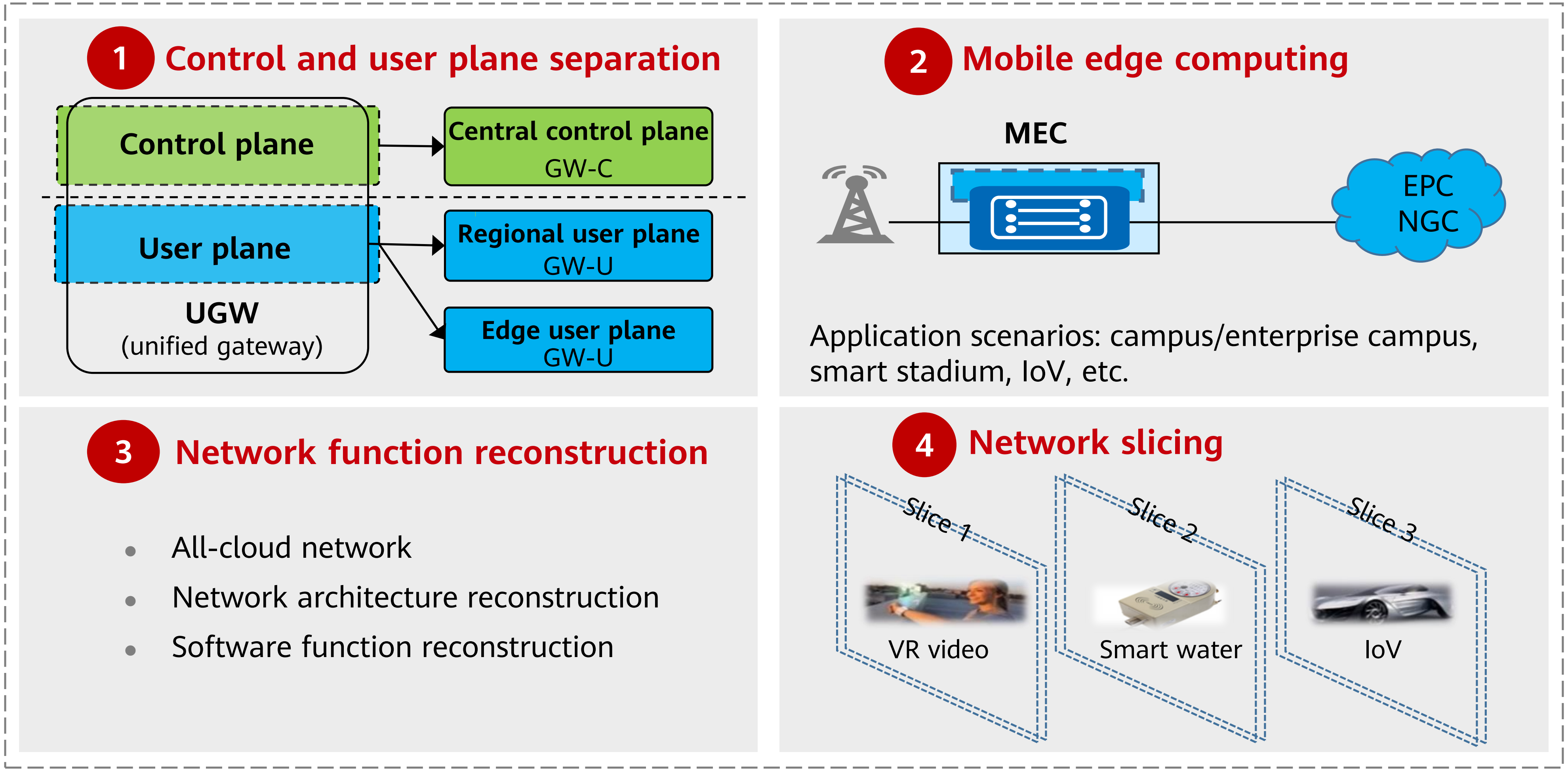
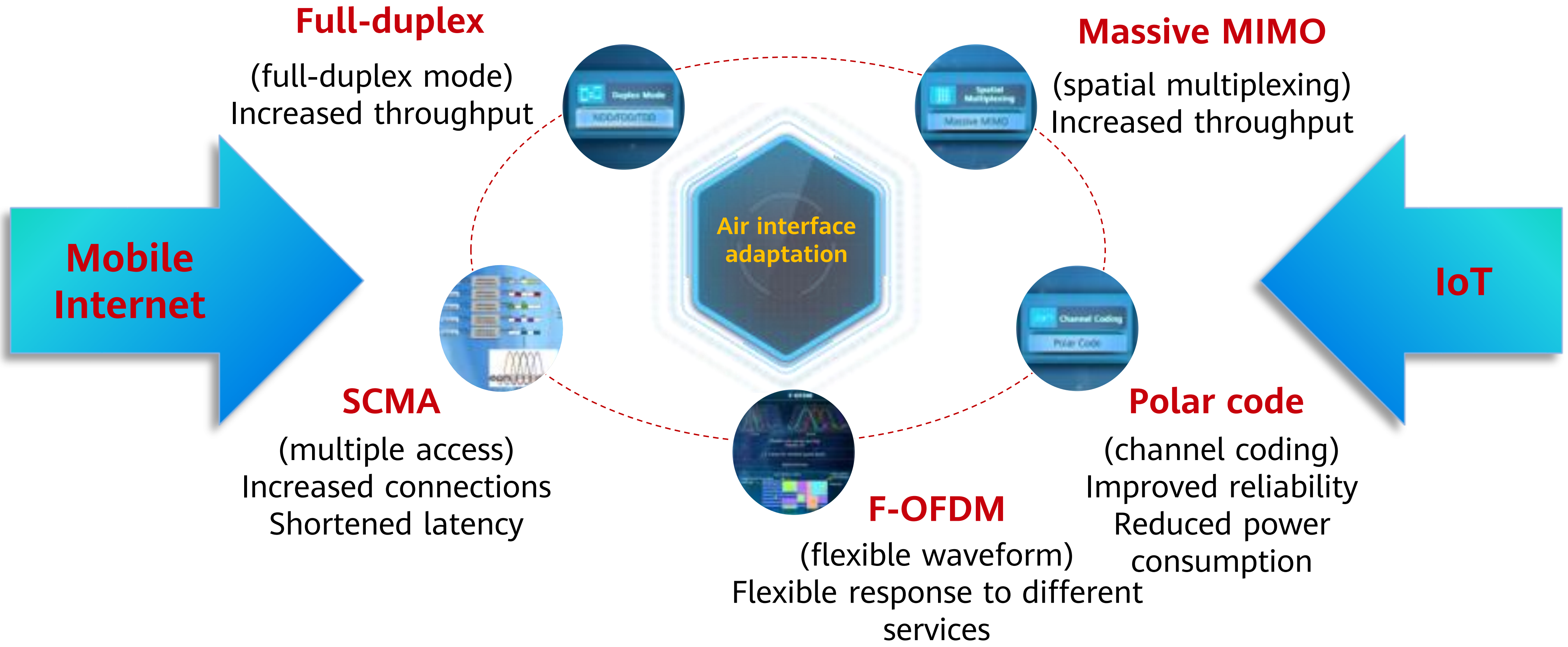
NGC: Service-oriented, with Four Types of Services

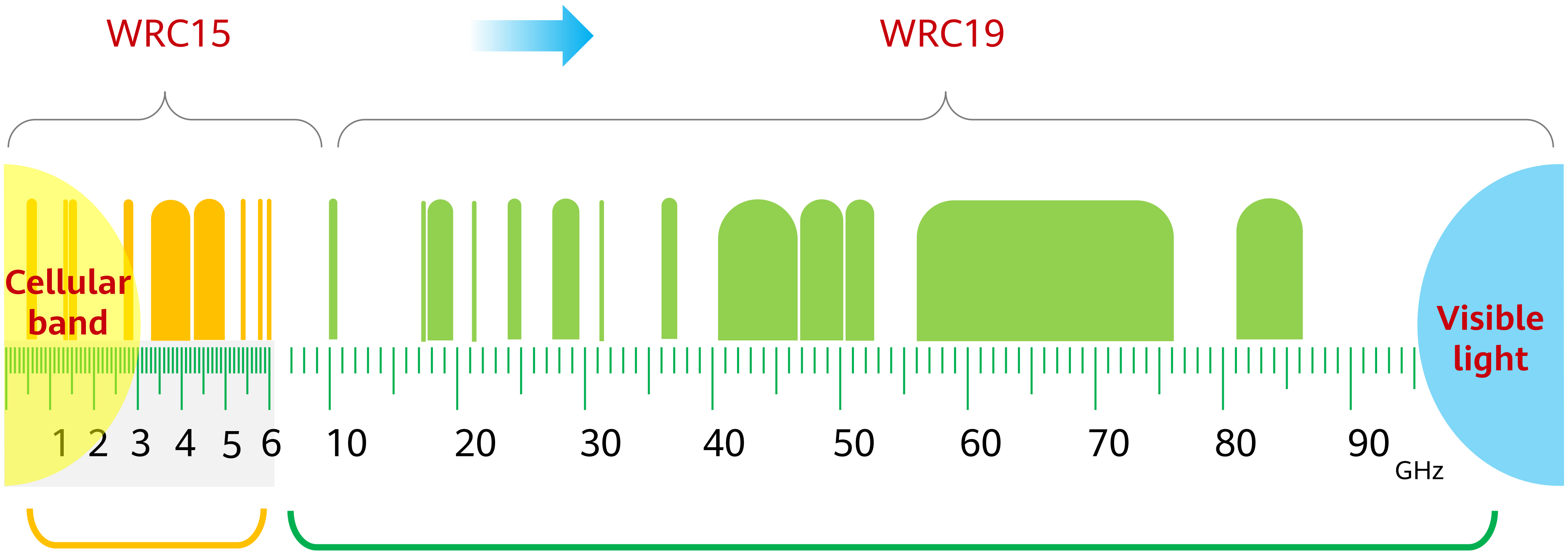


5G New Radio



The new radio can flexibly adapt to different services, delivering a three-fold improvement of spectral efficiency.

5G Aggregates All Frequency Bands



~ For coverage and capacity

~ For capacity and self-backhaul

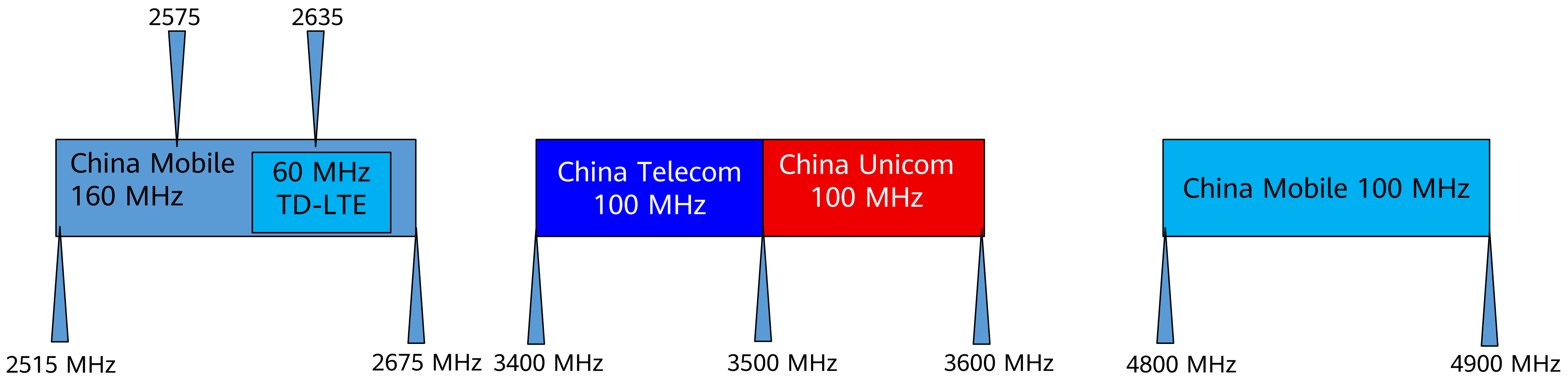
C-band (3.4–3.6 GHz) can provide at least 200 MHz global frequency bands.

WRC19 candidate bands for IMT above 6 GHz: 24.25-27.5, 37-40.5, 42.5-43.5, 45.5-47, 47.2-50.2, 50.4-52.6, 66-76, 81-86 GHz

28 GHz (27.5–29.5 GHz) for industrial use

Allocation of Mid and Low 5G Bands in China

- The MIIT has approved the license for the use of the medium and low frequency bands for 5G by China's three major operators.
  - China Telecom: 3400–3500 MHz (100 MHz)
  - China Unicom: 3500–3600 MHz (100 MHz)
  - China Mobile: 2515–2675 MHz and 4800–4900 MHz
    - 2515–2575 MHz, 2635–2675 MHz, and 4800–4900 MHz frequency bands are newly added, and the 2575–2635 MHz frequency band is refarmed from China Mobile's existing TD-LTE (4G) frequency band.



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eMBB

- In eMBB scenarios, 5G needs to provide enhanced mobile Internet services:
  - Services such as VR/AR/MR require higher rates.

VR

Everything you see is unreal.

AR

You can tell the difference between the 'real' and the 'virtual'.

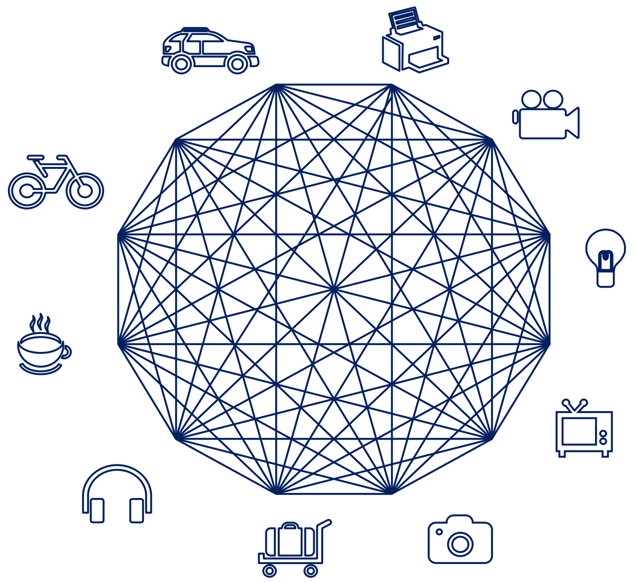
MR

You cannot tell the difference between the 'real' and the 'virtual'.

Immersion → **Interaction** → **Imagination** → **Panoramas**

mMTC

- In mMTC scenarios, 5G needs to provide IoT services with massive connections.
  - Internet of everything – large-scale IoT

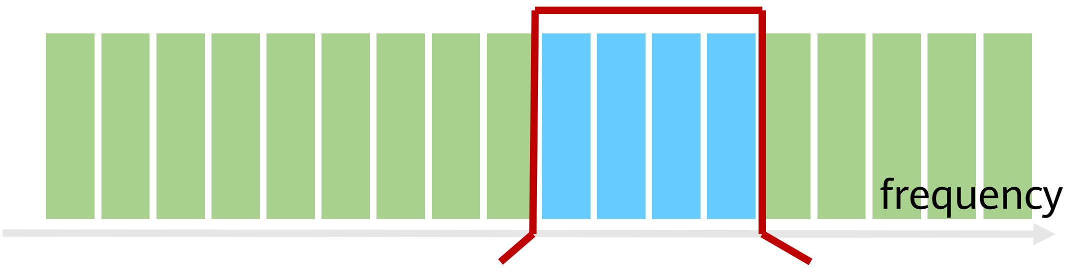


All things connected

NB-IoT Already Evolved to NR

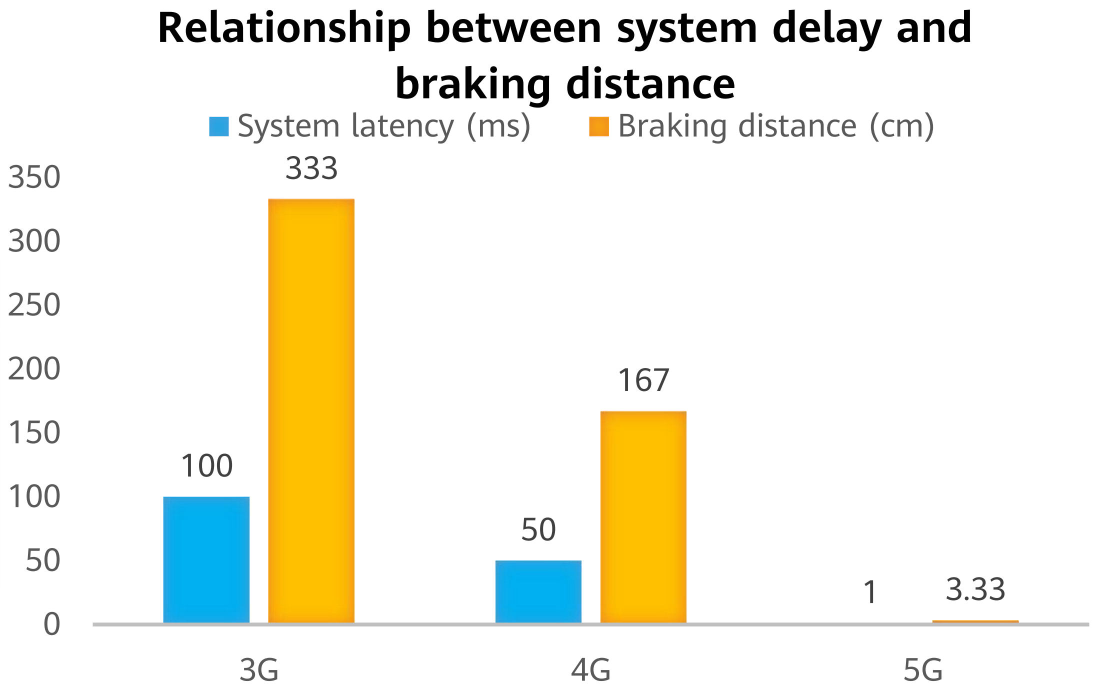
The ITU-R WP 5D#35e remote conference held by the International Telecommunication Union (ITU) announced that 3GPP 5G technologies (including NB-IoT) meet the requirements of IMT-2020 5G technical standards and are officially accepted as ITU IMT-2020 5G technical standards.

NB-IoT systems embedded into 5G



URLLC

- In URLLC scenarios, 5G needs to provide ultra-high reliability and ultra-low latency services.
  - In V2X scenarios, services such as assisted driving and automated driving require low latency.
  - Scenarios demanding high real-time performance, such as smart healthcare and remote surgery, require low latency.



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Contents

Three 5G Business Solutions Driving Business Success

5G Business Solutions

B2C: 5G enriches life

Experience 5G anytime, anywhere

- **Business insight**: 3 key success factors
- **Solution**: Leading VR service solution;
  Digital indoor solution
- **Best practice**: LG U+ China Mobile, Elisa, ...

B2B: 5G boosts industry

Industry-level quality, ensuring SLA

- **Business insight**: Blue ocean market, starting from connectivity
- **Solution**: Rapid and economical business connections;
  Guaranteed SLA solution
- **Best practice**: STC, China Unicom, Sunrise, ...

B2H: 5G enables wireless optical fibers

8K

Quick launch and experience of wireless optical fibers

- **Business insight**: Three scenarios drive business development.
- **Solution**: All-scenario CPEs + WTTx suite
- **Best practice**: Globe, Telcom, 3, ...

B2C Industry Insight: Three Key Success Factors

5G Brings More New Services

New video: more details, immersive experience

1080p
120˚ 2D → 4K/8K
360˚ 3D/4D

New live broadcast: onsite-like experience

Single view → Unlimited view

New games: any game, any device

Dedicated devices and games → Cloud gaming

Rapid Increase of 5G B2C Users

2001->2010 → 3G: 9Y

2009->2015 → 4G: 6Y

2019->2022 → 5G: 3Y

500 million user growth

5G will be two times faster than 4G and three times faster than 3G, reaching 500 million users.

Three Key Factors for 5G B2C Success

- ✓ High-quality network
- ✓ Rich content
- ✓ Flexible multi-dimension tariffs

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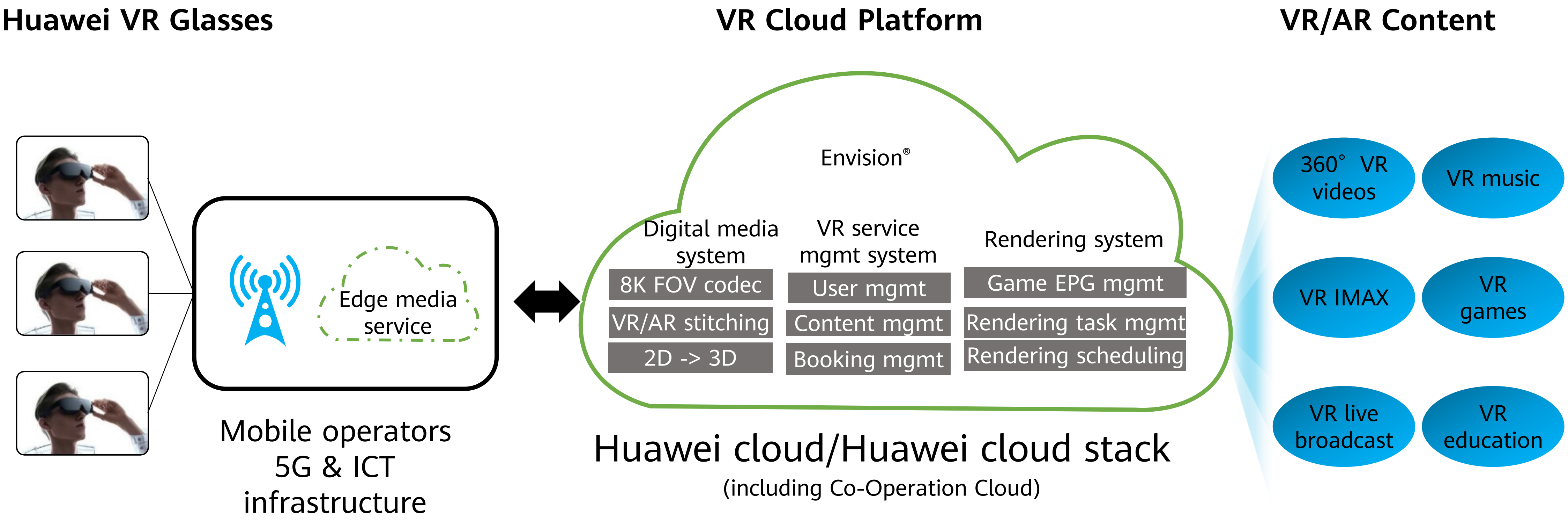
Solution: Driving VR/AR Business Success



Commercial cases:

- China Telecom: e-Cloud VR
- China Unicom: Wo Video

B2B Industry Insight: Blue Ocean Market, Starting from Connectivity

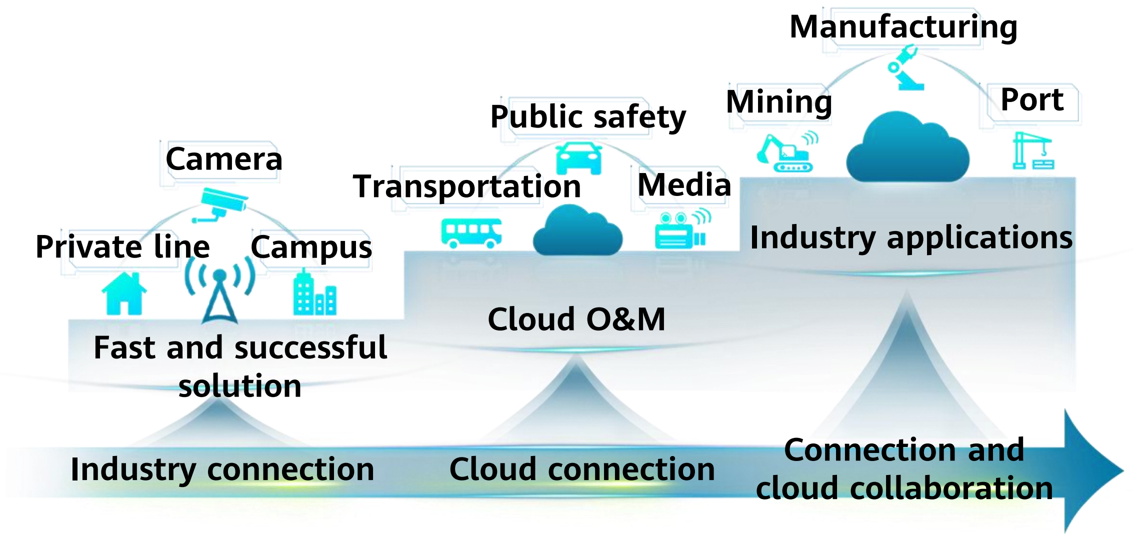
B2B Services: Blue Ocean Market for Operators' Business

5G value chain: **1.83** trillion

5G-driven GDP growth: **6.9** trillion

Job opportunities: **11** million

5G B2B Success Starts from Connectivity



5G private line

5G campus

5G public safety

5G transportation

5G port

5G manufacturing

Solution: Fast and Economical Business Connection

Fixed Private Line Scenario

The AR650 gateway facilitates 5G connections on enterprise private networks, meeting enterprise VPN and security requirements.

Enterprise private line

Cameras with built-in 5G modules facilitate HD video surveillance.

Video surveillance

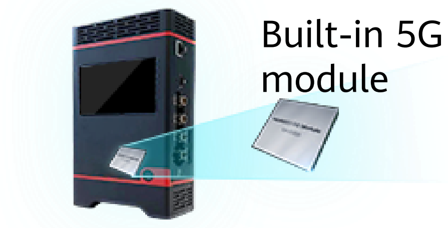
Wireless Private Line Scenario

The world's first industrial-grade CPE facilitates remote control in industrial scenarios and provides more stable connections in complex environments.

Remote control

The video codec with built-in 5G modules makes the 5G backpack lighter and makes the battery power supply last longer.

Live broadcast



B2H Industry Insight: Three Scenarios Drive Service Development

FWA as the main service at the early stage of 5G

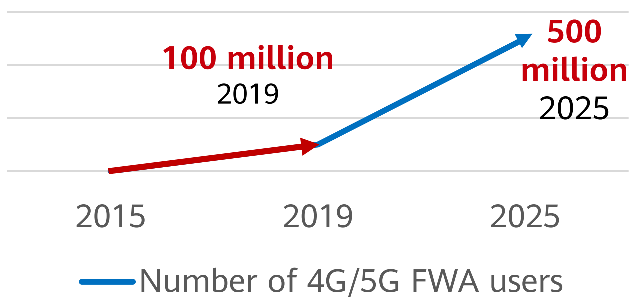
230+
4G FWA network

10+
countries lead the use of FWA.

30+
5G FWA network

10+
networks have more than 1 million users.

Rapid growth of 4G/5G FWA users



New "MFC" = Mobile + FWA

Mobile-First Convergence

ARPU
3x

Mobile churn rate: **0.5x**

Ultimate gigabit experience

4G FWA
5-50 Mbps

5G FWA
100-1000+Mbps

Equal profit with eMBB

5x spectral efficiency VS eMBB
(The coverage range of an outdoor CPE is 30+ dB greater than that of a mobile phone.)

All-scenario support

4G FWA
Basic broadband

5G FWA
Premium broadband

- ✓ Connection of unconnected households
- ✓ Copper line replacement
- ✓ Optical fiber replacement

Better business prospects

5G FWA
- High-quality user experience
- Guaranteed bit rate

Flexible investment
- **C-band & sub-3 GHz**: hybrid eMBB/FWA
- **mmWave**: on-demand deployment

Fast ROI
Two-year ROI@FWA + eMBB

Solution: Fast HBB Connection - 5G FWA Series

5x spectrum performance increases FWA profitability

VS

@same resource

50 GB — Smart phones

250 GB — N5866 (outdoor)

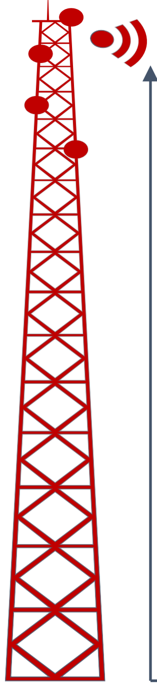
High-performance CPE

✓Higher antenna gain (11 dBi)

✓4R/8R CPE, doubling capacity

E2E capability of the WTTx suite

- 1-minute service provisioning
- Easy digital installation within 1 hour
- 1 unified operation platform



Dense urban areas
mmWave CPE

200 m to 300 m

Urban areas
CPE

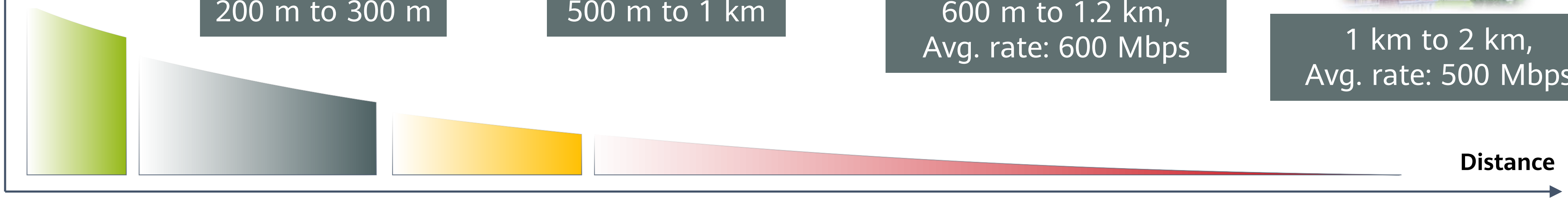
500 m to 1 km

SMEs
N5368X

600 m to 1.2 km,
Avg. rate: 600 Mbps

Suburban areas
N5368X2

1 km to 2 km,
Avg. rate: 500 Mbps



Distance

300 MHz (indoor) 500 MB (near a window) > 800 MHz (outdoor)

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Quiz

1. (Multiple Choice) What are the three 5G application scenarios defined by ITU?
   - A. eMBB
   - B. eMTC
   - C. mMTC
   - D. uRLLC
2. (Multiple Choice) Which two of the three 5G application scenarios are closely related to IoT?
   - A. eMBB
   - B. eMTC
   - C. mMTC
   - D. uRLLC

Summary

- In this course, you have learned about the most popular wireless communications technology: 5G, including its standards evolution, industry development process, and key technologies.
- You have also learned about the three application scenarios of 5G: mMTC, URLLC, eMBB, and 5G solutions in the industry.
- If you want to learn more about 5G technology details, please attend the 5G course training.

Thank you.

Bring digital to every person, home, and organization for a fully connected, intelligent world.

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Huawei Industrial IoT Gateways

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Foreword

- Amidst global competition, the net profit of industrial manufacturing continues to decline, while traditional business models are forced to transform. Emerging from this is a wide unknown market space – industrial interconnection. With opportunity for growth and profit, industrial interconnect scenarios involve harsher environments, require more diversified interfaces to adapt, face more network security challenges, and are more difficult to maintain than in enterprises or the family home.
- To keep up, Huawei has designed and launched a series of high-end, mid-range, and low-end IoT gateways. These feature-rich gateways stand out for their unmatched edge computing, IoT platform support, and extensive adaption to industrial interconnection scenarios.

Objectives

- Upon completion of this course, you will be able to:
  - Understand basic concepts and features of industrial IoT gateways.
  - Master key technologies of industrial IoT gateways.
  - Understand Huawei industrial IoT gateway products and features.
  - Understand application scenarios of Huawei industrial IoT gateways.

Contents

Extensive Application of IoT in Industrial Scenarios

Intelligent meter reading

Ubiquitous power IoT promotes the development of smart meters.

Smart transportation

Traffic video surveillance
Information collection and release

Intelligent power distribution

Power distribution automation and information collection
Large-scale construction in developed countries/regions

Intelligent energy efficiency management

Intelligent building management, enhancing energy efficiency

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Challenges Faced by IoT in the Industry Field

Gap between enterprise IP products and the stringent industrial-grade requirements of IoT fields

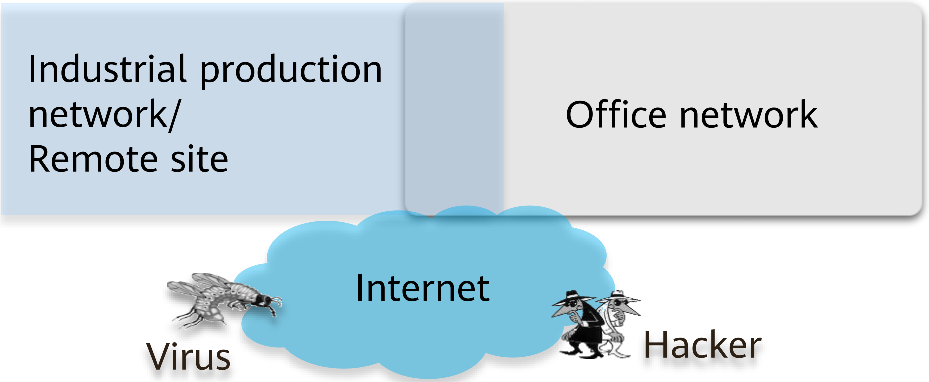
Industrial-grade requirements		Enterprise routers
Temperature: –40°C to +70°C		Temperature: 0°C to 40°C
Dustproof and waterproof	***VS.***	Non-compliant
Strong anti-electromagnetic interference		Non-compliant

Diverse industrial interfaces and protocols

BPL, PLC, ZigBee, RF/Sub-GHz,
RS485, RS422, RS232, Modbus,
IEC 62056, IEC 60870-5-101, IEC 104...

Can you differentiate their application scenarios? Do multiple networks need to be maintained? Does a protocol converter need to be purchased?

Security risks on open networks

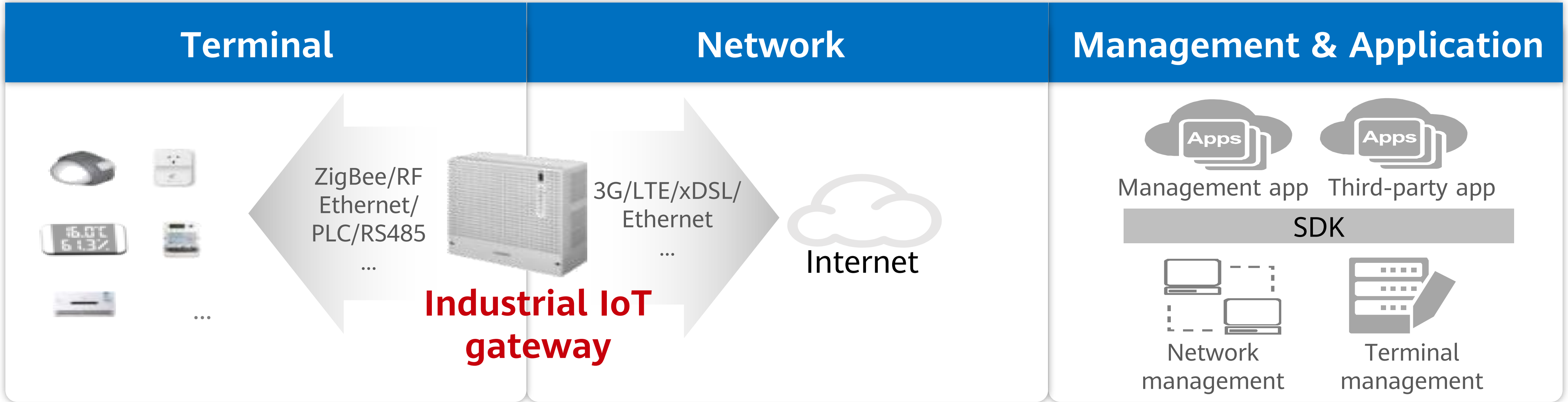


Complex IoT network O&M


Dispersed sites, heavy deployment workload, and difficult management
High requirements on engineers' skills and expertise

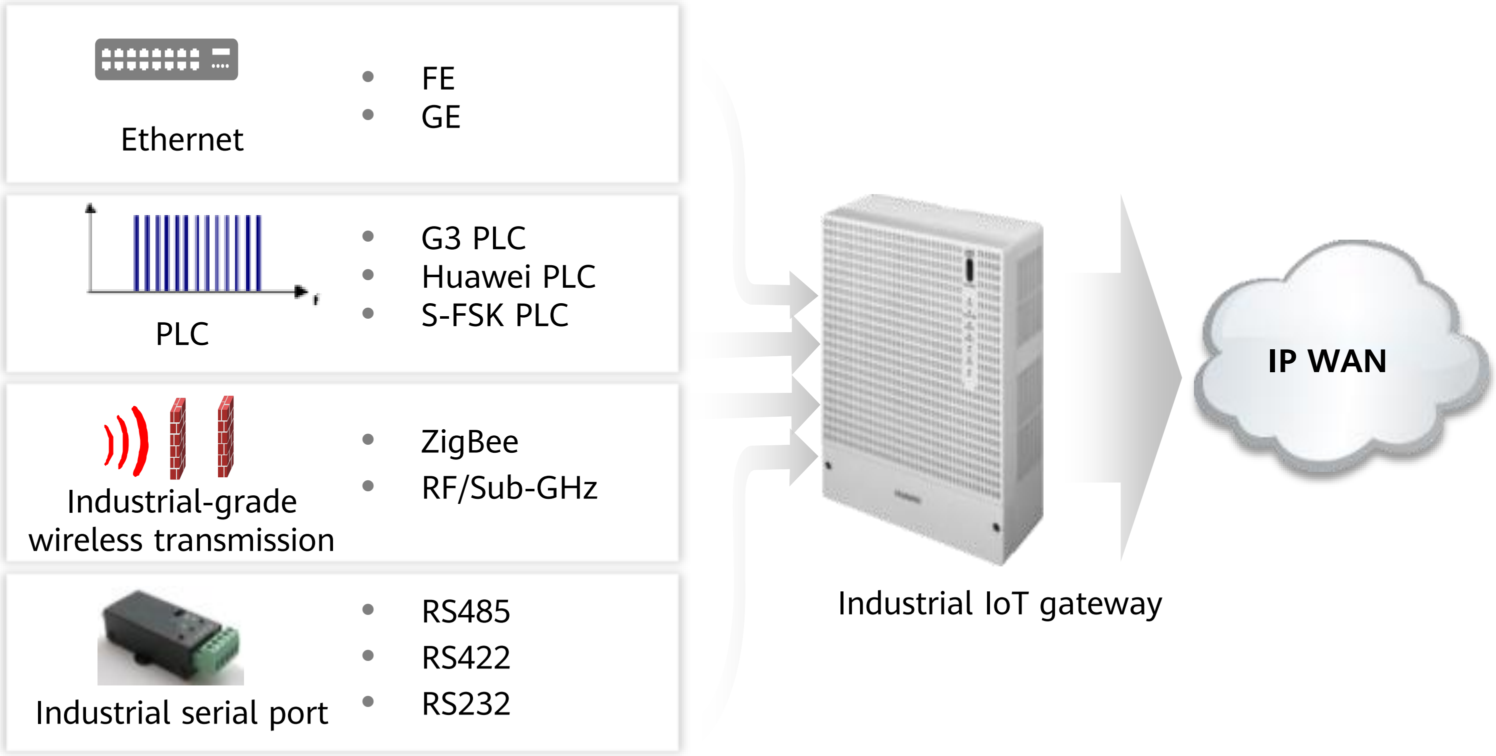
Why Industrial IoT Gateways

- An industrial IoT gateway functioning as the aggregation device on the local network provides:
  - Uplink transmission channels
  - Edge computing capabilities, ensuring a real-time local response
- A converged gateway designed for industrial IoT applications supports:
  - Adaptation to harsh industrial environments
  - Industrial field interfaces/IP-based protocols



Positioning of Industrial IoT Gateways

- Huawei industrial IoT gateways are designed for industrial IoT applications. They integrate routing, switching, wireless, and security functions.
    - Industrial-grade standard design
    - Extensive interfaces and protocols
    - Edge computing
    - Security encryption
    - Centralized management
    - ...



- In addition to open and standard Ethernet interfaces, Huawei industrial IoT gateways also support diverse industry interface and bus standards, **meeting the requirements for interconnection and communication between old and new devices. These gateways help enterprises maximize their investments and achieve smooth transition to IP-based networks**.

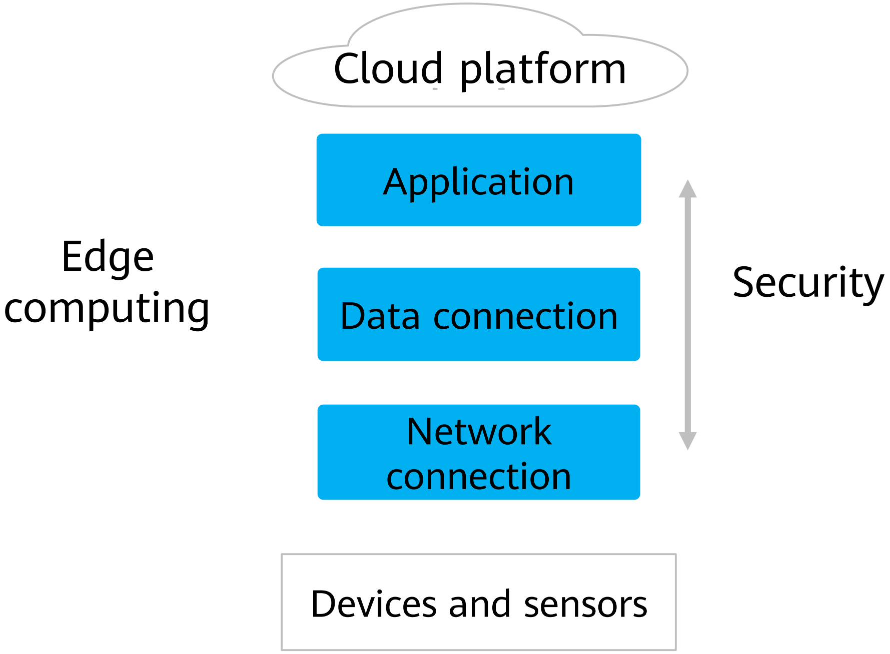
Contents

Edge Computing (1/2)

- What Is Edge Computing?
  - Edge computing provides connection, computing, storage, control, and application functions on network edge nodes close to terminals to meet users' requirements for real-time services, intelligence, security, and data aggregation. Leveraging mature communication technologies, edge computing distributes computing, storage, and security capabilities on edge nodes. The computing, storage, and communication loads of the central node are distributed to edge nodes with weak computing capabilities. This minimizes the latency and cost and improves reliability of services, while protecting user privacy at the edge. Edge computing enables the transformation of networks from a cost center to a business value center.
- Core Benefits of Edge Computing
  - **Real-time services**: Dynamic path adjustment, real-time data analysis, and event response in milliseconds are supported.
  - **Intelligent analysis and processing at the edge**: Services can be deployed at the edge and flexibly adjusted. Automatic O&M can be implemented for networks.
  - **Data aggregation**: Data fragmentation is eliminated, invalid noise is shielded, and data is uploaded on demand.
  - **Private security domains**: data, node, and network security domains

Edge Computing (2/2)

- An open platform that integrates core capabilities such as connection, computing, storage, control, and application is deployed at edge nodes close to terminals or data sources to meet users' requirements for real-time services, intelligence, data aggregation, and security.

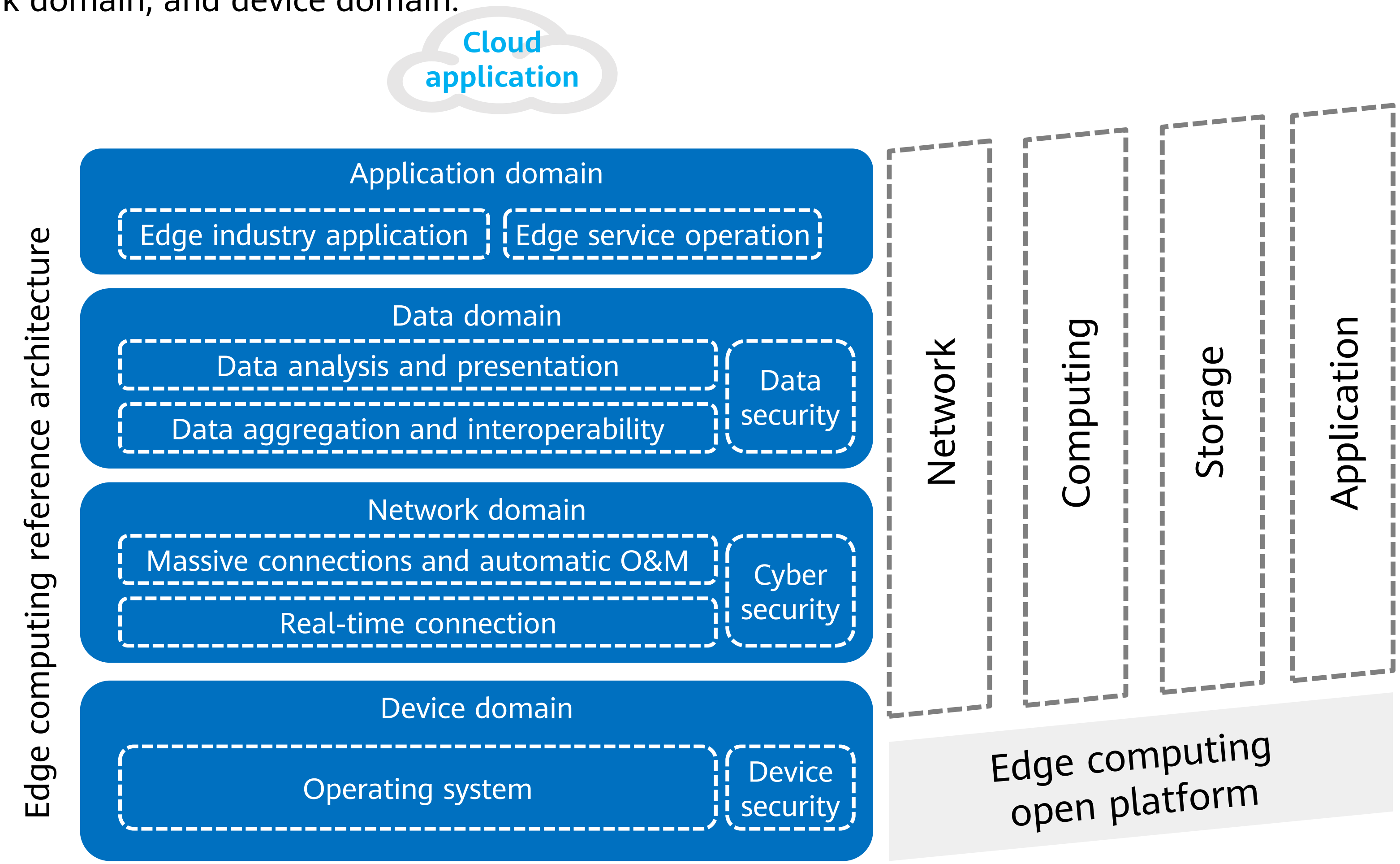


Traditionally, data must be sent to a server for processing, resulting in a long latency, which cannot meet requirements of IoT services.

Currently, the local gateway provides containers to process data locally, minimizing the latency and improving reliability.

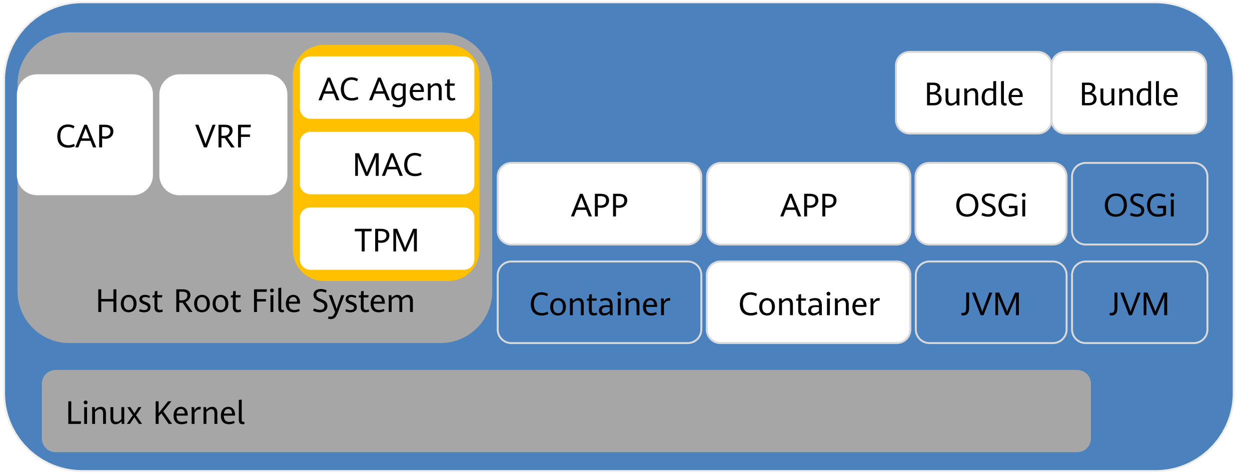
Hierarchical Edge Computing Architecture

- The Edge Computing Consortium (ECC) divides the edge computing architecture into four domains: application domain, data domain, network domain, and device domain.



Edge Computing Openness Capabilities of AR Series Routers

- Container-level tool chain
  - Customers can develop and deploy their own applications.
- App-level container
  - Customers can deploy their own applications on the device as Docker containers.
- JVM
  - Customers can run open Java software on the device.
- JVM + OSGi framework
  - Customers only need to develop bundles, so that their service apps can be deployed in the OSGi framework.



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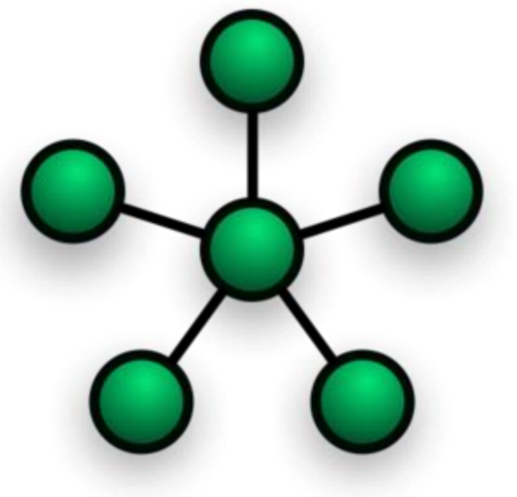
Communication Networking Technologies

- A network topology refers to the layout of computers and devices on a communication network, representing the physical or logical arrangement of network elements (NEs). If two networks have the same connection model, their network topologies are of the same type, though the physical connections inside the two networks and the distances between nodes may be different.

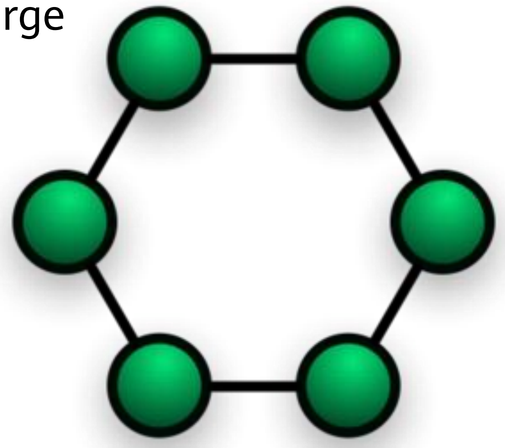
Star Topology

- The star topology is a topology in which all nodes are connected through a central network device such as a hub or a switch.
- It has the following advantages:
  - ✓ Simple structure, facilitating management
  - ✓ Easy control, facilitating network construction
  - ✓ Short network latency, ensuring efficient transmission
- It also has some disadvantages:
  - ✓ High cost
  - ✓ Low reliability
  - ✓ Poor resource sharing capability



Ring Topology

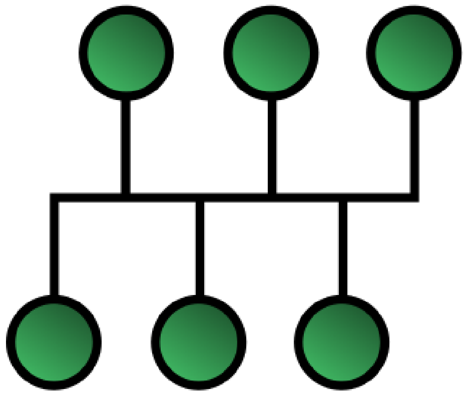
- The ring topology is widely used on LANs. On a ring network, packets of data travel from one device to the next until they reach the destination. This structure eliminates the dependency on the central node for communication between end users.
- The ring topology has the following characteristics:
  - ✓ Information flows towards a fixed direction on a network, and there is only one path between two nodes, simplifying path selection.
  - ✓ The control software is simple.
  - ✓ Information is transmitted over nodes on the ring network in sequence. If there are a large number of intermediate nodes, the information transmission rate will be lowered, increasing the network response time.
  - ✓ The ring network is closed, causing difficulties in expansion.
  - ✓ If a node is faulty, the entire network will break down, resulting in low reliability.
  - ✓ It is difficult to locate faults on branch nodes.



Bus Topology

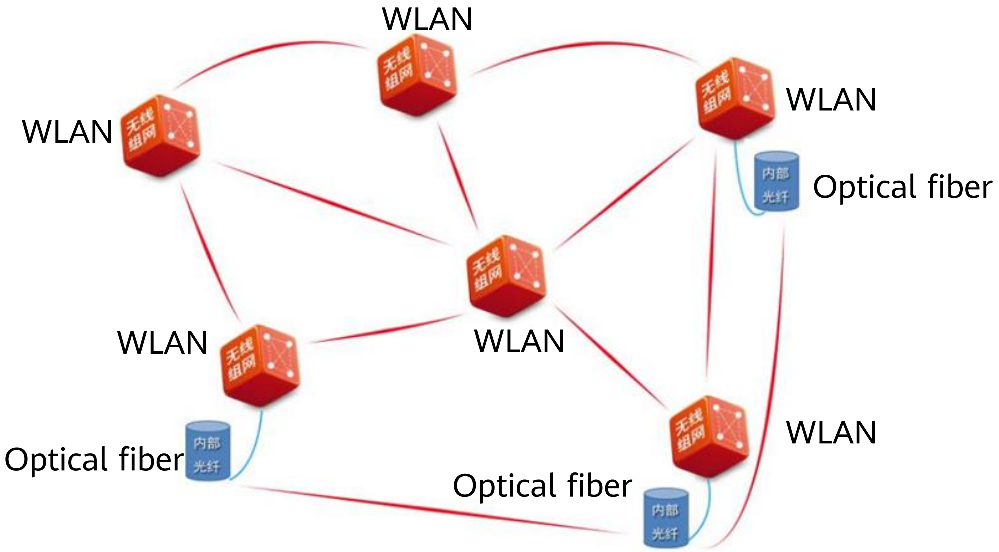
- Bus topology (or bus network) is commonly referred to as a "linear bus" because all the nodes are physically connected in a straight line.
- The bus topology has the following characteristics:

The structure is simple, facilitating expansion. When a node needs to be added, only one branch interface needs to be added on the bus to connect to the branch node. When the maximum bus load is reached, other buses can be expanded. A small number of cables are needed, facilitating installation. Simple and reliable devices are used. It is difficult to locate faults on branch nodes.



Mesh Topology

- A wireless mesh network is also called a multi-hop network. It is a new wireless network technology that is totally different from a traditional wireless network. It does not rely on the preset infrastructure, and allows for temporary networking, rapid deployment, and is resilient to damage even without a control center.
- A wireless mesh network uses the mesh topology, which is a multipoint-to-multipoint network topology. In this mesh topology, network nodes are connected in a wireless multi-hop manner through adjacent network nodes.



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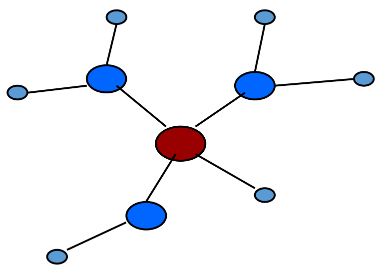
Huawei RF Mesh Networking Technology

- Why mesh networking technology?
  - Wider radio signal coverage
  - Network self-organization, self-recovery, and traffic self-balancing
  - Higher bandwidth and lower transmit power
- Mesh technology characteristics
  - Network setup: network access and address allocation
  - Route forwarding: routing algorithm (AODV, RPL, etc.)
  - Neighbor discovery: MAC layer beacon, neighbor discovery (ND)
  - Authentication and encryption: PANA + EAP-PSK, EAPoL, etc.
- Implementation layers
  - Layer 2 mesh: link-layer mesh, for example, IEEE 802.11s for WLAN and IEEE 802.15.5 for WPAN
  - Layer 3 mesh: network-layer mesh, for example, 6LoWPAN+RPL

APP	PANA(RFC 5191), EAP(RFC 3748), etc
Transport Layer	UDP(RFC 768)
Network Layer	RPL(RFC 6550), ND(RFC 4861)
	IPv6(RFC 2460..)
Data Link Layer	6LoWPAN (RFC 6282)
	IEEE 802.15.4-2011
Physical Layer	IEEE 802.15.4g-2012

RF mesh protocol stack



Contents

Huawei Industrial IoT Gateway Portfolio

AR550-H
L3 switching, power distribution and industrial control

- 4GE combo
- 8FE+24FE

AR550C
L2 switching, power distribution and video surveillance

- Smaller size
- Built-in PoE

AR2504E-H
Transformer station monitoring and TDM network reconstruction

- Dual power supplies
- 2 x WSIC slots

AR532/531
Power IoT and intelligent meter reading

- PLC
- ZigBee
- RF

AR502S
Outdoor IoT gateway model

- LTE+2GE
- RF/RS485

AR169
Smart retail, education, energy efficiency, and business O2O

- 1GE COMBO+4GE
- ZigBee, RS232
- Android

AR515C
Vehicle-mounted video surveillance

- 4 x PoE FE, LTE, and Wi-Fi
- Computing + storage

AR501S
Sensor access gateway

- Noise, temperature, humidity, gas, and PM2.5 sensor

AR502EGR
Power monitoring, environment monitoring, and lighting

- LTE + 2 x GE + RS232/RS485/DIDO/RF (6LoWPAN)

AR509CG-Lc AR509CG-Lt AR509CG-Lt-N
ATMs, billboards, power distribution networks, and backhaul networks

- LTE + 4 x GE
- LAN + RS232

AR503E train model
Wi-Fi for railway trains

- 110 V voltage, complying with EN 5015
- 4 x PoE FE, LTE, and Wi-Fi
- Computing + storage

Product Introduction – AR530 Series

Data collection
- Interrogation and scheduled meter reading
- Alarm and event reporting
- Flexible parameter configuration

Data storage
- Load curve
- Daily frozen data
- Monthly frozen data

DCU

Meter management
- Up to 1000 PLC meters connected to a single DCU
- Clock time calibration
- Ad hoc network
- Firmware upgrade

Security management
- Whitelist, preventing unauthorized access
- AES-128 encryption
- PKI security certificate

Item	AR532
Ethernet port	1GE + 1GE combo
3G/4G interface	GPRS: 850 MHz/900 MHz/1800 MHz/1900 MHz
PLC interface	PLC
RF interface	RF (433/915 MHz)
Other interfaces	2 x RS485, 2 x DI, 2 x DO, 1 x USB 2.0, infrared
IP rating	IP51
Maximum number of meters	1000 PLC meters or 500 RF meters
Input voltage	AC: 90 V to 290 V
Dimensions	290 mm x 180 mm x 95 mm

AR532

- Huawei AR532 supports remote data collection and end-to-end security protection.

Product Introduction – AR500 Series

Product	AR502EGRc-Lc	AR509CG-Lc
Fixed Ethernet port	2 x GE	1 x GE WAN + 4 x GE LAN (PoE)
GPRS/3G/4G	4G LTE	4G LTE
VDSL2	-	Supported
Industrial serial port	1 x RS232, 1 x RS485, 6 x DI/DO	1 x RS232
Power supply	DC: 8 V to 36 V	DC: 12 V
Operating temperature	–20°C to +70°C	–25°C to +60°C
Dimensions	100 mm x 150 mm x 44 mm	190 mm x 215 mm x 44 mm

AR502EGRc-Lc

AR509CG-Lc

- 4G wireless access
- Industrial serial port: applicable to onsite data collection in industrial environments
- SNMP NMS: enables remote management
- Wireless video backhaul

Product Introduction – AR2500 Series

Product	AR2504-H	AR2504-D-H
Fixed Ethernet port	4 x GE combo, 4 x GE RJ45	4 x GE combo, 4 x GE RJ45
Power supply	AC: 100 V to 240 V, 50 Hz/60 Hz (90 V to 264 V, 47 Hz to 63 Hz) DC: 110 V to 250 V (88 V to 300 V)	DC: 24 V to 48 V (18 V to 60 V)
Operating temperature	–40°C to +65°C	–40°C to +60°C
Dimensions	442 mm x 220 mm x 44 mm	442 mm x 220 mm x 44 mm

AR2500

- IEC 61850-3/IEEE 1613 compliant
- Up to 24GE and two 10GE ports
- Millisecond-level self-healing ring protection
- Remote topology management, batch configuration or upgrade

Product Introduction – AR550 Series

Product	AR550C-4GE	AR550E
Fixed Ethernet port	2 x 2.5G SFP 4 x GE RJ45	2 x 10GE 2 x 2.5GE 8 x GE SFP 8 x GE RJ45
Power supply	Dual DC power supplies: 9.6 V to 60 V (industrial terminal)	Dual DC power supplies: 9.6 V to 60 V (industrial terminal) Dual PoE power supplies: 44 V to 57 V (industrial terminal)
Operating temperature	–40°C to +70°C	–40°C to +60°C
Dimensions	44 mm x 133 mm x 150 mm	175 mm x 133 mm x 150 mm

AR550E

- Proper functioning under strong magnetic interference, complying with IEEE 1613
- Dual power supplies for redundancy, DI/DO alarm
- Mean time between failures (MTBF): > 50 years
- USB-based deployment, plug-and-play

Contents

Huawei Industrial IoT Gateway Application Scenarios – Charging Pile (1)

A power company deploys ZigBee access modules, industrial computers, and 4G routers to implement the charging pile solution. The complex solution causes the following problems:

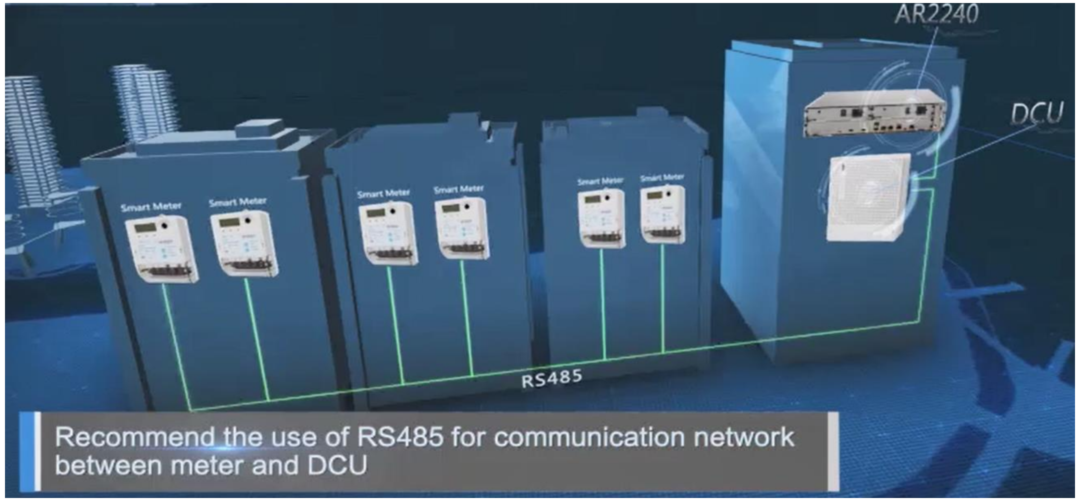
- Low service online rate
  - Industrial computers have high power consumption but poor heat dissipation, and is prone to breakdowns. ZigBee is prone to interference.
- Low O&M efficiency
  - No unified NMS is available, resulting in difficulties managing a large number of terminals. Engineers need to visit sites to diagnose faults and upgrade applications.
- High communication cost
  - A large number of communication components are required, resulting in high investment costs. Frequent multi-point failures also lead to high O&M costs.

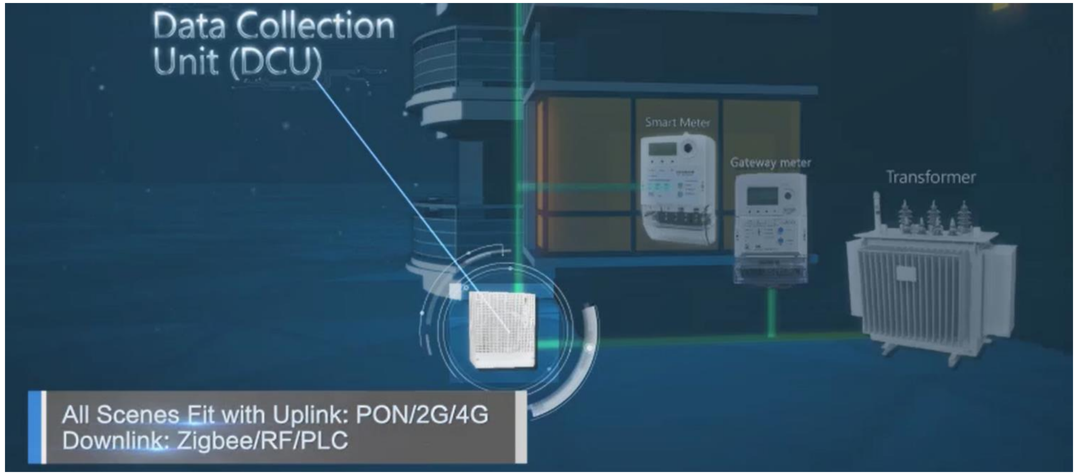
Huawei Industrial IoT Gateway Application Scenarios – Charging Pile (2)

- Huawei provides the smart charging pile IoT solution for the power company to optimize its charging operations management solution. Huawei's industrial-grade edge computing gateway AR502 replaces the live-network ZigBee modules, industrial computers, and routers, improving communication reliability and reducing operation costs. The cloud-based Agile Controller-IoT connects to the company's fast charging operations platform to manage communication devices and edge computing applications, improving operational efficiency.
- The industrial-grade gateway reduces CAPEX by 52%.
- Agile Controller-IoT remotely manages a large number of terminals, reducing OPEX by 60%.
- Intelligent edge computing and local real-time service processing improve charging efficiency.

Huawei Industrial IoT Gateway Application Scenarios – Meter Reading

- Huawei provides an end-to-end smart meter reading solution for electric power companies, helping them achieve comprehensive upgrades from meters to applications:
  - **Smart meter**: Traditional mechanical electricity meters are replaced by feature-rich smart prepaid electricity meters, which provide multiple electricity theft detection methods, including generating alarms upon cover opening, reverse cable connection, and a high-intensity magnetic field. Information about current, voltage, power, and electricity consumption is reported in real time using PLC-IoT technology.
  - **Meter reading network**: Meters communicate with DCUs over power lines through PLC. The DCUs aggregate data to the industrial gateway, and then to the main control center through carriers' public networks, achieving 100% success rate for meter reading.
  - **IoT platform-based application system**: Huawei's powerful IoT platform centrally manages data, connections, and devices and is pre-integrated with partners' application systems such as billing, prepayment, and fee collection. It also offers many advanced functions such as data statistics collection and analysis, real-time line loss analysis, and electricity theft analysis, improving operational efficiency.





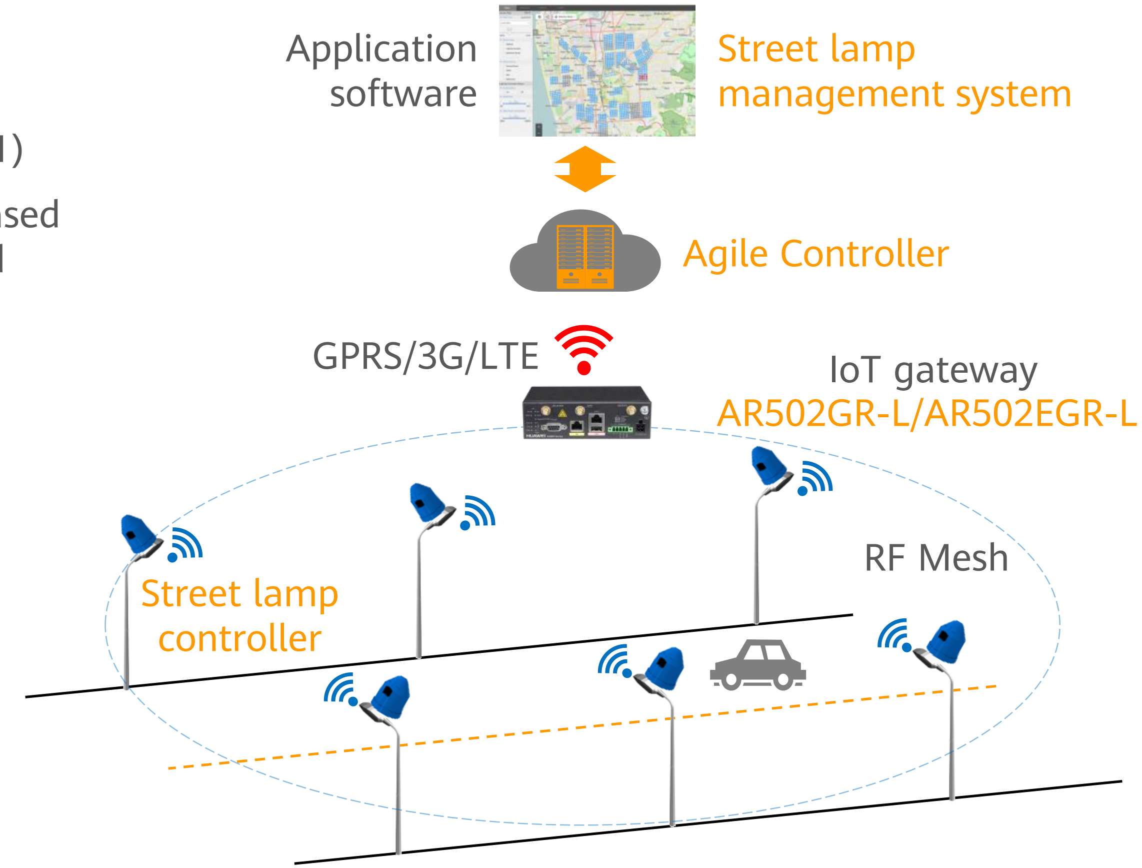
Huawei Industrial IoT Gateway Application Scenarios – Bus

- Company B is licensed to broadcast TV content via LCD screens in 50,000 buses, and needs to replace or upgrade its original audio and video media players to transform their marketing practices. Huawei's vehicle-mounted mobile Internet solution and agile gateway AR511 provide a wide range of capabilities and has become the optimal choice for company B.
- Huawei AR511 features an open architecture, allowing for expansion and customization. The AR511 can dynamically allocate dedicated CPU, memory, and hardware storage resources for new services. Customers can customize apps with more personalized and competitive services to better meet service needs.

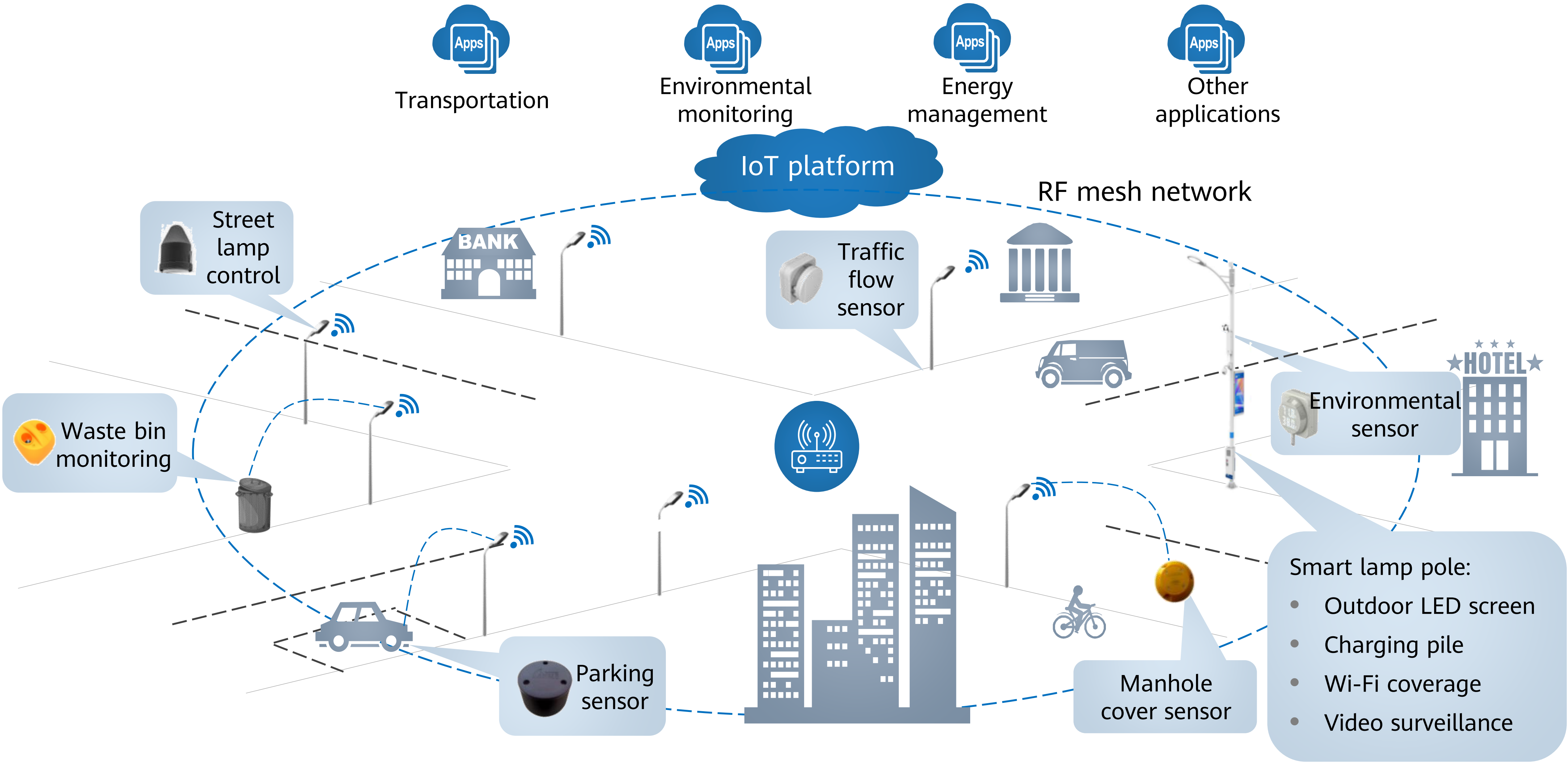
1. The new vehicle-mounted terminal provides HDMIs for video/audio to implement the TV and ad services on buses. In addition, it supports Wi-Fi, reducing investment and facilitating unified device management.
2. Wi-Fi services allow convenient Internet access for passengers.
3. The new vehicle-mounted terminal complies with global industry standards and is dustproof, waterproof, shockproof, and is resistant to high-temperatures.
4. Vehicle-mounted ICT devices carry and distribute most application services. The vehicle-mounted ICT platform has an open, scalable, and customizable architecture to enable easy integration with partners' applications.
5. Company B plans to cover 150,000 vehicles with their hardware resources across the country. As the number of partners increases, apps need to be updated frequently. Therefore, new applications need to be quickly distributed to vehicle-mounted devices on each bus.

Huawei Industrial IoT Gateway Application Scenarios – Street Lamp

1. External lock-up street lamp controller (with ports complying with ANSI C136.41)
2. Wireless mesh technology based on IEEE 802.15.4 (ZigBee and 6LoWPAN RF)
3. Feature-rich controller: on-off switch, dimmer, meter, alarm, integrated brightness sensor
4. Hierarchical reliability design
5. GIS-based street lamp management application software



From Street Lamp IoT to Campus IoT



Quiz

1. (Multiple Answers) What are the challenges faced by industrial IoT gateways? ( )
   A. Harsh environment
   B. Diverse interfaces
   C. Security threats
   D. Difficult network maintenance
2. (Single Answer) What is the latency for edge computing? ( )
   A. 1 ms
   B. 10 ms
   C. 100 ms
   D. 1s

Summary

- This course describes the differences between the gateway requirements in industrial scenarios and those in common enterprise scenarios. Throughout this course, you have learned the principles of edge computing and mesh networking technologies, as well as Huawei industrial IoT gateway products and their usage.

Thank you.

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每个组织，构建万物互联的智能世界。

Bring digital to every person, home, and organization for a fully connected, intelligent world.

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Home IoT Gateways

Foreword

- Home gateways are the unified aggregation egress of smart devices. The development of communications technologies has seen home gateways become increasingly important, which have evolved from wired to wireless routers and now deliver complete home coverage.
- A smart home gateway is the heart of a smart home, collecting system information, managing information input and output, implementing centralized and remote control, and device interconnectivity.

Objectives

- After completing this course, you will understand:
  - Functions of a smart home gateway
  - Architecture of the Huawei smart home solution
  - Huawei HiLink solution
  - Huawei smart home gateway products

Contents

Home Network Development (1)

Services

Home devices

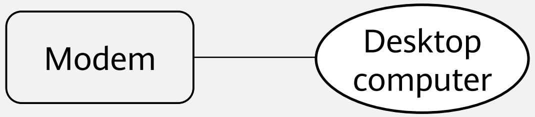
Network structure

Basic broadband service

- High bandwidth

Modem (xDSL copper access)

Past



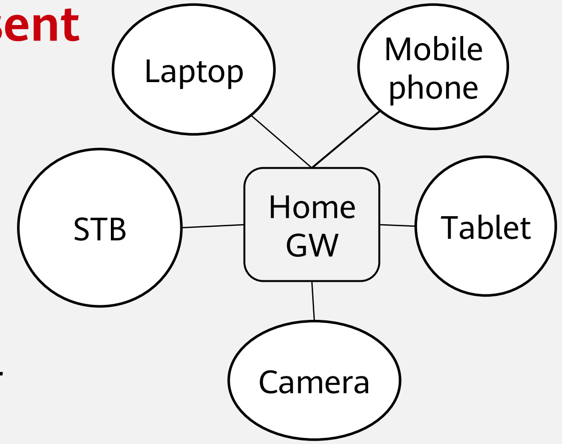
Hub

Diverse home services

- High bandwidth
- Home gateway
- IPTV STB

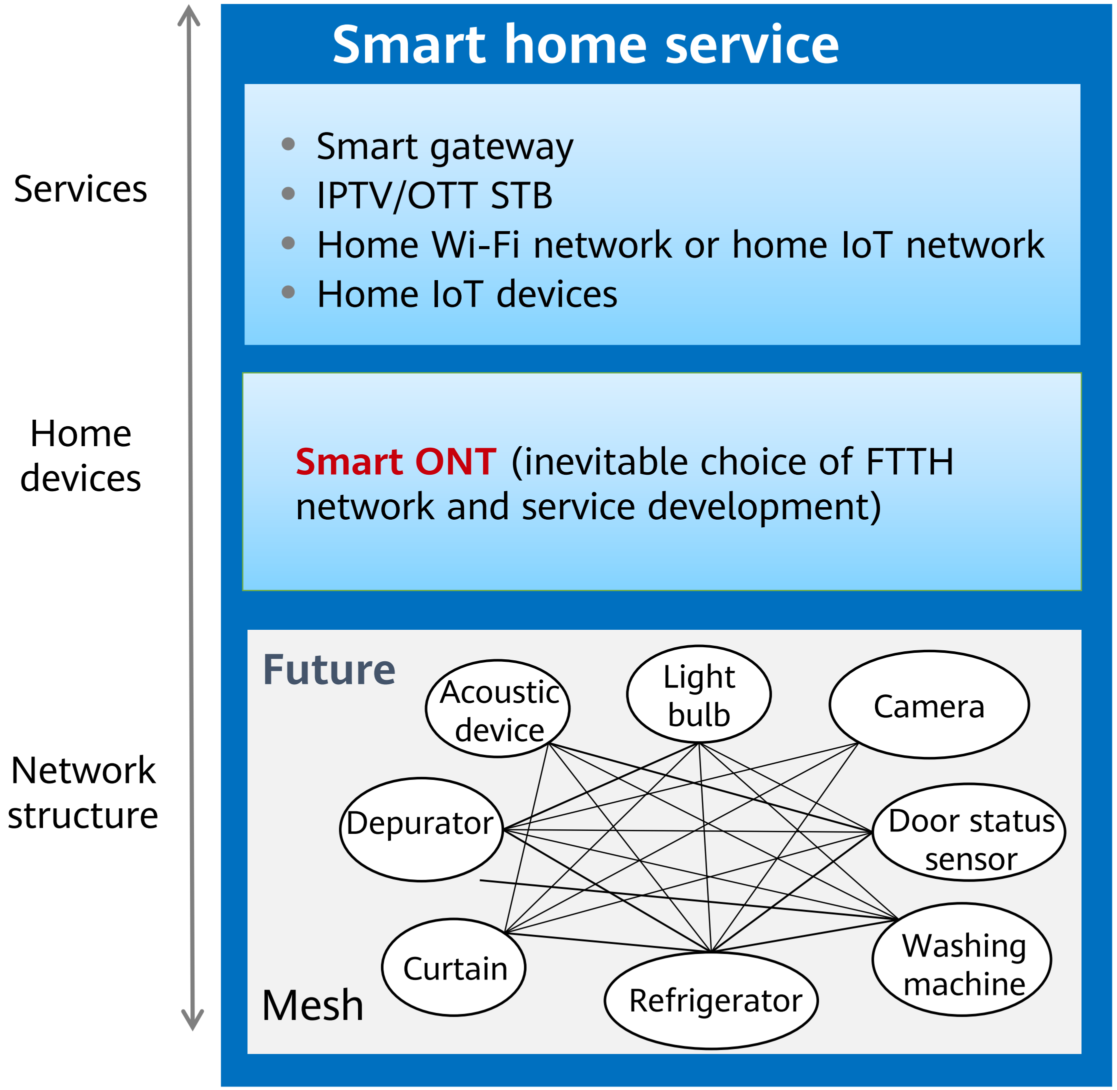
Home gateway or modem
(FTTH fiber access)

Present



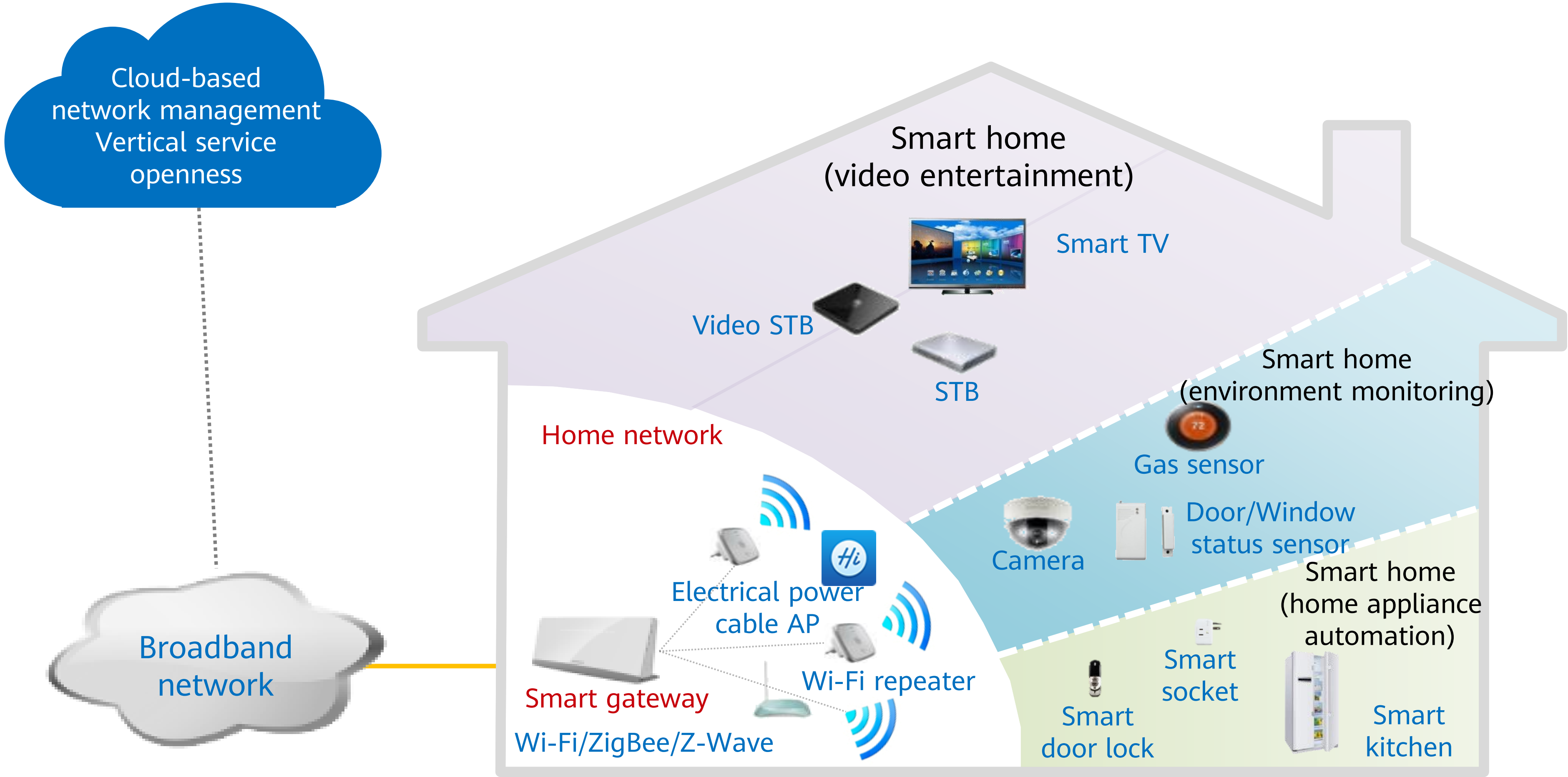
Star

Home Network Development (2)



- The smartphone revolution in 2006 not only promoted the development of wireless communication networks, but also promoted the development of home networks. Smart devices (such as mobile phones and tablets) need to connect to home Wi-Fi to ensure high performance and reliability.
- Fixed broadband access has also evolved from copper to fiber. In addition to providing high-speed Internet services, SoC technology gives greater processing ability to home devices (ONTs) on the FTTH network, nurturing the development of the home network and service integration.

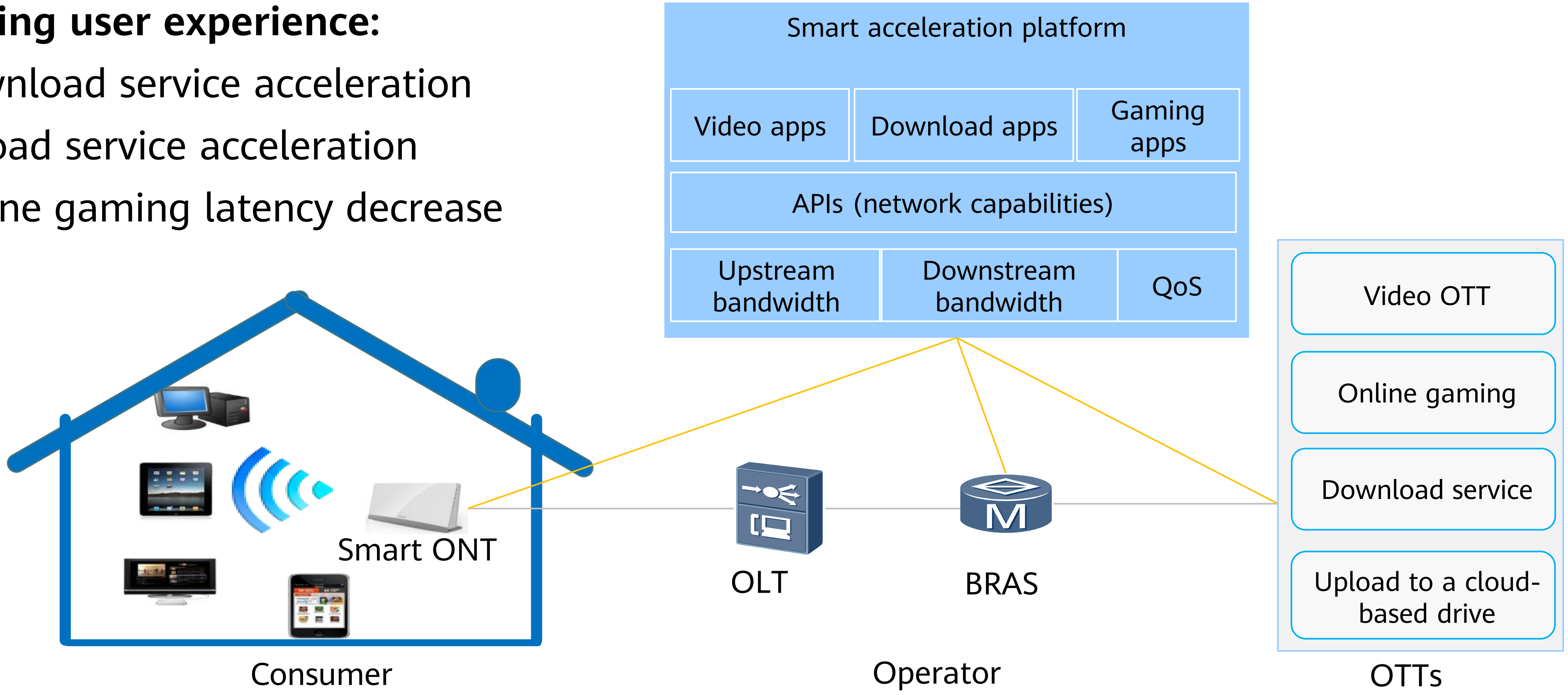
Smart Home Network



Smart gateway = "brain" of the home

Smart ONTs: Smart Acceleration

- **Improving user experience:**
  - Download service acceleration
  - Upload service acceleration
  - Online gaming latency decrease
  - ...



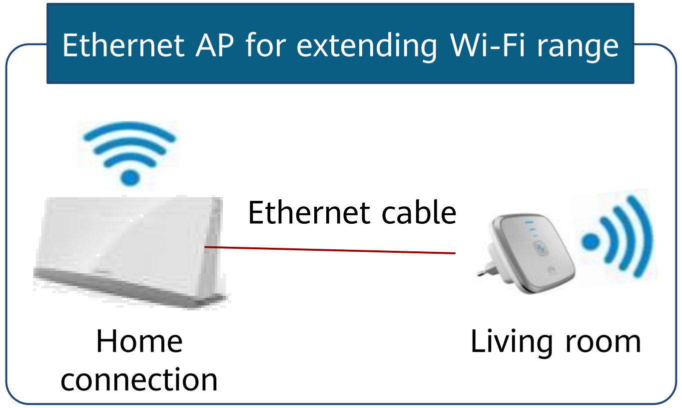
- Supporting user-friendly operations, improving service experience and promoting bandwidth operation
- Helping OTT players quickly develop cloud-based service acceleration plug-ins

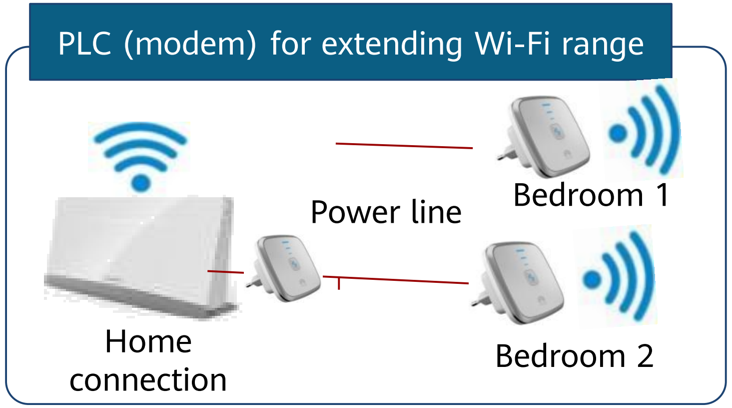
Smart ONTs: Comprehensive Home Wi-Fi Coverage

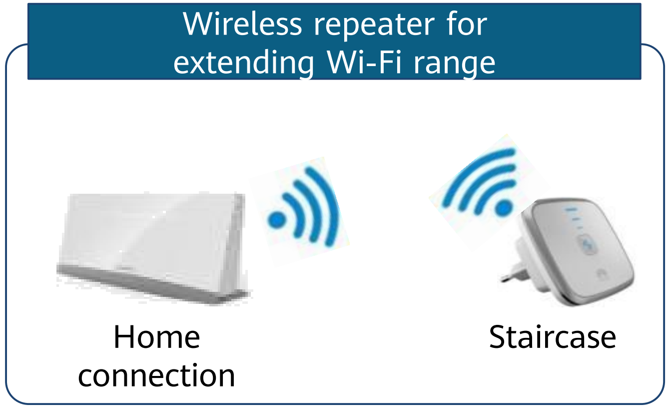
Best-effort Wi-Fi coverage

⇩

Multi-AP coverage







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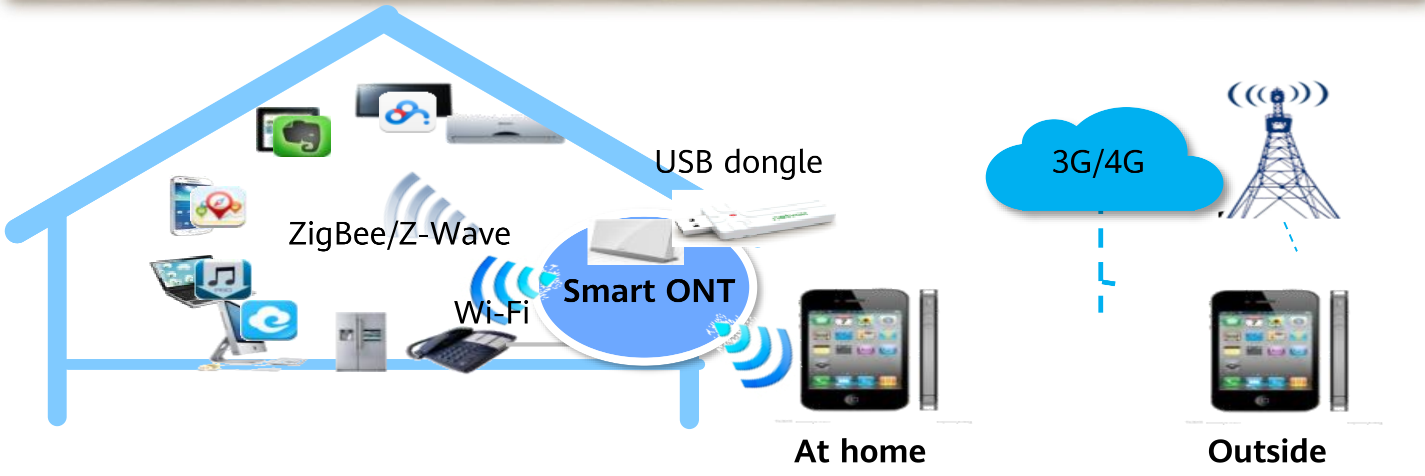
Smart ONTs: Intelligent Interconnection



@Home

- Mobile app management
- Appliance control
- Security check
- Video storage
- ...

ZigBee/Z-Wave: short-distance and low-power wireless communications technology

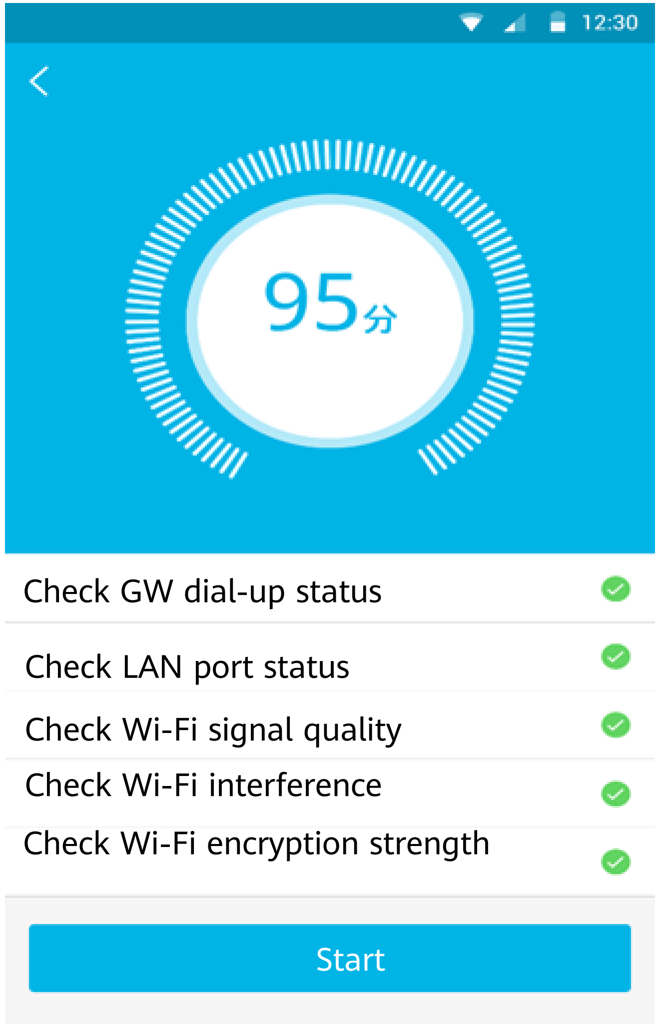
USB dongle: a plug-and-play device that transmits ZigBee signals and extends Wi-Fi coverage

@Outside

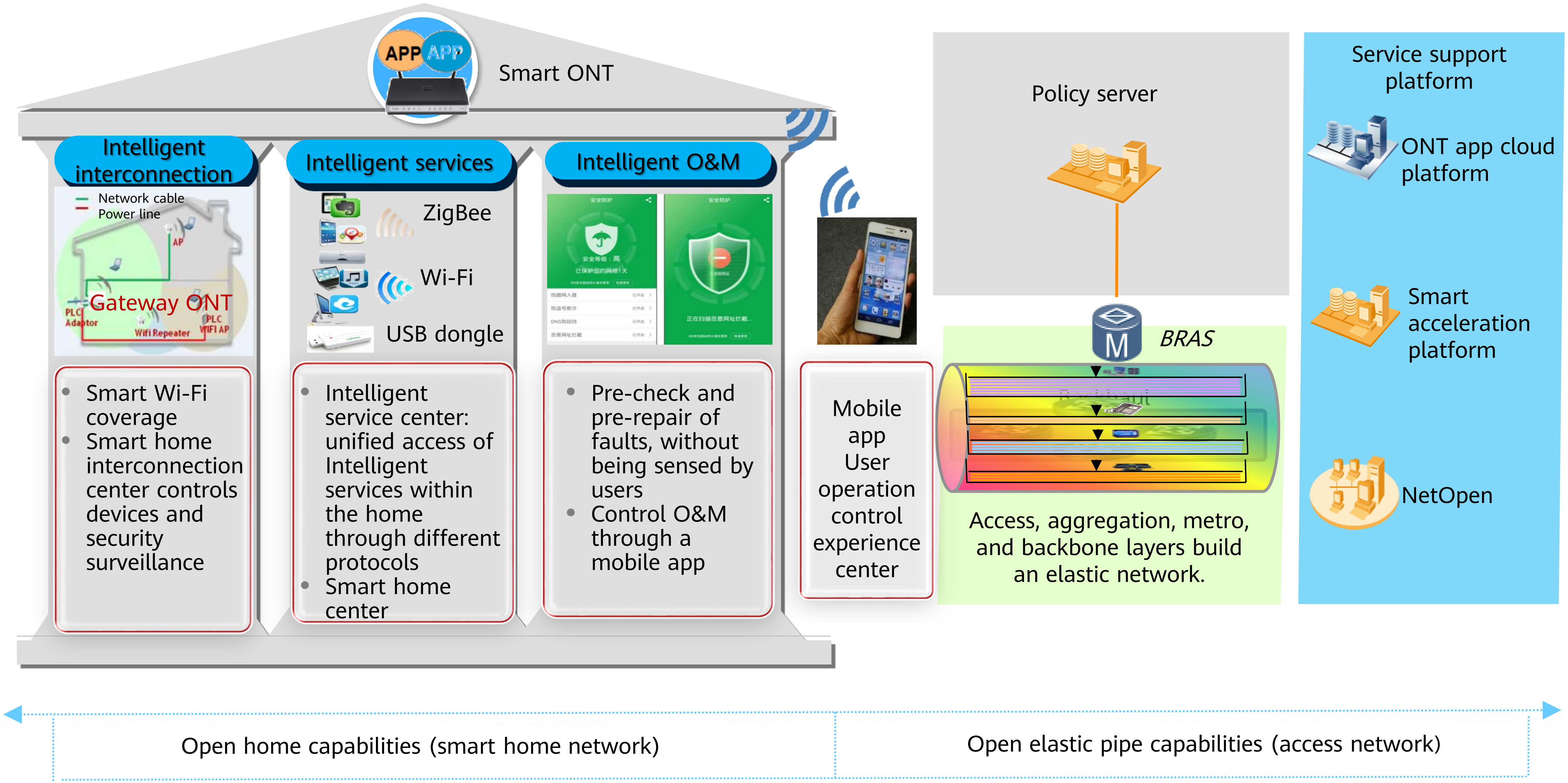
- The preceding functions are implemented by connecting to the ONT through a 3G/4G network.

Smart ONTs: Intelligent O&M

- Visible and manageable home networks
  - Device status clearly visible on UI
  - Self-service O&M
- Internet speed test
  - Quick, simple, and accurate speed test
- One-click health check
  - Network status prediction
- Diagnosis and maintenance
  - Broadband fault diagnosis by symptom, and app-based gateway maintenance and weekly reports
- Notifications
  - Notifications when smart devices go online or offline



Open Capabilities of Smart ONTs



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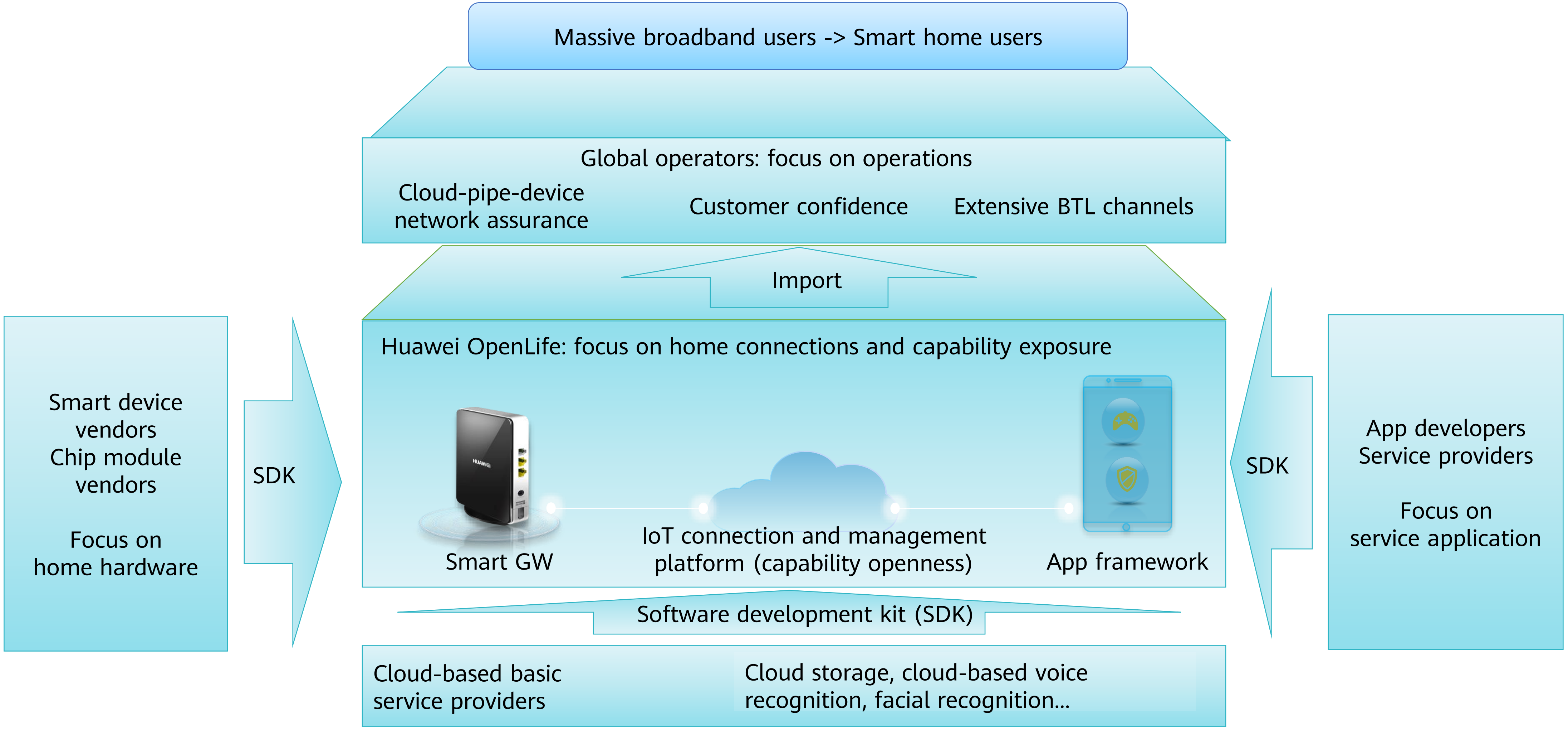
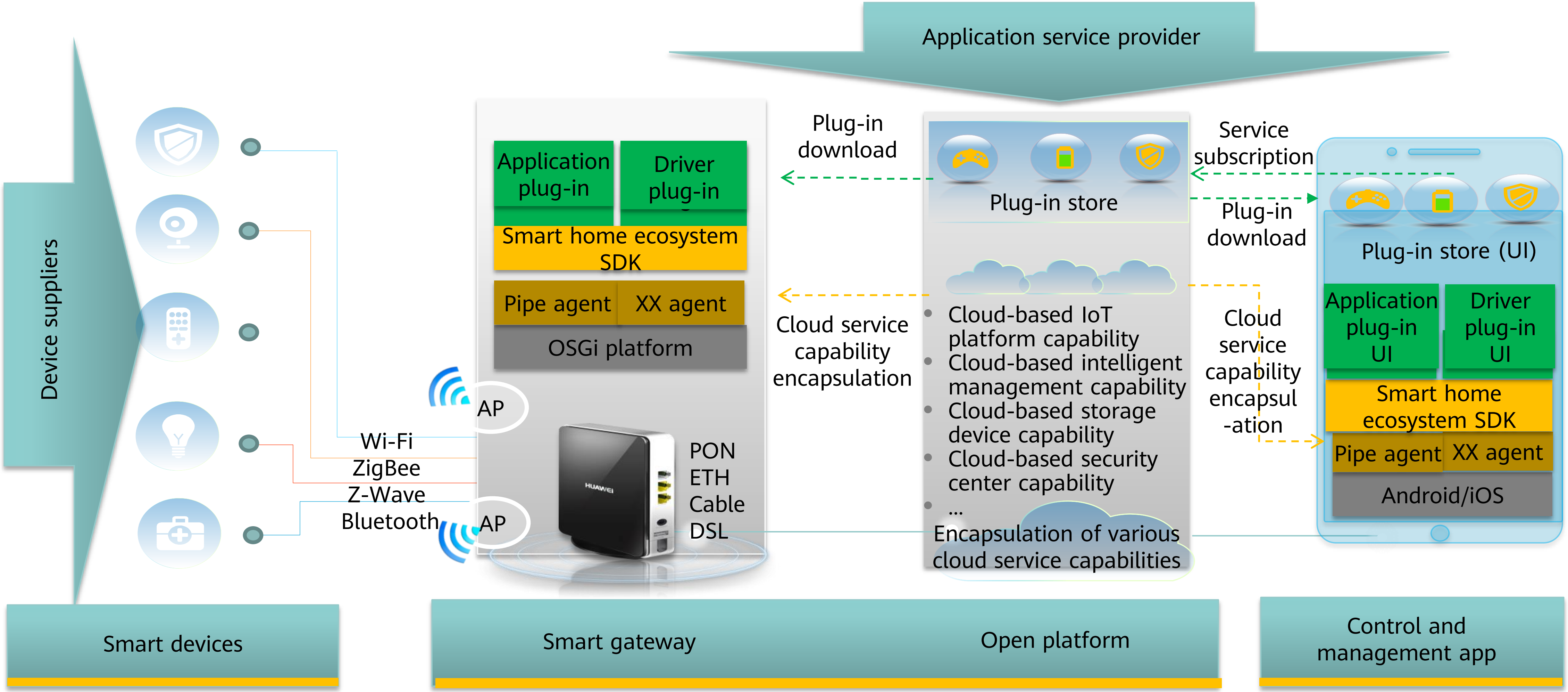
Huawei Smart Home Solution (1)

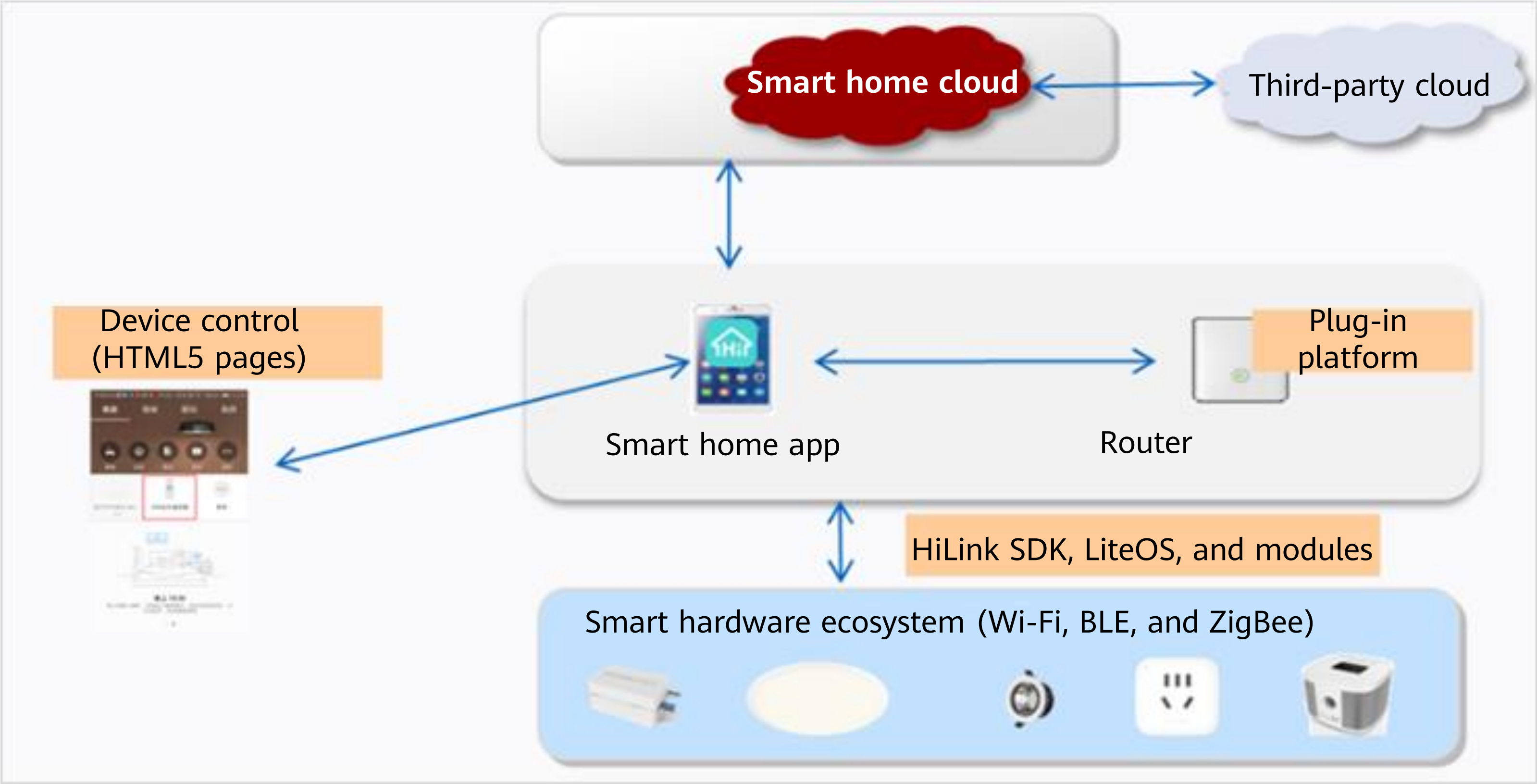


Huawei Smart Home Solution (2)



Huawei HiLink Technical Solution

- The Huawei HiLink smart home developer platform provides a complete set of solutions. This platform establishes a community of developers that guides developers from environment construction to integration and testing, as well as offering one-stop development services.



Huawei HiLink Platform

- The Huawei HiLink smart home developer platform is an open platform with Huawei HiLink as the core. It provides developers with a complete set of cloud-to-device smart home solution services. Through these services, developers can quickly build smart hardware, cutting the time to market (TTM) of products. The HiLink ecosystem facilitates smooth hardware interaction, establishing an open, interconnected, and co-constructed smart home ecosystem.
- The platform is:
  - Open and jointly constructed: one-stop development services for developers
  - Simple-to-use: one-click network connection and unified management of smart hardware through an app
  - Secure and reliable: end-to-end differentiated chip-level security capabilities
  - Low-cost: low resource usage means low cost smart devices

Huawei HiLink Access (Ecosystem Connection)

- The Huawei HiLink platform allows HiLink ecosystem hardware to be connected and can interact with ecosystem devices.

HiLink module
Based on Huawei LiteOS kernel and in-house
JavaScript engine that is service-oriented, with low technical bar and cost

HiLink SDK
Support for multiple modules and chips, and quick integration with low requirements

HiLink router
Huawei quality-assured, open capability platform, ecosystem-level connection and local intelligent control

HiLink Connection Modes

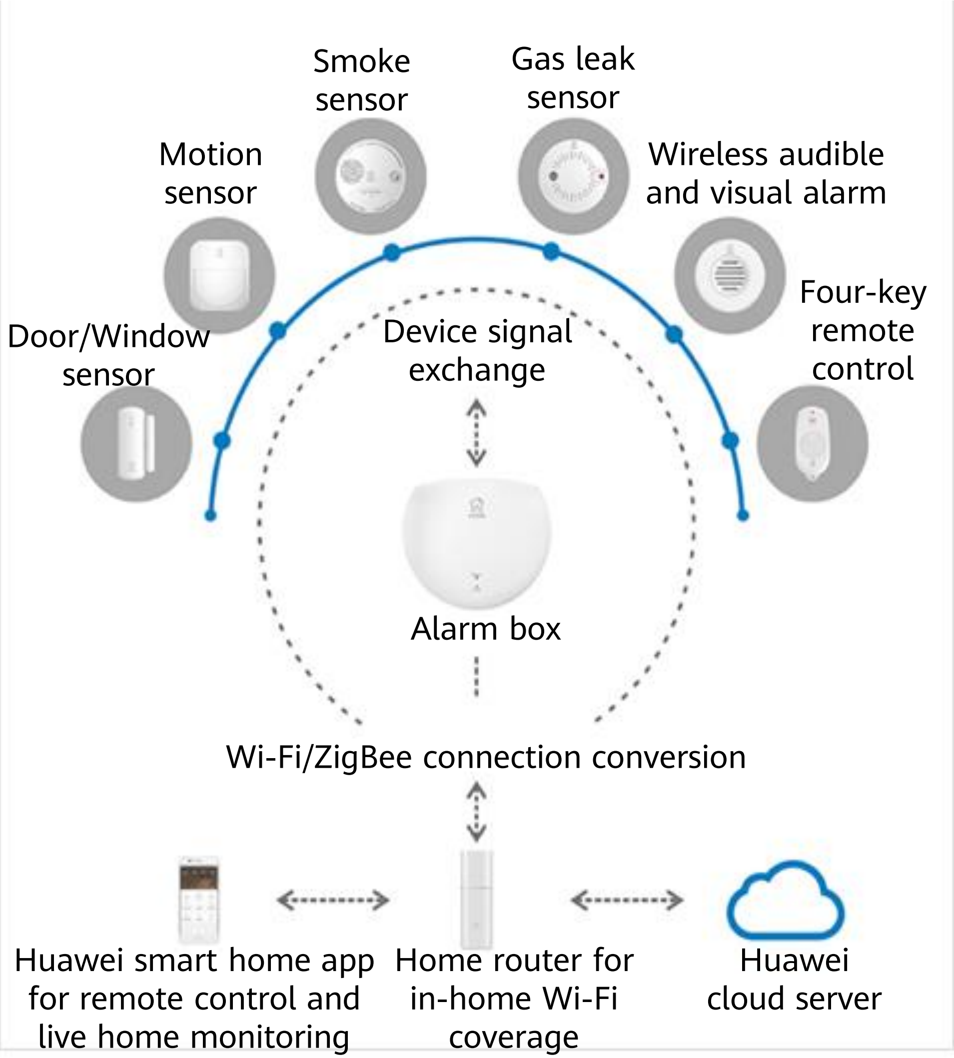
- Direct hardware
  - HiLink SDK and Huawei LiteOS certified Wi-Fi modules are used for development on firmware sides to the HiLink cloud. Connections are integrated and added to the HiLink ecosystem.
- Cloud-based
  - OAuth 2.0 authorization is used to establish connections with the Huawei HiLink cloud and share devices on the HiLink cloud. In this way, devices can be displayed and controlled by Huawei 1+8 devices.

Integration of Huawei HiLink Device SDK

- The Huawei HiLink Device SDK must be integrated on smart devices so that smart devices can connect to the Huawei HiLink smart home cloud platform.
- The HiLink Device SDK applies to smart devices with operating systems and complex control functions, and also smart products with functions developed on modules and without MCUs.
- Products can be set up, registered, and operated after the HiLink Device SDK is integrated on products.

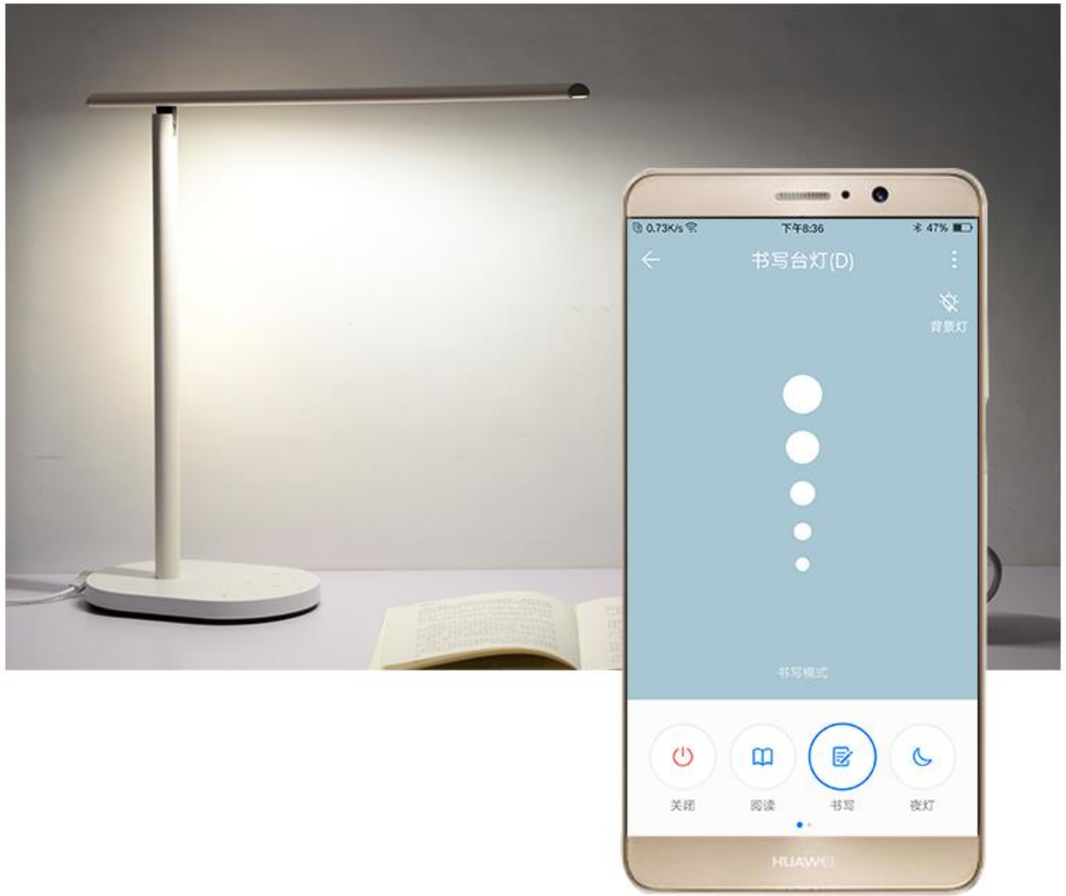
Huawei HiLink Device SDK: Bridging

- When a bridge device integrated with the HiLink Device SDK is connected to the HiLink cloud platform, the device's sensors automatically connect to the HiLink cloud platform. Various protocol devices such as Bluetooth, ZigBee, and non-IP protocol devices can be connected to the HiLink cloud platform.
  - The alarm box functions as a bridge device, and non-Wi-Fi sensors (such as a ZigBee smoke sensor) are mounted to the box for connection to the HiLink cloud platform.
  - The alarm box functions as the information hub for sensors. It reports real-time information about the sensors to the app, and also delivers instructions from the app to the sensors.



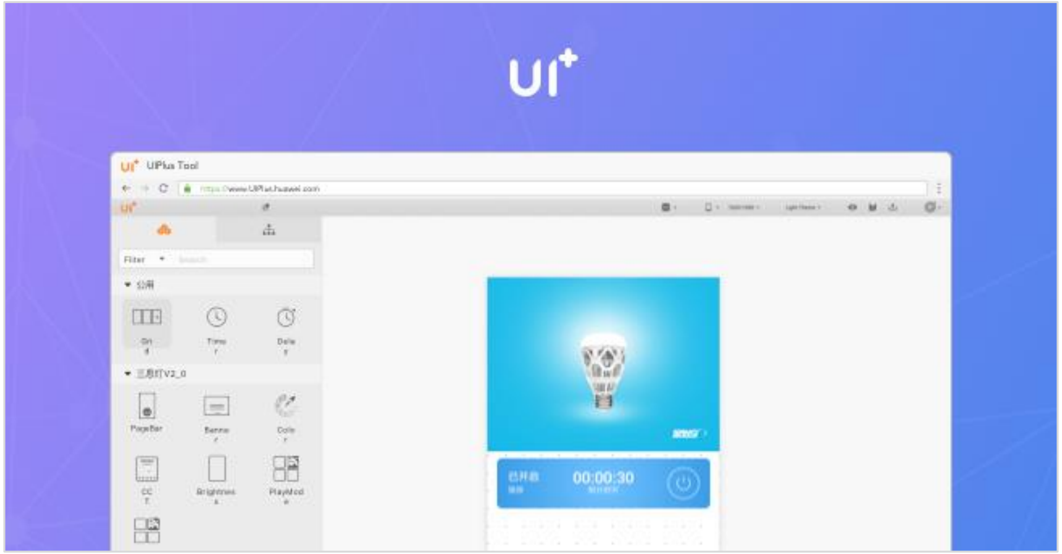
Huawei HiLink Device SDK: Lighting

- Through the HiLink Device, users can monitor their home anytime and anywhere via their phones. The HiLink Device SDK works with the Huawei smart home app to provide automatic control in a smart home environment.
  - Remotely control lights, switch between different modes, and adjust brightness
  - How about: Timer setting, lights can be set to turn on/off at fixed periods
  - Device interconnectivity (for example, motion sensor turns on a light)



UX Design & UI+ for Huawei EMUI Smart Home

- The Huawei EMUI smart home UX design specifications provide guidance on how to design the UIs of smart home applications and UIs of connected devices that are consistent and user-friendly. The templates aim to help partners quickly construct UIs that seamlessly connect to the Huawei smart home platform.
- The UI+ is an engineering tool that features the design experience architecture of the EMUI smart home. It can be used to quickly develop apps through visualized orchestration, allowing users to preview and commission real devices in real time, and supports quick and concurrent rollout of multiple devices.



Contents

Product Overview: Parent-Child Router

Item	Q1	Q2 Pro
Speed	Parent router: 450 Mbps Child router: 150 Mbps	Parent router: 1167 Mbps Child router: 1167 Mbps
Frequency band	2.4 GHz	2.4 GHz & 5 GHz
Dual-band concurrency	Not supported	Supported
PLC transmission protocol	HomePlug AV 200 Mbps	G.hn gigabit power line technology, supporting the PLC Turbo technology
Dimensions	Parent router: 150 mm x 65 mm x 194.3 mm Child router: 46 mm x 46 mm x 38 mm	Parent router: 112 mm x 73.3 mm x 183.5 mm Child router: 75 mm x 46.3 mm x 103 mm

Huawei parent-child router Q1

Huawei parent-child router Q2 Pro

- Plug-and-play and fast extension
- PLC-extended network, stable and high-speed
- Password-free connectivity of Huawei HiLink smart devices, and automatic synchronization of router Wi-Fi modifications
- Huawei HiLink smart home ecosystem adapts to apps and provides a one-stop experience for route management and smart home

Product Overview: Honor Router Pro

Item	Pro	Pro 2
Speed	Dual-band concurrency: 1167 Mbps	Dual-band concurrency: 1167 Mbps
Frequency band	2.4 GHz & 5 GHz	2.4 GHz & 5 GHz
CPU	GigaHome dual-core 1 GHz CPU	GigaHome quad-core 1.4 GHz CPU
IPv4/IPv6	Supported	Supported
Dimensions	104 mm x 104 mm x 108 mm	115 mm x 115 mm x 108 mm

Huawei Honor router Pro

Huawei Honor router Pro 2

- Network port blind mating, and simple configuration
- Greater connection stability and responsiveness of smart home appliances
- Interconnection with HiLink inside devices, and upgrade support for smart home devices such as home appliances, lighting, energy, security protection, and audio and video devices

Product Overview: Honor Distributed Router

Item	Honor Distributed Router
Speed	Dual-band concurrency: 1167 Mbps
Frequency band	2.4 GHz & 5 GHz, and selection from the dual bands
HiLink adaptation	One-click HiLink pairing, and WPS compatible
Dimensions	105 mm x 105 mm x 78 mm

Huawei Honor distributed router

- Advanced MU-MIMO technology is ideal for concurrent user Internet access
- Dual-network support, dual frequency bands (2.4 GHz/5 GHz), network port blind mating, and automatic channel optimization in time
- Plug-and-play secondary router, intelligent network optimization, recommended router installation, and support for 5G networking and mesh technology, delivering high-speed Wi-Fi to multiple rooms simultaneously

Product Overview: Huawei 5G CPE Pro

Specifications	Huawei 5G CPE Pro
Speed	Dual-band concurrency: 1167 Mbps
Frequency band	2.4 GHz & 5 GHz, and selection from the dual bands
CPU	Balong 5000 multi-mode chip and GigaHome dual-band Wi-Fi chip
HiLink adaptation	Password-free HiLink device access, and automatic synchronization of Wi-Fi account changes
Dimensions	99 mm x 107 mm x 215 mm

Huawei 5G CPE Pro

- 2 GB network ports configured, supporting 4G+ or limited broadband Internet access
- Huawei's first 7-nanometer 5G multi-mode chip, Balong 5000, delivers a theoretical peak download speed of up to 2.3 Gbps
- Huawei's smart home app intelligently recommends the optimal location for installing the Huawei 5G CPE Pro

Quiz

1. (Single Choice) What is the future smart home network structure?
   A. Hub
   B. Star
   C. Tree
   D. Mesh
2. (True or False) Huawei HiLink platform support Direct Hardware and Cloud-based connection modes to access the platform.

Summary

- This document:
  - Explains the development path of home networks;
  - Describes the functions of smart home gateways within households;
  - And presents the architecture of Huawei's smart home solution and HiLink solution, including the connections modes of the HiLink platform and integration cases of the HiLink Device SDK.
- The document also shows Huawei smart home gateway products.

Thank you.

Bring digital to every person, home, and organization for a fully connected, intelligent world.

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IoT Platform

Foreword

- In recent years, IoT services have been developing rapidly but there have been some challenges. The IoT industry requires a reliable, secure platform that supports device access decoupling and provides open capabilities.
- The industry-leading HUAWEI CLOUD IoT platform provides customers with complete northbound and southbound APIs. It pre-integrates typical communication protocol plug-ins to help customers quickly launch services.

Objectives

- Upon completion of this course, you will:
  - Know the requirements for IoT platforms.
  - Understand the functional architecture of the HUAWEI CLOUD IoT platform.
  - Understand and be able to identify the different services provided by the HUAWEI CLOUD IoT platform.
  - Be able to describe the characteristics of the HUAWEI CLOUD IoT platform.

Contents

IoT Is Ushering In Industry Innovation and Transformation

60% of enterprises are using or are about to deploy IoT services.

24% IT budget is used for IoT investment.

63% of enterprises had gained significant return on IoT investment.

Public utilities 3.5 billion**

Smart city 6.2 billion

IoV 1.6 billion

Smart home 1.1 billion

Positioning 2.5 billion

Retail 0.1 billion

Healthcare 650 million

Internet of elevators 23 million

IoT as a service

90%+ enterprises store IoT data and roll out services in the cloud.

* Survey data of 1,096 companies from 11 verticals in 17 countries

** Number of IoT connections by 2025

Source: Machina, Circle-research, Gartner, IDC, and Huawei Research

Major Challenges Facing the IoT Industry

Long rollout period

- Slow service rollout
- Fragmented applications, slow development, and long TTM

Too many standards

- Numerous devices make integration difficult
- Different device/sensor manufacturers and protocols

Difficult network selection

- Complex network connection
- Diverse networks: 2G/3G/4G/NB-IoT
- Security, real-time, and QoS requirements

How do we address these challenges in the development of the IoT industry?

Requirements for the IoT Platform

- A secure, reliable platform that supports device access decoupling and capability openness is required to develop IoT services.

01 Device access decoupling

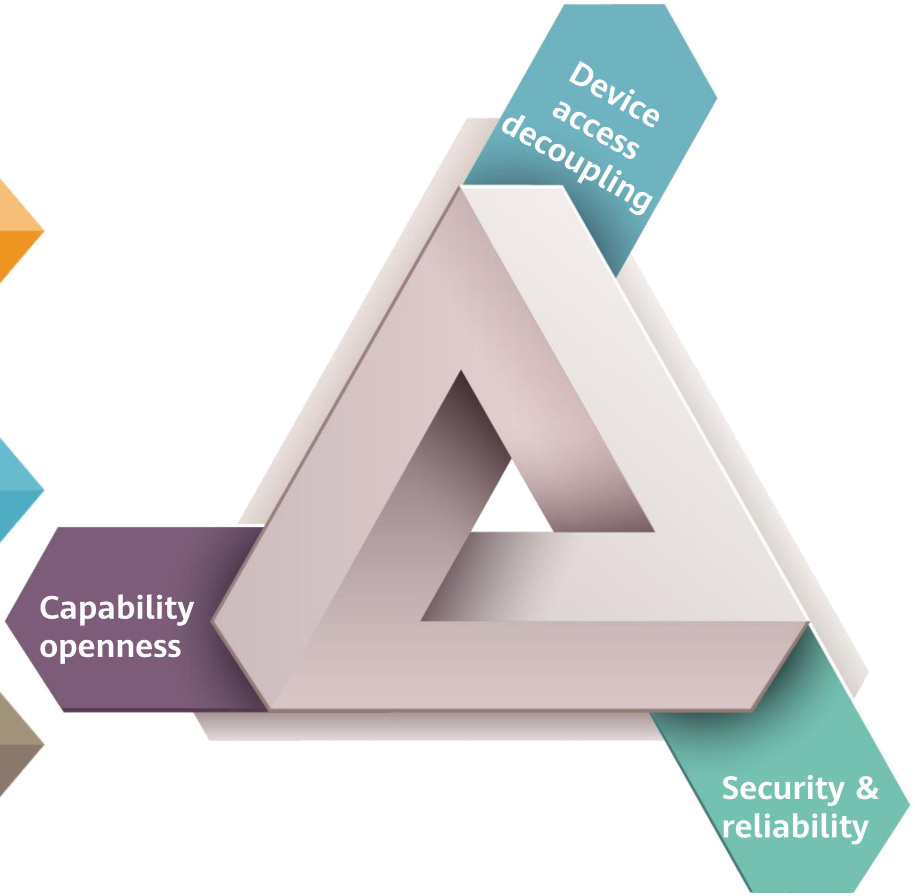
- Pre-integrated platform, lightweight development, quickly response to market demands
- Leaving technical details to the IoT platform

02 Security & reliability

- Virtualized system, cloud deployment
- Device access authentication and API authentication

03 Capability openness

- Open device access
- Open service application expansion
- Industry pre-integration and openness management



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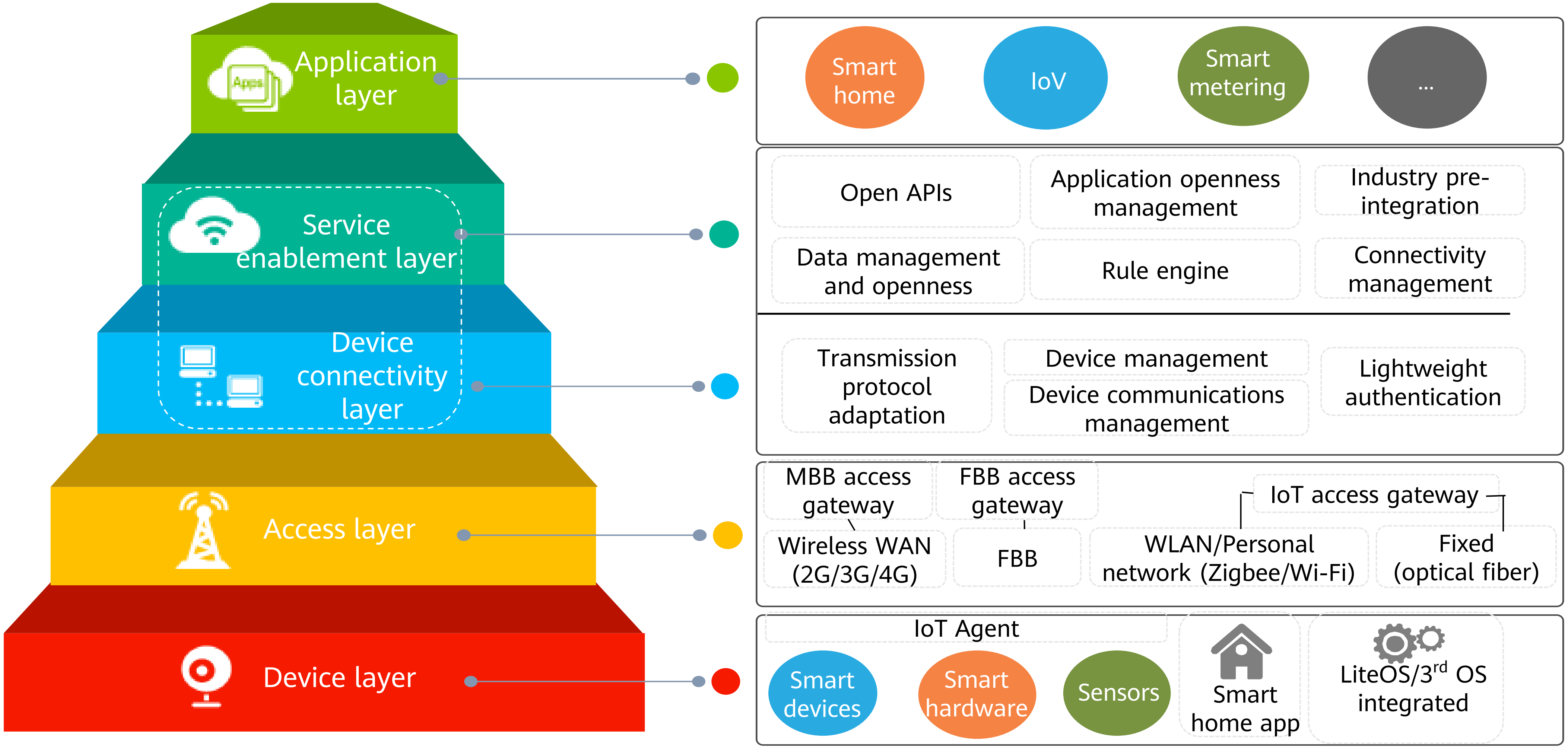
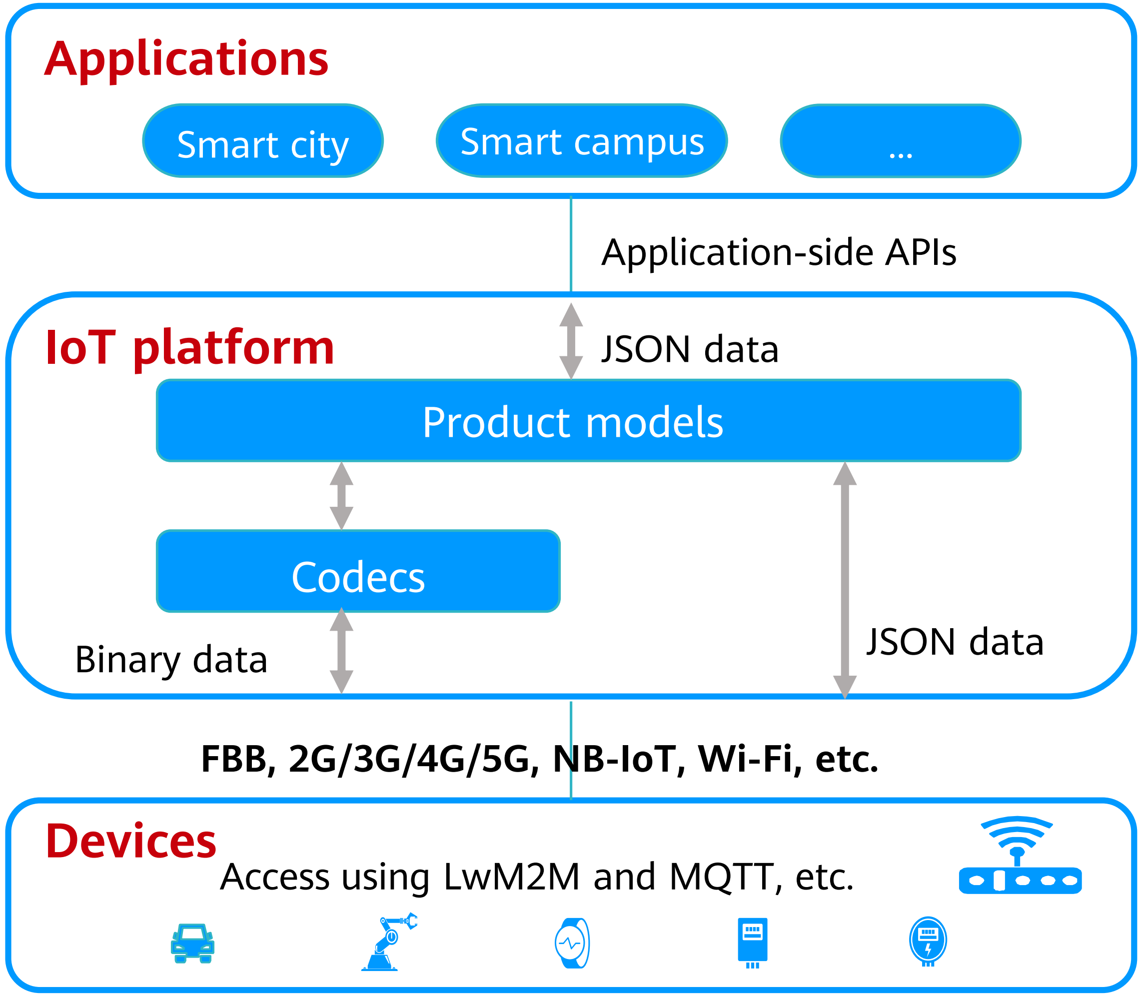
Functional Architecture of the HUAWEI CLOUD IoT Platform



HUAWEI CLOUD IoT Platform



- The HUAWEI CLOUD IoT Platform connects and manages a large number of devices. It works with other HUAWEI CLOUD services to quickly build IoT applications.
- A complete IoT solution consists of the IoT platform, devices, and applications.
  - The IoT platform is located between applications and devices. It hides differences between device interfaces to enable quick device access. It provides robust capabilities to help developers quickly construct diverse IoT applications.
  - Devices can access the platform via FBB, 2G/3G/4G/5G, NB-IoT, and Wi-Fi, and other networks. They can report service data to the platform using MQTT or LwM2M over CoAP. Devices can also receive commands from the platform.
  - Applications call platform APIs for device management, data reporting, command delivery, and other service scenarios.

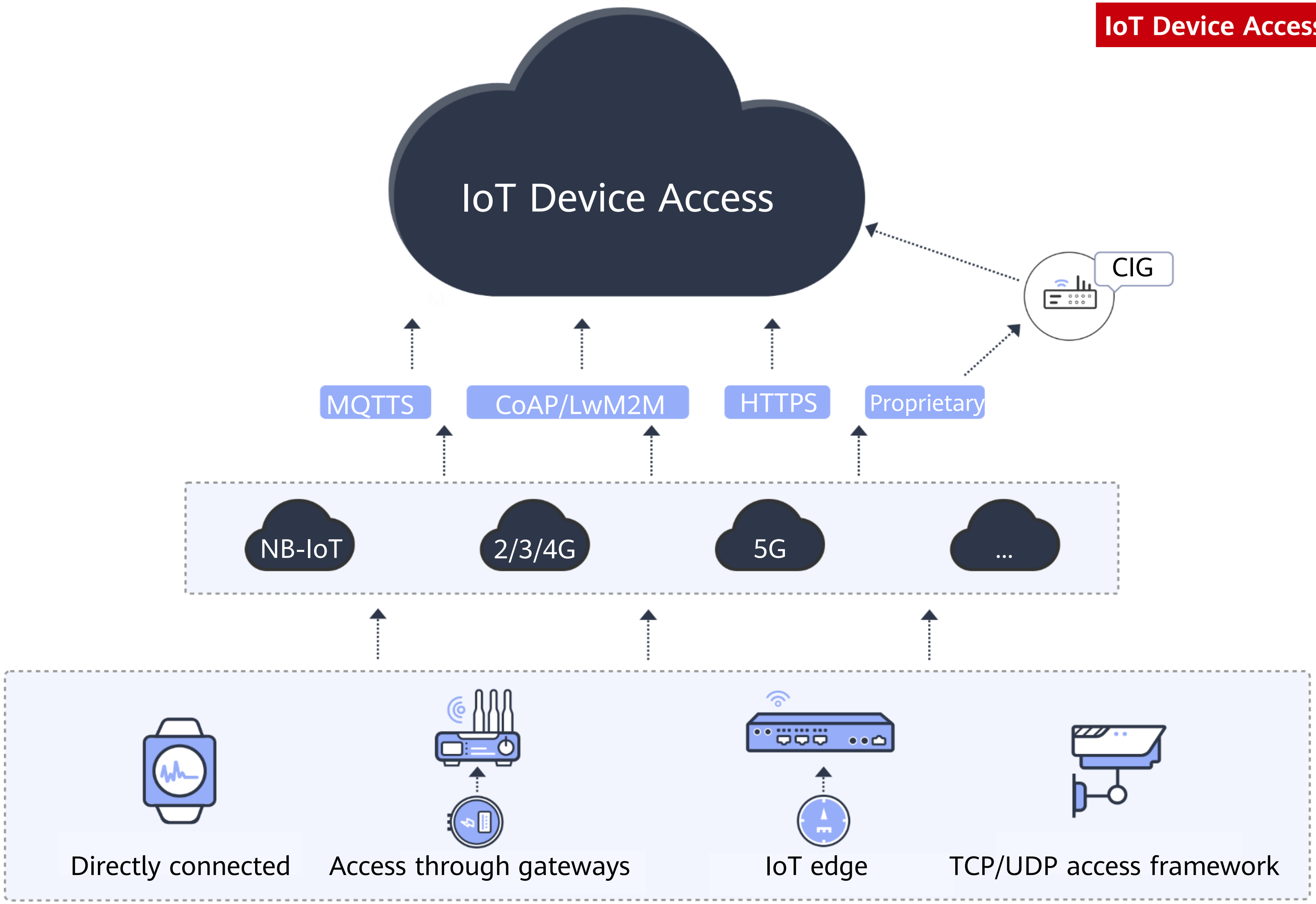
HUAWEI CLOUD IoT Services

- The HUAWEI CLOUD IoT solution provides the following services:

Service	Category	Description
IoT Device Access	Device connectivity	Devices can connect to the IoT platform using multiple protocols in multiple access modes.
	Device management	The IoT platform can manage devices and device data.
	Data forwarding	The IoT platform can forward data to other HUAWEI CLOUD services.
	Application integration	Applications can access the IoT platform and call APIs provided by the platform.
IoT Studio		Developers can construct IoT applications without coding.
IoT Analytics		The IoT platform can analyze device data.
Other related services	IoT Edge	The IoT platform can work with other IoT services to build a solution.
	Global SIM Link	

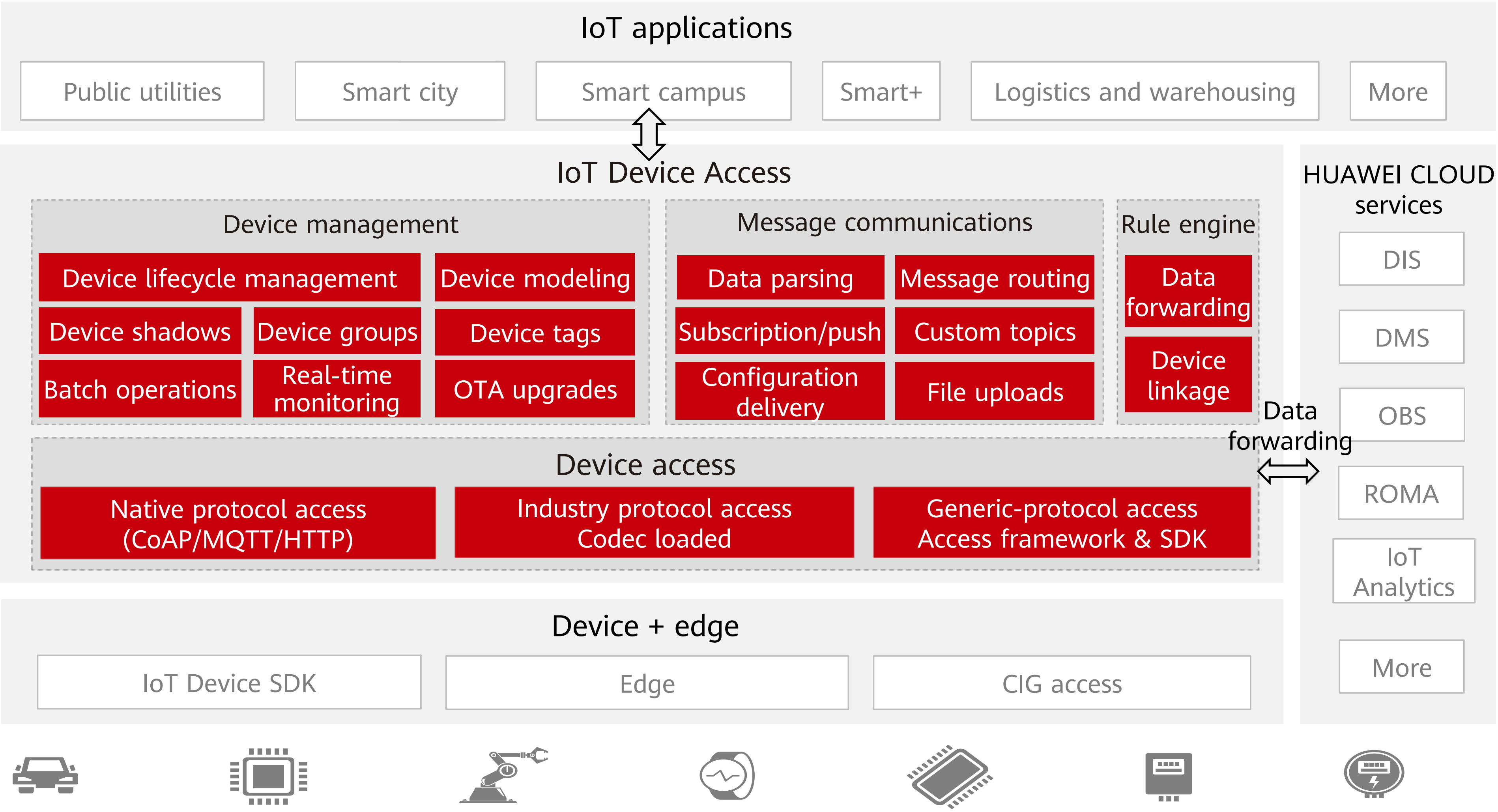
Contents

IoT Device Access (1)



IoT Device Access (2)

IoT Device Access | Protocols | CIG



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IoT Device Access (3)

IoT Device Access | Protocols | CIG

Core competitive strength

Diverse: multiple access protocols, covering all access scenarios

- 10+ native protocols and 30+ industry protocols
- Plugin framework for industry protocol customization
- 10 access modes covering different access scenarios

Fast: simplified access, cloud ready from the start

- IoT SDKs pre-integrated on chips and modules
- Two AT commands to complete device access
- 10-fold higher device integration efficiency

Better: reliable, high-concurrency access, on-demand data forwarding

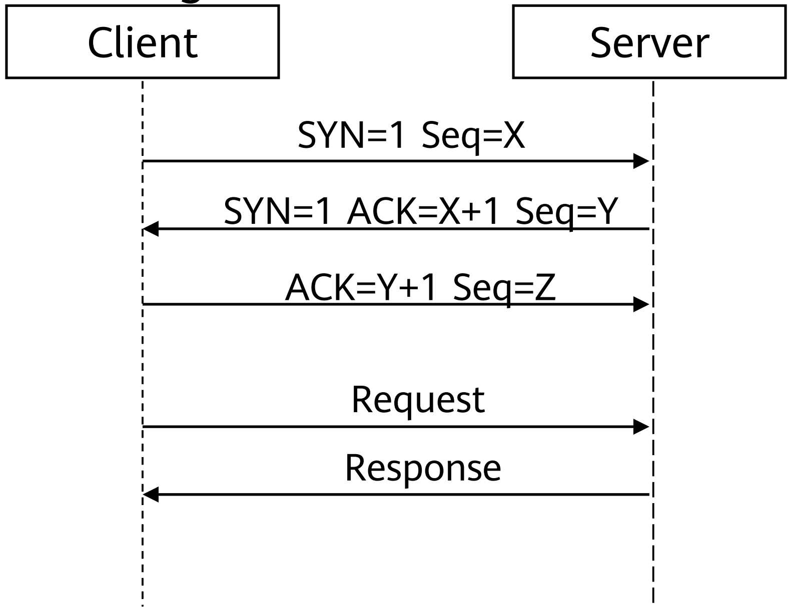
- 100,000 TPS concurrency for a single instance and millions of concurrent connections for a tenant
- 100+ custom data forwarding rules and 10+ data forwarding modes for a tenant
- Flexible, simple HTTP push and high-throughput AMQP push

Economical: simple billing modes, and cost-effective service

- No charge for time spent connected
- 50% less expensive than building the platform yourself

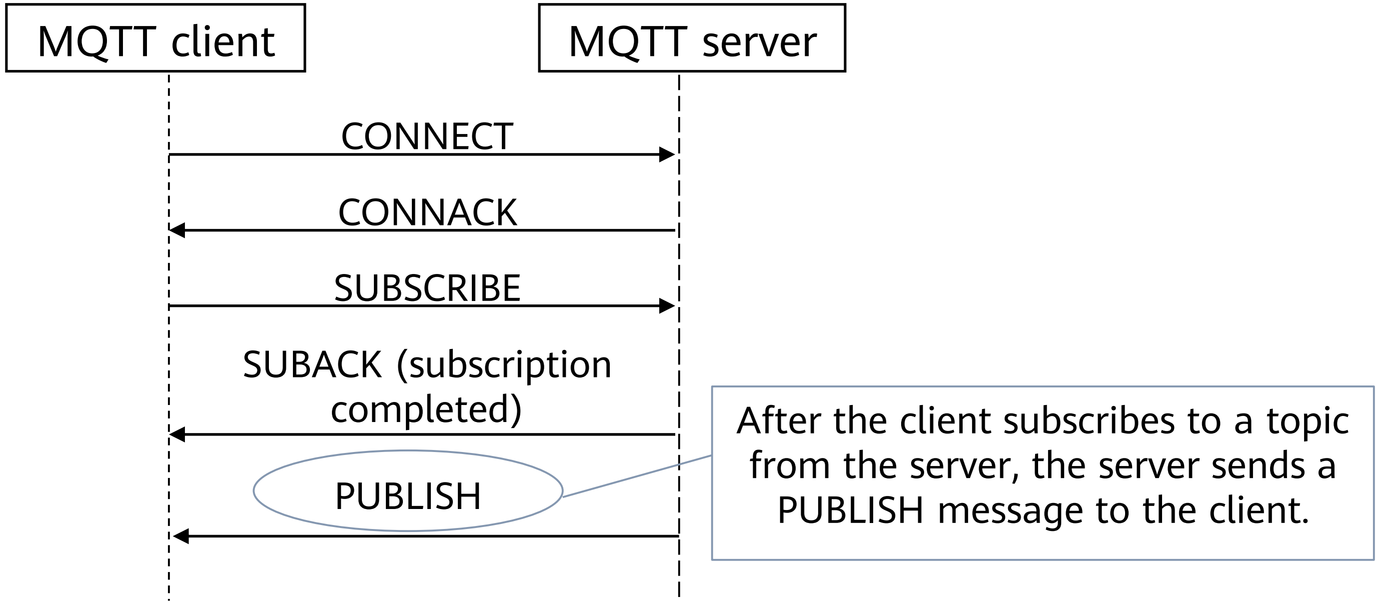
Typical IoT Protocols - HTTP

- The HyperText Transfer Protocol (HTTP) is an application-layer protocol used for communications between web servers and browsers. It makes the browser more efficient and reduces the amount of data to transmit. It ensures that a computer correctly and quickly transmits hypertext documents and determines the priority of the document contents to transmit and display, for example, to display text prior to images.



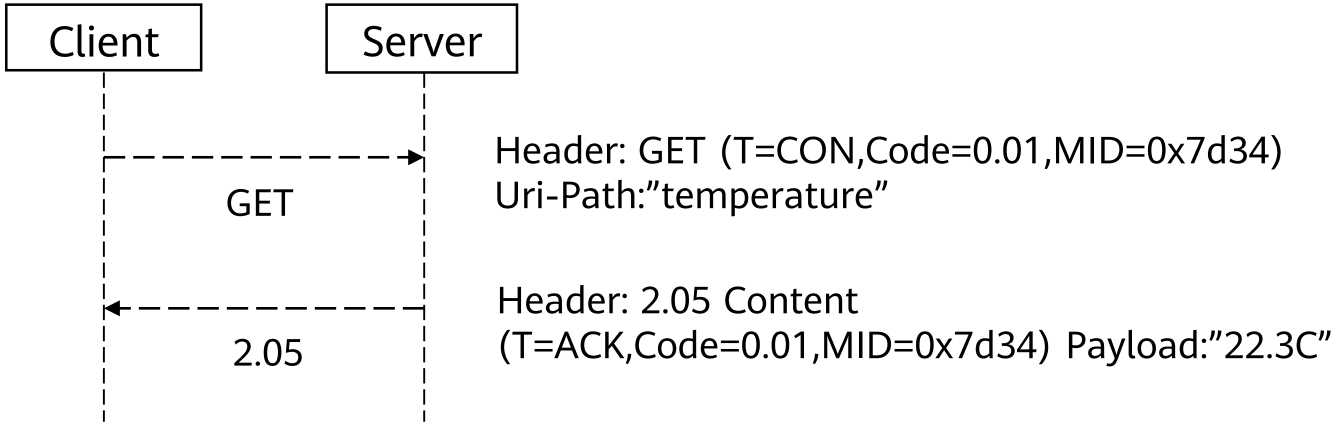
Typical IoT Protocols - MQTT

- Message Queuing Telemetry Transport (MQTT) is an instant messaging protocol developed by IBM. MQTT uses a subscription/publish model. The client subscribes to desired information from the server, and the server pushes the information to the client.

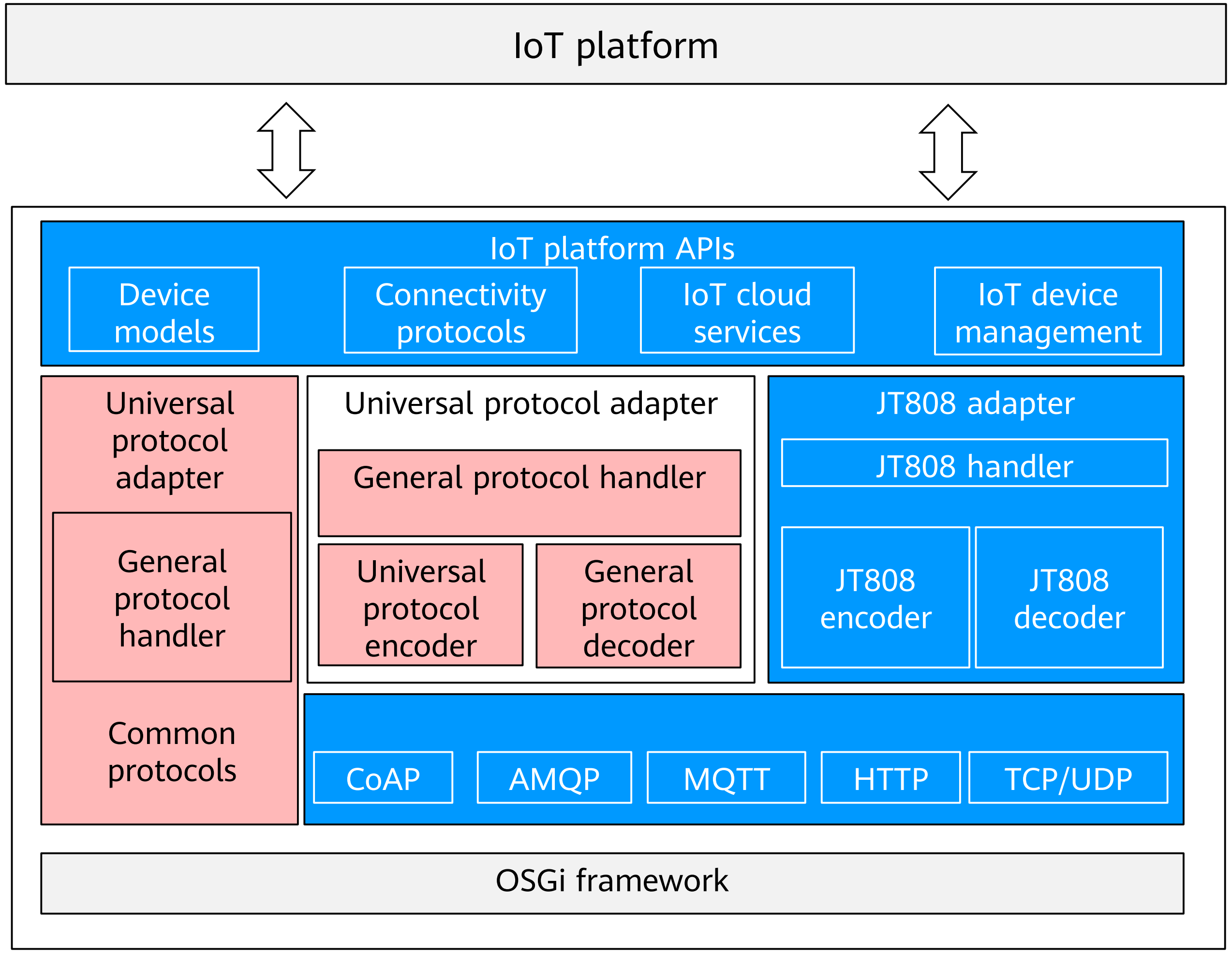


Typical IoT Protocols - CoAP

- Constrained Application Protocol (CoAP) is designed for resource-limited devices (such as sensor nodes) and networks (such as NB-IoT and LoRa). CoAP is based on HTTP. CoAP uses a request/response model, in which the client initiates a request and the server responds to the request. CoAP optimizes the packet length and offers reliable communications to address the issues that may occur on HTTP in restricted conditions.



CIG Framework



Deployment modes

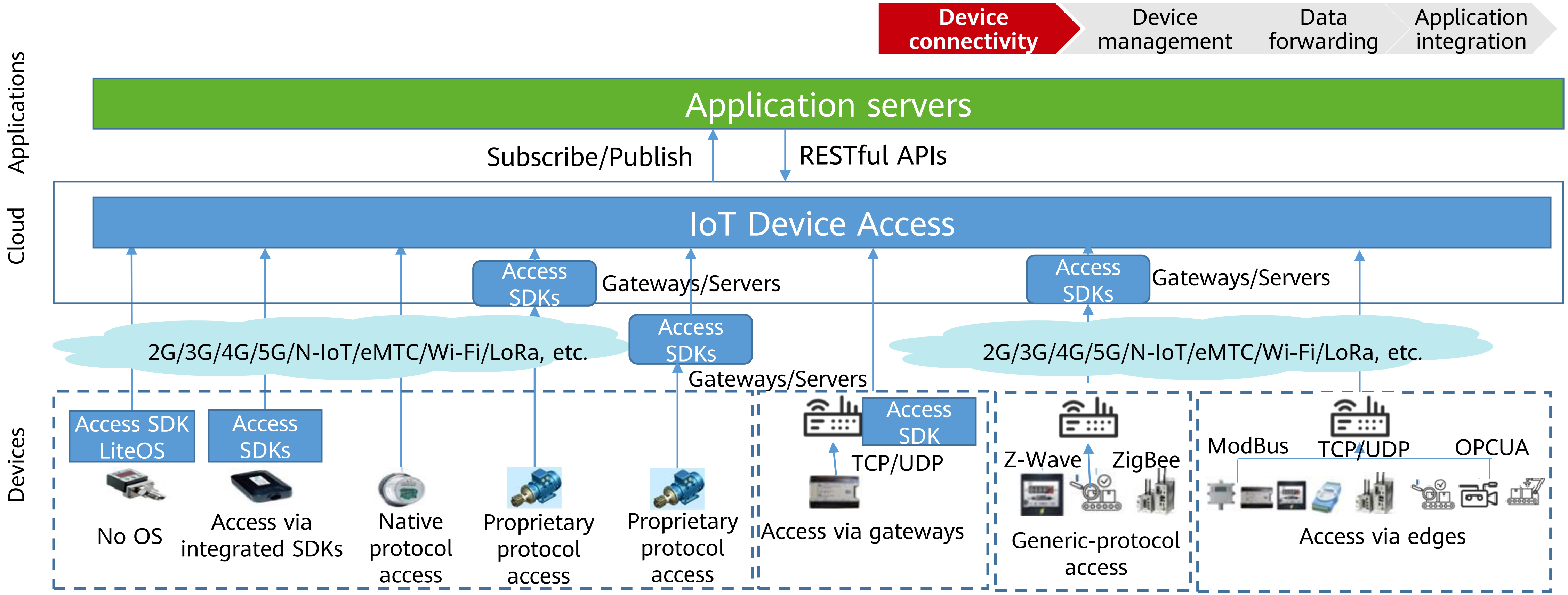
- Deployed on the IoT platform
- Independently deployed

Functions

- Open OSGi architecture, plug-and-play
- Device access using different protocols
- Quick ecosystem construction
- Dynamic plug-in loading
- New device access completed in 1 day

infrastructure
Protocol plug-in framework
Third-party plug-ins

Multi-protocol Access



Native protocols

- MQTT(S)
- CoAP over LwM2M
- HTTP(S)

IoT edge + gateways

- Support for Modbus and OPCUA
- Third-party protocols loaded to edge gateways as plug-ins
- Industry protocol access provided by partners

CIG access

- Support for TCP/UDP access and conversion of proprietary protocols into MQTT for access
- Deployment of SDKs on the local gateway or in the cloud

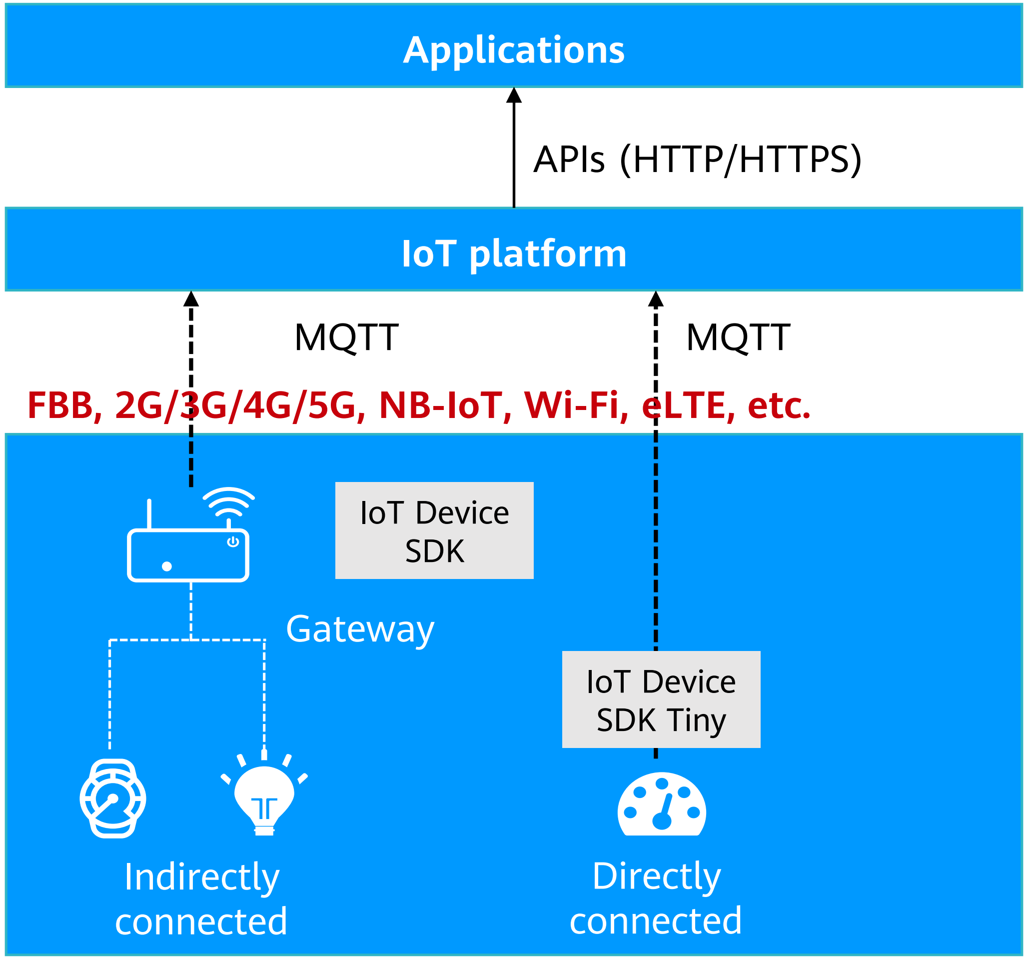
Protocol plug-in access

- Official plug-ins: IoV industry protocol, 32960, JT808
- Custom plug-ins loaded for access of industry-specific protocols

HUAWEI

Using IoT Device SDKs for Access

Device connectivity | Device management | Data forwarding | Application integration



- You can use IoT Device SDKs to quickly connect devices to the IoT platform.
- After being integrated with an IoT Device SDK, devices that support the TCP/IP protocol stack can directly communicate with the IoT platform.
- Devices that do not support the TCP/IP protocol stack, such as Bluetooth and Zigbee devices, need to use a gateway integrated with the IoT Device SDK to communicate with the platform.
- The IoT platform provides SDKs in multiple languages, including C and Java.

HUAWEI CLOUD IoT Device SDKs

Device connectivity › Device management › Data forwarding › Application integration

SDK Name	RAM Capacity	Flash Capacity	CPU Frequency	Development Language
IoT Device SDK Tiny	> 32 KB	> 128 KB	> 100 MHz	C

Device SDK Tiny: suitable for devices with weak computing capabilities

Water metering | Roadside parking | Smart street lamps | Gas metering | Bicycle sharing

- Support for MQTT(S), CoAP, and LwM2M, and retransmission
- OTA upgrades and device shadow query
- Password authentication, certificate authentication, and bootstrapping
- Device data reporting, and bidirectional communications
- Custom topics
- Custom log collection
- C language

SDK Name	RAM Capacity	Flash Capacity	CPU Frequency	Development Language
IoT Device SDK	> 4 MB	> 2 MB	> 200 MHz	C. Java, Android, and C#

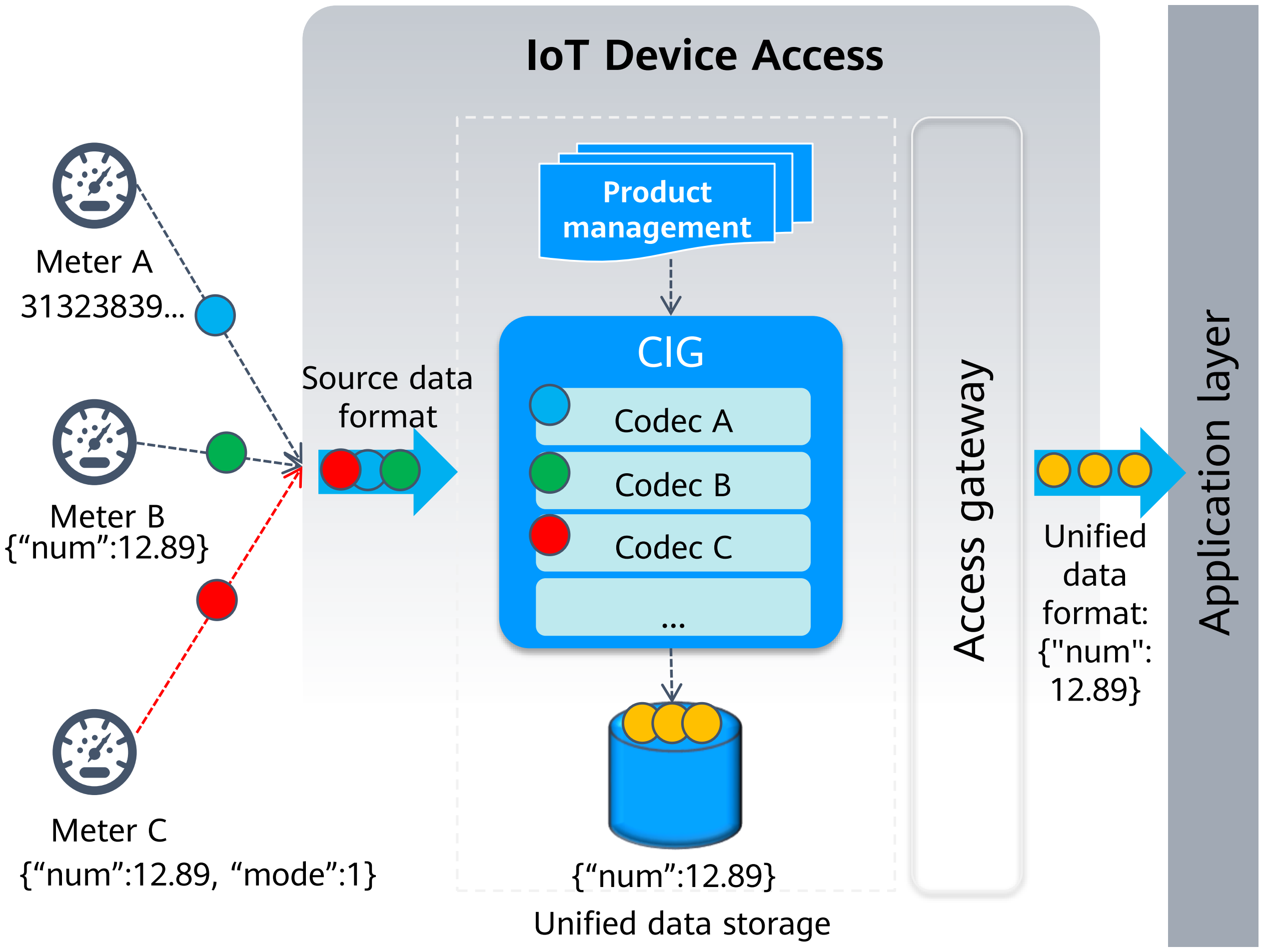
Device SDK: suitable for intelligent devices and gateways with strong computing capabilities

Security monitoring | Child tracking | IoV | Smart home

- Support for MQTT(S), CoAP, and LwM2M, and retransmission
- OTA upgrades and device shadow query
- Password authentication, certificate authentication, bootstrapping, and **generic-protocol access**
- Device data reporting and bidirectional communications
- **Message forwarding for child devices, and child device addition, deletion, and modification (status update)**
- Custom topics
- Custom log collection
- Java, C, Android, and C# languages

Product Development: Product Model (Profile)

Device connectivity | **Device management** | Data forwarding | Application integration



Define a product

- **Method 1**: Define a product model on the console.
- **Method 2**: Modify a product model template provided by the IoT platform based on the service requirements.

Generate and deploy a codec

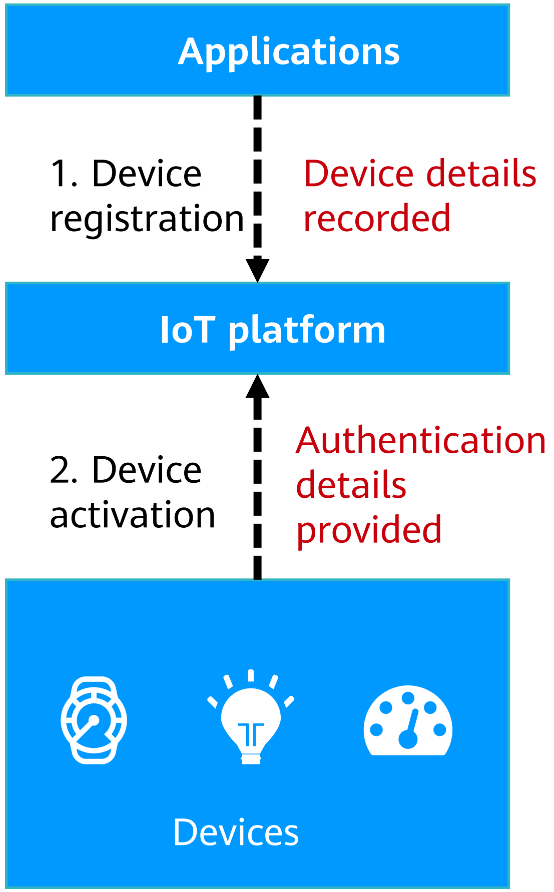
- **Step 1**: Define a codec on the console based on the product model.
- **Step 2**: Deploy a codec with a few clicks.

Benefits

- **To applications**: Device management is simplified. The IoT platform normalizes data provided by different manufacturers to form unified product models. Applications do not need to be aware of differences between devices.
- **To device manufacturers**: Device code does not need to be modified. Codecs are used to adapt to different enterprise requirements, simplifying maintenance.

Device Registration and Access Authentication

Device connectivity | **Device management** | Data forwarding | Application integration



- **Device registration**: Users register device details on the console or call the Registering Devices API to register device information. These devices can then connect to the IoT platform for connectivity and communications between them.

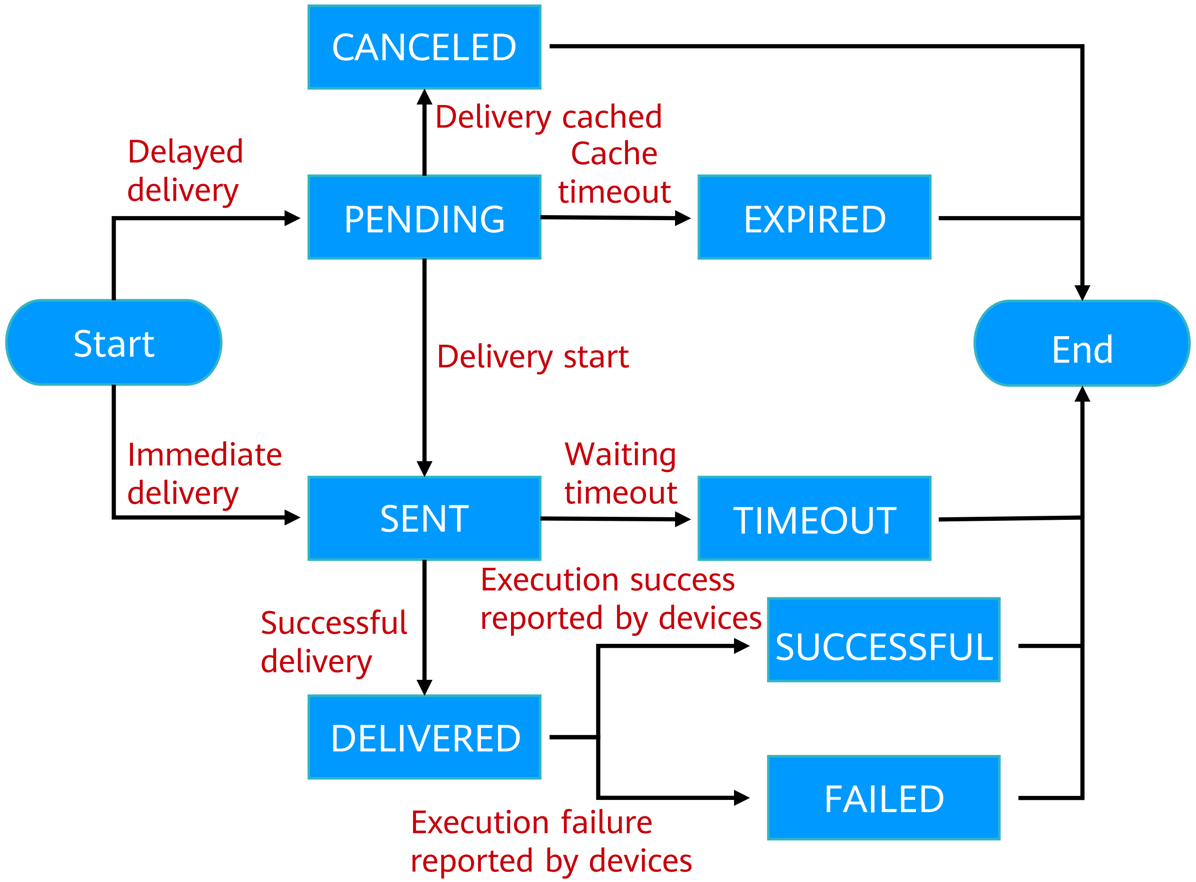
- **Device access authentication**: The IoT platform authenticates a device when it attempts to connect to the platform. The platform authenticates integrity and security of device data, device access data, and messages exchanged between the device and platform.

Command Delivery

- The product model of a device defines commands that can be delivered by the IoT platform to the device. The platform delivers commands to the device and modifies the service properties of the device to control the device.

The IoT platform has two ways to deliver commands:

- **Immediate delivery**: The platform delivers received commands immediately. If a device is offline, the commands cannot be delivered. Immediate delivery is applicable when commands must be delivered in real time.
- **Delayed delivery**: The platform queues received commands. When the device goes online, the platform delivers queued commands in the order they were received. Delayed delivery applies to scenarios that do not require real-time command delivery.



Device Linkage Rule

Device connectivity | **Device management** | Data forwarding | Application integration

Triggers

Time-based

Example: turning off the corridor light at 08:00

Data-based

Example: turning on the air conditioner when the temperature is higher than 25° C

Event-based

Example: sending a notification to a specific mobile phone if an alarm is generated

Actions

Action 1

Instructs the sensor to turn off the corridor light at 08:00.

Action 2

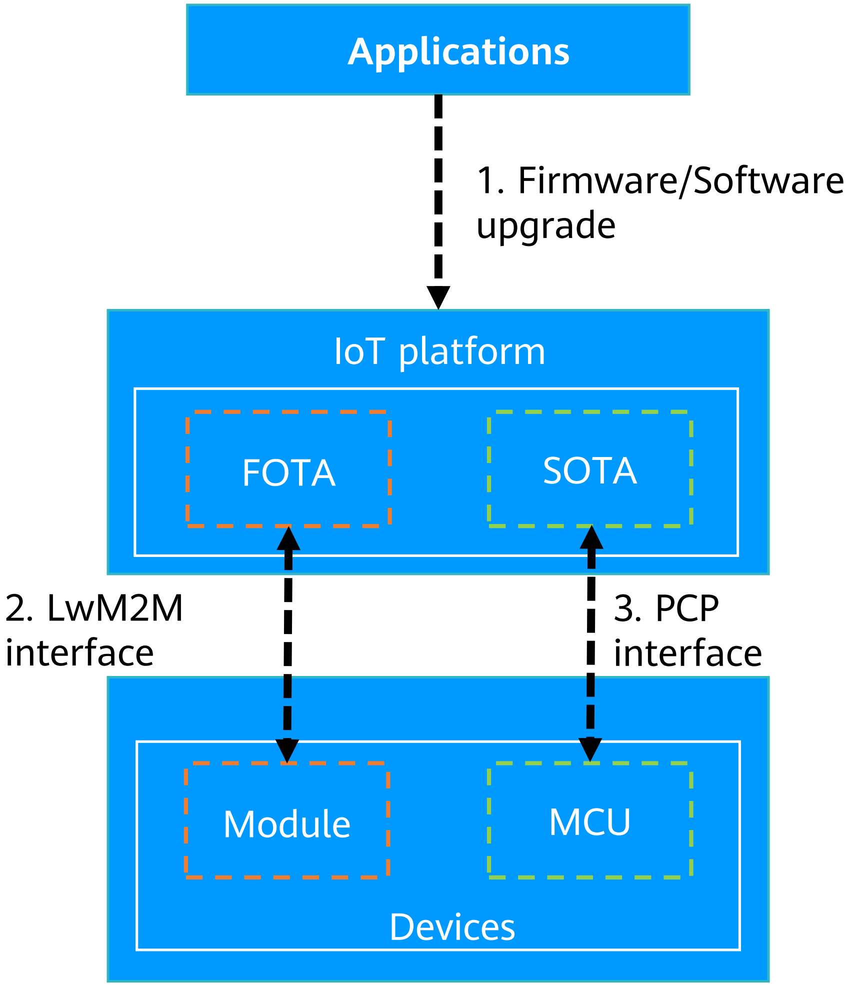
Instructs the sensor to turn on the air conditioner when the temperature is higher than 25° C.

Action 3

Instructs the sensor to send a notification to the specific mobile phone when an alarm is generated.

Firmware and Software Upgrades

Device connectivity | **Device management** | Data forwarding | Application integration

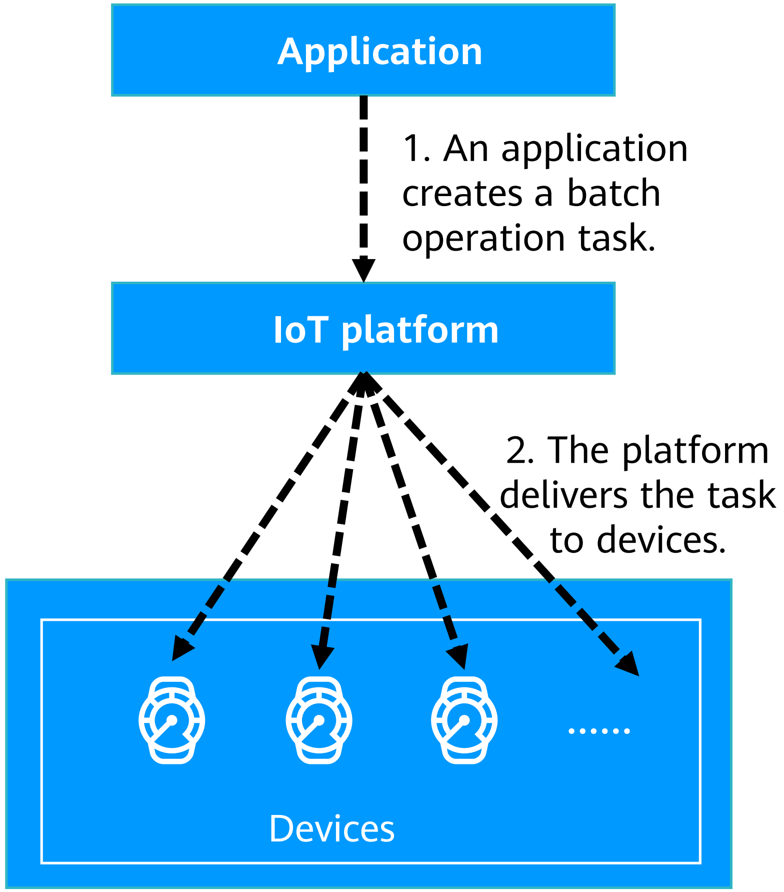


Firmware upgrade, also called firmware over the air (FOTA), allows users to upgrade device modules based on the LwM2M protocol.

Software upgrade, also called software over the air (SOTA), allows users to upgrade MCUs of devices based on Huawei's PCP upgrade protocol.

Batch Operations

Device connectivity | **Device management** | Data forwarding | Application integration



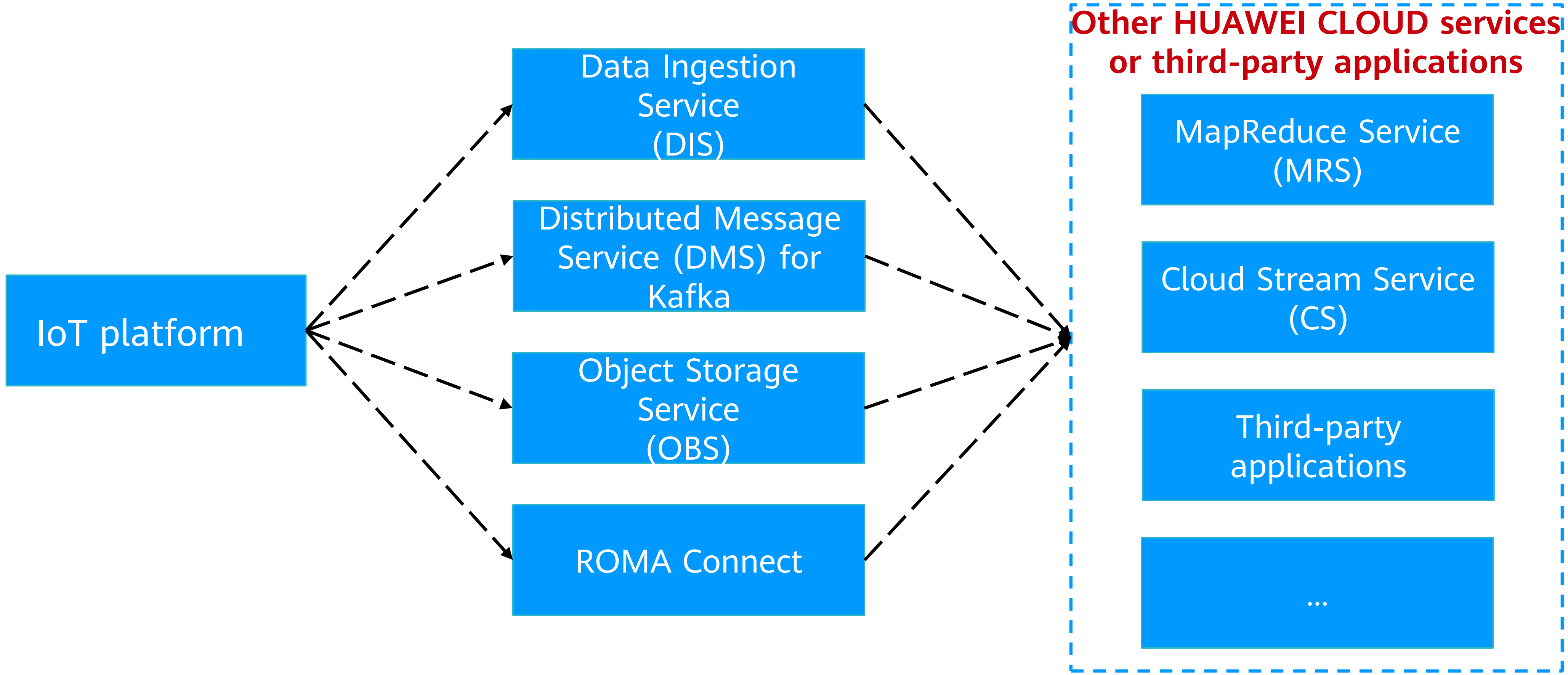
The IoT platform supports batch device registration and batch firmware/software upgrade:

- **Batch device registration**: It takes a long time to register a large number of devices one by one. To speed up the process, batch registration is recommended. Currently, batch registration can only be performed on the console.
- **Batch firmware/software upgrade**: You can create a batch software/firmware upgrade task on the platform to upgrade software/firmware of devices in batches.

Data Forwarding

Device connectivity | Device management | **Data forwarding** | Application integration

- The IoT platform can work with other HUAWEI CLOUD services to process and forward device data on demand. You do not need to purchase servers to store, calculate, and analyze device data.



Application-side APIs

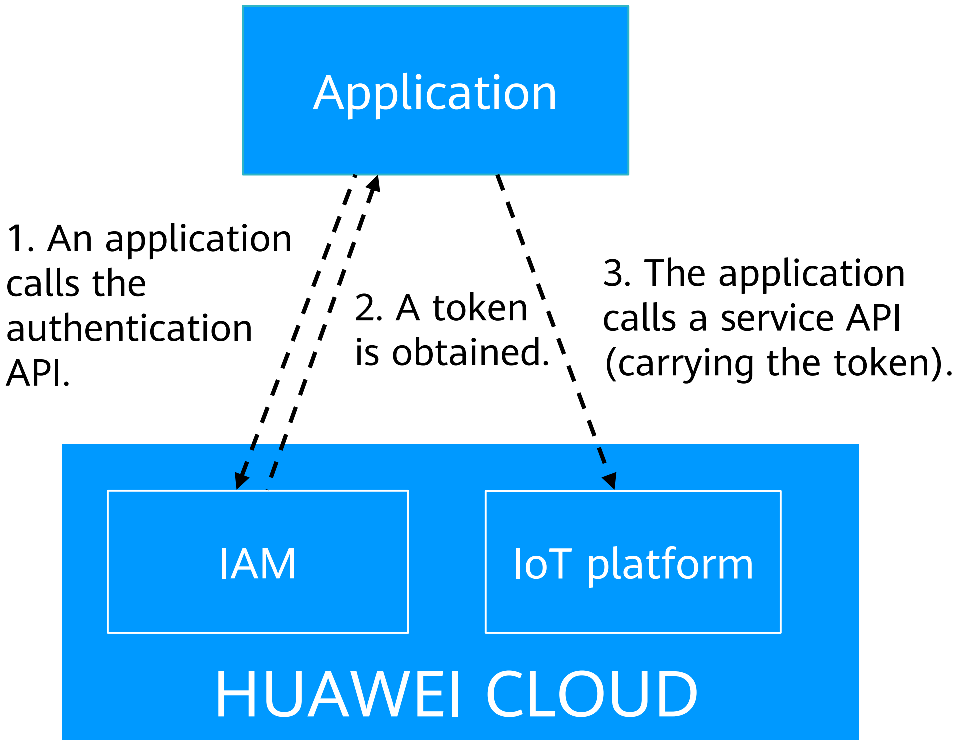
Device connectivity | Device management | Data forwarding | **Application integration**

- The IoT platform provides more than 40 RESTful APIs for third-party application developers to quickly integrate IoT platform functions. Currently, the IoT platform provides the following types of APIs:

API Category	Description	API Category	Description
Subscription management APIs	Used by applications to subscribe to device information. If the subscribed device information changes, the IoT platform pushes messages to the applications.	Product management APIs	Used by applications to manage products. Products created using APIs do not include codecs.
Tag management APIs	Used by applications to manage tags. Only device tags are supported.	Device management APIs	Used by applications to manage devices, including adding, deleting, modifying, and querying devices and resetting device secrets.
Batch task APIs	Used by applications to perform batch operations on connected devices. Only batch software or firmware upgrades are supported.	Device shadow APIs	Used by applications to manage device shadows, including querying shadow data and setting desired values.
Device CA certificate management APIs	Used by applications to manage device CA certificates, which are used for device access authentication.	Device command APIs	Used by applications to deliver commands to devices. Command names must be defined in the product models.
Group management APIs	Used by applications to manage groups and group members. Groups are used to manage devices by group.	Device property APIs	Used by applications to query and modify device properties.
Device message APIs	Used by applications to deliver messages to devices. The difference between messages and commands is that messages can be customized and do not need to be defined in product models.	Rule management APIs	Enables applications to manage rules. Different APIs are used to create condition-triggered rules and scheduled rules.

Application Registration Authentication

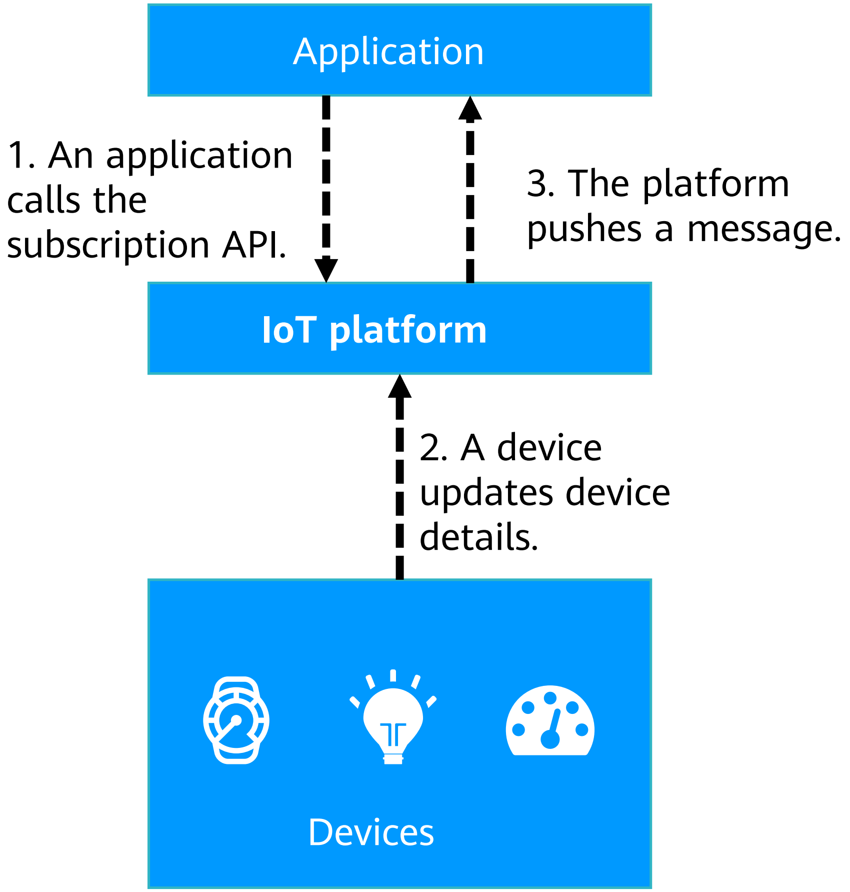
Device connectivity | Device management | Data forwarding | **Application integration**



- IoT applications developed based on the HUAWEI CLOUD IoT platform call APIs provided by the platform. The platform uses token authentication provided by HUAWEI CLOUD Identity and Access Management (IAM) to ensure that only authorized users can access the platform and use resources and service suites for application development.
- Before calling an API, an application must carry API credentials (such as the account name, username, and password) to obtain a token. The application then uses the token to call the API to implement services. The token is valid for 24 hours. After the token expires, the application needs to obtain a new token.

Subscription/Push

Device connectivity | Device management | Data forwarding | **Application integration**

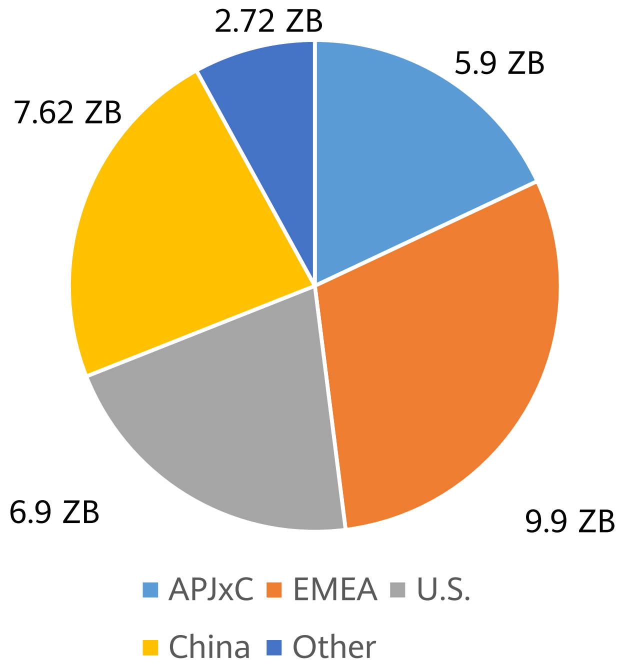


- An application can send a subscription request to the IoT platform through an API to notify the platform of the types of notifications to be received, for example, a change in device service details, device data, or device registration.
- When device details are updated on the IoT platform, the IoT platform pushes messages to the application over HTTP/HTTPS.
- In any given push message, the IoT platform functions as a client and the application functions as the server. The IoT platform calls the API of the application and pushes messages to the application.
- In this case, if the subscription callback URL is an HTTPS address, you need to upload the CA certificate to the IoT platform. The CA certificate is provided by the application.

Contents

Why Is Data Analysis Required?

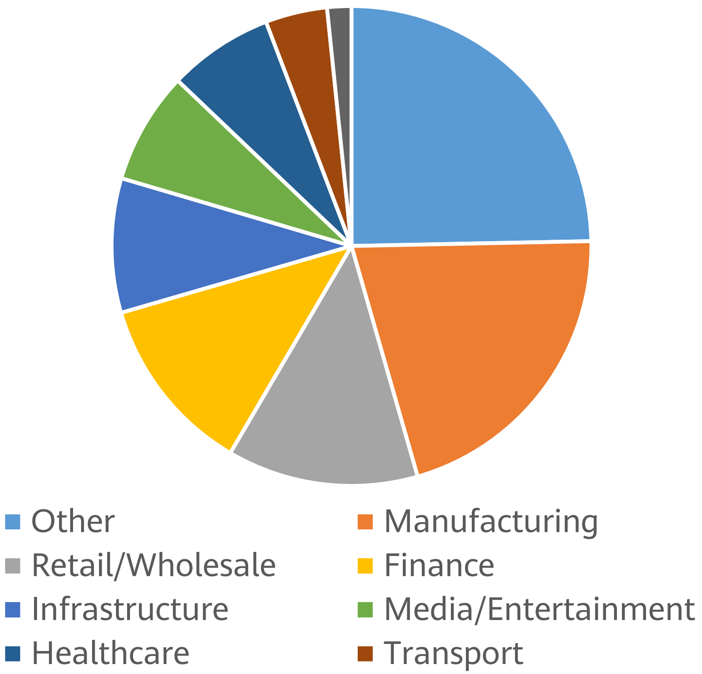
32 ZB big data stored in 2018 globally



China has surpassed the US in data volume and the gap is expected to keey growing.

Data source: China Big Data Industry Panorama in 2019 by Qianzhan Industry Research Institute

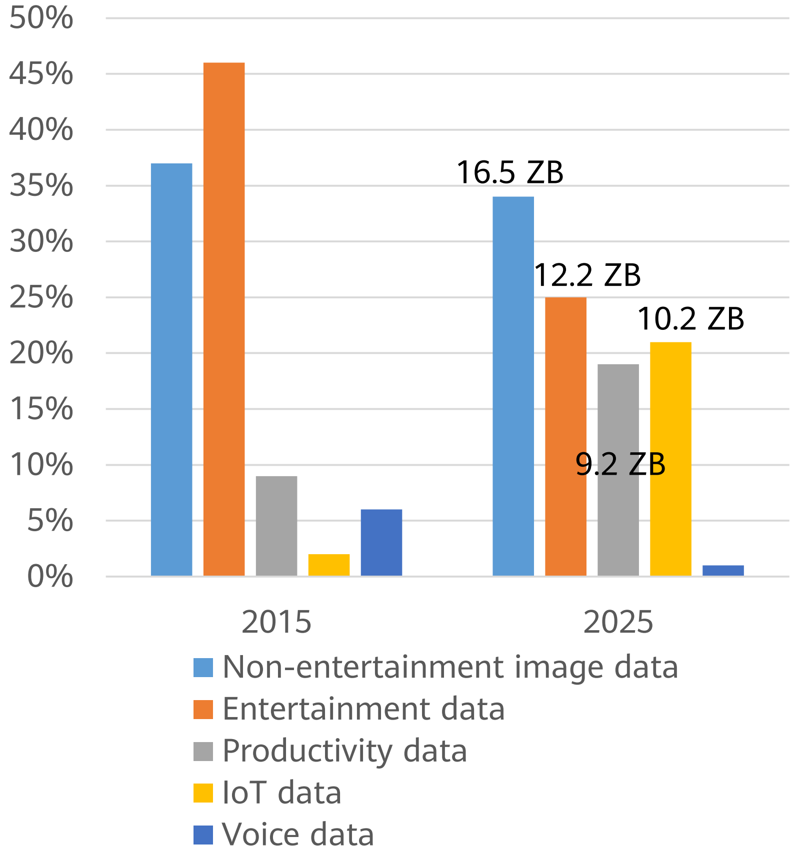
Structure of global data generated in 2018 (by industry)



Note: Infrastructure includes public utilities and the telecom industry.

Manufacturing, retail, finance, and infrastructure are the main industries that generate data, accounting for 55% of the total data volume.

Data type share changes in China 2015-2025



It is estimated that the proportion of data that is IoT related will reach 21% by 2025, representing faster growth than any other type of data.

IoT Data Characteristics

Inexpensive storage

How can I select different storage and compression policies for hot, cold, and warm data to reduce overall costs while ensuring query effectiveness?

Huge
data volume

Low
value density

Thorough data mining

How can I extract valuable information from massive quantities of IoT data? How can I obtain a sufficiently robust set of analytical tools?

More efficient processing

How can I optimize each phase of the data processing? How can access, cleansing, storage, analysis, and presentation all be optimized for continuous data injection from IoT devices?

High
time sensitivity

Low
data quality

Effective data quality management

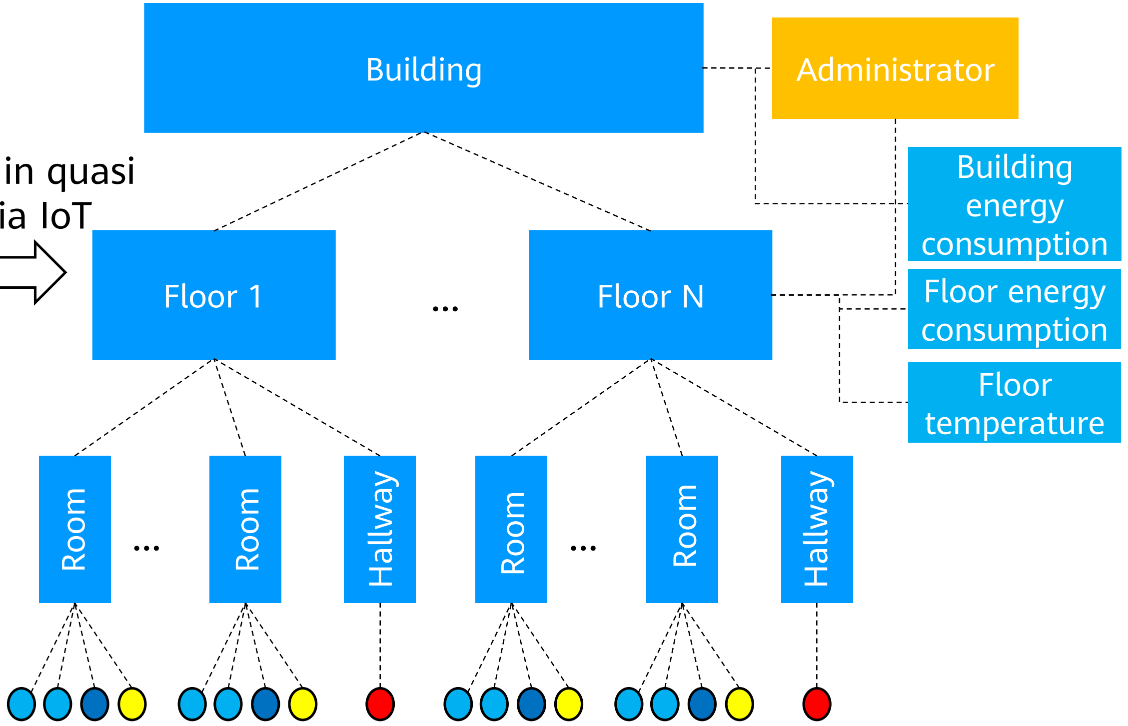
How can I establish a reliable data quality evaluation system and properly process poor-quality data?

IoT Analytics: Asset Model

- Establish relationships between things, between things and space, and between things and people, so that data can be understood in context.
- Use IoT+ asset models to build **digital twins** that are in quasi-real-time synchronization with things in the physical world.
- Model-based abstraction provides a unified, **service-oriented** data basis for data analysis.

Physical world

Synchronized in quasi real-time via IoT

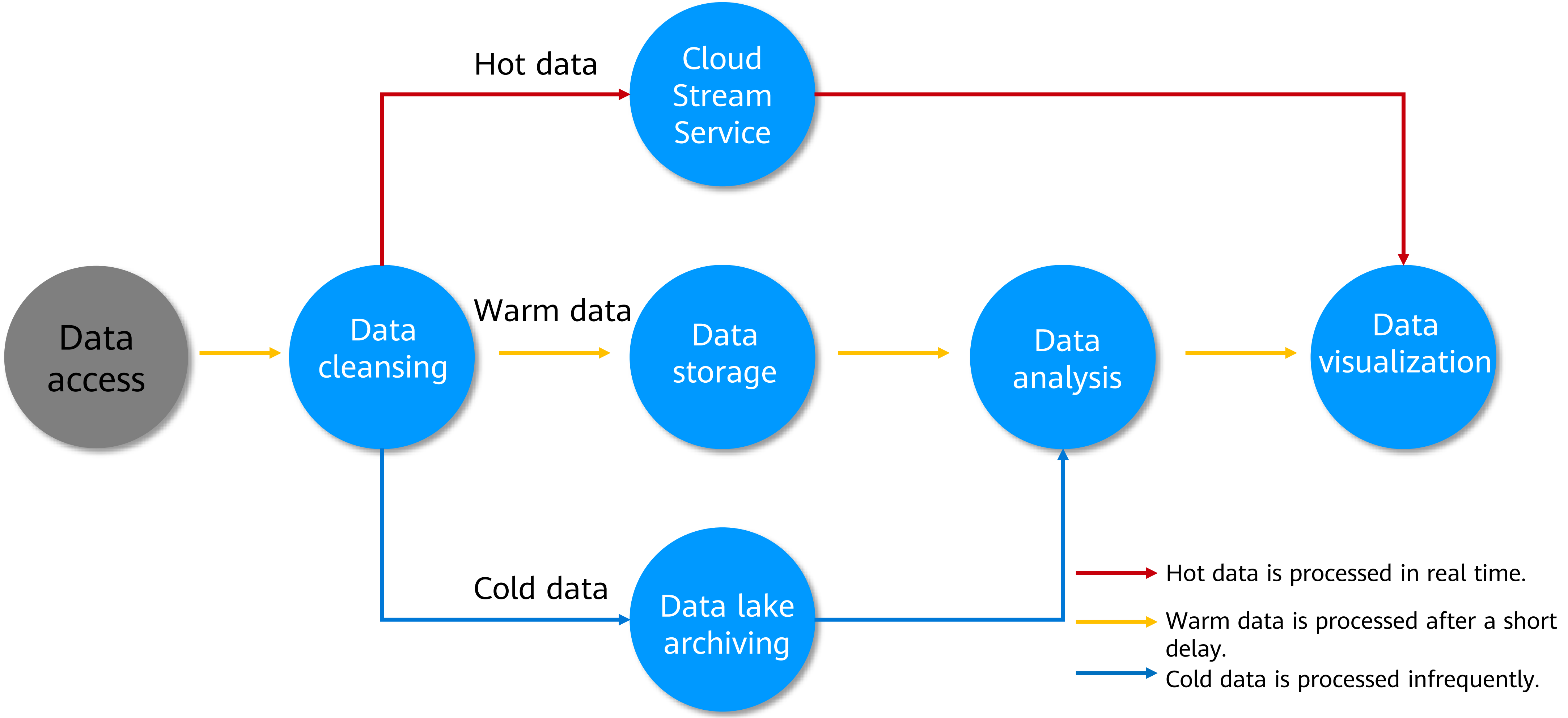


IoT sensors (physical measurement points)

IoT Analytics: Time Series Data Processing Is the Key

Write performance	How do we meet the requirements for high concurrency and real-time write for a large number of devices?
Compression ratio	Some IoT devices may generate a large amount of data. Higher compression directly reduces costs.
Query efficiency	How do we meet high-performance query requirements, especially time-based aggregation query, for IoT data accumulated over a long period of time?

IoT Analytics: Multi-temperature Data Management Maximizes Processing Efficiency



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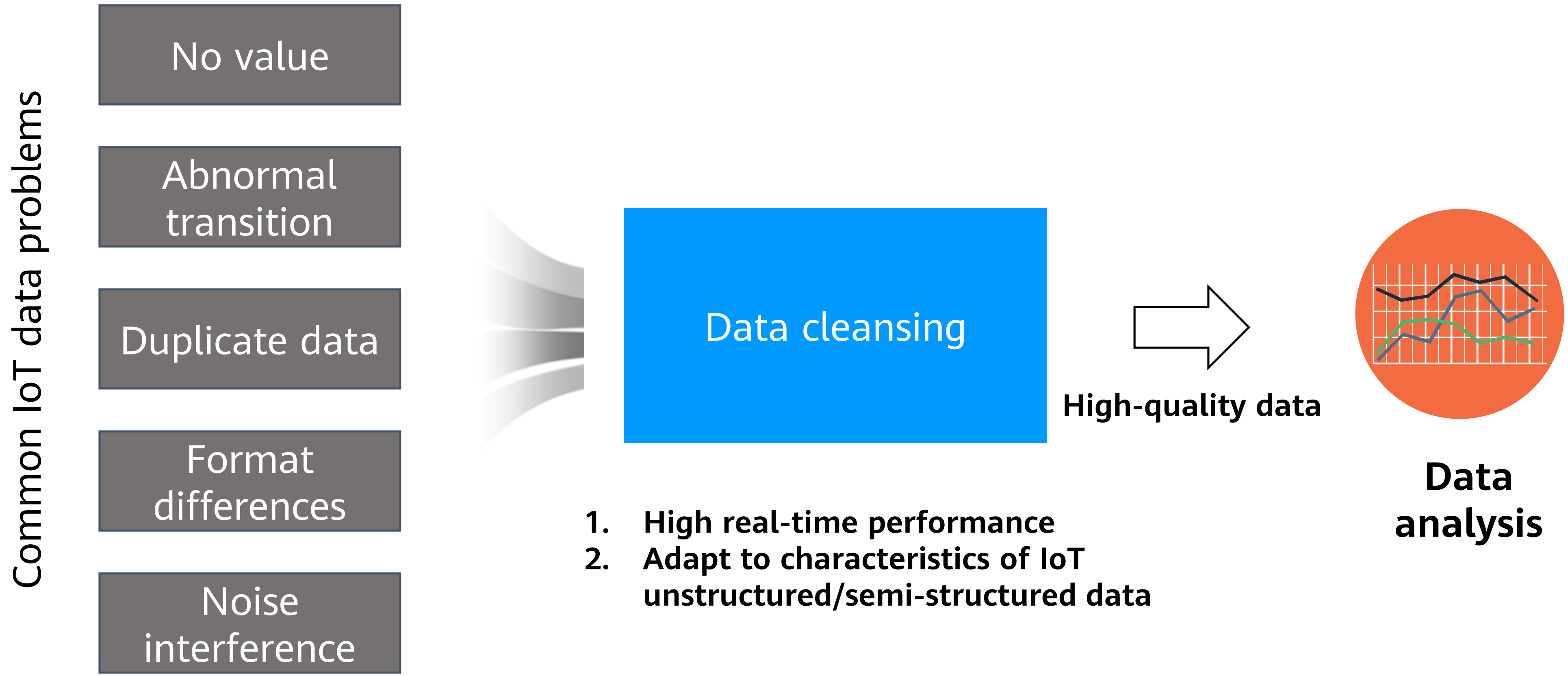
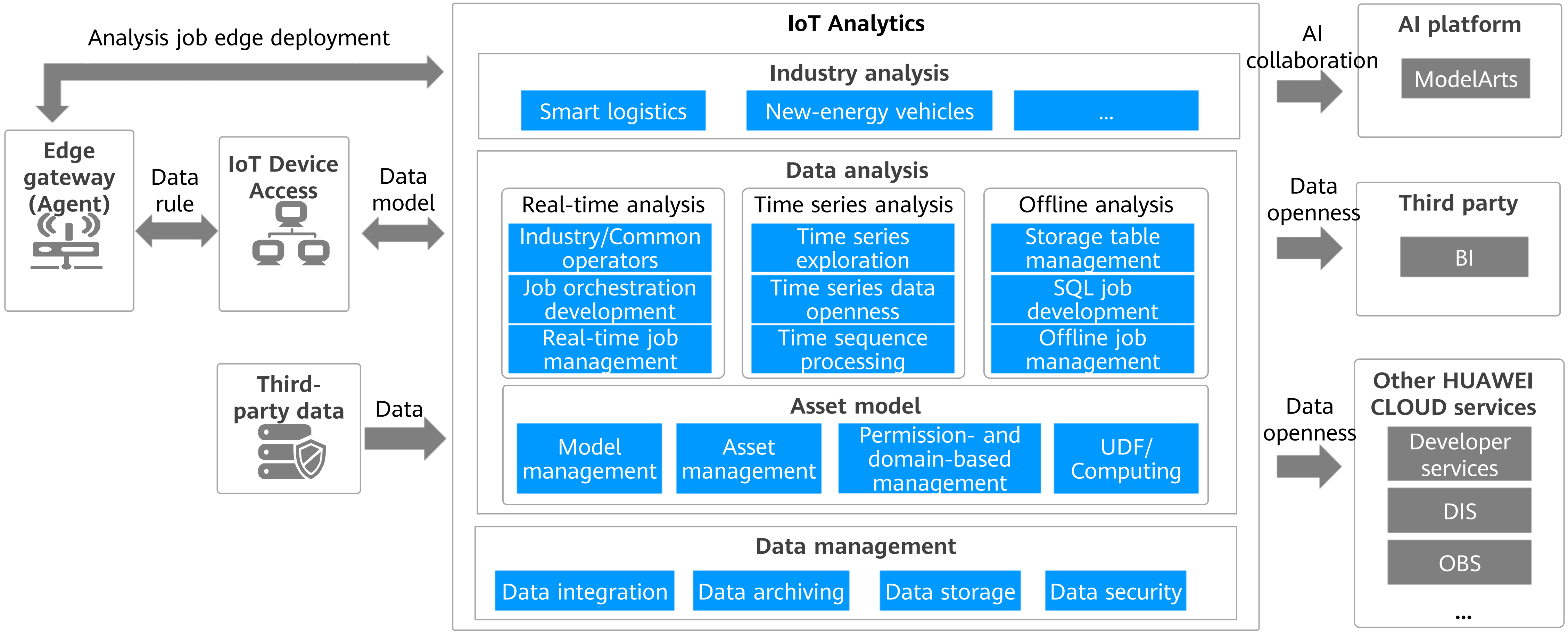
IoT Analytics: Efficient Data Cleansing Provides High-Quality Data for Analysis

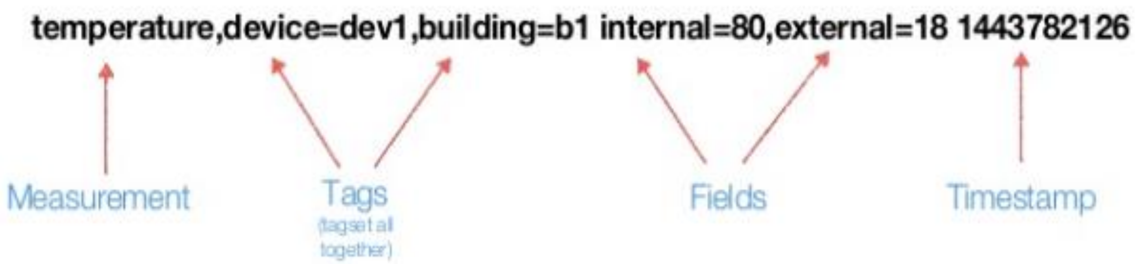


Data Analysis Architecture



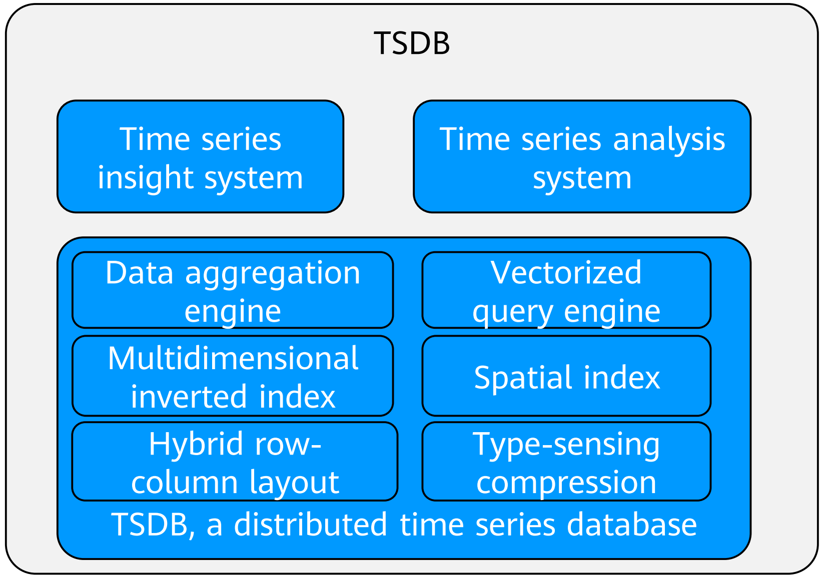
Time Series Analysis

IoT data has time series characteristics.



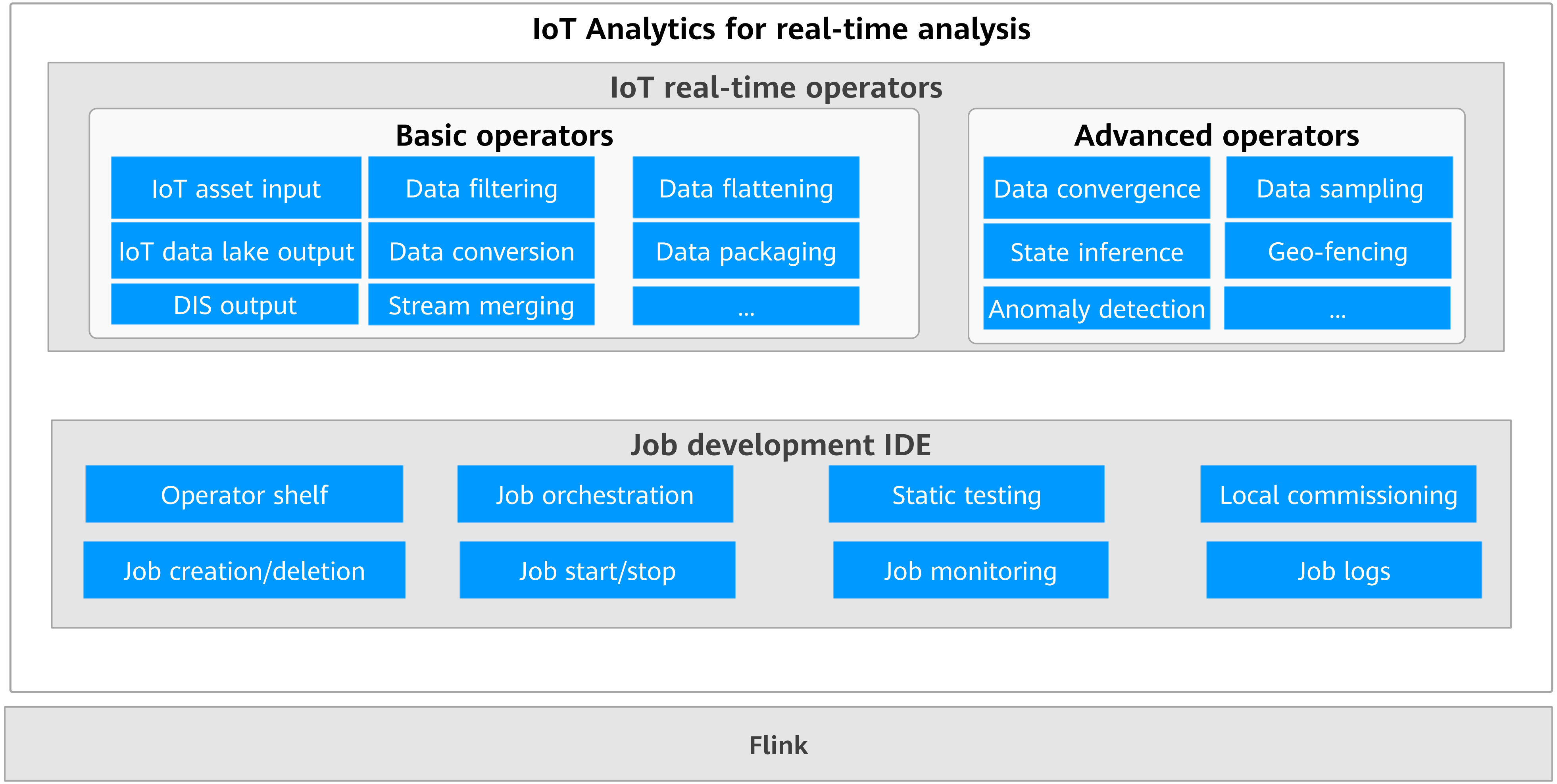
The following key data is collected on a regular basis:

1. Timestamp
2. Fields
3. Tags
4. Measurement

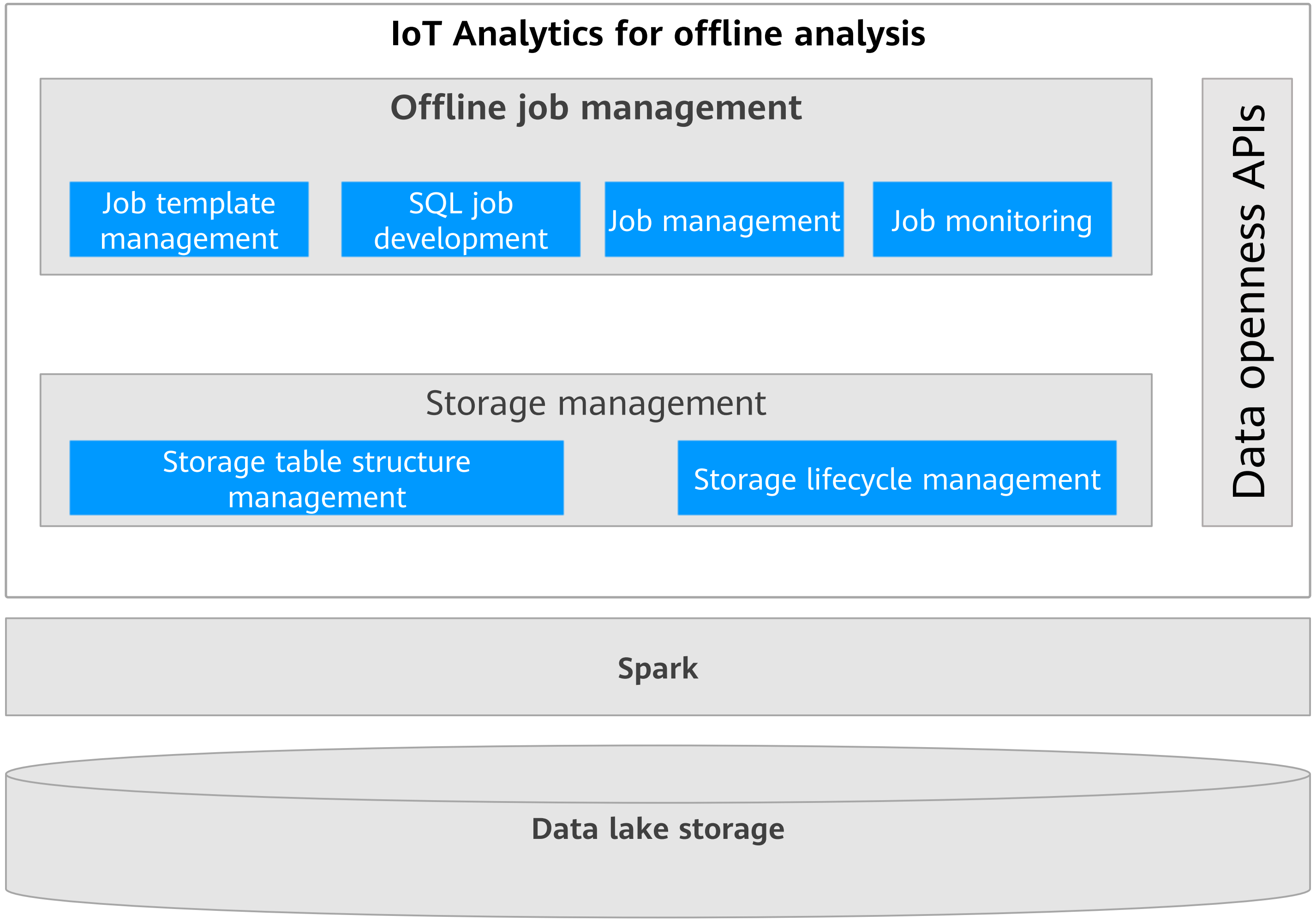


- **High compression ratio**
  A dedicated compression algorithm for time series data with an approximately 20x compression ratio
- **Efficient data query**
  Multi-node and multi-thread parallel query, vectorized query engine
- **Efficient data writing**
  Trillions of data points written every day

Real-Time Analysis



Offline Analysis



Contents

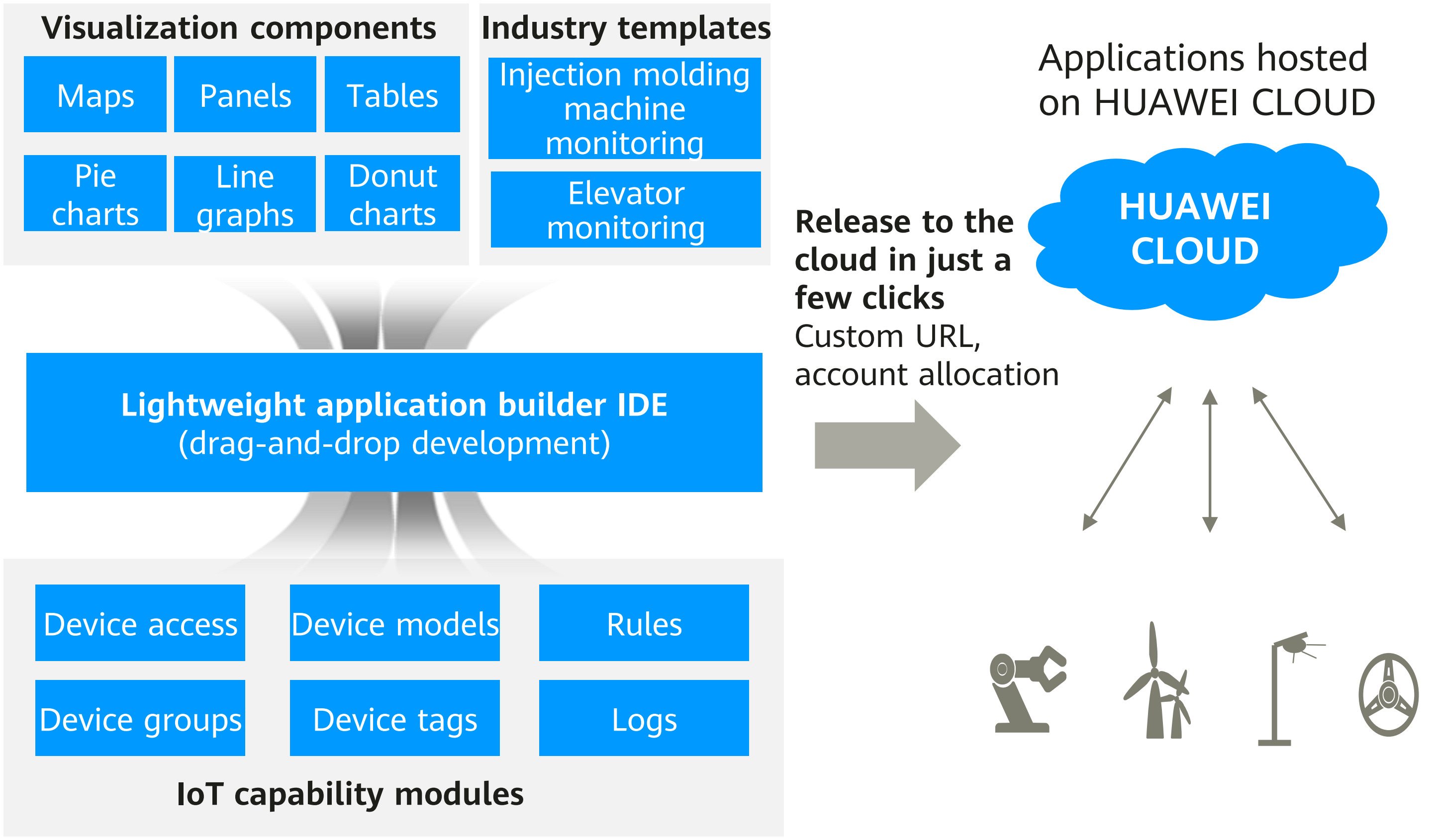
IoT Studio

Pain Points

- Small- and medium-sized enterprises want to quickly build applications with limited up-front investment.
- Small- and medium-sized device manufacturers have limited personnel available for software development. Software development, application construction, and IoT service rollout are slow and expensive.

Key Features

- **Quick build**: An IoT web application can be built in just 5 to 10 minutes, thanks to 30+ visualized components
- **Low cost**: on-demand, free industry templates
- **Easy O&M**: professional O&M support for application hosting from Huawei

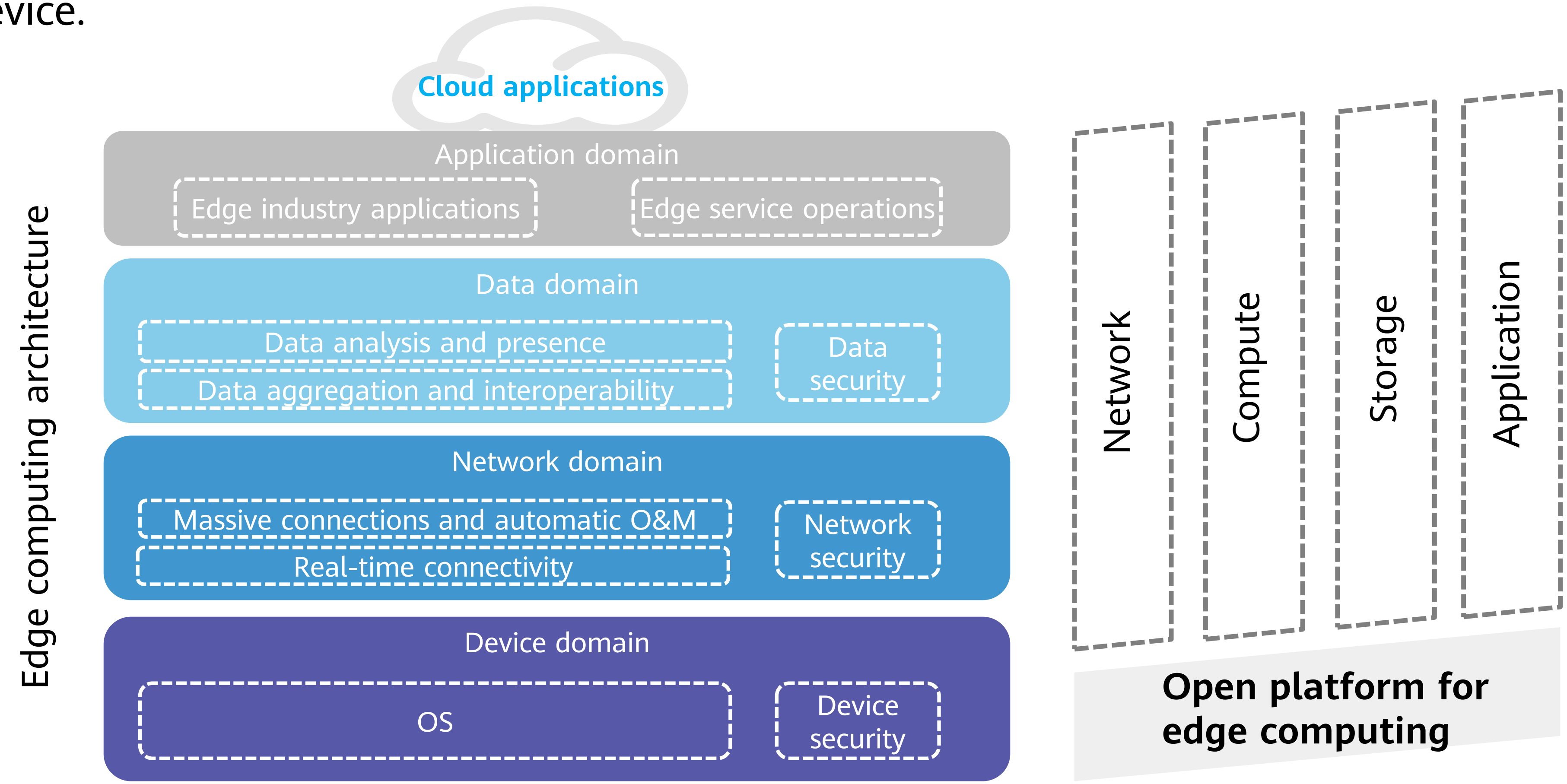


Contents

Edge Computing Architecture

Edge computing | Global SIM Link

- The ECC divides the edge computing architecture into four domains: application, data, network, and device.



Four Factors Promoting Rapid IoT Edge Development

Edge computing Global SIM Link

- Low latency: Building a solution at the edge reduces service delay as services can be processed closers to where they are needed.
- Massive data: Data volumes at the edge are rapidly increasing. Transmitting the data directly to the cloud is expensive. Local data analysis and filtering conserve bandwidth.
- Privacy: Enterprise and individual private data is processed at the edge to ensure enterprise and operations security.
- Local autonomy: Offline processing and self-healing capabilities that do not depend on the cloud are required.

Edge Computing Services - IoT Edge (1)

Edge computing Global SIM Link

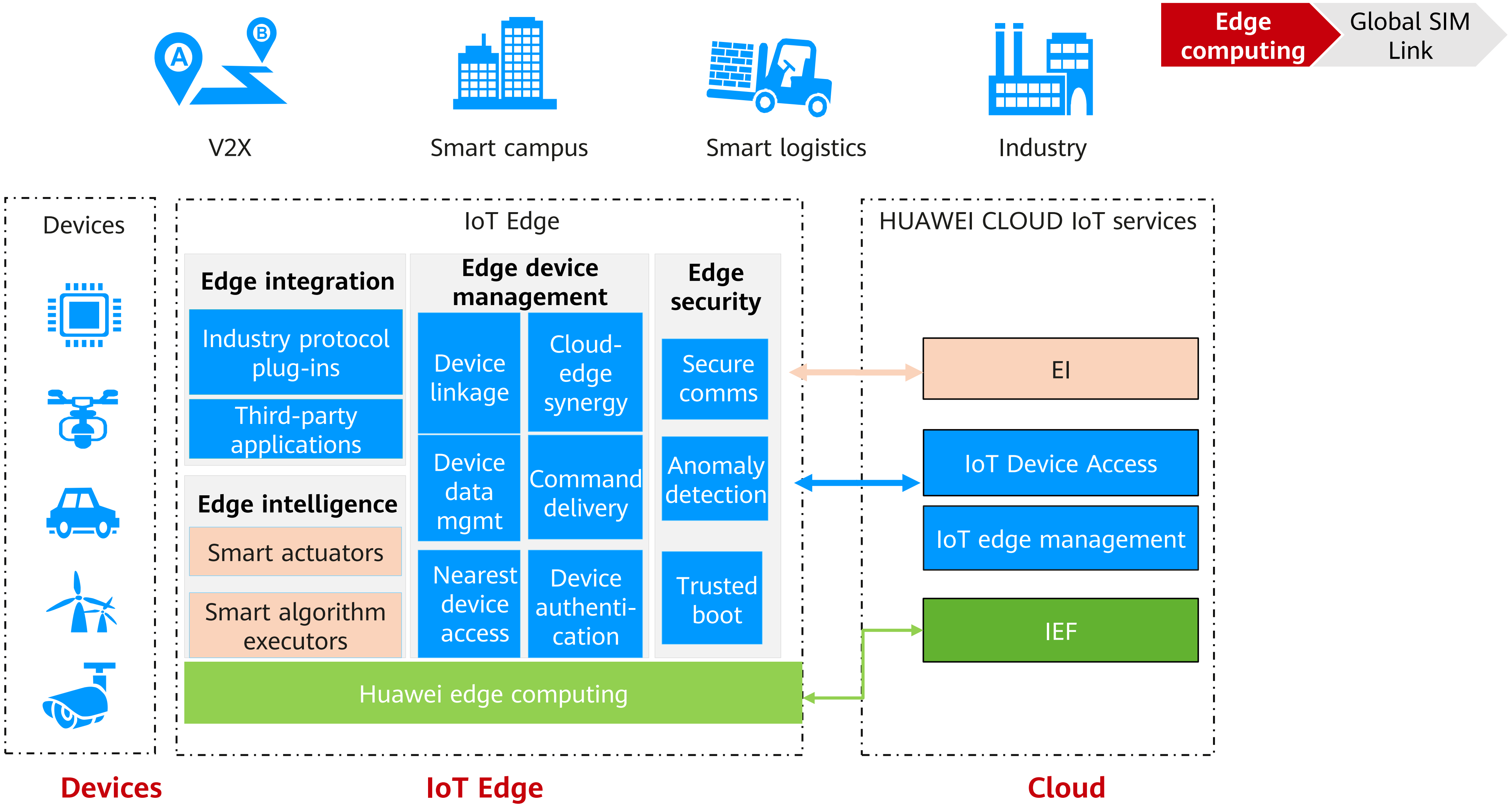
Pain Points

- **Low latency**: Building a solution at the edge reduces service delay as services can be processed closers to where they are needed.
- **Massive data**: Data volumes at the edge are rapidly increasing. Transmitting the data directly to the cloud is expensive. Local data analysis and filtering conserve bandwidth.
- **Privacy**: Enterprise and individual private data is processed at the edge to ensure enterprise and operations security.
- **Local autonomy**: Offline processing and self-healing capabilities that do not depend on the cloud are required.

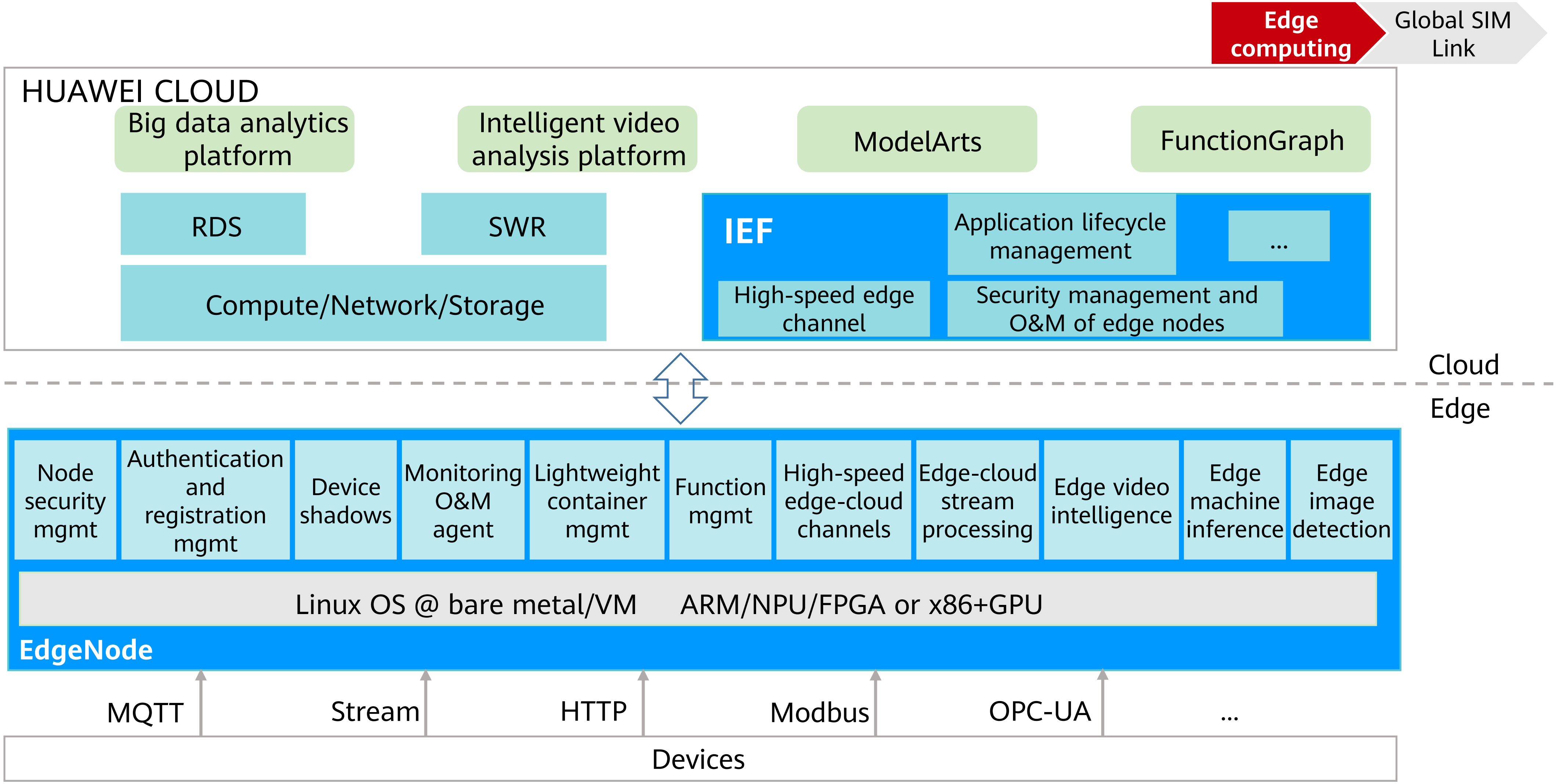
Key Features

- **Edge-cloud synergy**: unified deployment, O&M, and service management of edge and cloud systems
- **Open architecture**: integration with third-party services
- **A unified framework and loose hardware coupling**: abstract hardware interfaces, a unified framework, and plug-and-play edge services
- **Unified AI** model development and process scheduling: cloud-based training and edge-based execution; cloud-based services and logic pushed to the edge based on service requirements, and synergy between service, data, and functions

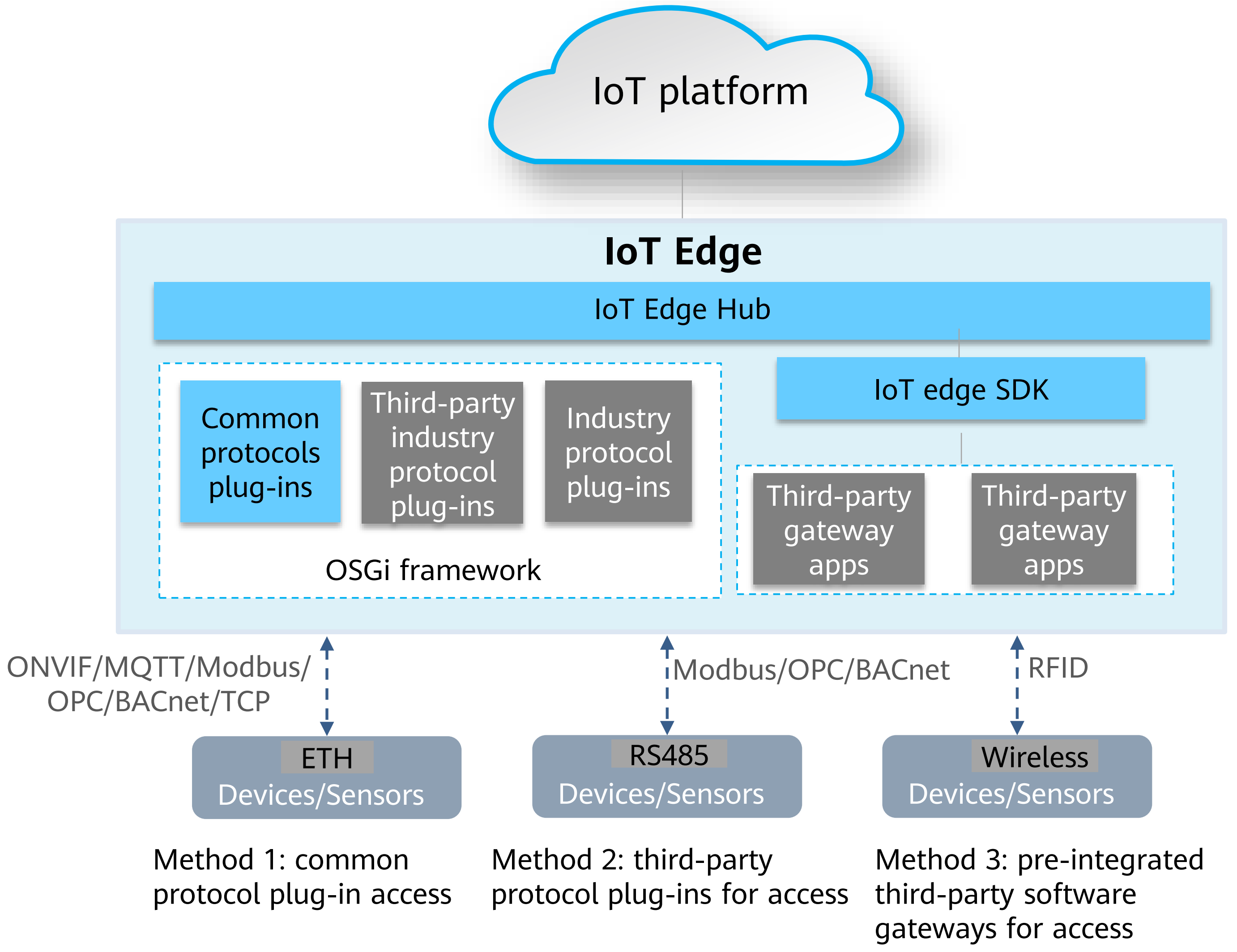
Edge Computing Services - IoT Edge (2)



Edge Computing Services - Intelligent EdgeFabric (IEF)



Characteristics of Edge Computing Service (1)



Edge computing | Global SIM Link

Open framework supports protocol extension.

- The OSGi framework supports dynamic loading of third-party protocol plug-ins, which are plug-and-play.
- Multi-language SDKs are provided for quick connection to third-party software gateways.

Multi-protocol

- Support for multiple popular protocols such as MQTT, ONVIF, CoAP, TCP, Modbus, OPC, and BACnet

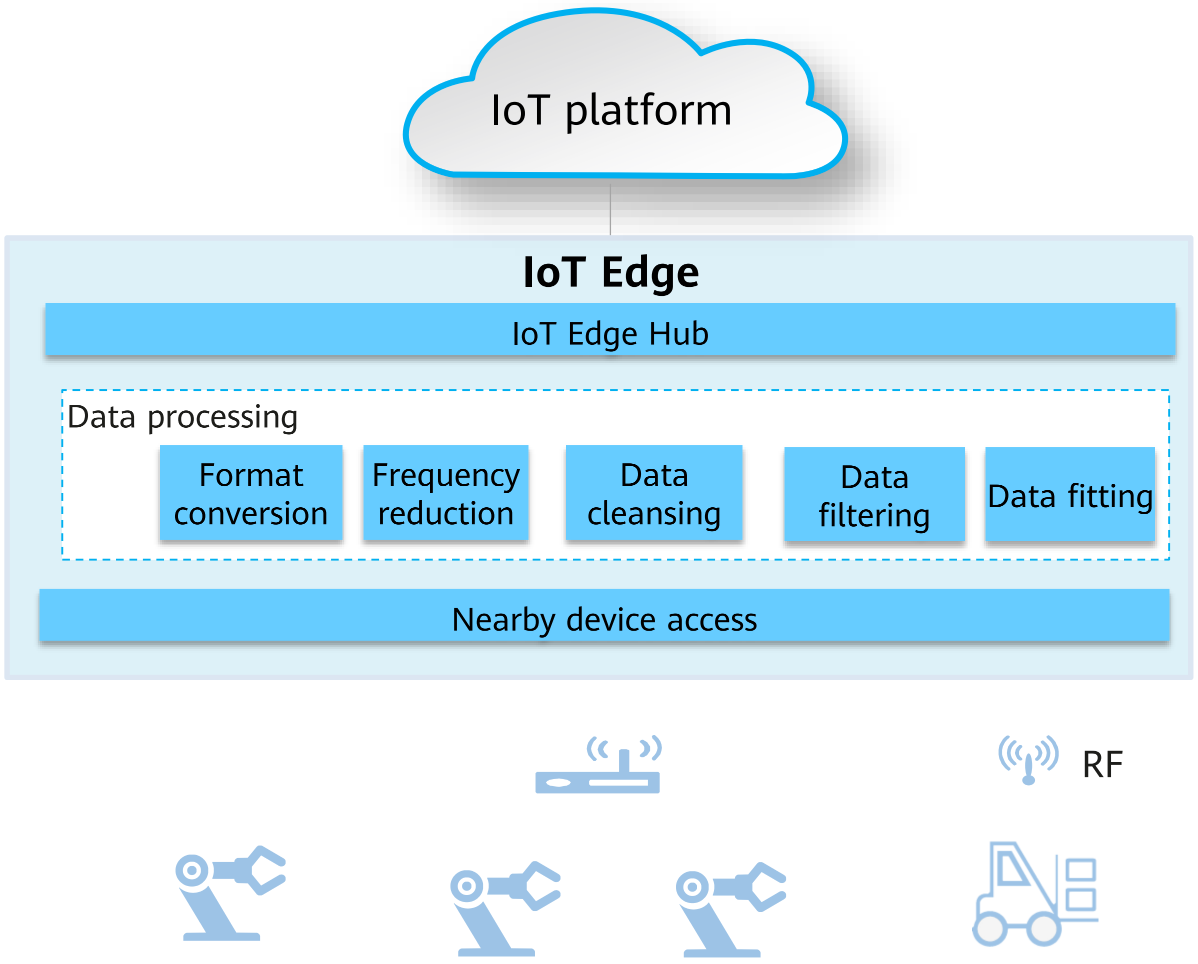
Diversified interfaces

- Industrial serial ports: RS232, RS485, and DI/DO
- Ethernet interfaces: FE and GE
- Wireless interfaces: RFID, Wi-Fi, and Bluetooth

Multi-interface, multi-protocol, and multi-language SDKs for quick device connection

Characteristics of Edge Computing Service (2)

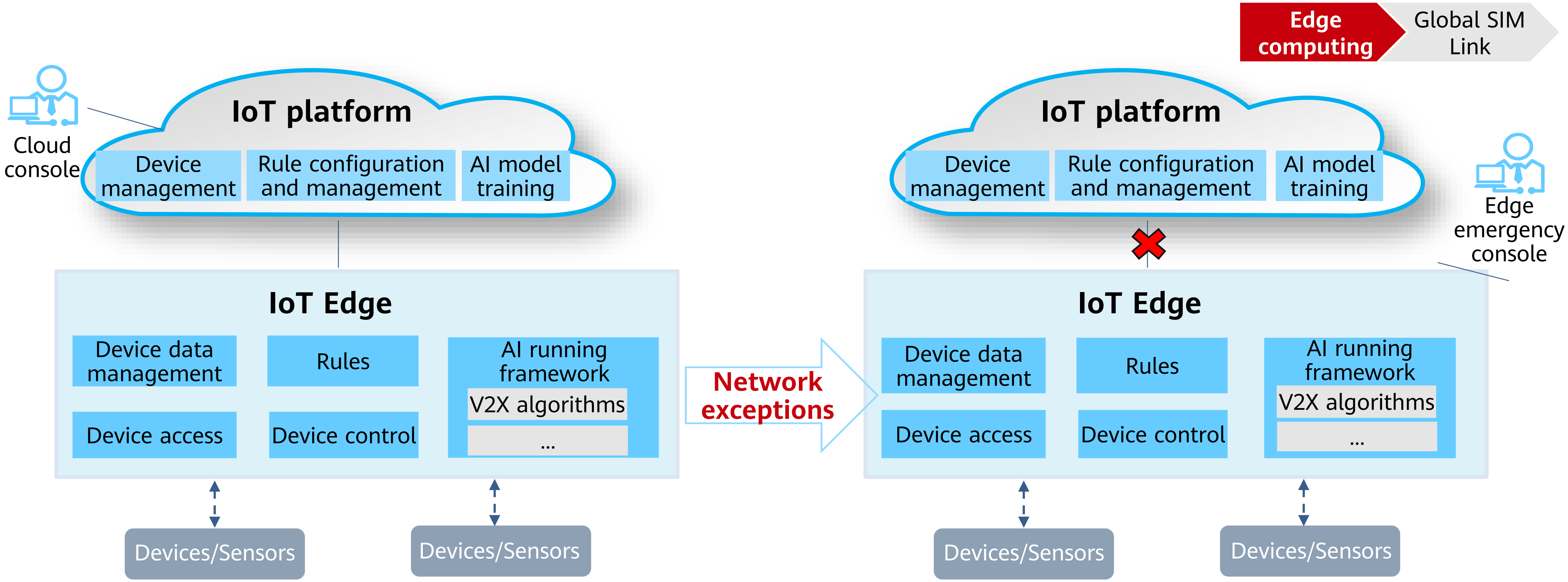
Edge computing | Global SIM Link



- **Format conversion**: conversion of different data formats and units
- **Frequency reduction**: custom data reporting periods
- **Data cleansing**: data deduplication and invalid data identification
- **Data filtering**: raw data filtering and reporting by data type and field
- **Data fitting**: multi-dimensional data calculation and fitting

Edge data processing in multiple scenarios

Characteristics of Edge Computing Service (3)



- **Central device and data management in the cloud**
- **Rules configured in the cloud and executed at the edge**
- **AI models trained in the cloud and executed at the edge**

Local autonomy ensures service continuity when the network is abnormal.

- **Emergency console at the edge for local management of devices and data**
- **Proper running of delivered rules and models, no service loss**
- **Data synchronized to the cloud after network recovery**

Global SIM Link

Edge computing | **Global SIM Link**

Pain Points

- Long period
- Difficult management
- High costs
- Information security

Key Features

✓ **Lifecycle management**
- Real-time SIM card status monitoring
- Real-time SIM card status management

✓ **Intelligent network handover**
- Remote SIM card provisioning
- Intelligent network handover based on network conditions

✓ **Connection diagnosis**
- One-click SIM card diagnosis

✓ **Automation rules**
- Customized automatic processing rules
- Customized platform capabilities

Global SIM Link

SIM card management
- Network coverage in 200+ countries/regions
- SIM card lifecycle management
- Remote eSIM/SOC SIM card provisioning, flexible selection of the optimal network

Device provisioning
- No configuration required during production; automatic access point selection upon power-on
- Nearest device access

Device access
- Multi-protocol access
- Local device access
- Device/Network diagnosis

Network enhancement
- Multi-mode, multi-access, multi-path monitoring
- Multi-connectivity policies
- Multi-SIM management

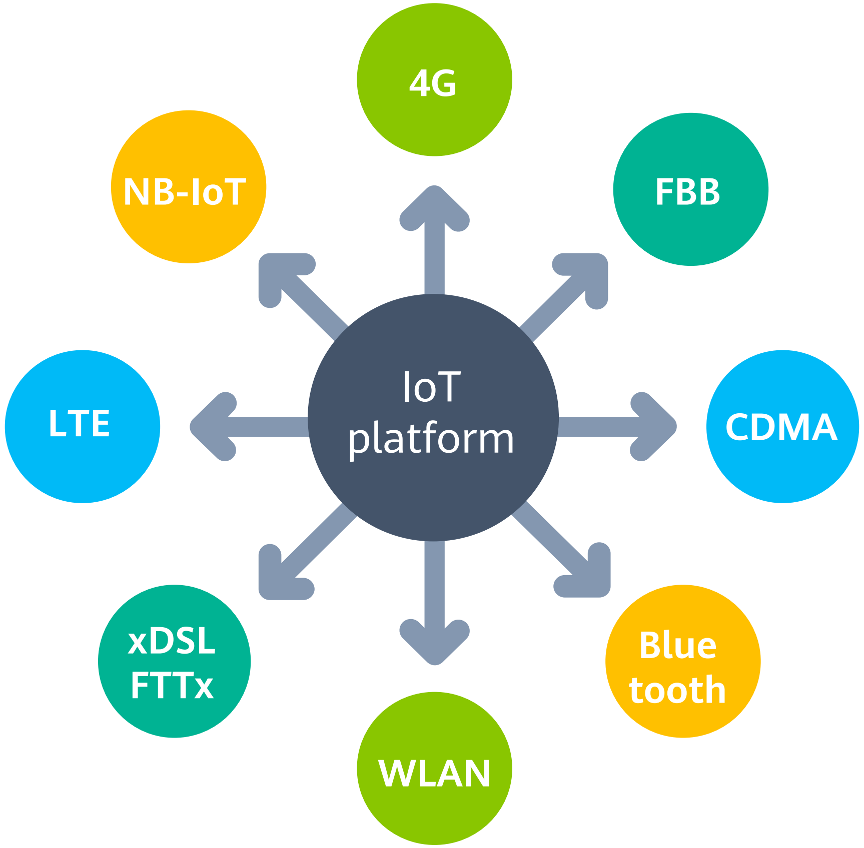
Global network coverage

MQTT, CoAP, HTTP, HTTPS, TCP, UDP, etc.

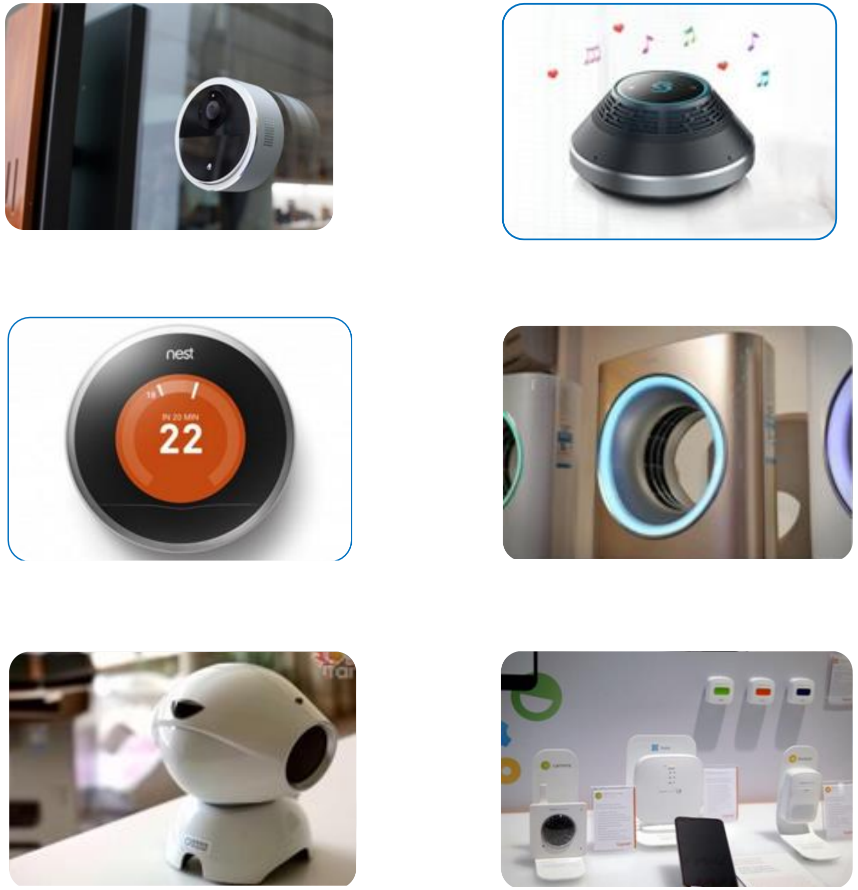
HUAWEI

Contents

Access Agnostic



Accessible any way you want



Accessible from any device

Reliable

System reliability

System clusters and VM reliability

Network reliability

1+1 mutual backup and pool modes

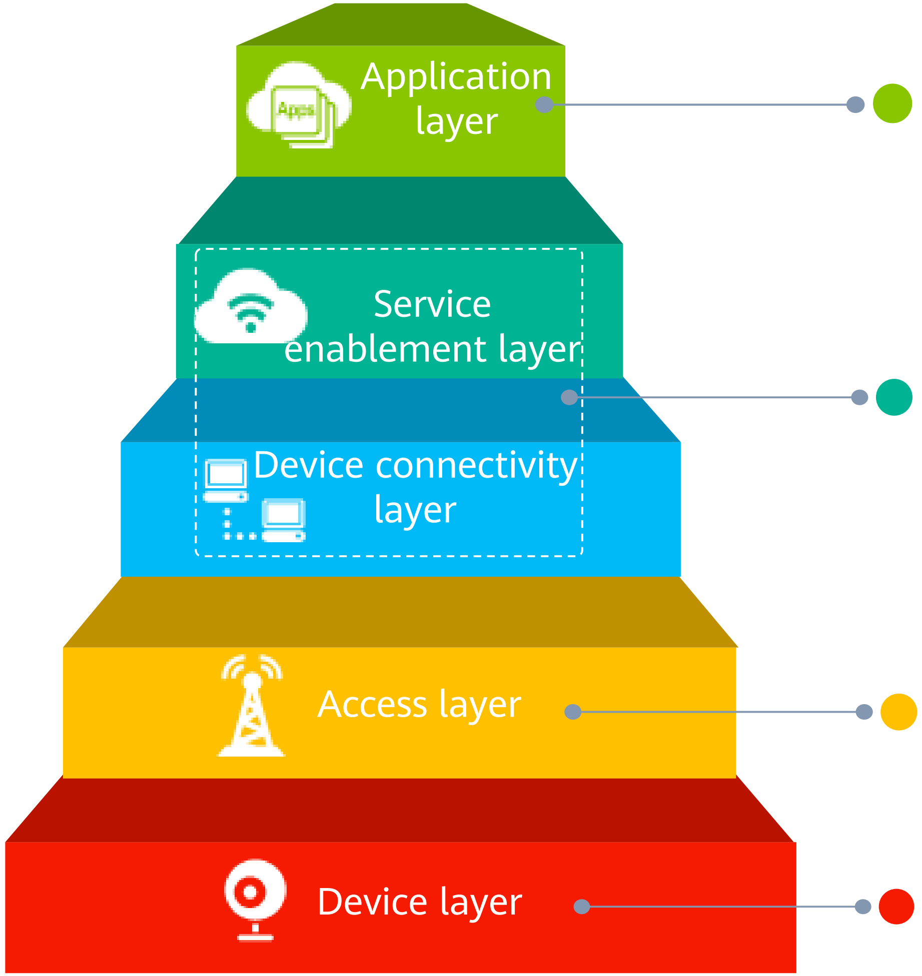
Service reliability

Traffic control, data encryption, and sensitive information shielding

Module reliability

Reliability policies provided by the rule engine module, API server module, and database module

Secure



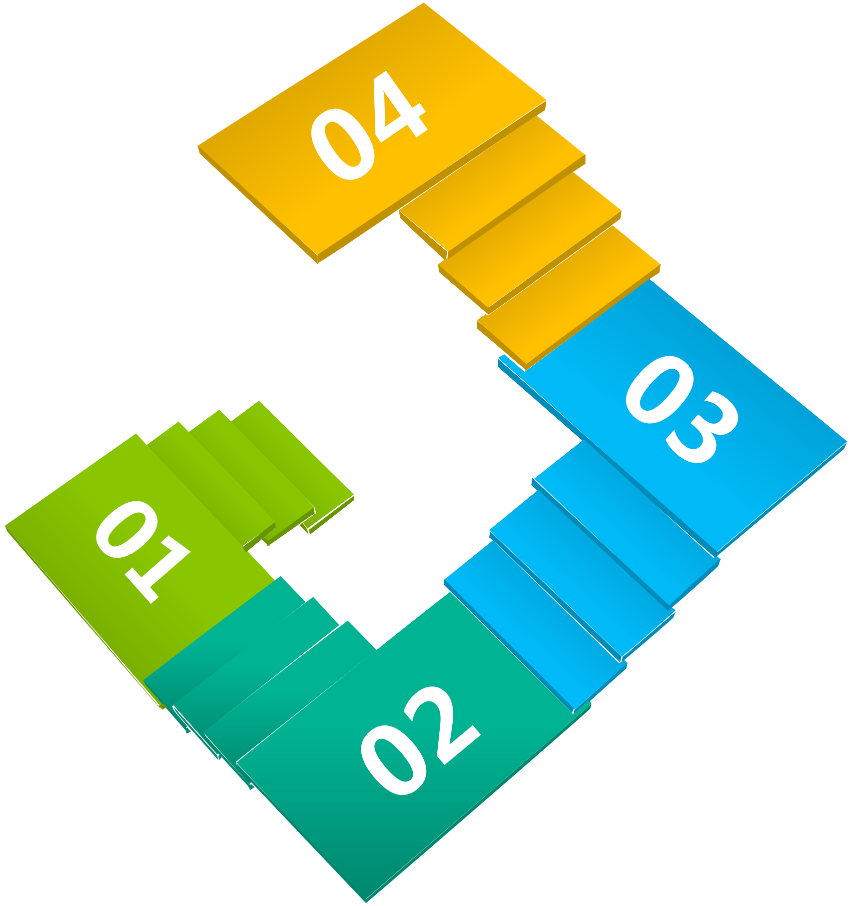
Service: ID authentication, service authentication, groups/policies, privacy protection, integrity, confidentiality, secret security, anti-repudiation, anti-replay, availability, and AES encryption

Platform: networking security, confidentiality, privacy, integrity, authentication, groups/policies, key security, availability, OAM, remote configuration security, software download authorization, and administrator grading

Access: confidentiality, data source authentication, device authentication, integrity, availability, and timeliness

Sensor: physical protection, access control, authentication, non-repudiation, confidentiality (grading), integrity, privacy, and availability

Scalable and Flexible

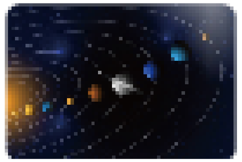


01

Flexible platform deployment

Freedom to choose a server or the cloud

02



Aggregated vertical capabilities

Deployment for one industry or multiple shared industries

03

Compatibility

No restrictions on devices from different manufacturers

04

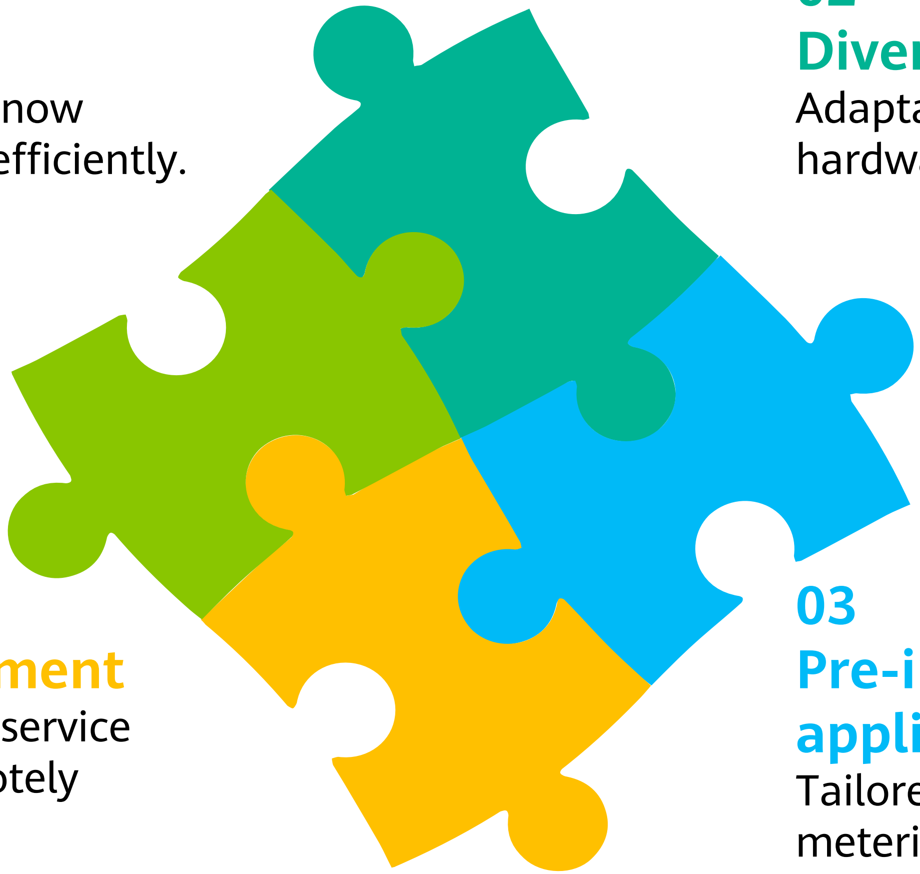
Modularized services/Flexible combination

Flexibility to deploy a single or multiple services

Open

01
Open APIs
Third-party applications are now integrated faster and more efficiently.

02
Diverse IoT Agents
Adaptable to different OSs and hardware.



03
Pre-integrated with high-value applications
Tailored for smart home, IoV, and smart metering applications.

04
Open device management
Service providers use a web-service interface to access and remotely operate devices.

Quiz

1. (True or False) HUAWEI CLOUD IoT platform supports two command delivery mode: immediate delivery and delayed delivery.
2. (True or False) Before connecting an IoT application to the IoT platform, authentication is required.
3. (Multiple Choice) Which of the following services are provided by the HUAWEI CLOUD IoT platform?
   A. IoT Device Access
   B. IoT Studio
   C. IoT Analysis
   D. IoT Edge

Summary

- This course covered the main challenges faced by the IoT industry and the importance of the IoT platform. It then described the hierarchical architecture, services, and characteristics of the HUAWEI CLOUD IoT platform.

Thank you.

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每个组织，构建万物互联的智能世界。

Bring digital to every person, home, and organization for a fully connected, intelligent world.

HUAWEI

IoT Platform Secondary Development

Foreword

- The HUAWEI CLOUD IoT platform enables southbound and northbound data exchange. Developers need to perform secondary development using this platform to implement end-to-end IoT services.

Objectives

- Upon completion of this course, you will:
  - Understand the main content of product development
  - Be able to describe development process on the device side
  - Master the process of calling APIs developed on the application side
  - Understand content and operations of routine cloud management

Contents

Introduction to Platform Secondary Development

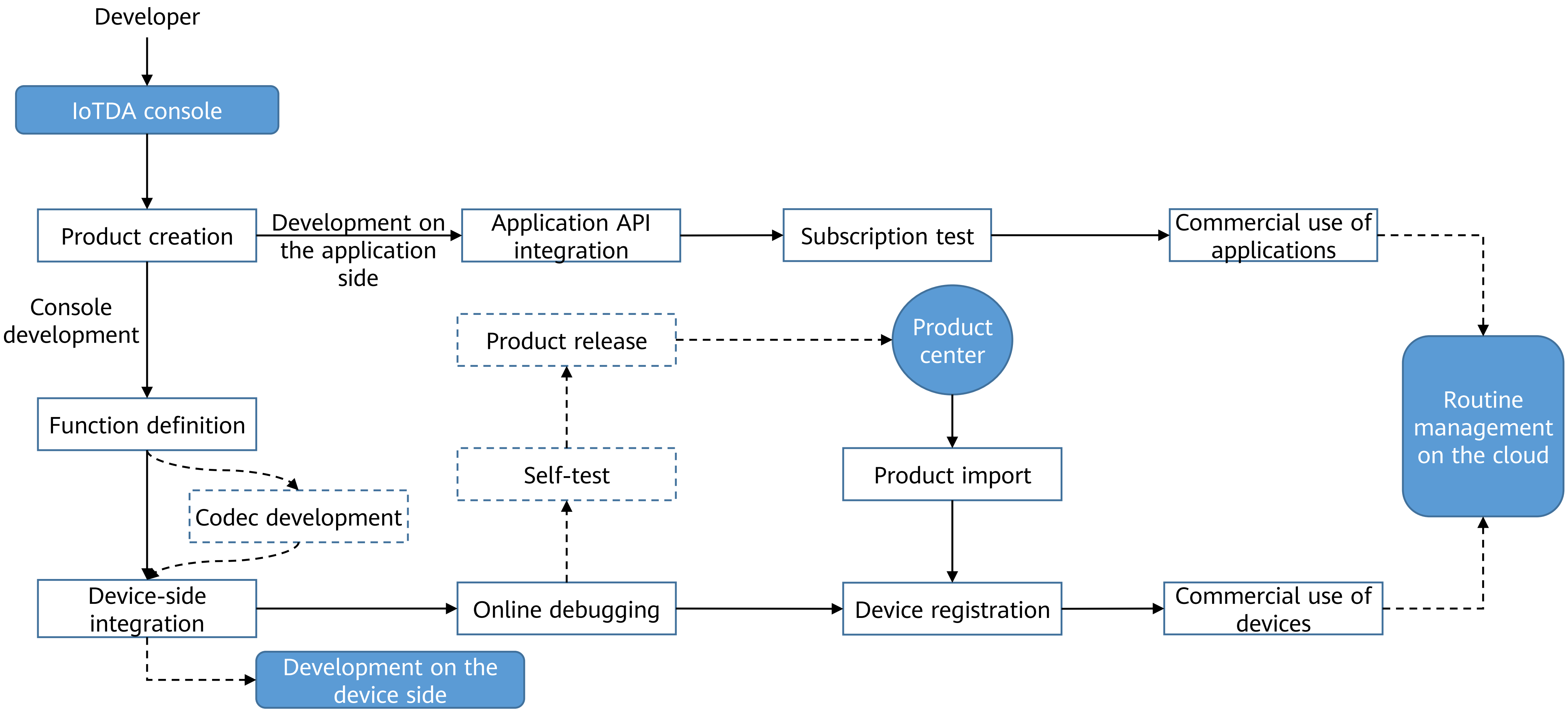
- To create an IoT solution based on the HUAWEI CLOUD IoT platform, you must perform the operations described in the table below.

Operation	Description
Product development	Manage products, develop product models and codecs, and perform online debugging on the IoT Device Access (IoTDA) console.
Development on the application side	Carry out development for interconnection between applications and the platform, including calling APIs, obtaining service data, and managing HTTPS certificates.
Development on the device side	Integrate and interconnect devices with the IoT platform, including connecting devices to the IoT platform, reporting service data to the platform, and processing commands delivered by the platform.

- The process of using IoTDA, including product, application, device, and routine management.
  - **Product development:** You can perform development operations on the IoTDA console. For example, you can create a product or device, develop a product model or codec online, perform online debugging, carry out self-service testing, and release products.
  - **Development on the application side:** The platform provides robust device management capabilities through APIs. You can develop applications based on the APIs to meet requirements in different industries such as smart city, smart campus, smart industry, and IoV.
  - **Development on the device side:** You can connect devices to the platform by integrating SDKs or modules, or using native protocols.
  - **Routine management:** After a physical device is connected to the platform, you can perform routine device management on the IoTDA console or by calling APIs.

Contents

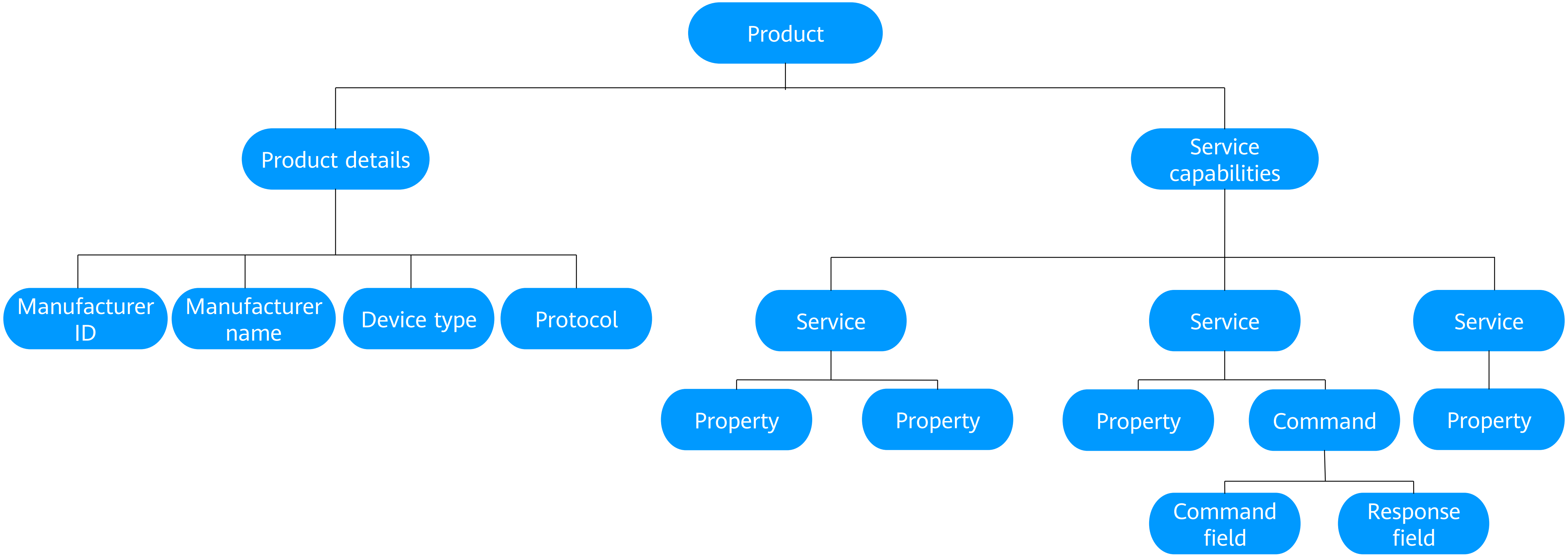
Development Process: Product Development and Development on the Application Side



Product Model (1)

- A product model, also known as a **profile**, defines the properties of a device, such as the color, size, collected data, identifiable commands, and reported events. The manufacturer, device type, and device model are used together to uniquely identify a product model. You can easily develop product models on the IoTDA console without writing any code.
- A profile (product model) is a file that describes **what a device is, what it can do, and how to control it**. You can build an abstract model of a device by defining a product model on the IoT platform so that the platform can know what services, properties, and commands are supported by the device, such as its color or any on/off switches. After defining a product model, you can use it for device registration.

Product Model (2)



- On the IoT platform, the product model is the key to device access. It contains the capabilities and services of a device and the data formats of upstream and downstream device messages. For example, when a device reports data to the IoT platform, the IoT platform matches the product model based on the keywords of the reported data and verifies the data format. **Only data that is matched is saved on the IoT platform.** If the reported data is not matched with the configuration in the product model, the data is considered invalid and dropped.

Product Model (3)

- Product Details
  - Product details describe basic information about a device, including the manufacturer ID, manufacturer name, device type, and protocol.
  - For example, the manufacturer name of a water meter could be ‘HZYB', the manufacturer ID 'TestUtf8ManuId', the device type 'WaterMeter', and the protocol 'CoAP'.
- Service Capabilities
  - Service capabilities of a device need to be defined. Device capabilities are divided into several services. The properties, commands, and command parameters of each service are defined in the product model.
  - Take a water meter as an example. It has multiple capabilities, such as reporting data about the water flow, alarms, power, and connections, and receiving commands from a server. When describing the capabilities of a water meter, the profile includes five services, each of which has its own properties or commands.

Service Capability - Water Meter

Service	Description
Basics (WaterMeterBasic)	Used to define parameters reported by the water meter, such as the water flow, temperature, and pressure. If these parameters need to be controlled or modified using commands, you also need to define parameters in the commands.
Alarm (WaterMeterAlarm)	Used to define data reported by the water meter in various alarm scenarios. Commands need to be defined if necessary.
Battery (Battery)	Used to define data including the voltage and current intensity of the water meter.
Transmission rule (DeliverySchedule)	Used to define transmission rules for the water meter. Commands need to be defined if necessary.
Connectivity (Connectivity)	Used to define connection parameters of the water meter.

- The HUAWEI CLOUD IoT platform provides multiple methods for developing product models. You can select one that suits your needs.
  - Importing models (preset product models on the platform)
  - Uploading a profile (offline development)
  - Importing models in an Excel file
  - User-defined functions (online development)

Profile Example

Properties/Commands

Agriculture

Service Description:

Add Property

Property Name	Data Type	Mandatory	Access Mode	Operation
Temperature	integer	False	Executable,Readable,Writable	Copy | Edit | Delete
Humidity	integer	False	Executable,Readable,Writable	Copy | Edit | Delete
Luminance	integer	False	Executable,Readable,Writable	Copy | Edit | Delete

Add Command

Command Name	Downlink Parameter	Response Parameter	Operation
Agriculture_Control_Light	Light	Light_State	Copy | Edit | Delete
Agriculture_Control_Motor	Motor	Motor_State	Copy | Edit | Delete

Contents

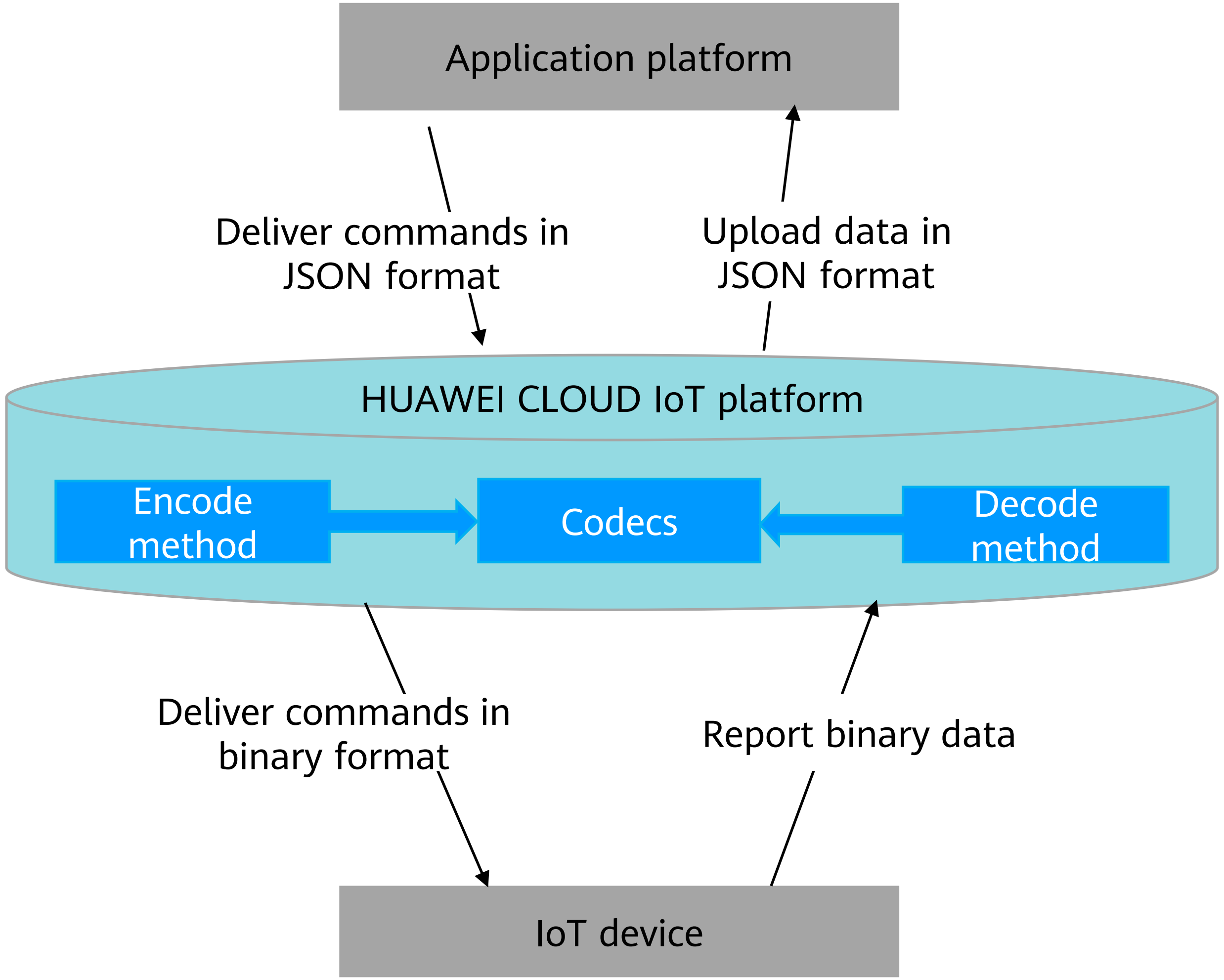
Codec (1)

- What Is a Codec?
  - The codec decodes binary data reported by devices into JSON data that can be read by the application and encodes downstream command data in JSON format of the application into binary data that can be executed by devices.
- Why Is the Codec Used?
  - NB-IoT devices use data in binary or TLV format.
    - CoAP is used for communication between NB-IoT devices and the IoT platform. The payload of CoAP messages carries data at the application layer, at which the data type is defined by the devices. Because NB-IoT devices have high requirements on power consumption, their application layer data is not in JSON format.
  - The application does not understand data in binary or TLV format.

Codec (2)

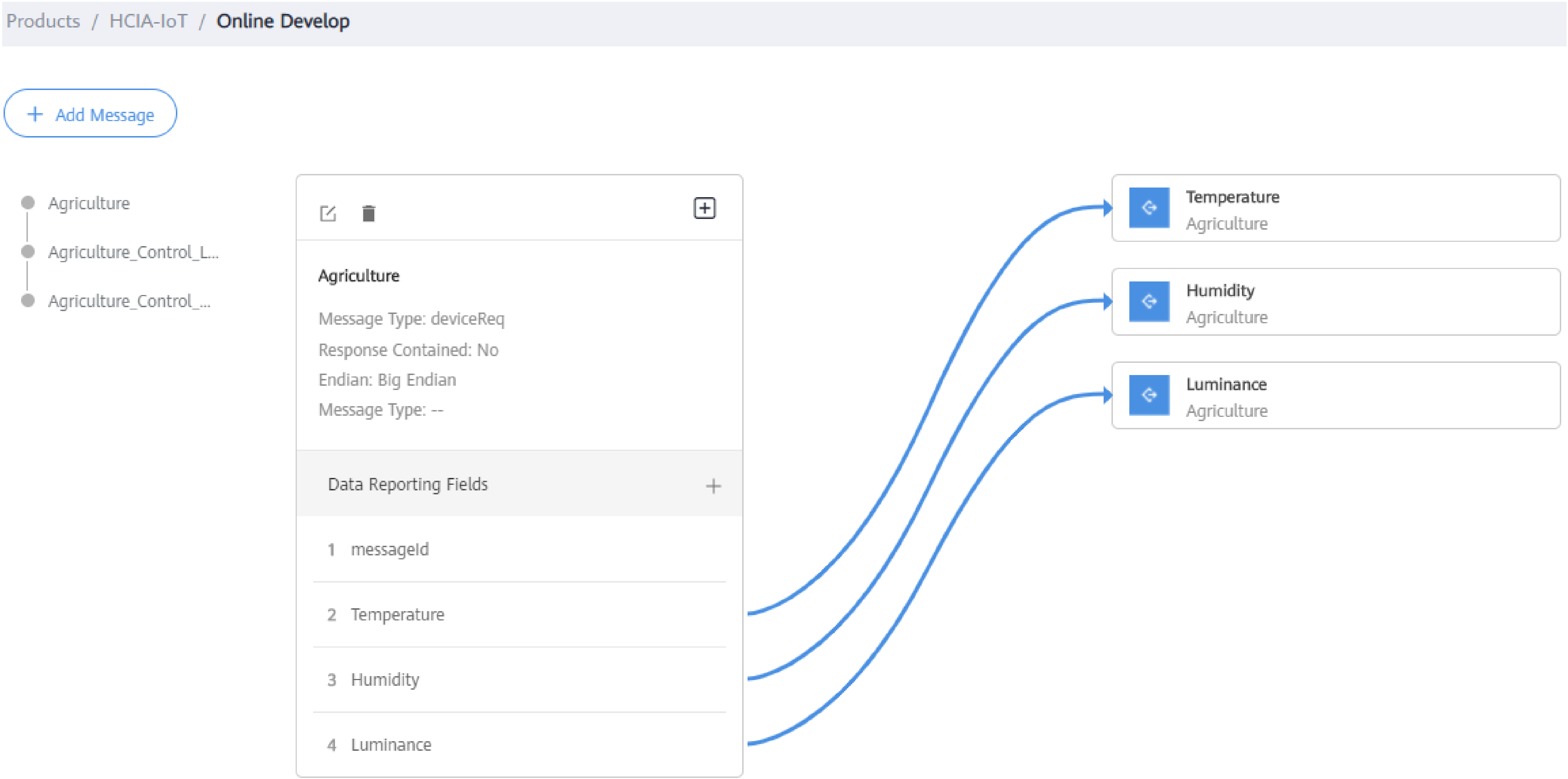
- Developing a Codec
  - The platform provides three methods for developing codecs. Offline codec development is complex and time-consuming. **Graphical codec development** is recommended.
    - **Graphical development**: The codec of a product can be quickly developed in a visualized manner on the IoTDA console.
    - **Offline Development**: A codec is developed through secondary development based on the Java codec demo to implement encoding, decoding, packaging, and quality inspection.
    - **Script-based development**: JavaScript scripts are used to implement encoding and decoding.
  - The IoT platform abstracts and encapsulates the original codec development code. Therefore, developers can develop codecs simply by defining the format of code streams reported by devices and mapping the properties in the code streams and the profiles in a graphical way. When the development is complete, the codec is automatically generated and can be deployed on the IoT platform.

Codec (3)



Application platform
Deliver commands in JSON format
Upload data in JSON format
HUAWEI CLOUD IoT platform
Encode method
Codecs
Decode method
Deliver commands in binary format
Report binary data
IoT device

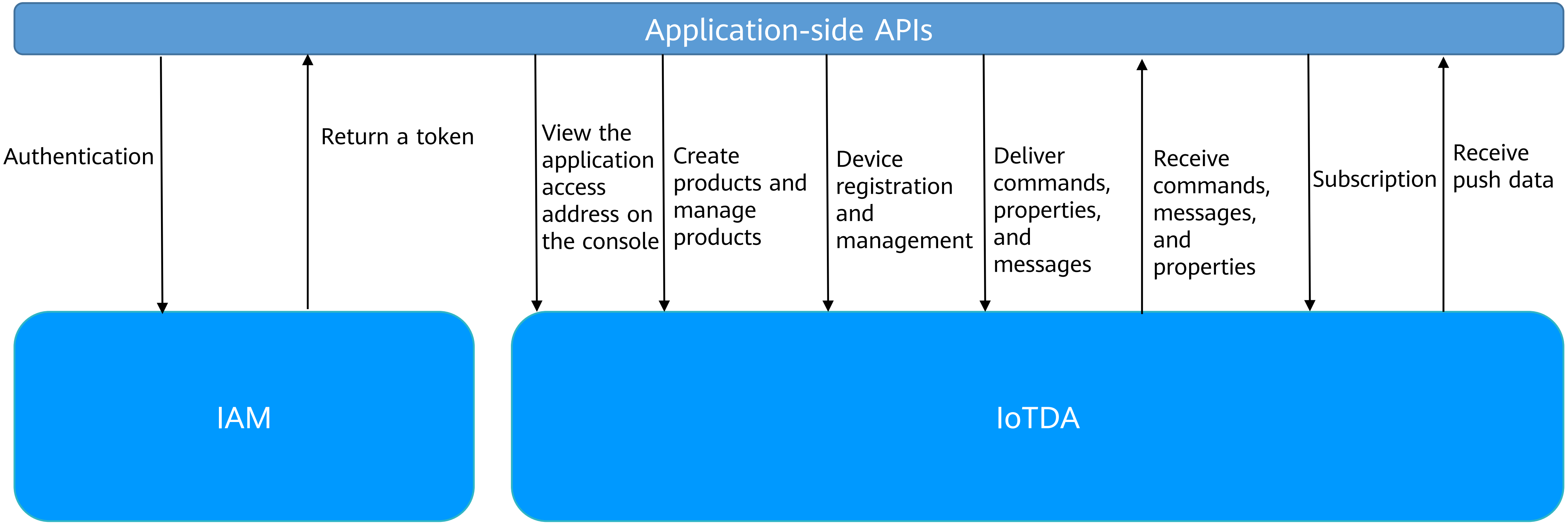
Codec Example



Contents

Development on the Application Side

- The IoT platform provides APIs to make application development more easy and efficient. You can call these open APIs to quickly integrate platform functions, such as product, device, subscription, and rule management, as well as device command delivery.



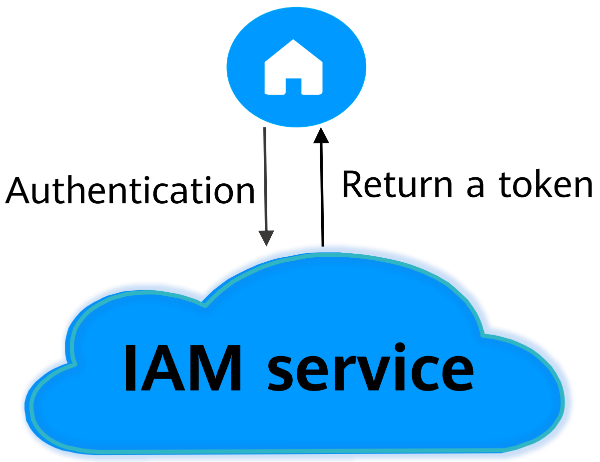
Northbound APIs of the IoT Platform

- The HUAWEI CLOUD IoT platform provides various northbound RESTful APIs for application developers to quickly develop IoT applications based on the capabilities provided by the platform.
- Northbound APIs provided by the HUAWEI CLOUD IoT platform include:
  - Subscription management
  - Product management
  - Device management
  - Device messages
  - Device commands
  - Device properties
  - Device shadows
  - Device group management
  - Tag management
  - Resource space management
  - Batch task
  - Batch task file management
  - Device CA certificate management
  - Rule management

Action	Description
GET	Obtains resources from the server.
POST	Creates a resource from the server.
PUT	Updates resources on the server.
DELETE	Deletes resources from the server.

Parameter	Description
header	Parameter of the HTTP message header.
path	Parameter of the path part in the URL.
query	Parameter behind the question mark (?) in the URL.
body	Parameter of the HTTP message body.

Application Access Authentication



Method: POST

Request:

```
https://iam.cn-north-4.myhuaweicloud.com/v3/auth/tokens

Content-Type: application/json //Body:{

    "auth": {
        "identity": {
            "methods": [
                "password" ],
            "password": {
                "user": {
                    "name": "username",
                    "password": "********",
                    "domain": {
                        "name": "domainname"
                    }
                }
            }
        },
        ...
    }
}// username indicates the IAM username, and password indicates the password for logging in to HUAWEI CLOUD.
```

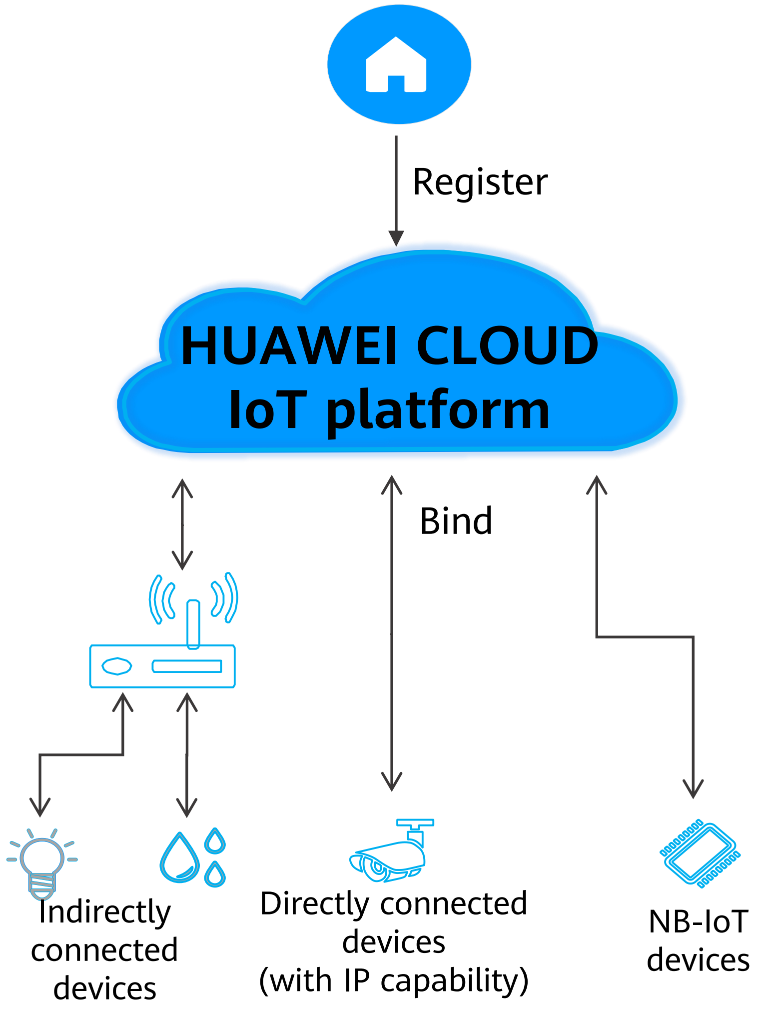
Response:

```
//Status Code:
Status Code: 201 Created
// Response header:

X-Auth-Token:MIIatAYJKoZIhvcNAQcCoIIapTCCGqECAQExDTALB... //Body: {

    "token": {
        "catalog": [],
        "expires_at": "2020-01-04T09:05:22.701000Z",
        "issued_at": "2020-01-03T09:05:22.701000Z",
        "methods": [
            "password"
        ],
        "project": {
            "domain": {
                "id": "d78cbac186b744899480f25bd022f...",
                "name": "IAMDomain"
            },
...
} //X-Auth-Token is the secret used for subsequent device and data operations.
```

Creating a Device



Method: POST

Request:

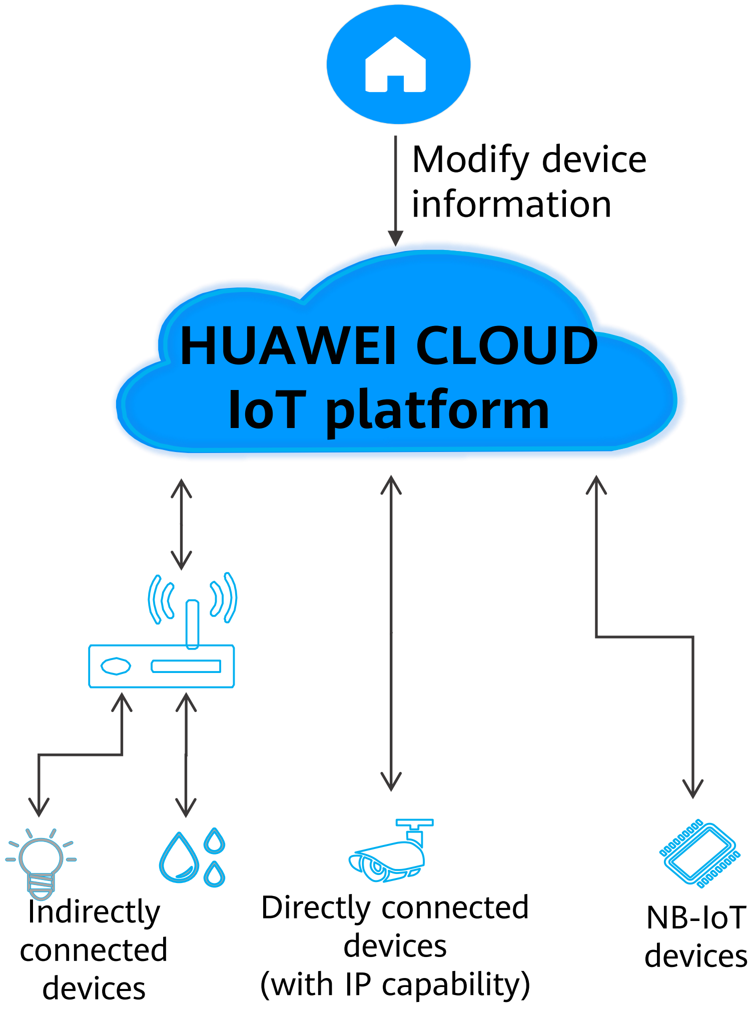
```
https://{Endpoint}/v5/iot/{project_id}/devices
Content-Type: application/json
X-Auth-Token: ********
Instance-Id: ********
{
  "device_id" : "d4922d8a-6c8e-4396-852c-164aefa6638f",
  "node_id" : "ABC123456789",
  "device_name" : "dianadevice",
  "product_id" : "b640f4c203b7910fc3cbd446ed437cbd",
  "auth_info" : {
    "auth_type" : "SECRET",
    "secure_access" : true,
    "fingerprint" : "dc0f1016f495157344ac5f1296335cff725ef22f",
    "secret" : "3b935a250c50dc2c6d481d048cefdc3c",
    "timeout" : 300
  },
  ...
}
```

Response:

```
// Status Code:
Status Code: 201 Created

Content-Type: application/json
// Body:
{
  "app_id" : "***",
  "app_name" : "***",
  "device_id" : "***",
  "node_id" : "***",
  "gateway_id" : "***",
  "device_name" : "***",
  "node_type" : "***",
  "description" : "***",
  "fw_version" : "1.1.0",
  "sw_version" : "1.1.0",
  "auth_info" : {
    "auth_type" : "SECRET",
    "secret" : "***",
    "fingerprint" : "***",
    "secure_access" : true,
    "timeout" : 300
  },
  ...
  }
}
```

Modifying Device Information



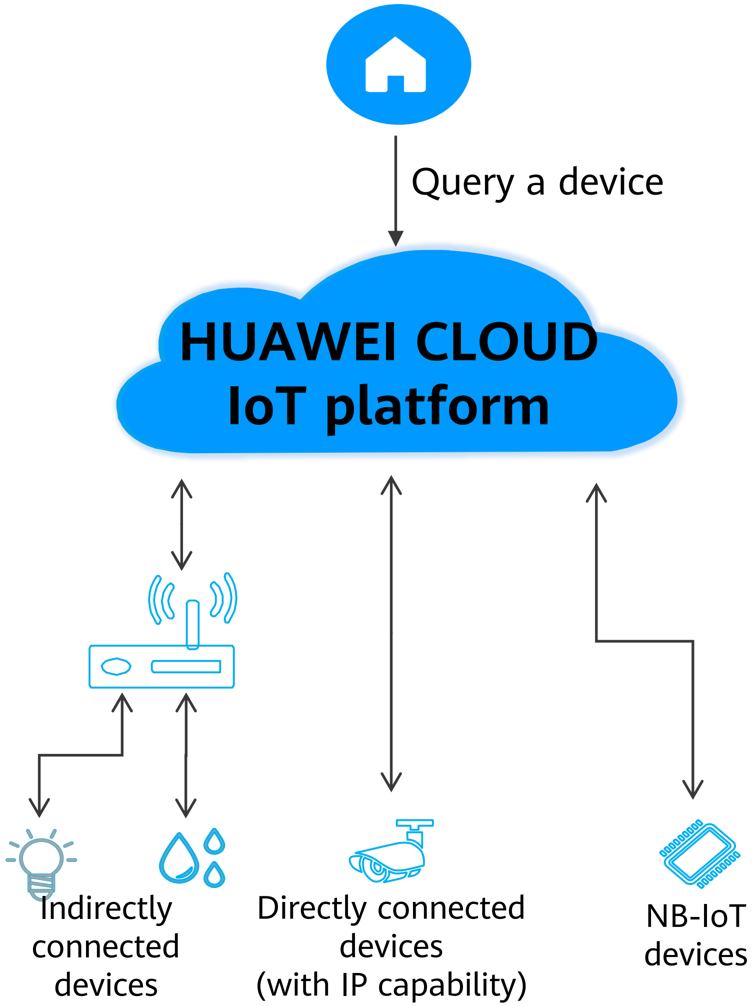
Method: PUT

Request:
https://{Endpoint}/v5/iot/{project_id}/devices/{device_id}
Content-Type: application/json
X-Auth-Token: ********
Instance-Id: ********

```
{
  "device_name" : "dianadevice",
  "description" : "watermeter device",
  "extension_info" : {
    "aaa" : "xxx",
    "bbb" : 0
  },
  "auth_info" : {
    "secure_access" : true,
    "timeout" : 300
  }
}
```

Response:
// Status Code:
Status Code: 200 OK

Querying a Device



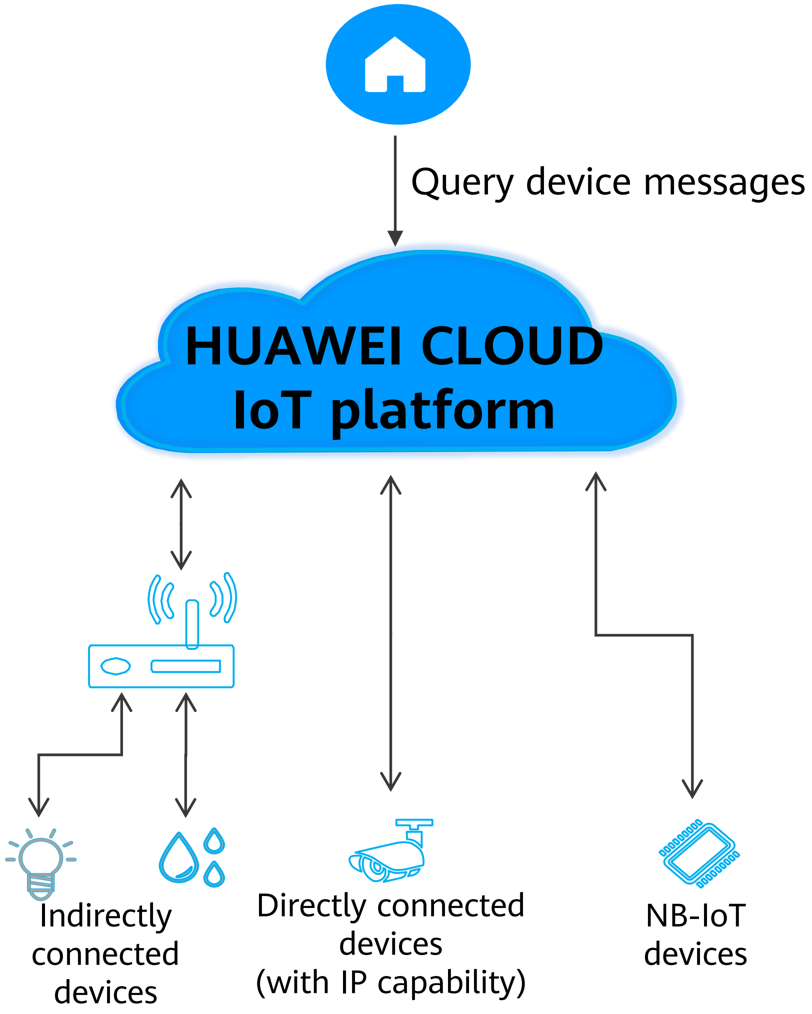
Method: GET

Request:
https://{Endpoint}/v5/iot/{project_id}/devices/{device_id}
Content-Type: application/json
X-Auth-Token: ********
Instance-Id: ********

Response:
// Status Code:
Status Code: 200 OK
Content-Type: application/json
//Body:

```
{
 "app_id" : "***",
  "app_name" : "***",
  "device_id" : "***",
  "node_id" : "***",
  "gateway_id" : "***",
  "device_name" : "***",
  "node_type" : "***",
  "description" : "***",
  "fw_version" : "1.1.0",
  "sw_version" : "1.1.0",
  "auth_info" : {
    "auth_type" : "***",
    "secret" : "***",
    "fingerprint" : "***",
    "secure_access" : true,
    "timeout" : 300
  },
...}
```

Querying Device Messages



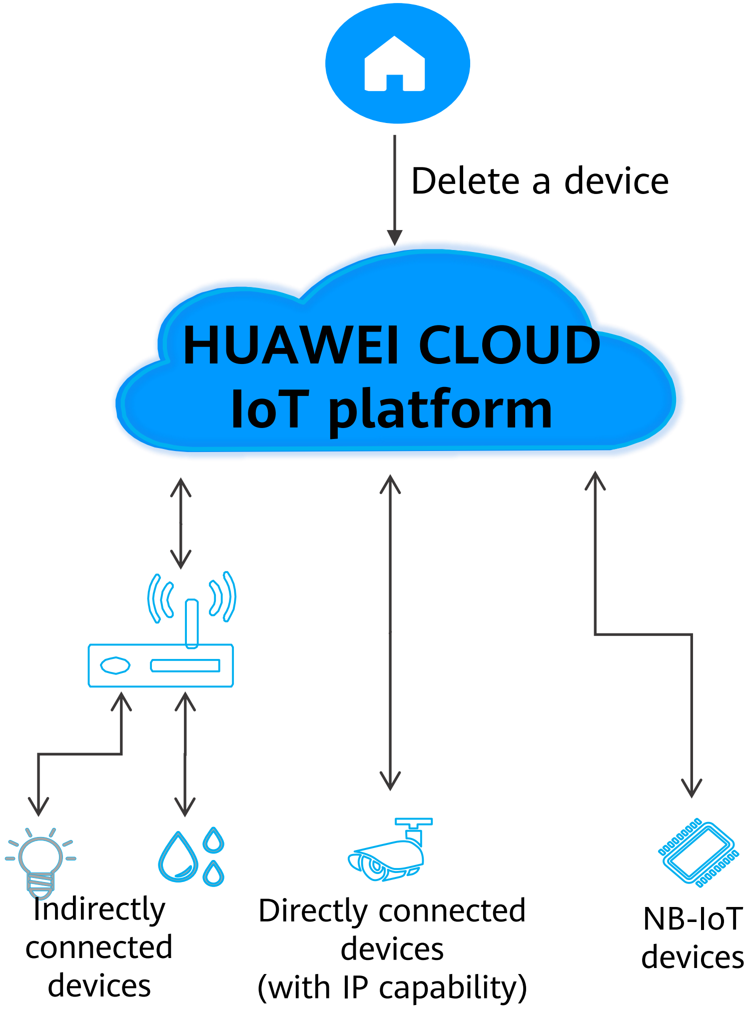
Method: GET

Request:
https://{Endpoint}/v5/iot/{project_id}/devices/{device_id}/messages
Content-Type: application/json
X-Auth-Token: ********
Instance-Id: ********

Response:
// Status Code:
Status Code: 200 OK
Content-Type: application/json


```
{
  "device_id" : "d4922d8a-6c8e-4396-852c-164aefa6638f",
  "messages" : [ {
    "message_id" : "b1224afb-e9f0-4916-8220-b6bab568e888",
    "name" : "message_name",
    "message" : "string",
    "topic" : "string",
    "status" : "PENDING",
    "created_time" : "20151212T121212Z",
    "finished_time" : "20151212T121212Z"
  } ]
}
```

Deleting a Device



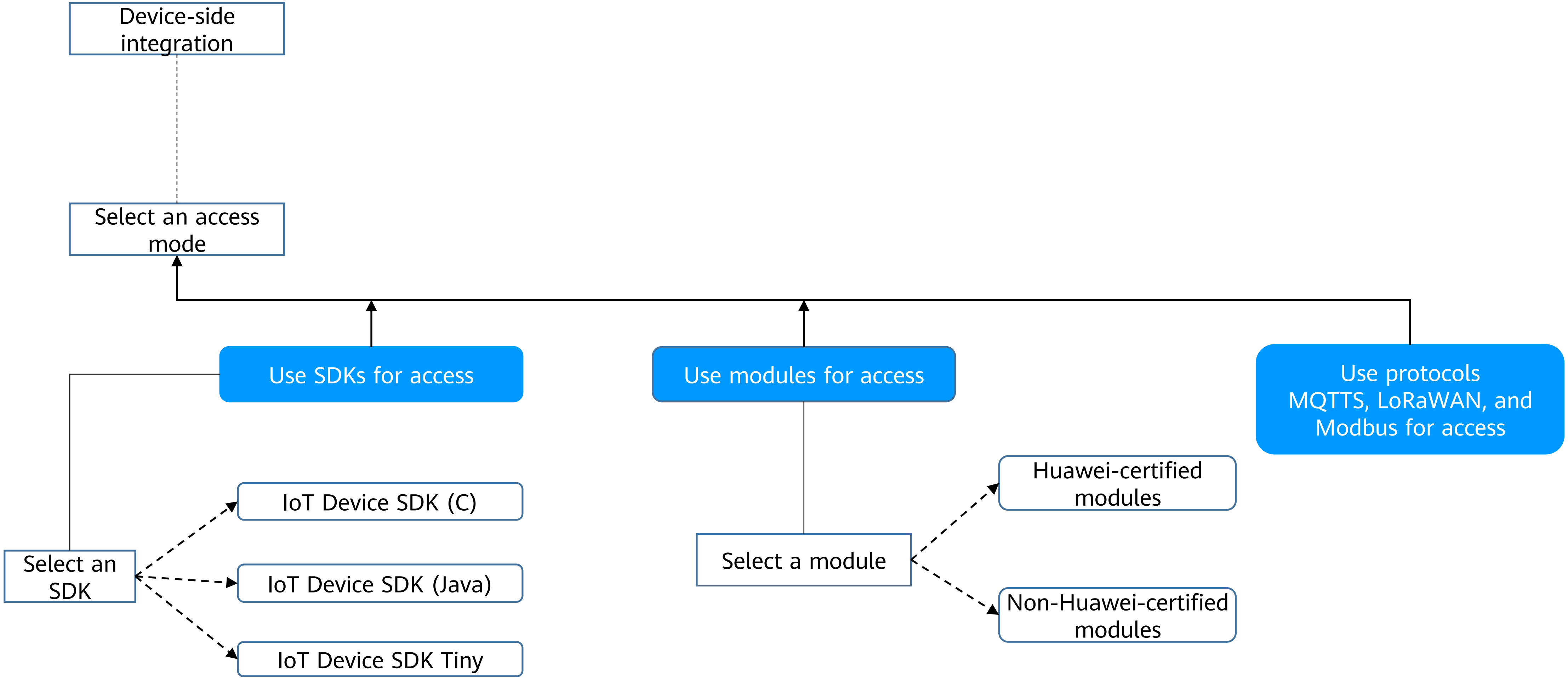
Method: DELETE

Request:
https://{Endpoint}/v5/iot/{project_id}/devices/{device_id}
Content-Type: application/json
X-Auth-Token: ********
Instance-Id: ********

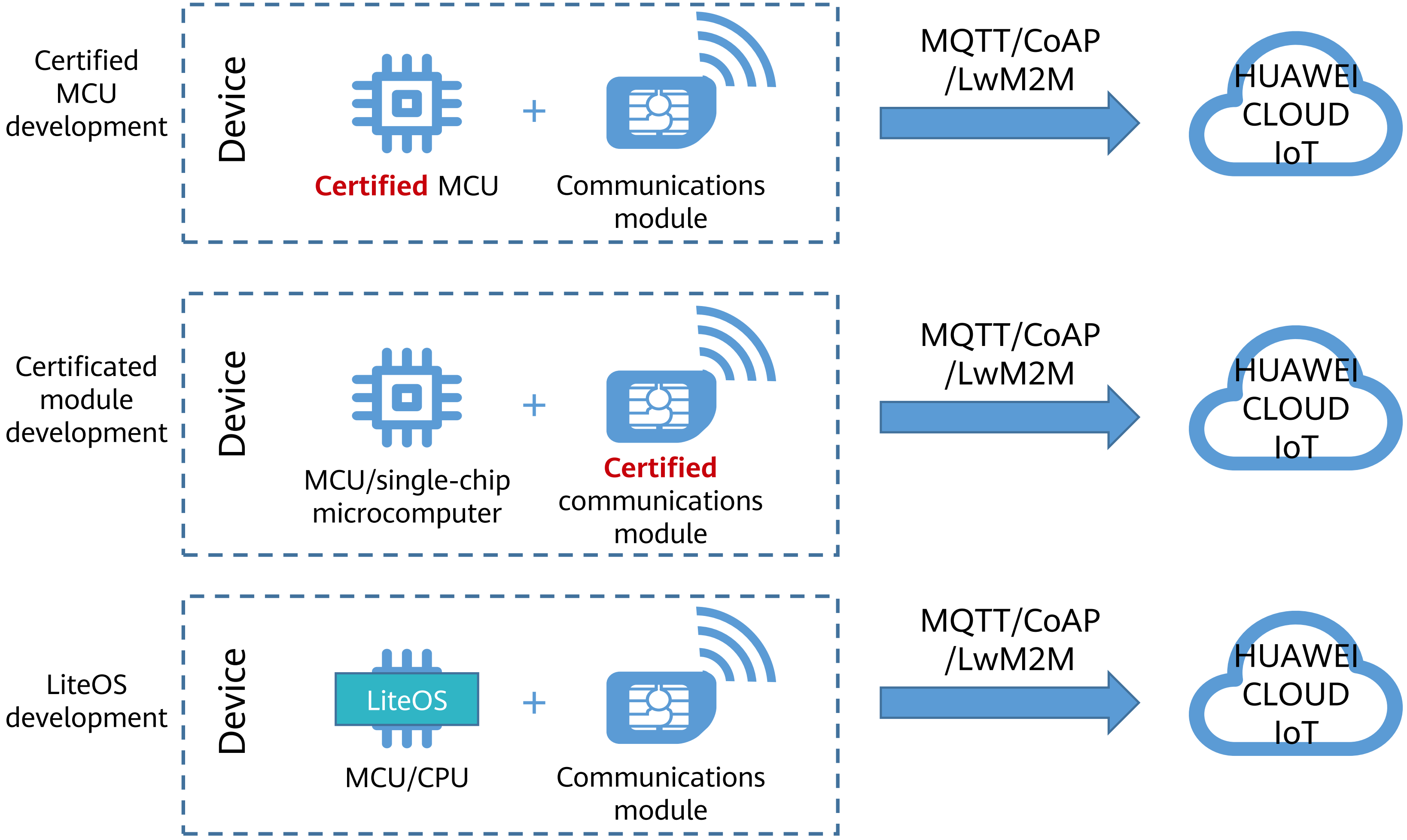
Response:
Status Code: 204 No Content

Contents

Platform Development Process: Development on the Device Side



Development on the Device Side (1)

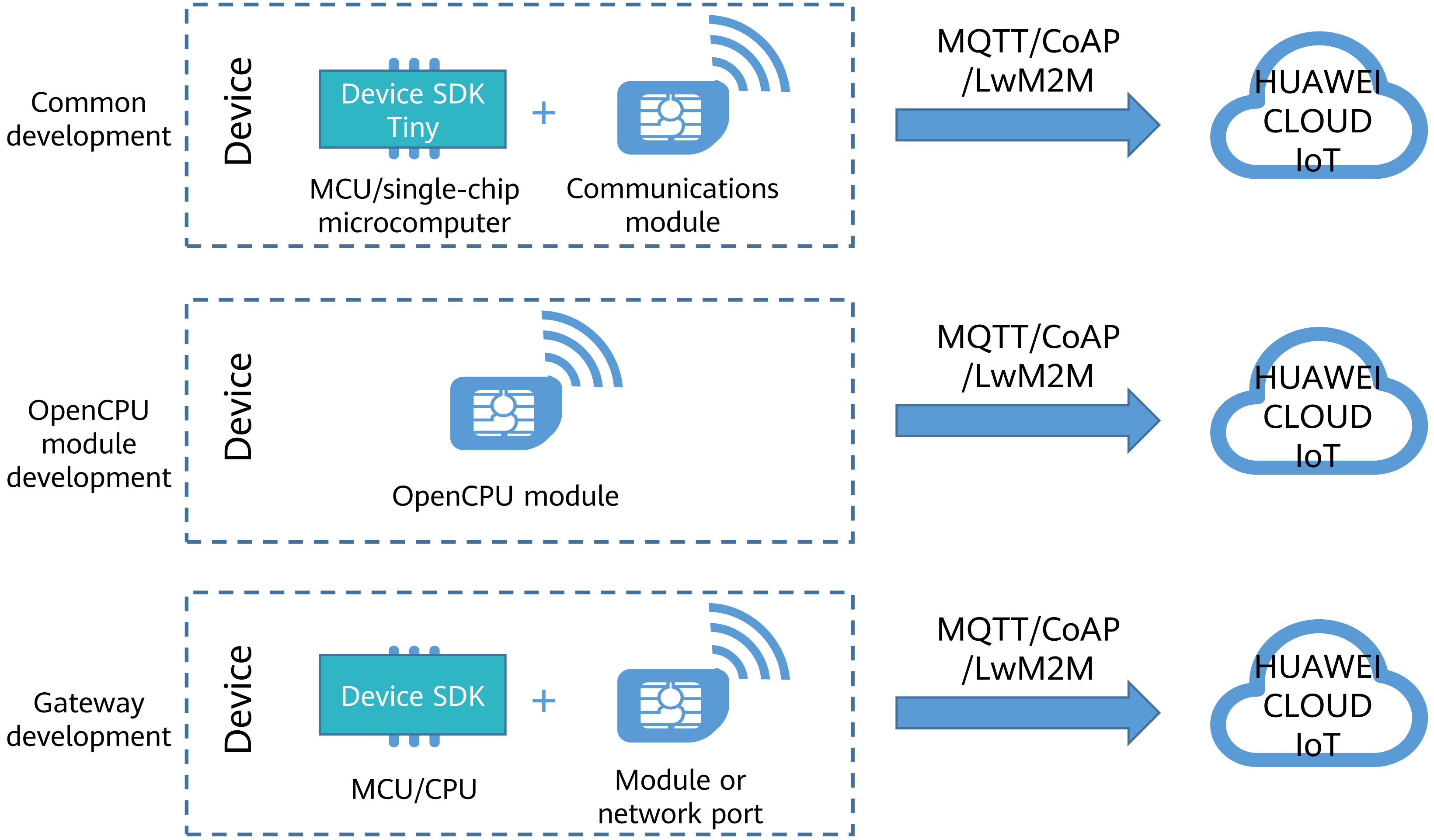


The device uses the Huawei-certified MCU to directly call functions, facilitating platform connection.

The device uses the Huawei-certified module to directly call AT commands, facilitating platform connection.

The device uses the MCU or CPU where Huawei LiteOS is installed, facilitating platform connection.

Development on the Device Side (2)



The device integrates the SDK Tiny into the MCU or single-chip microcomputer to connect to the platform.

The device uses the OpenCPU module to integrate the SDK to connect to the IoT platform.

The gateway integrates the Device SDK into the MCU/CPU to connect to the platform.

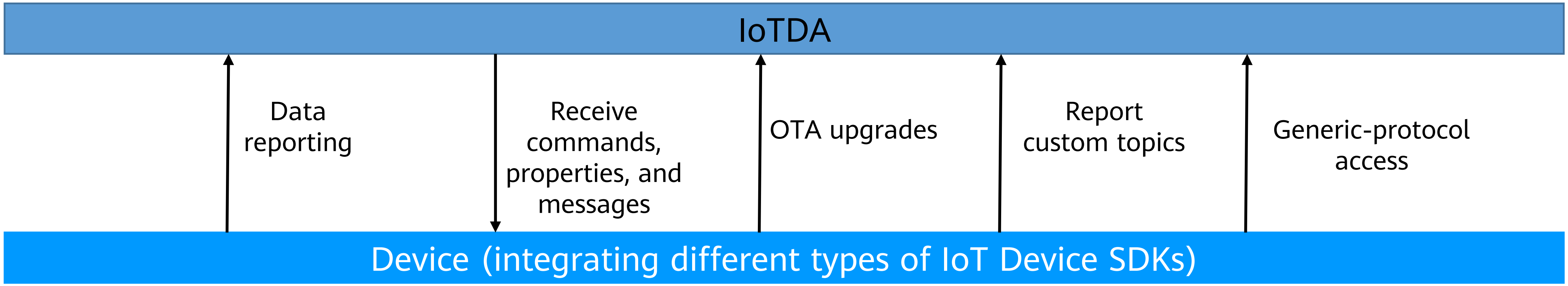
Using IoT Device SDKs for Access

- You can use Huawei IoT Device SDKs to quickly connect devices to the IoT platform. After being integrated with an IoT Device SDK, devices that support the TCP/IP protocol stack can communicate directly with the IoT platform. Devices that do not support the TCP/IP protocol stack, such as Bluetooth and Zigbee devices, need to use a gateway integrated with the IoT Device SDK to communicate with the platform.

1. Create a product on the IoTDA console or by calling the API **Creating a Product**.

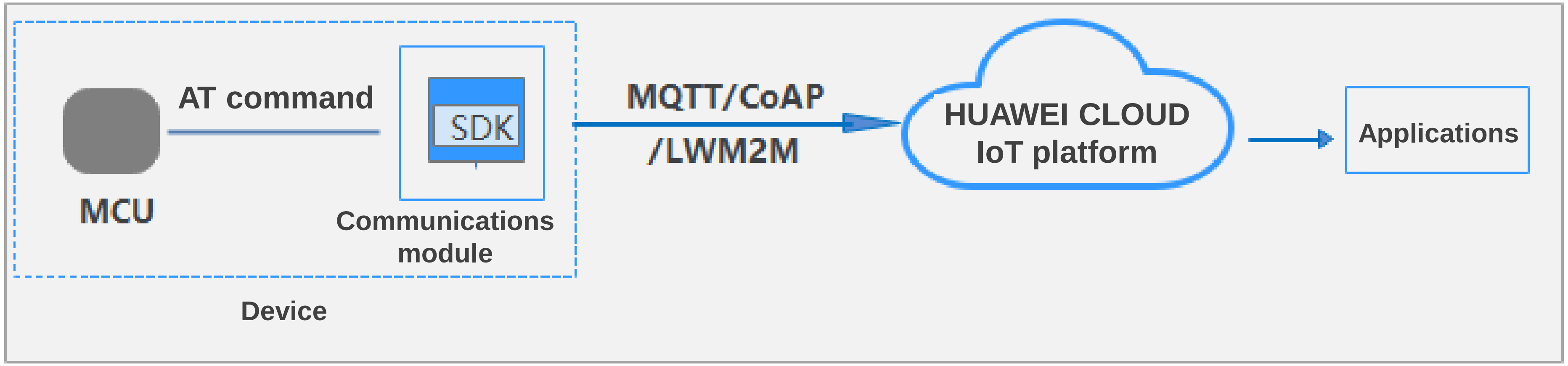
2. Register the device on the IoTDA console or by calling the API **Creating a Device**.

3. Implement the functions demonstrated in the figure, including reporting messages/properties, receiving commands/properties/messages, OTA upgrades, topic customization, and generic-protocol access.



Using Huawei - Certified Modules for Access

- Certified modules are pre-integrated with the IoT Device SDK Tiny. They have passed Huawei tests, and comply with Huawei's AT command specifications. The following benefits are available for Huawei-certified modules:
  - Device manufacturers do not need to worry about how to connect to the HUAWEI CLOUD IoT platform on the MCU (for example, how to set the secret encryption algorithm and clientID composition mode during MQTT connection setup). To connect their devices to the platform, they only need to invoke AT commands. This accelerates device interconnection and commissioning.
  - The MCU does not need to integrate the MQTT protocol stack or IoT Device SDK Tiny, greatly reducing MCU resource consumption.
  - Huawei releases certified modules on HUAWEI CLOUD Marketplace so that device manufacturers and service providers can purchase these certified modules to quickly connect to HUAWEI CLOUD IoT.
- The following figure shows how a certified module is used to connect a device to the platform.

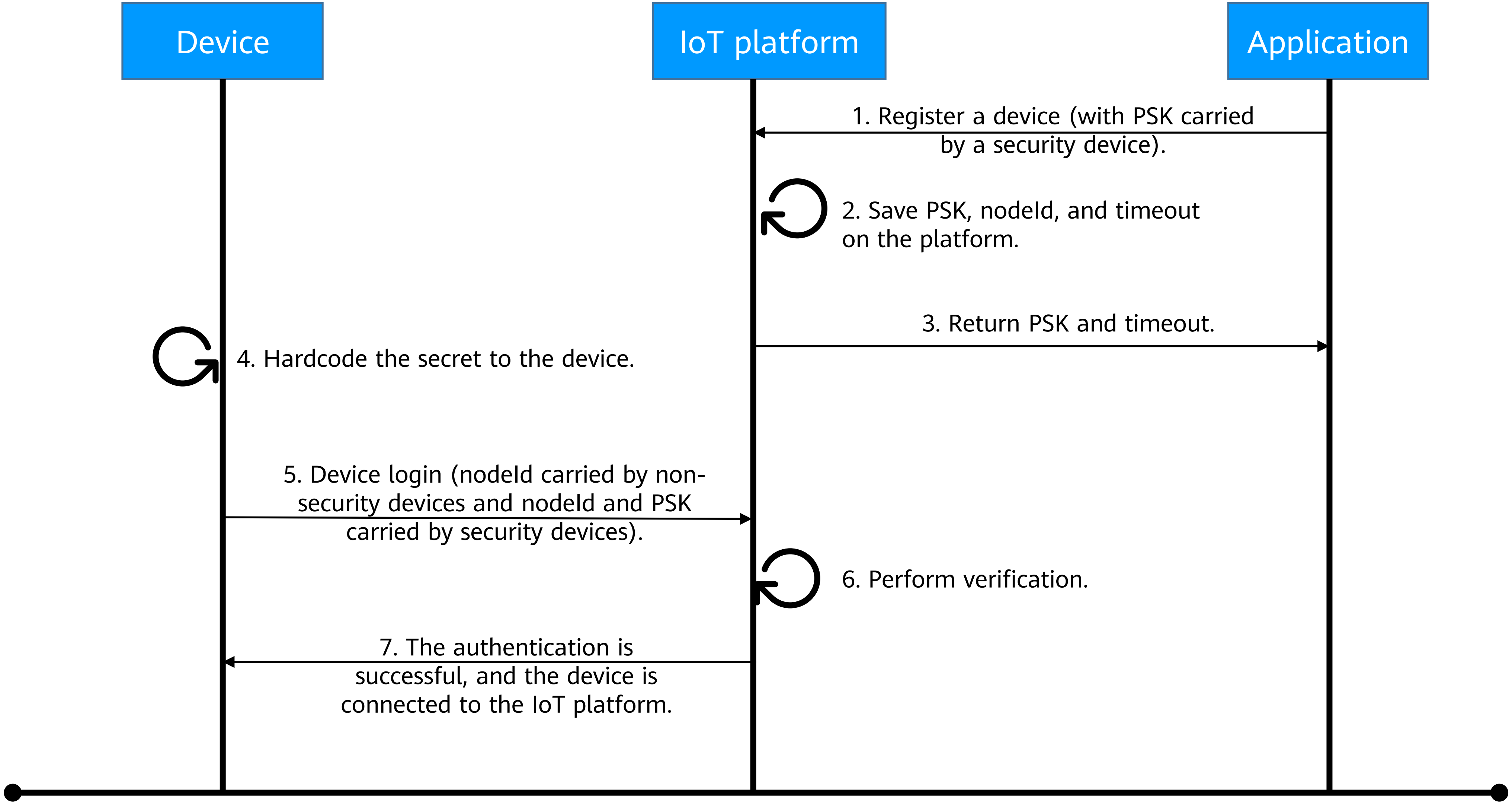


Device Authentication

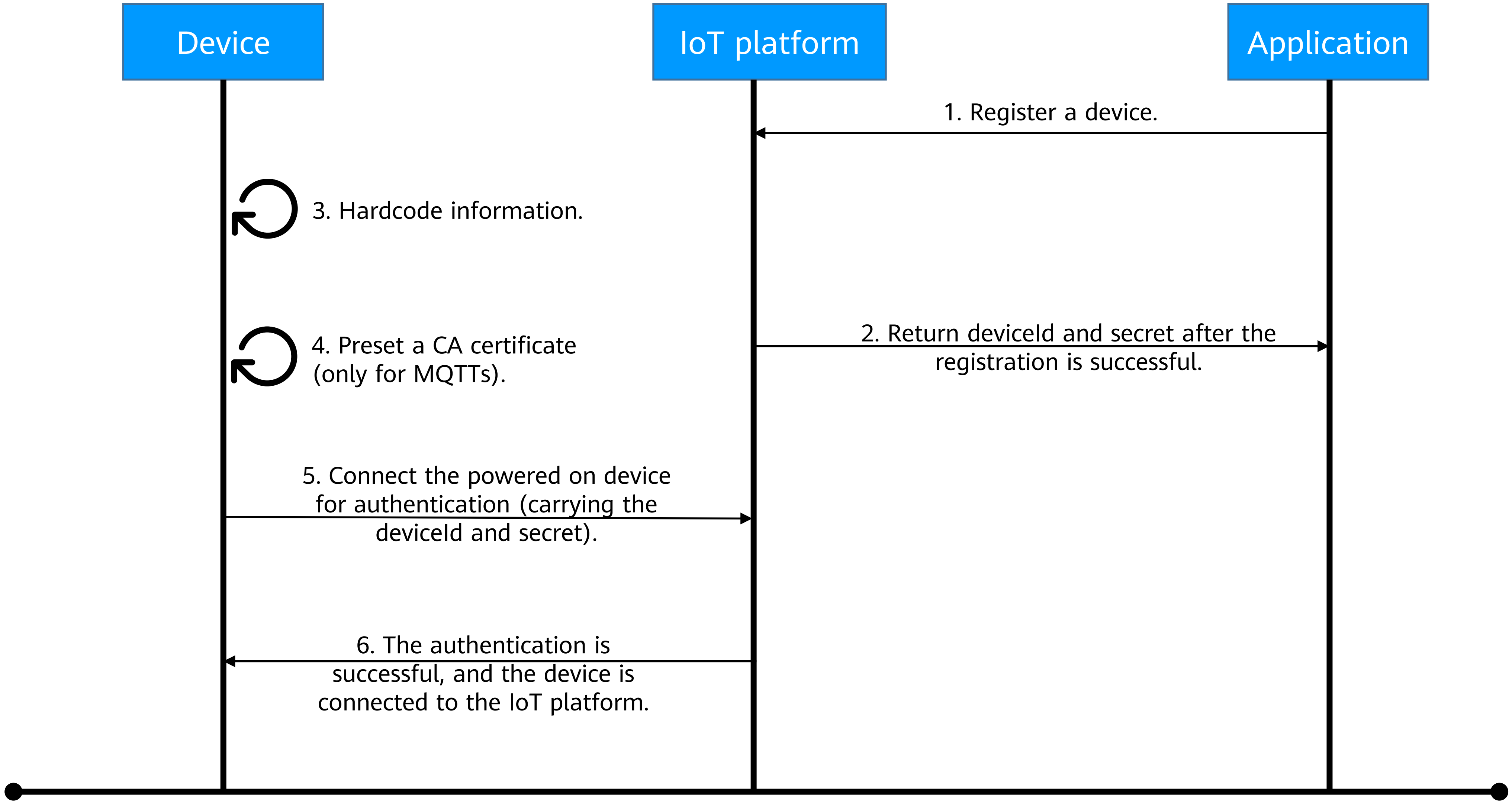
- The platform authenticates a device when the device attempts to access the platform. The authentication process depends on the access method.

Access Type	
Device connected using LWM2M over CoAP	Call the API **Creating a Device** or use the IoTDA console to register a device with the platform, and set the node ID (for example, the IMEI) as the verification code. The device can use the node ID to get authenticated and connect to the platform. When Datagram Transport Layer Security (DTLS) or DTLS+ is used, the transmission channel between the device and platform is encrypted by using a PSK.
Device using native MQTT or MQTTS	Call the API **Creating a Device** or use the IoTDA console to register a device with the platform, and hardcode the device ID and secret returned by the platform into the device. A CA certificate is preset on MQTTS devices, but not MQTT devices. The device uses the device ID and secret to get authenticated and connect to the platform.

Authentication for Devices Using LwM2M over CoAP

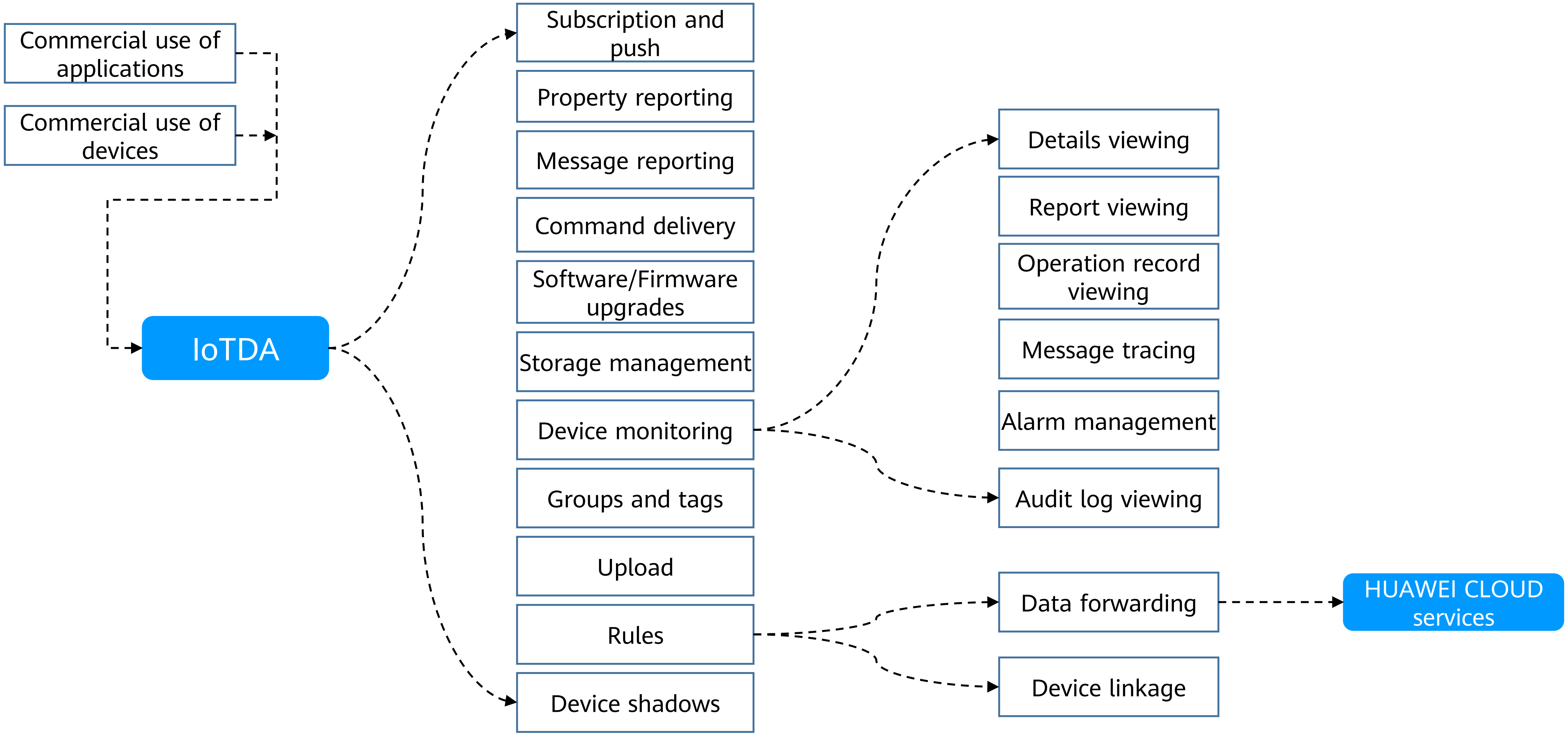


Authentication for Devices Using Native MQTT or MQTTS

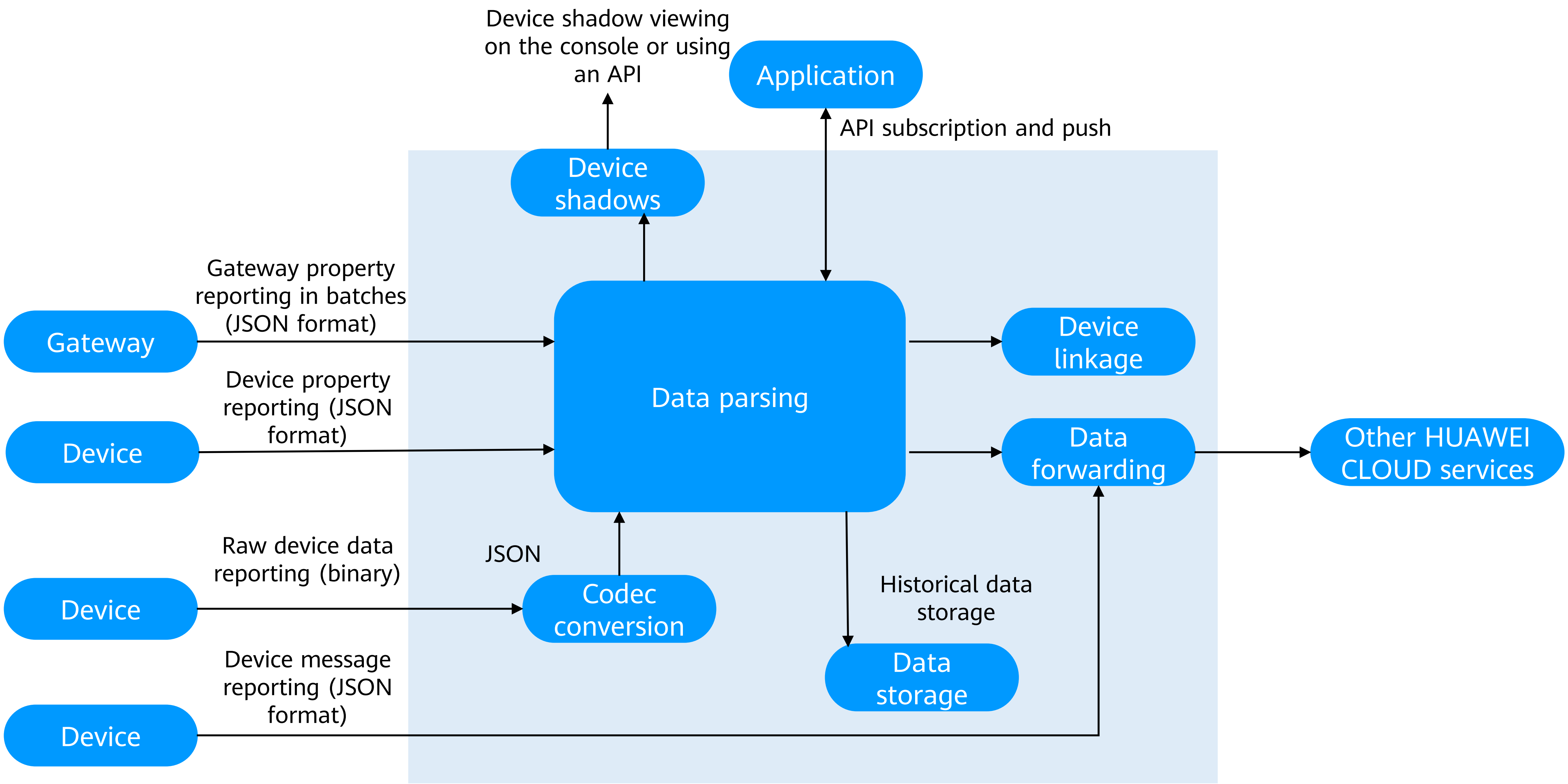


Contents

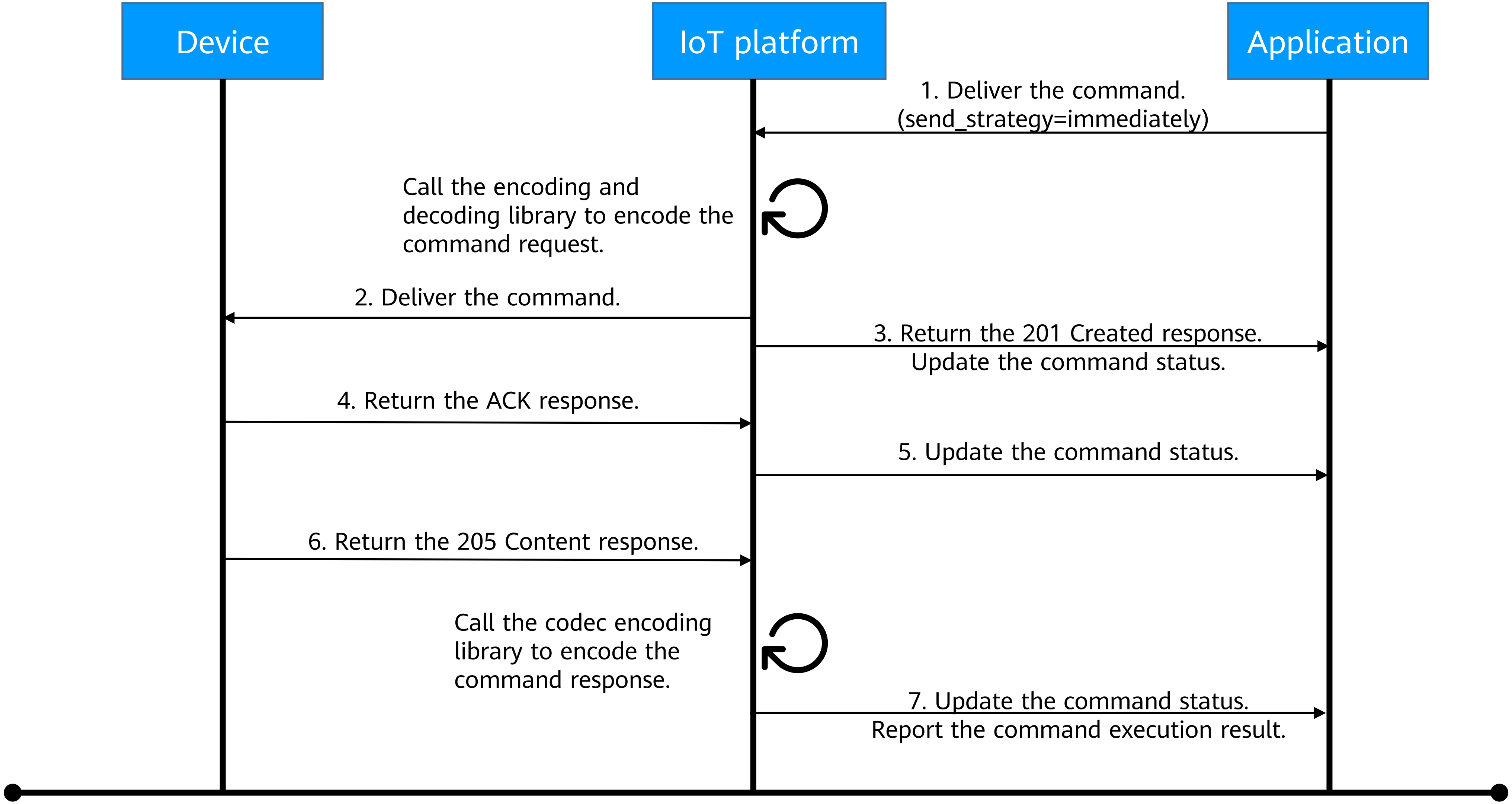
Platform Development Process: Cloud-based Routine Management



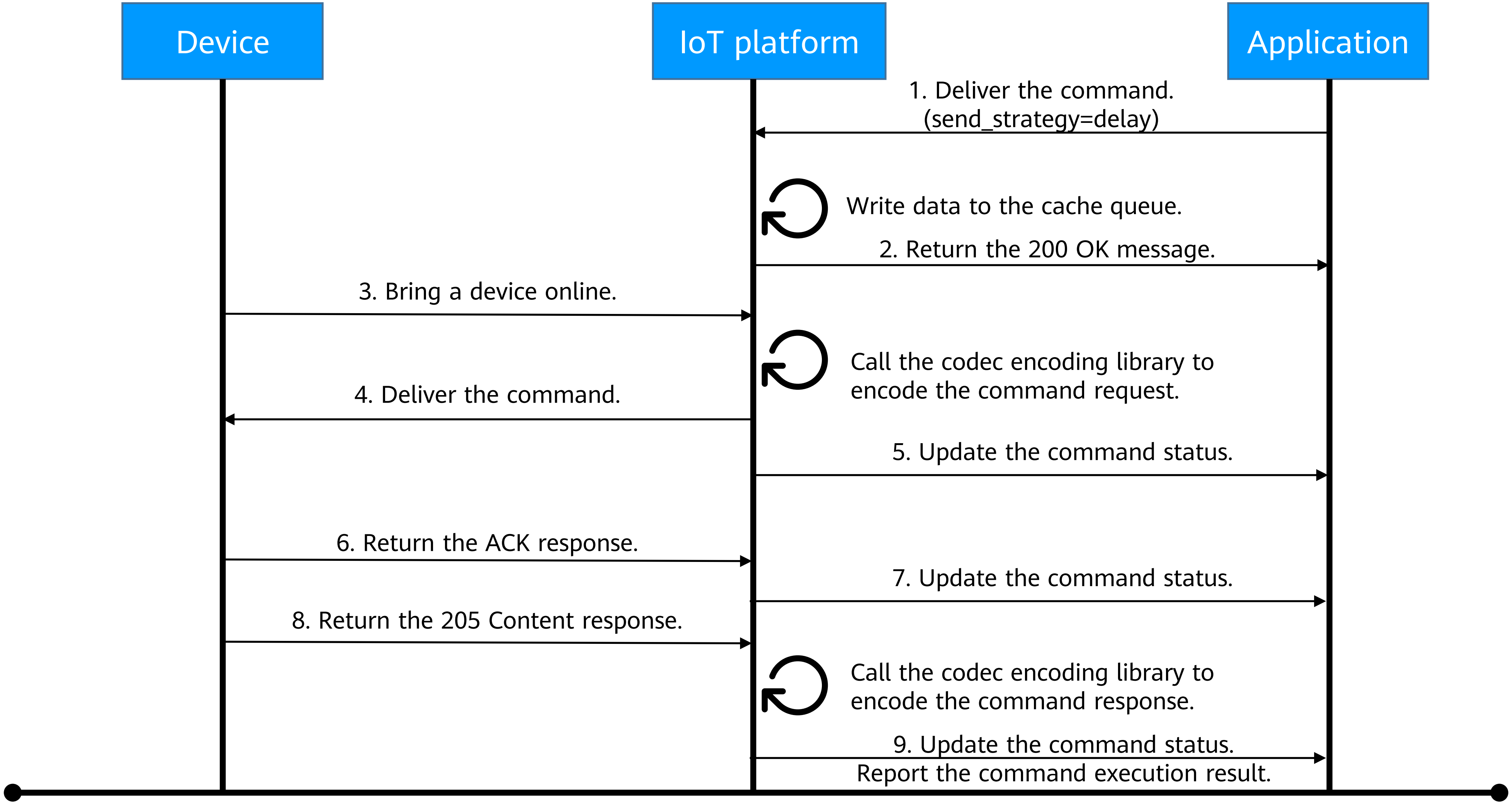
Data Reporting



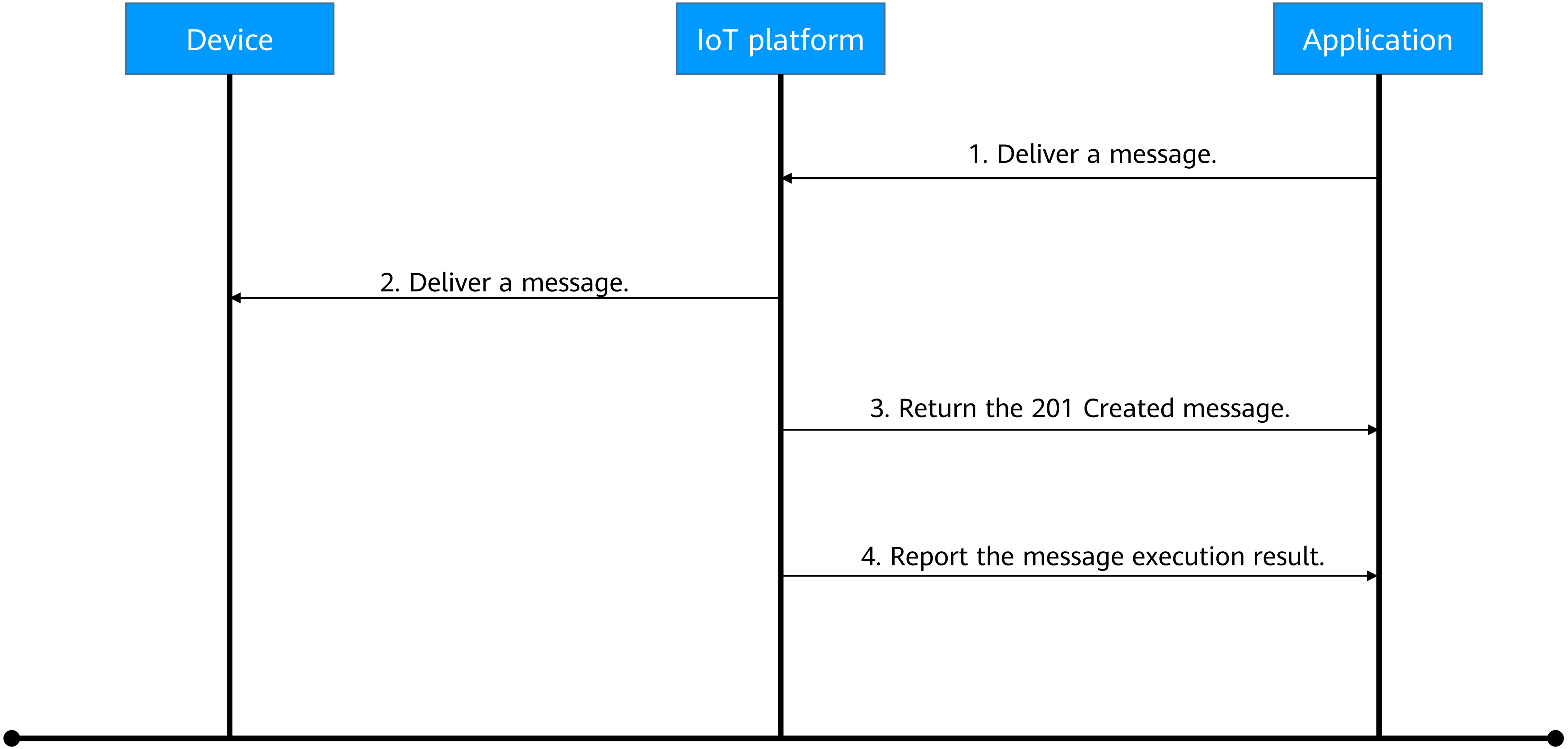
Immediate Delivery of LwM2M/CoAP Device Commands



Delayed Delivery of LwM2M/CoAP Device Commands



Immediate Delivery of MQTT Device Messages



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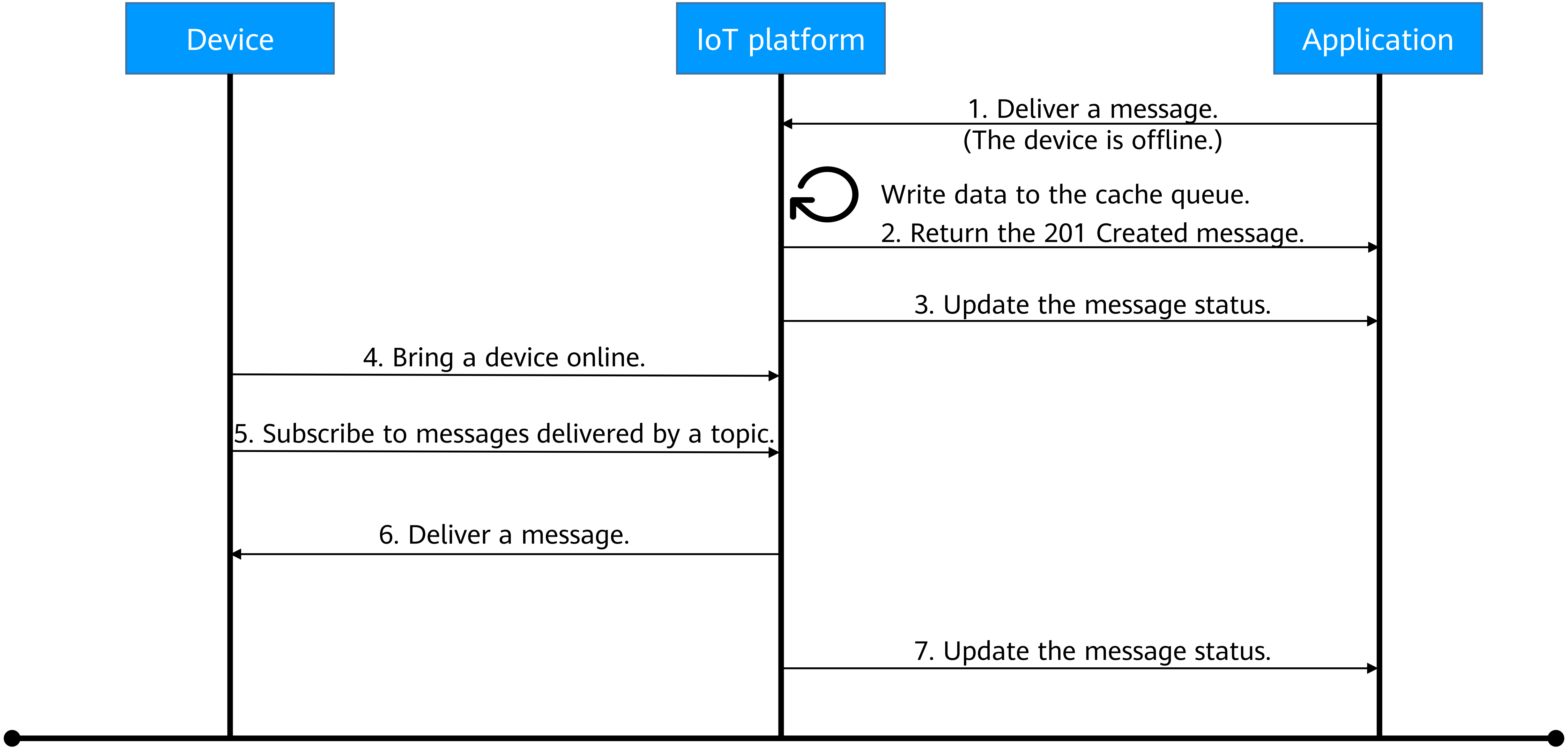
Delayed Delivery of MQTT Device Messages



Quiz

1. (Multiple Choice) Which of the following two formats are used by the IoT platform codec to convert data?

   A. Binary data

   B. Decimal data

   C. JSON data

   D. XML data

2. (True or false) An IoT application must be authenticated before being connected to the IoT platform.

Summary

- In this section, you learned how to perform secondary development on the IoT platform. Secondary development is classified into product development, development on the device side, development on the application side, and cloud-side routine management. Development on the product side includes product model development and codec development.

Thank you.

把数字世界带入每个人、每个家庭、
每个组织，构建万物互联的智能世界。

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IoT OS

Foreword

- Decades have passed since the operating system (OS) was created. The OS plays a vital role for humans, ranging from initially implementing human-computer interaction to controlling computers and other devices.
- What role does the OS play in the Internet of Things (IoT) era?

Objectives

- This course will enable you to:
  - Understand the basic knowledge and development history of the OS
  - Understand the functions of IoT OS
  - Understand Huawei LiteOS
  - Understand the application cases of Huawei LiteOS

Contents

OS Overview (1)

- What is an OS?
  - An OS is a computer **program that manages hardware and software resources**. The transactions that an OS processes include managing and configuring **memory**, setting priorities when allocating system resources, controlling **I/O devices**, and operating the network and file systems. Additionally, OSs provides an operation interface for users to interact with systems.
- In a computer, an OS is the most important basic system software. From the user perspective, the OS provides various services. From the programmer perspective, it mainly refers to the interface for users to log in. From the designer perspective, it refers to the connection between various modules and units to implement different functions. After decades of development, the computer OS has become one of the largest and most complex software systems.

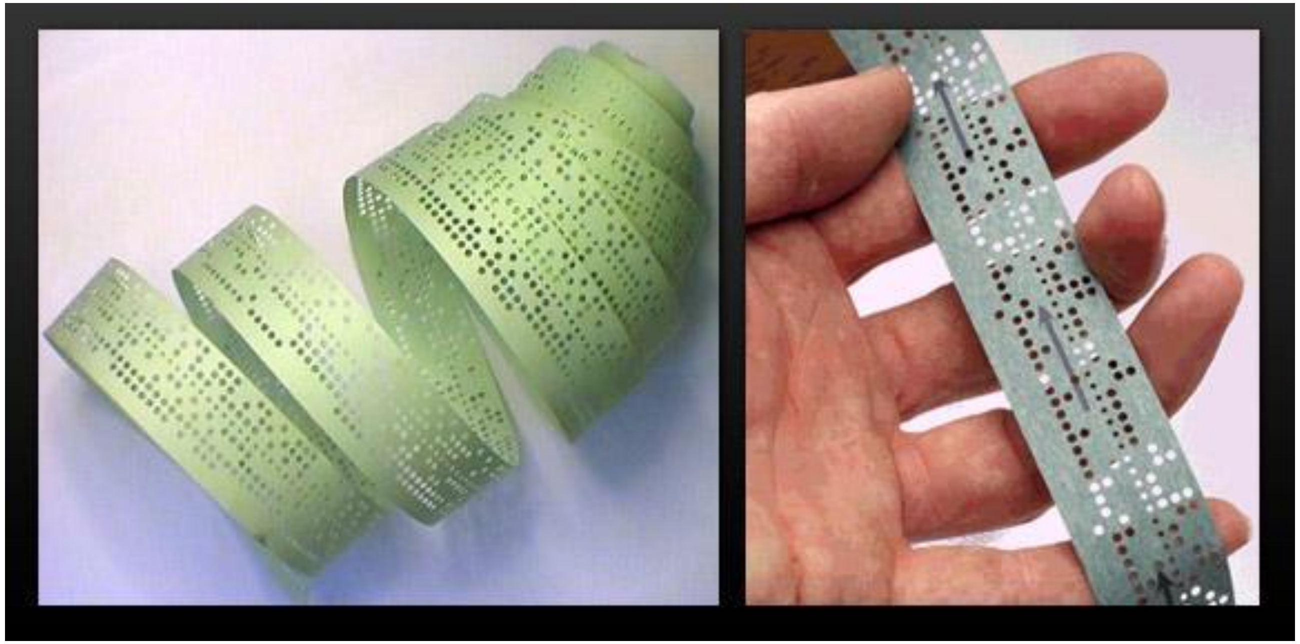
OS Overview (2)

- Microcomputer system
  - Hardware
    - Host
      - Central processing unit (CPU)
        - ALU
        - Controller
      - Main (internal) memory
        - RAM
        - ROM
    - Peripherals
      - External (auxiliary) memory (disk and CD-ROM)
      - Input device (keyboard, mouse, etc.)
      - Output device (monitor, printer, etc.)
  - Software
    - System software
      - OS (DOS, Windows, etc.)
      - Programming language handler
      - Development tools, network software, and diagnosis programs
    - Application software — Various software packages and network suites

The OS manages and controls all software and hardware resources.

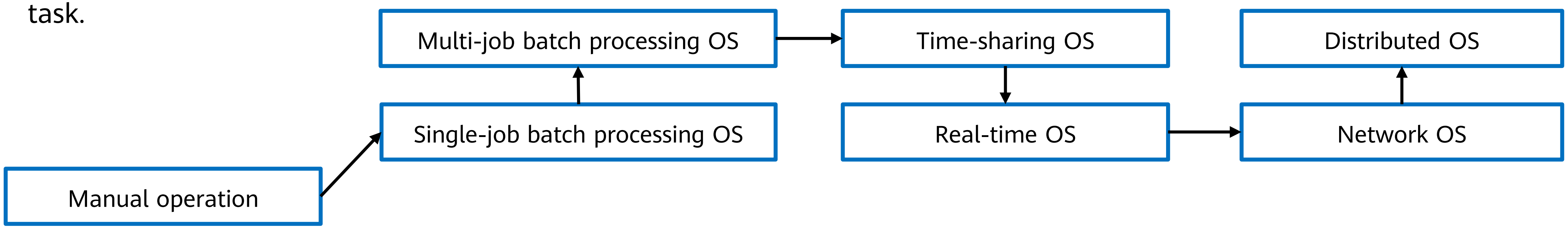
Earliest "OS"

- Punched tapes/cards
  - Manual operation
  - Punched tapes or cards are inserted into the input machine, enabling the programs or data on the tapes or card to be input to a computer for subsequent operations.

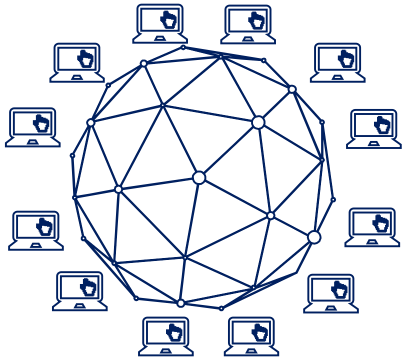


Evolution of the OS

- Batch OS
  - Single-job: Programs are loaded into the memory and executed individually.
  - Multi-job: Multiple programs are loaded into the memory and executed simultaneously.
- Time-sharing OS
  - The OS interleaves the execution of each program among users in short time slots. Each user can interact with the computer through a terminal.
- Real-time OS
  - An OS that implements a specific function within a defined time frame. Real-time OSs are divided into soft real-time OSs and hard real-time OSs.
- Network OS/Distributed OS
  - Sharing of various resources in the network and communication between computers. The difference between the distributed OS and network OS is that in the former, several computers cooperate with each other to complete the same task.



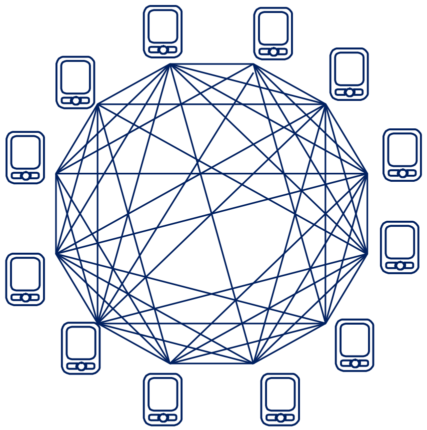
Internet Era to Mobile Internet Era to IoT Era



1 billion connections

Internet era
x86 architecture

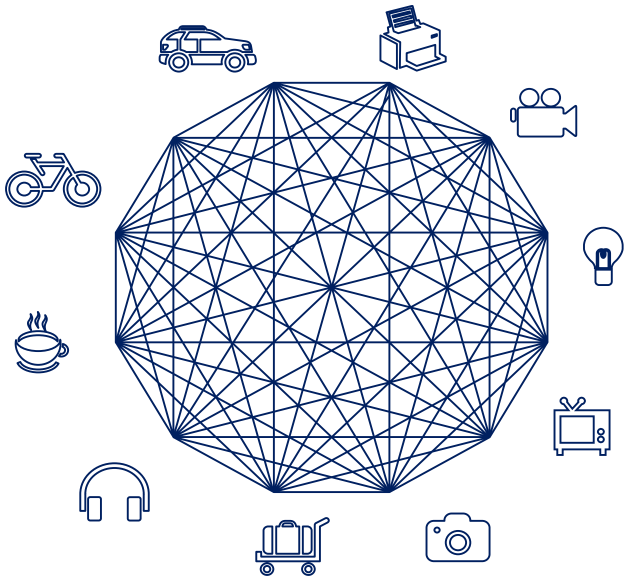
Windows



10 billion connections

Mobile Internet era
Arm architecture

Android/iOS



100 billion connections

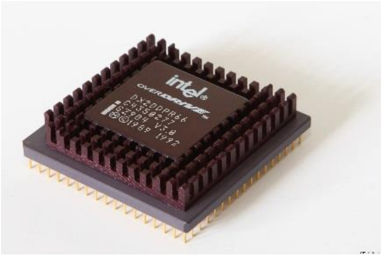
IoT era
x86, Arm, DSP, MIPS, FPGA, ...

IoT OS

Contents

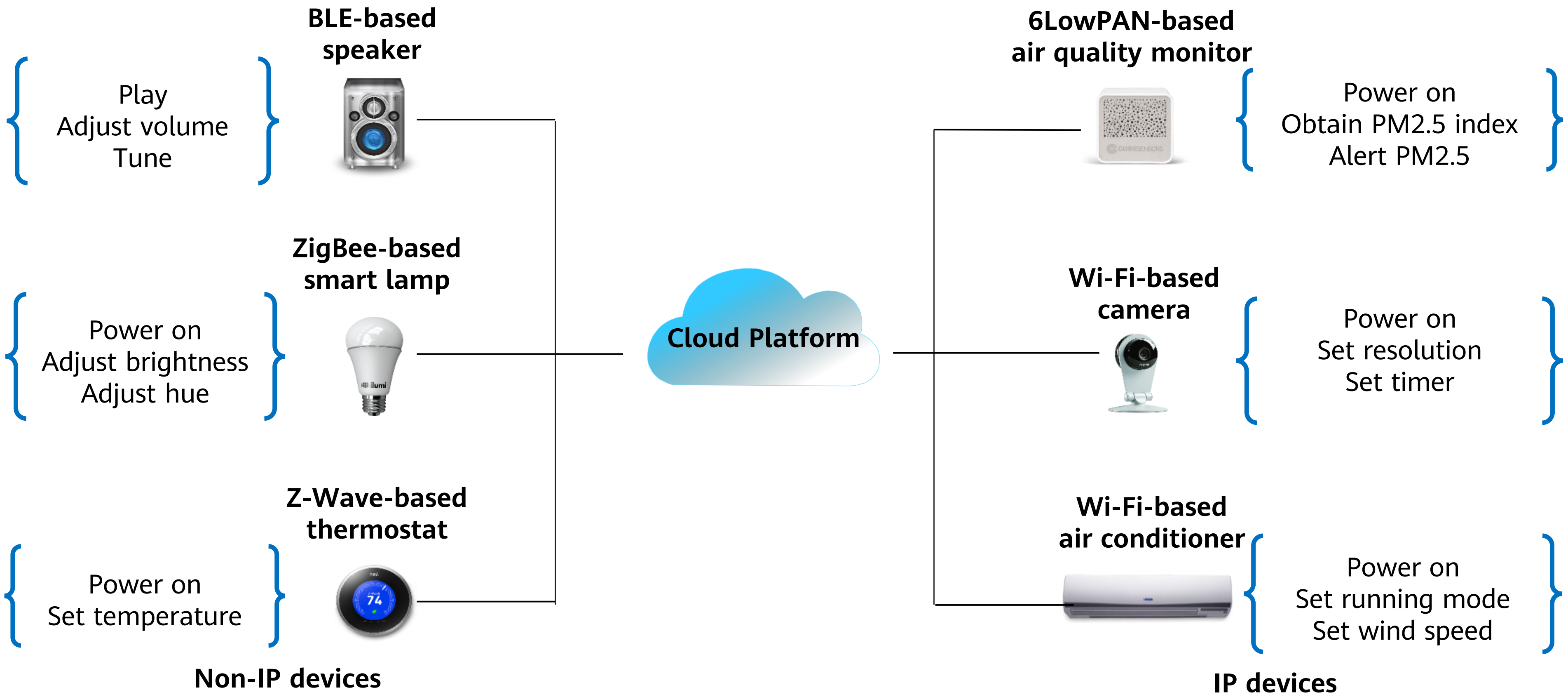
Challenges to IoT Terminal Development (1)

- IoT terminals have various chip and hardware types, requiring developers to adapt to hardware interfaces.



Challenges to IoT Terminal Development (2)

- IoT terminals involve various communications technologies and fast iterated communications modules. Developers need to select and adapt to the communications modules.



Challenges to the IoT OS

- Multi-sensor coordination that is complex to manage

- High requirements on performance and power consumption for videos

Motion DV

Portable camera

Peephole camera

Smart Terminals, Basis of IoT Development

Interconnection of different communication protocols

Smart connection

Smart networking

Self-discovery, self-connection, self-networking, and

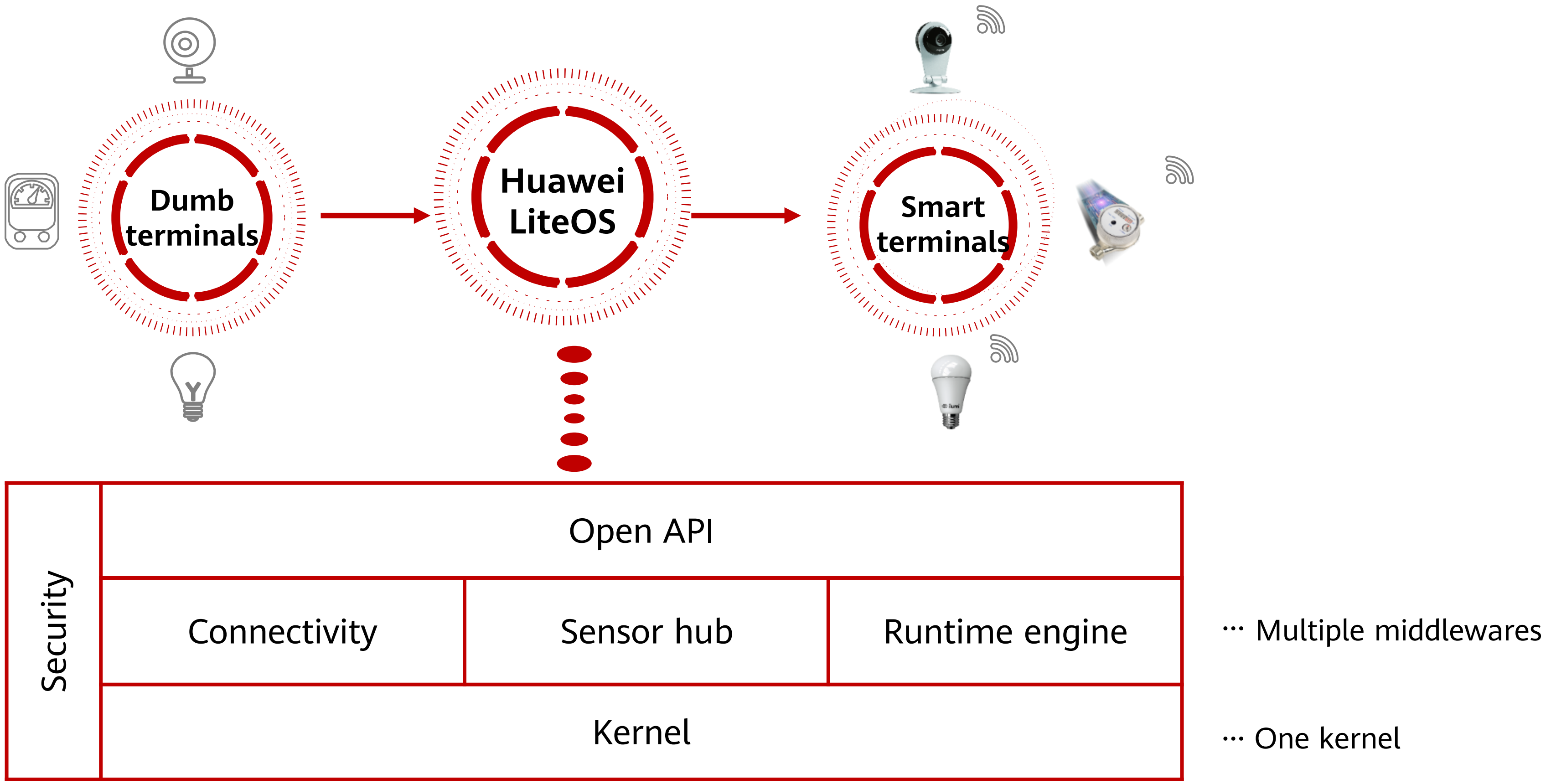
self-healing

Smart management

- Unified management of different types of sensor access and algorithm development
- Device-pipe-cloud security management

Huawei provides a complete and standard IoT LiteOS to accelerate the development of smart devices.

IoT OS - Huawei LiteOS



Contents

Huawei LiteOS History

2012 - Huawei LiteOS became open to Huawei consumer products.

2014 - Huawei LiteOS was shipped with Huawei consumer products.

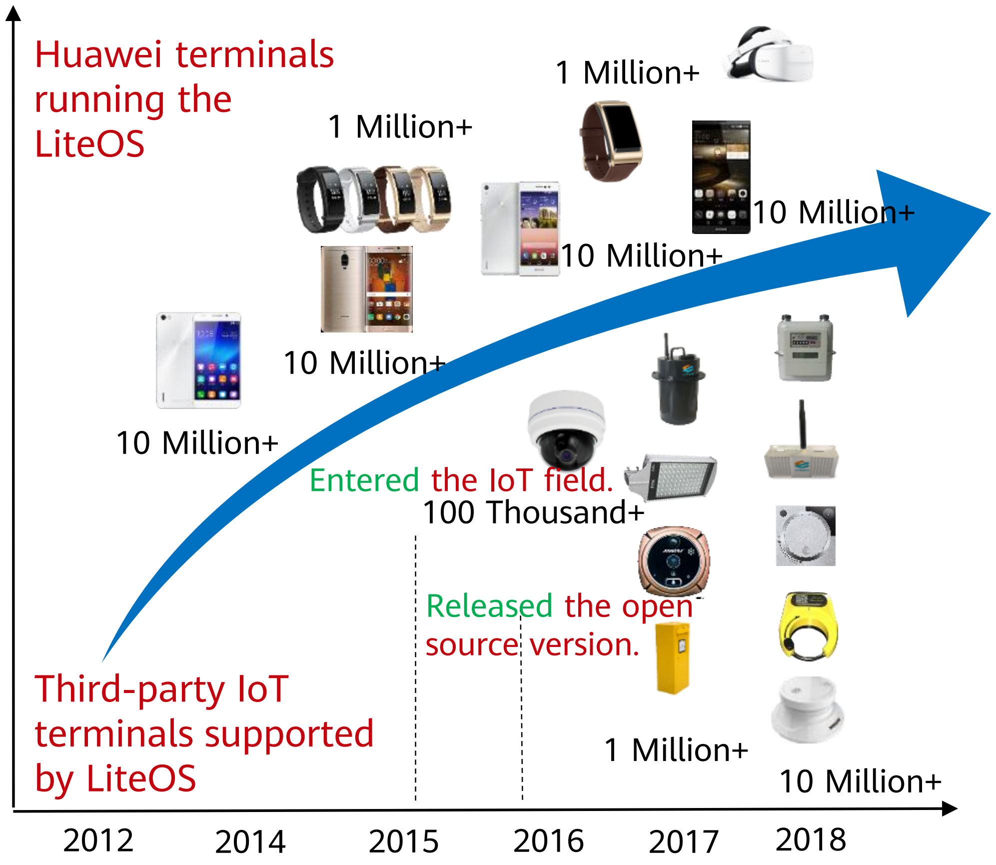
2015 - Open source Huawei LiteOS entered the IoT field.

2017 - Over 1 million and 50 million IoT and consumer products, respectively, were shipped.

2018 - Over 20 million NB-IoT products running Huawei LiteOS were shipped.

Huawei LiteOS Commercial Cases

Terminal products



NB-IoT chips and modules

Chips

The NB chips running the LiteOS account for more than 50% of the whole market.

Hi2115

MK8010Q

Xinyi NB-IoT

CK802

LETSWIN

LETSWIN NB

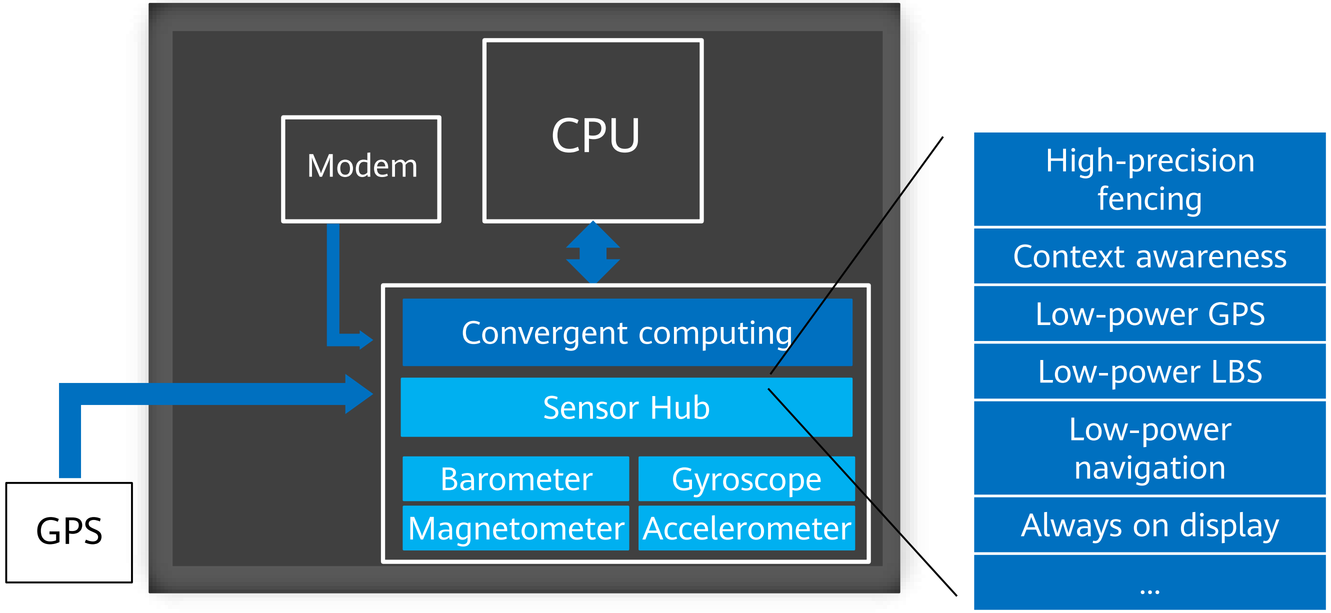
Modules

MCU Joint Commercial Solutions

LiteOS helps 90% of mainstream MCU chips launch their IoT solutions.

Huawei SmartSense Solution (1)

- Huawei P/Mate Series Flagship Phones
  - Huawei LiteOS runs on coprocessors loaded with the Kirin series chipsets.
  - The Huawei LiteOS smart sensing framework works with the photosensitive module to reduce pedometer power consumption and improve measurement accuracy.



Kirin SmartSense Solution

Huawei SmartSense Solution (2)

- Huawei Band
  - Huawei B3 is the smart device first showcased with Huawei LiteOS.
  - The Huawei LiteOS smart sensing framework is used to solve problems involving multi-sensor high-precision sampling and data synchronization. Motion detection accuracy has improved, and the response time when you raise your wrist to turn on the screen has shortened.
  - The ultra-low power consumption lengthens the standby time.

Huawei MobileCam Solution

- Huawei MobileCam Solution
  - Quick startup of Huawei LiteOS
  - Low power consumption enables battery-supplied power and outdoor usage of MobileCam as portable wearables.
  - Features such as smart hibernation and quick wakeup implement power saving and enable quick response.
  - 4G Wi-Fi connection and transmission support live streaming for motion DVs.

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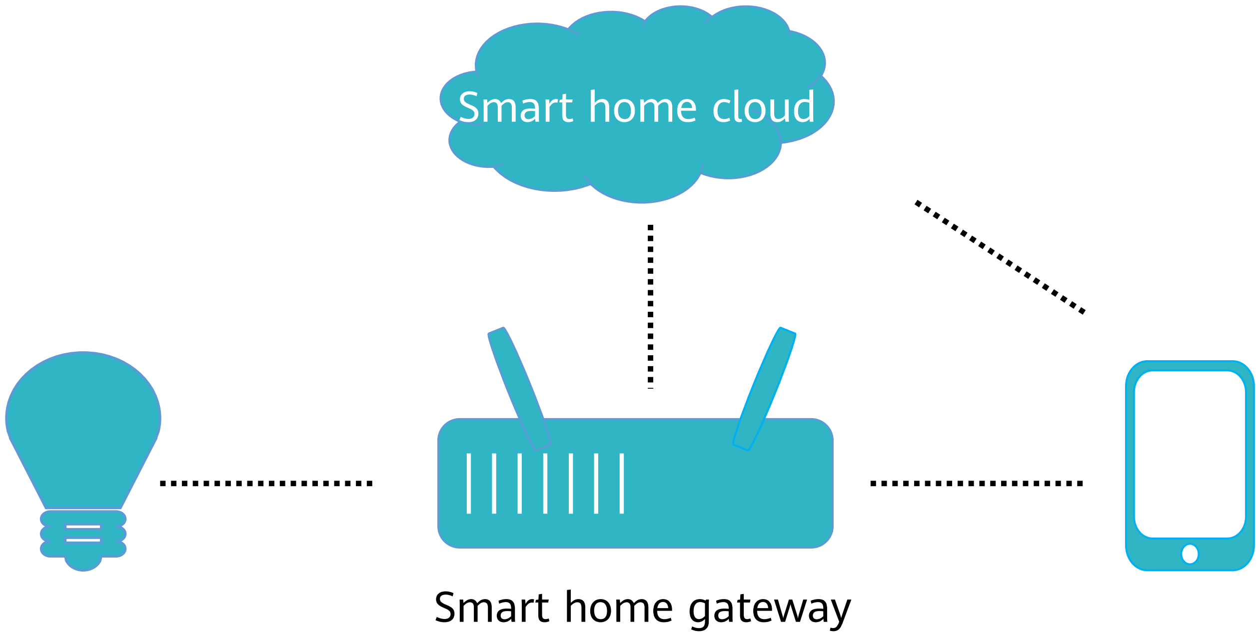
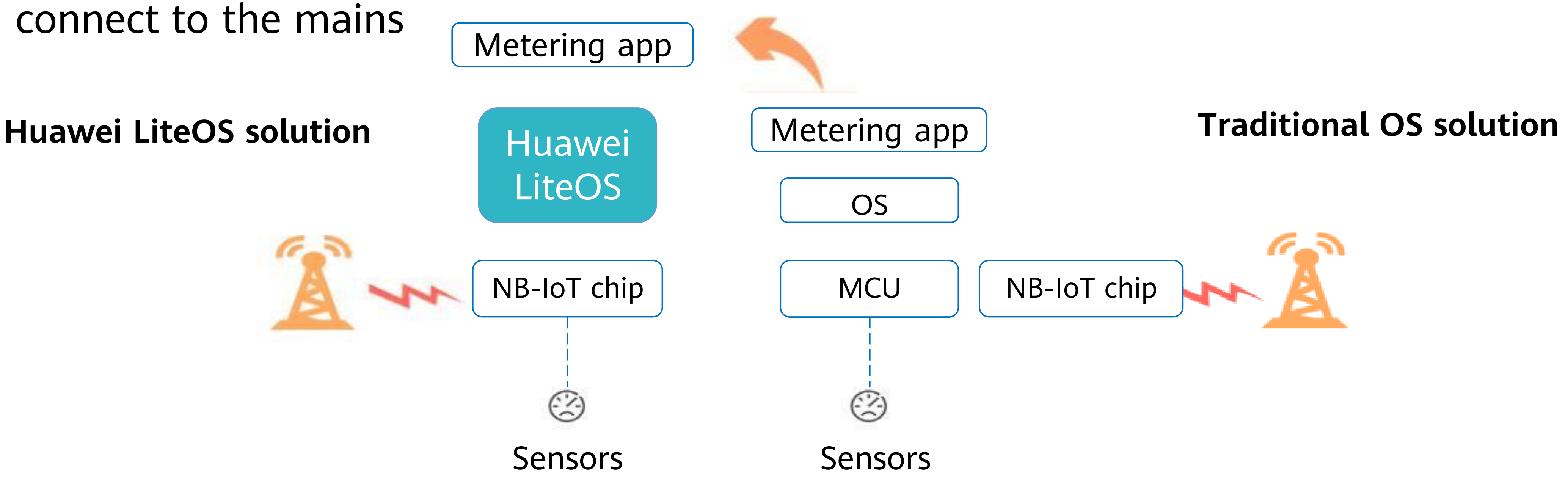
Huawei HiLink Smart Home Solution

- HiLink Smart Home Solution
- Huawei LiteOS enables the HiLink smart home solution based on smartphone sensors:
  - Screen operation, voice recognition, and gesture recognition
  - From multiple steps to one step

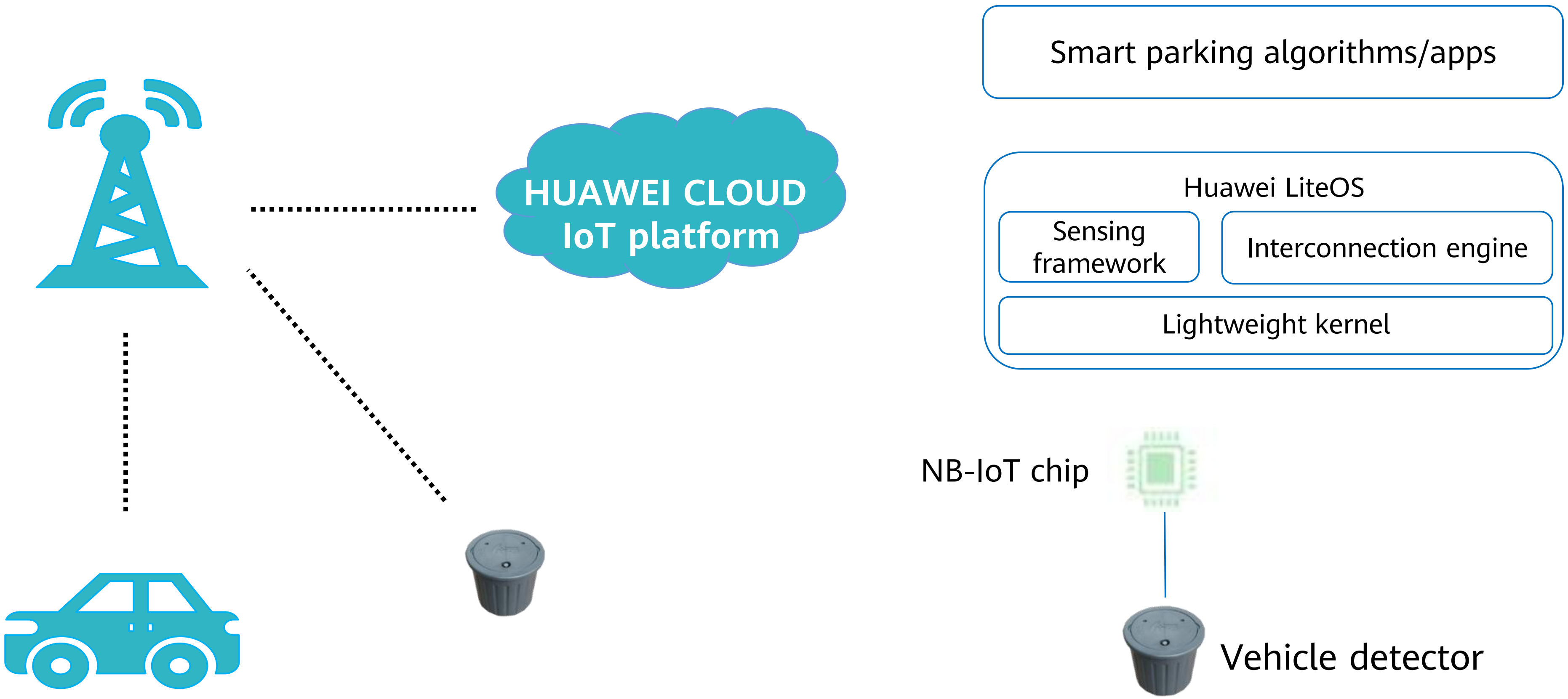


Huawei Smart Water Meter Solution

- Huawei LiteOS lightweight kernel:
  - Small size: MCU resources of the NB-IoT chips are shared to drive the miniaturization and unified upgrade of applications.
  - Low power consumption: single AA battery supplying five years of power; no need to connect to the mains



Huawei Smart Parking Solution



Quiz

1. (True or False) An OS is a computer program that only manages computer software resources.
2. (Single Choice) Which of the following standards must be met by smart terminals? (　　)
   A. Smart connection
   B. Smart management
   C. Smart networking
   D. All of the above
3. (True or False) Huawei LiteOS is a 1+N architecture.

Summary

- This chapter describes information related to the sensing layer, including the basic concepts of the OS, and the challenges and difficulties encountered by the IoT OS. It also covers the benefits and functions of the IoT OS, along with Huawei LiteOS and its application solutions.

Thank you.

Bring digital to every person, home, and organization for a fully connected, intelligent world.

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Sensing Layer Development

Foreword

- This document describes the basic knowledge required to develop the sensing layer, including single-chip microcomputers, sensors, and Huawei LiteOS architecture.
- Huawei LiteOS offers a one-stop software platform for developers, enabling intuitive development and connections for IoT devices, and delivering smarter services, an improved user experience, and more secure data.

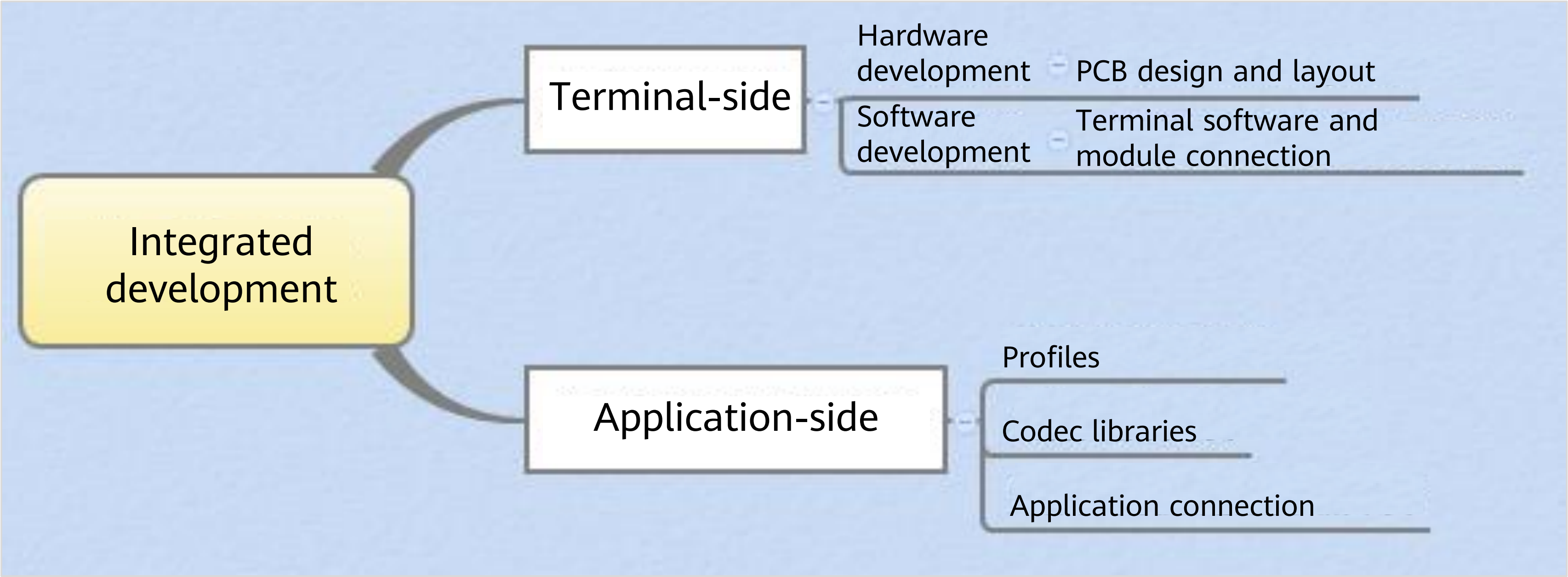
Objectives

- After completing this course, you will understand:
  - Basic knowledge on sensors
  - Core components of the single-chip microcomputer
  - Huawei LiteOS architecture
  - Basic kernel modules of Huawei LiteOS, their operation mechanisms and functions
  - Huawei LiteOS framework
  - Huawei LiteOS APIs

Contents

Overview of E2E Integrated Development

- E2E development includes terminal and application sides
  - Terminal-side: printed circuit board (PCB) design, terminal software development, and network access commissioning
  - Application-side: development of profiles and codec libraries; application development by calling IoT platform APIs



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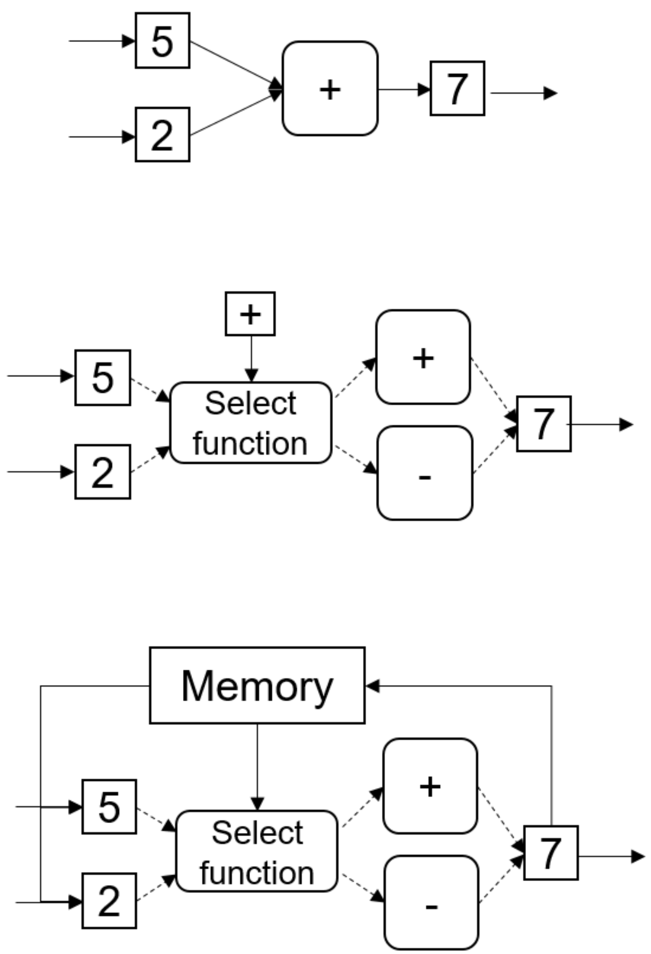
Microcomputer Working Principles



- During hardware development, developers can design circuits to implement various functions (for example, adding two numbers). However, the circuit can only implement a **single function**, meaning that new circuits are required for other functions.
- To implement multiple functions, you need to add a **multiplexer (MUX)** to the circuit, which will select the function to be implemented (for example, adding or subtracting two numbers).
- Once you add the **register**, the circuit can record previous results and subsequent instructions.
- Modern computers, whether large or micro, are designed based on this principle. But they contain hundreds of different operations to implement mathematical, logical, or storage functions.
- All programs process computer data through **a simple set of instructions**.

Instruction Set

- A computer instruction directs the work of a machine through instructions or commands. A program is a series of instructions arranged in a certain sequence. Program execution is the work process of a computer. An instruction set is used to calculate and control a computer system in a CPU. Each new CPU type is designed with a series of instruction systems that match other hardware circuits. CPU performance also determines whether the instruction set is advanced or not, which in turn is an important indicator of CPU performance.
- For example, convert Celsius to Fahrenheit.
  - **Input** a Celsius degree
  - **Subtract** 273
  - **Multiply** by 1.8
  - **Add** 32
  - **Output** the result

Common Arm instructions

Instruction	Description
MOV	Data transfer
AND	Logic AND
EOR	Exclusive OR
ORR	Logic OR
ADD	Addition
SUB	Subtraction
LDR	Data transfer from memory to register

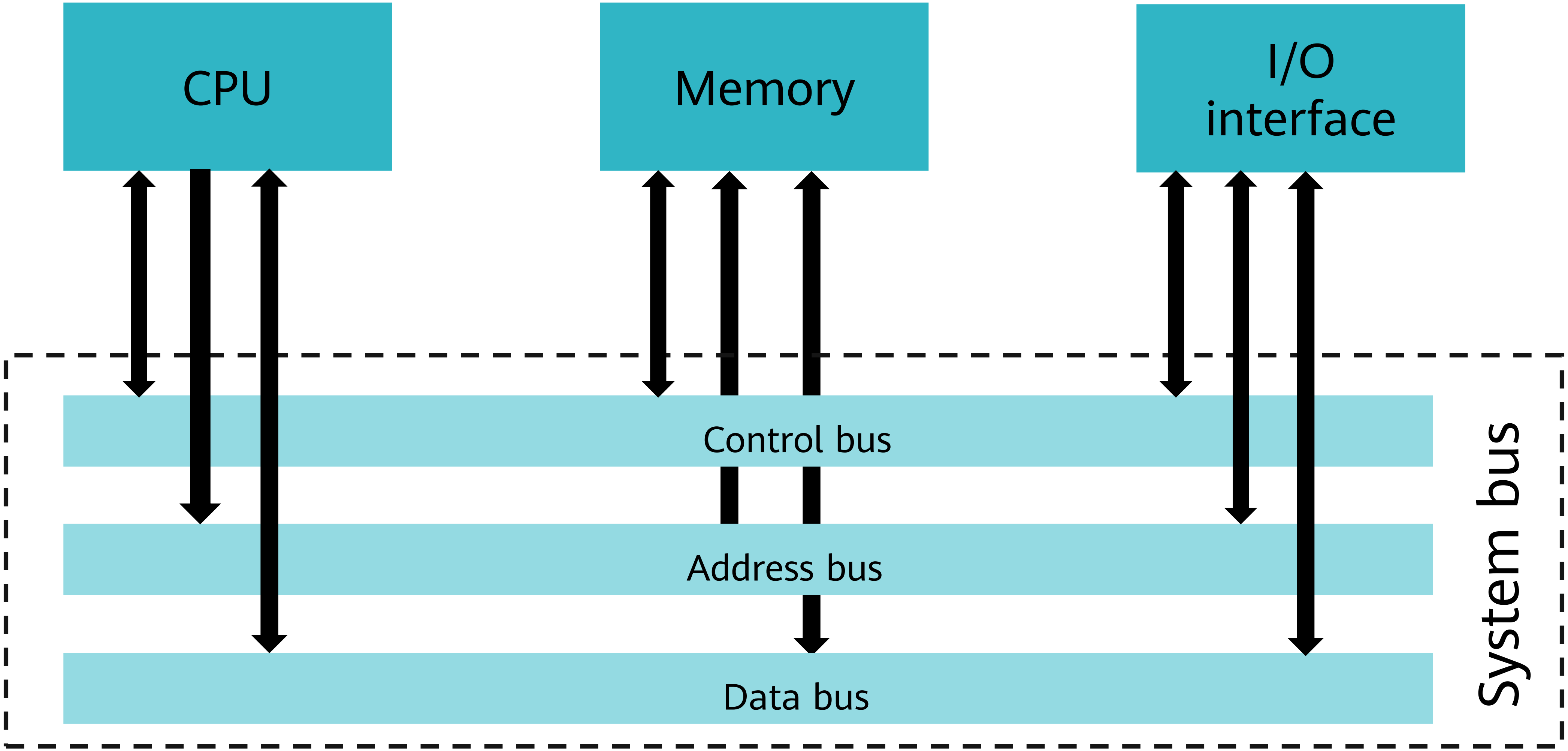
Processing Units

- There are two categories of modern programmable devices: microprocessors (MPUs) and microcontrollers (MCUs).
- An MPU is usually a central processing unit (CPU) placed in a computer, server, game device, or the like to process a task with high power consumption and complexity. MPUs can only be used to process data, and all necessary memories and peripherals must be connected separately.
- MCUs can also be used as single-chip microcomputers, which contain a CPU, memory, and a series of input and output devices. They are usually designed for MP3 players, cameras, remote control equipment, and other low-power embedded applications.

MPU

MCU

MCU Architecture



MCU Architecture: CPU & Memory

- CPU
  - The CPU controls the entire system in the MCU. It reads and decodes program instructions in serial mode, performs the tasks that require a processor, and generates control signals for other tasks. It performs all arithmetic and logical operations. MCUs with the same CPU can execute the same programs.
- Memory
  - The storage system includes a memory and an address decoding circuit.
  - Generally, there are two types of memories: random access memory (RAM) and read-only memory (ROM).
    - RAM stores data (such as operation results) **running in the program, which disappears after power-off.**
    - ROM stores **programs that need to be executed by the MCU. Data is not lost after power-off.**

MCU Architecture: I/O Interface & Bus

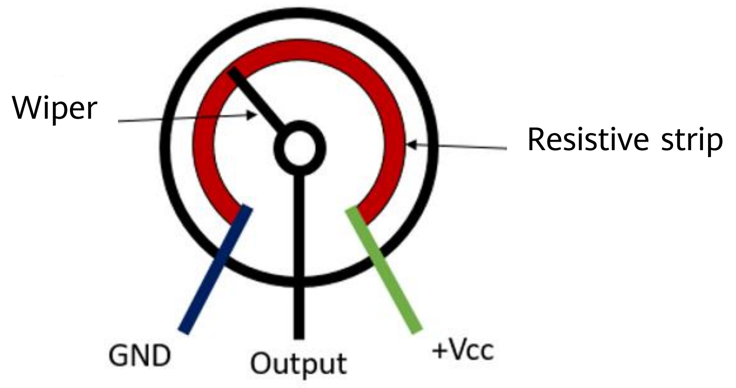
- I/O interface
  - An interface that connects an external device to an MCU. There are three types: digital I/O, analog I/O, or serial interface.
- Bus
  - A bus, like a conductor, can connect various parts and communicate data. Generally, there are three types of buses in MCUs:
    - Data bus: a bidirectional bus that transfers data between the processor and the memory and I/O interface.
    - Address bus: selects the bus for the processor to read or write to a specific memory location. The address bus has a unidirectional data flow, from the processor to the memory and I/O interface.
    - Control bus: consists of multiple independent control/signaling lines. A typical signal includes a read/write line, and indicates the direction of data traveling using a data bus.

Digital and Analog

- The world of computers consists of binary numbers 0 and 1, which essentially describe everything that we can see in relation to computers. However, the human world is simulated and while digital signals computer use are very convenient, we cannot find them in real life.
- For example, attributes such as brightness, temperature, and distance are a simulation in nature. The most important question for a computer is how to use a digital signal to represent an analog value in nature.
- Let's take an electric light switch as an example:
    - Typically, a switch can either be on or off, which can be represented by 0 and 1.
    - However, if the switch controls the brightness of the bulb, we need to represent all the values from zero to the maximum brightness. In this case, how do we use digital signals to represent the values?

Digital and Analog - ADC and DAC

- Usually, a single-chip microcomputer has an analog to digital converter (ADC) and a digital to analog converter (DAC) to convert between analog and digital signals.
- A single-chip microcomputer can use the ADC interface as an input interface to convert external analog signals into digital signals. For example, an ADC interface with a rated voltage of 3.3 V can accept ranges from 0 V to 3.3 V. A 2-bit ADC represents four different voltage levels.
- Conversely, the DAC interface outputs digital signals from a single-chip microcomputer as analog signals for use. Without using the DAC to classify voltage, the interface can only indicate whether the voltage is low or high.



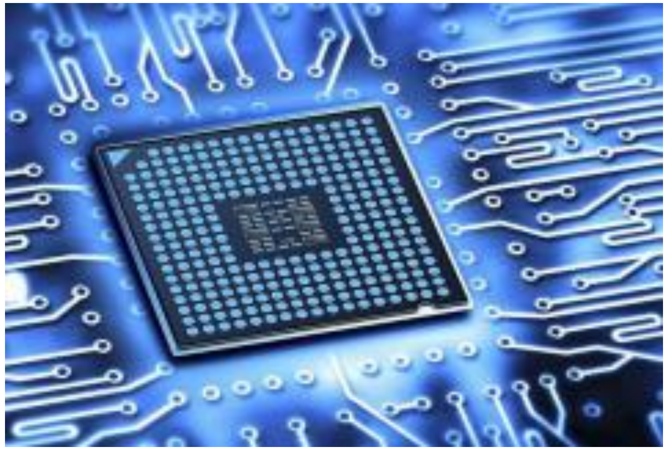
Analog voltmeter

2-bit	Voltage
00	0 V
01	1.1 V
10	2.2 V
11	3.3 V

Contents

Sensing Technology

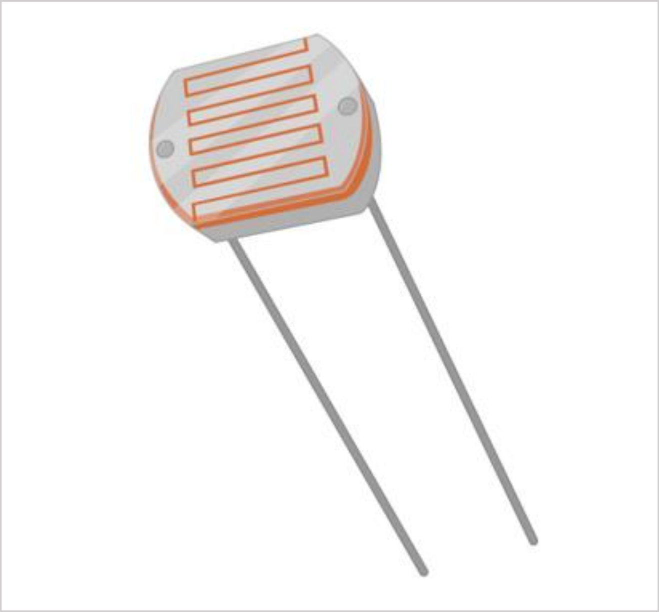
- Information technology is made up of three pillar technologies: computer, communications, and sensing. In terms of the Internet of Things (IoT), sensing technology is an important indicator to measure a country's informatization level.
- Sensing technology refers to sensors, which can sense an ambient environment or special substance. They can offer sensing functions for gas, light, temperature and humidity, human body, and more. Sensors convert analog signals into digital ones and send them to a CPU for processing. The final output may be gas concentration parameters, light intensity parameters, temperature and humidity data, and so on.

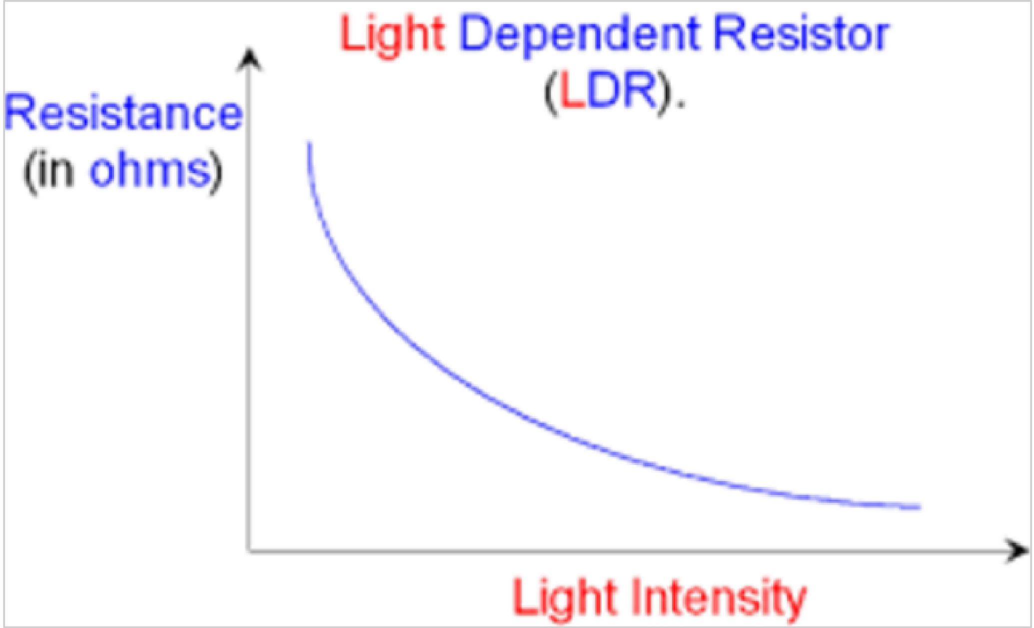


Sensors and Their Classification

- A sensor is a detection apparatus that can sense measured information and convert it into an electrical signal or another form of information, to then output it according to a specific rule, meeting the requirements for information transmission, processing, storage, display, recording, control, and so on.
- We often compare the functions of sensors with the five human senses:
  - Photoelectric sensor - vision
  - Acoustic sensor - auditory
  - Gas sensor - olfactory sense
  - Chemical sensor - taste
  - Pressure-sensitive, temperature-sensitive, and fluid sensor - tactile
- In terms of basic sensing functions, there are 10 types of sensing elements: temperature, photosensitive, gas, force, magnet, humidity, sound, radiation, color, and taste.

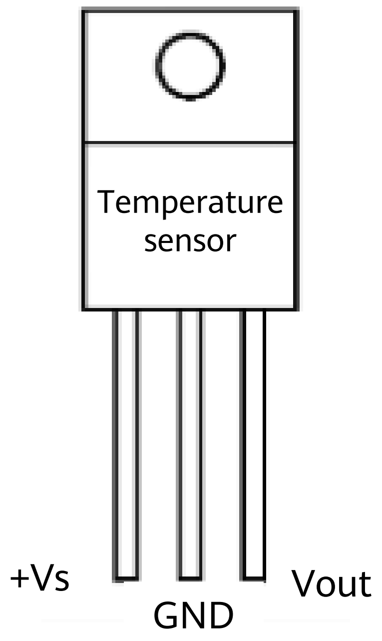
Photoelectric Sensor

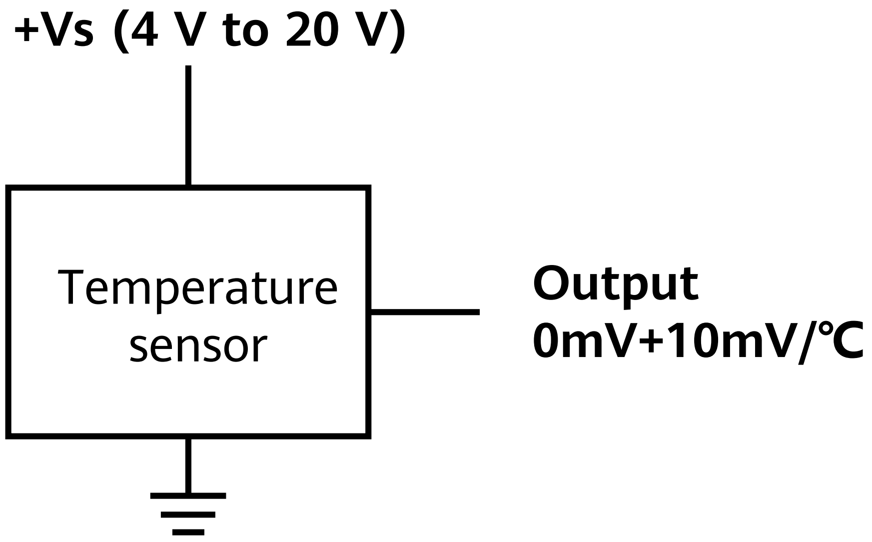




A photoelectric sensor converts optical signals into electrical signals by using a photosensitive element. It is sensitive to wavelengths near the visible light spectrum, including infrared and ultraviolet wavelengths. Beyond detecting light, it can also be used as a detection element to form other sensors.

Temperature Sensor

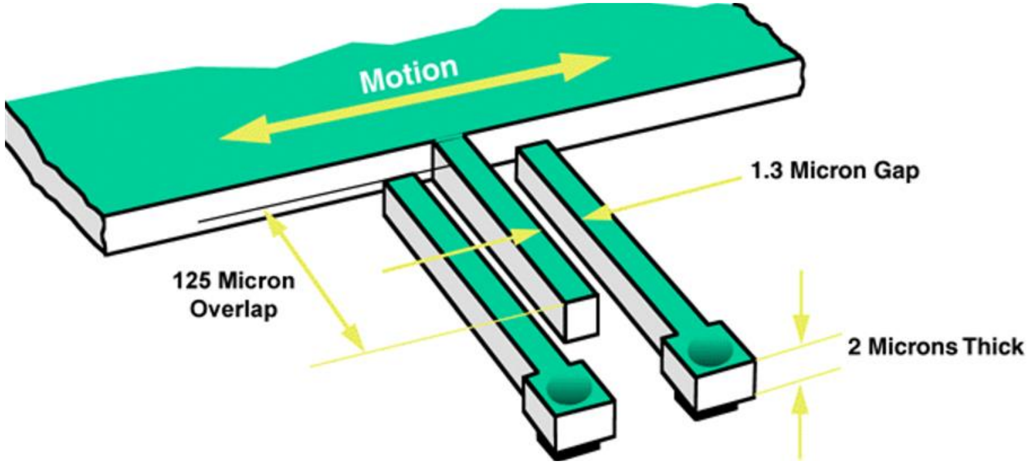




A temperature sensor converts temperature information into an available output signal. There are two types of temperature sensors, classified by the characteristics of sensing materials and electronic components: resistance temperature detector (RTD) and thermocouple sensor. An RTD is a thermistor that uses the variability of metal resistance to measure temperature. A thermocouple sensor connects two different metal wires at one end. When one end of the thermocouple is heated, there is an electric potential difference in the thermocouple circuit, which can be used to calculate the temperature.

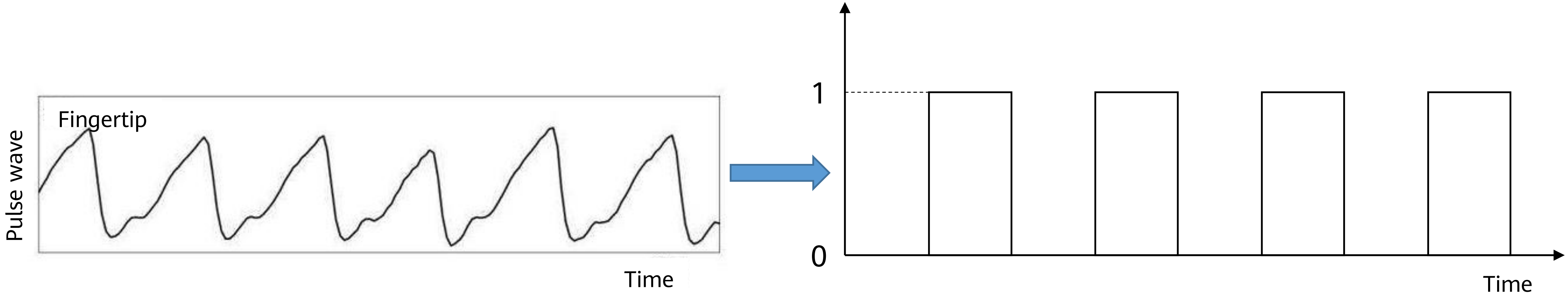
Acceleration Sensor

- An acceleration sensor measures acceleration, and is usually composed of a mass block, damper, elastic element, sensitive element, adaptive circuit, and so on.
- Most acceleration sensors work according to the principle of piezoelectric effect. Typically, these sensors use internal crystal deformation caused by acceleration. The deformation generates voltage, so the acceleration can be converted into a voltage output as long as the relationship between the generated voltage and the applied acceleration is calculated.
- Acceleration sensors are widely used in seismic monitoring, automobile safety, game control, pedometer, anti-shake (AS), and automatic image flipping.



Heart Rate Sensor

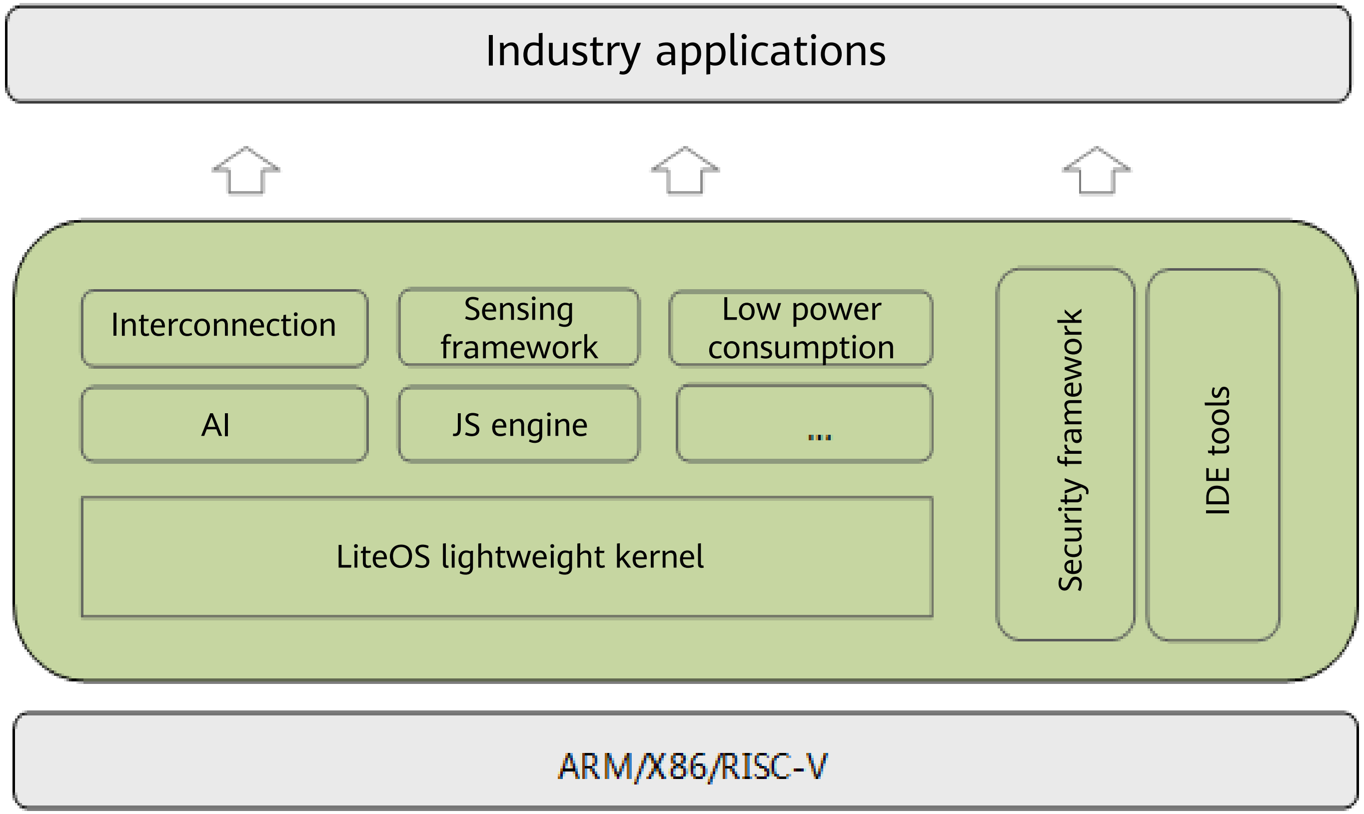
- A heart rate sensor detects pulse-related signals.
- There are three types of heart rate sensors that collect signals in different ways: piezoelectric, piezoresistive and photoelectric. Piezoelectric and piezoresistive sensors use micro-pressure materials to convert the pressure process of pulsation to signal output. Photoelectric sensors convert the change in light transmittance of a blood vessel in a pulsation process into a signal for output through reflection or transceiving.



Contents

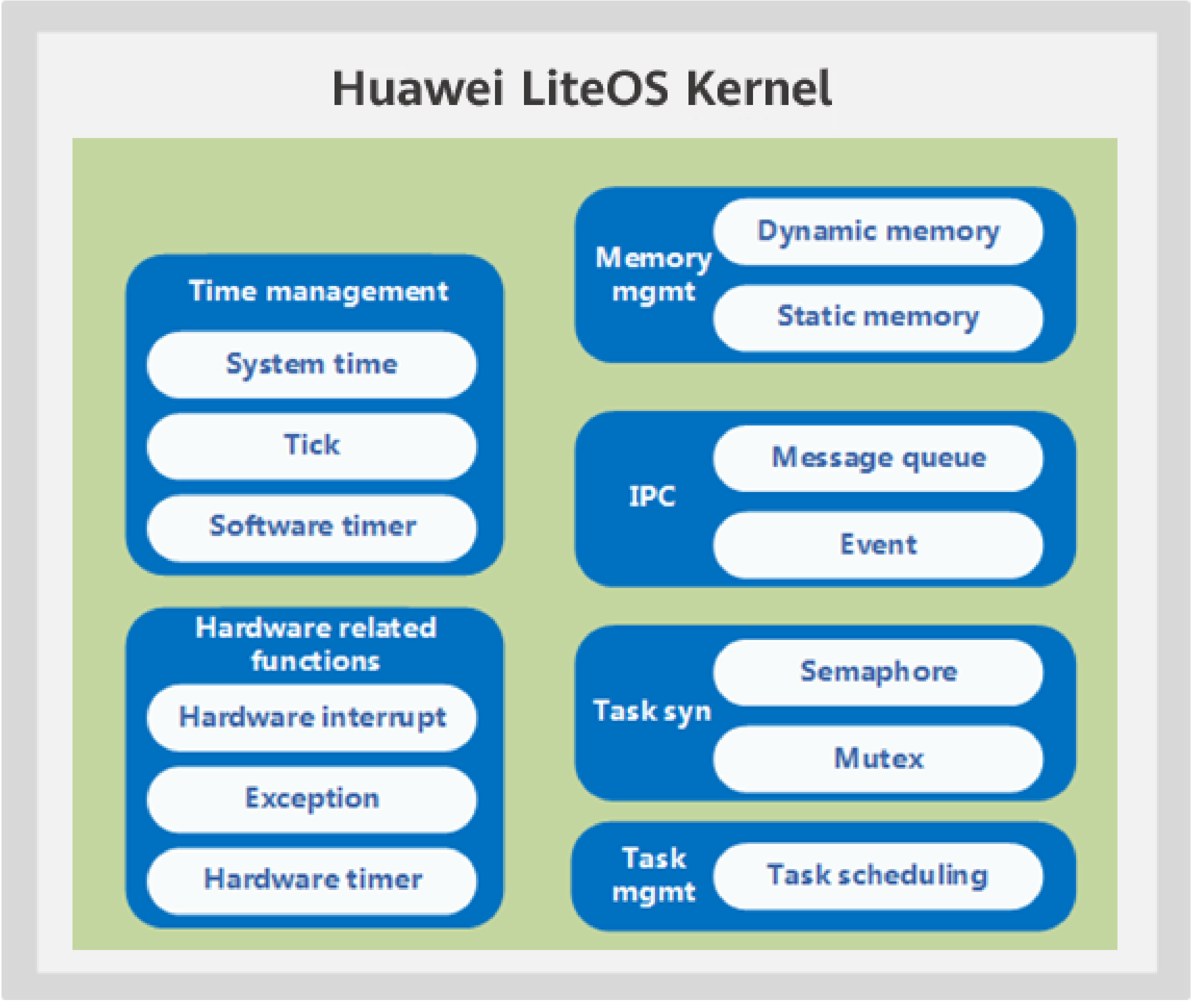
Huawei LiteOS Framework

- Huawei LiteOS is a lightweight IoT OS developed by Huawei. This system complies with the BSD-3 open-source license agreement and can be widely used in smart homes, wearable devices, Internet of Vehicles (IoV), urban public services, manufacturing and so on.



Huawei LiteOS Kernel

- Huawei LiteOS Kernel is the simplest Huawei LiteOS. It consists of basic OS components such as task management, memory management, time management, communication mechanism, interrupt management, queue management, event management, and timer. The Huawei LiteOS Kernel can run independently.
- It also supports the tickless mechanism to better adapt to low-power consumption scenarios.



HUAWEI

Kernel Modules - Task

Task | Memory | Interrupt

- A task is the minimum running unit that competes for resources from a system perspective. A task can use or wait for the CPU, use memory space, and run independently of other tasks.
- A task can be created, deleted, delayed, suspended, resumed, locked, and unlocked for task scheduling.
- Tasks in Huawei LiteOS are scheduled in preemption mode, and time slice rotation scheduling mode is also supported.
- A total of 32 priorities are defined, with priority 0 being the highest and 31 being the lowest. High-priority tasks can interrupt low-priority tasks, which can only be scheduled after high-priority tasks are blocked or completed.

Task Programming Instance

- Task interface description:

Function Category	Interface Name	Description
Task creation and deletion	LOS_TaskCreate	Creates a task, so that the task is ready for scheduling.
	LOS_TaskDelete	Deletes a task.
Task status control	LOS_TaskResume	Resumes a suspended task.
	LOS_TaskSuspend	Suspends a task.
	LOS_TaskDelay	Delays a task.
Task scheduling control	LOS_TaskLock	Locks a task.
	LOS_TaskUnlock	Unlocks a task.

- Programming instance (Example: los_api_task.c)
- Compilation result:

```
LOS_TaskLock() Success!
Example_TaskHi create Success!
Example_TaskLo create Success!
Enter TaskHi Handler.
TaskHi LOS_TaskDelay Done.
Enter TaskLo Handler.
TaskHi LOS_TaskSuspend Success.
TaskHi LOS_TaskResume Success.
```

Kernel Modules - Memory

Task | **Memory** | Interrupt

- Memory is a very important resource in a system. Memory management, a core function of the OS, is to initialize, allocate, and release memory resources.
- Huawei LiteOS provides two types of memory management algorithms: membox for static memory allocation; and bestfit, bestfit_little, and two-level segregated fit (tlsf) for dynamic memory allocation.
- It also provides memory statistics and memory overwriting detection functions.

Kernel Modules - Dynamic Memory

Task | **Memory** | Interrupt

- A fixed-size memory block in the dynamic memory pool is allocated to a user.
- All memory blocks are linked together using linked lists. A TLSF has multiple linked lists. When a memory block is released to the memory pool, the idle blocks before and after the memory block are linked automatically. Each block starts with a header structure for management and allocated blocks have the same header structure.
- Advantages
  - Allocation on demand; large blocks are cost-effective
- Disadvantages
  - Memory is wasted if there are many small blocks due to the management header.
  - Fragments in the memory pool
  - High performance overheads

Kernel Modules - Static Memory

Task | **Memory** | Interrupt

- A preset (fixed)-size memory block in the static memory pool is allocated to a user during initialization.
- It is also called an object pool, though it is essentially an object array.
- Advantages
  - Higher performance than in dynamic memory management
  - Highly efficient memory allocation and releasing without a header structure for management in each block
  - No fragment in the static memory pool
- Disadvantages
  - Fixed size, not allocated on demand
  - Inappropriate for large object management

Memory Management Programming Instance

Task | **Memory** | Interrupt

- Memory management interface description:

Function Category	Interface Name	Description
Memory initialization	LOS_MemInit	Initializes a fixed-size of memory from the dynamic memory pool.
Dynamic memory allocation	LOS_MemAlloc	Allocates a fixed-size of memory from the dynamic memory pool.
Dynamic memory release	LOS_MemFree	Releases the allocated memory.

- Programming instance (Example: los_api_dynamic_mem.c)
- Compilation result:

```
mempool init ok!
mem alloc ok
        *p_num = 828
mem free ok!
```


HUAWEI

Kernel Modules - Interrupt

Task | Memory | **Interrupt**

- An interrupt is the process where the CPU stops to execute a new program.
- With the interrupt mechanism, the CPU can execute other tasks when the CPU is no longer needed. When a new task requires the CPU, the CPU can interrupt its current task to respond to the interrupt request by generating an interrupt signal. This ensures the CPU does not spend too much time waiting and querying the task's status.
- Huawei LiteOS supports interrupt response and non-response.
- An interrupt can be initialized, created, started, stopped, resumed, enabled, and masked.

Kernel Modules - Interrupt Operation Mechanism

Task | Memory | **Interrupt**

When an interrupt is generated, the processor performs the following operations in sequence:

- Saves the current processor status information.
- Loads exception or interrupt processing functions to the PC register.
- Transfers control to the handler function and starts execution.
- After the processing function is executed, the processor status information is restored.
- Returns from an exception or interruption to the previous program's execution point.

Inter-Task Communication

- The multi-task synchronization, mutual exclusion, and communication of Huawei LiteOS are as follows:
  - Queue
  - Event
  - Semaphore
  - Mutex

Kernel Modules - Queue

Queue Event Semaphore Mutex

- A queue (AKA message queue) is a data structure commonly used for inter-task communication that receives messages from tasks or interrupts and determines whether to store messages in its own space based on interfaces.
- When a user processes a service, the message queue provides an asynchronous processing mechanism that allows the user to put a message into a queue for later processing. The queue can also buffer messages for transferring data between tasks.
- A queue can be created, deleted, sent, and received.

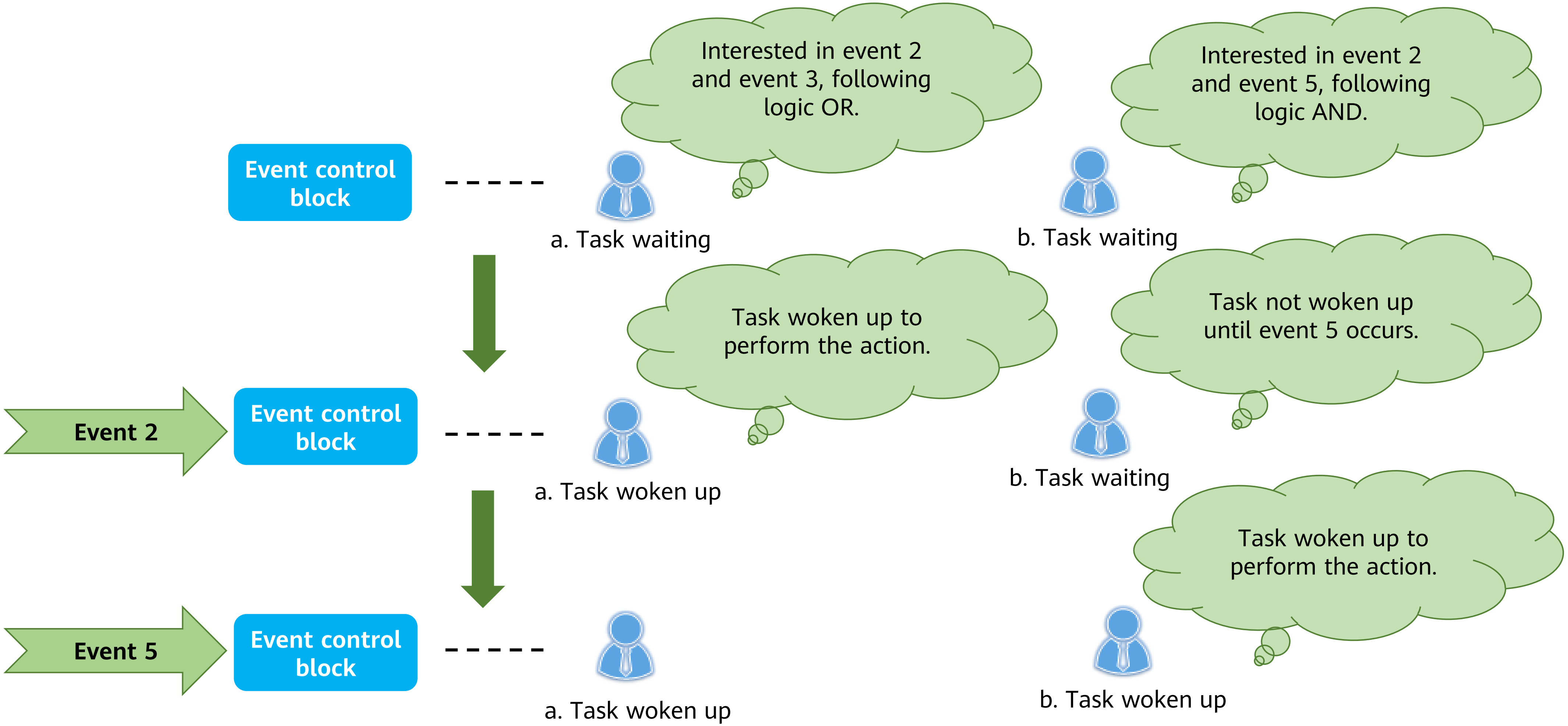
Kernel Modules - Event

Queue | **Event** | Semaphore | Mutex

- An event is a mechanism for inter-task communication and synchronization. However, communication between events does not involve data transmission.
- An event is not associated with a task, and is independent of other events. A 32-bit variable is used to identify an event type that occurs in a task, of which each bit indicates its type. There are 31 event types. Among them, the 25th bit is reserved, 0 indicates no event has occurred, and 1 indicates the opposite.
- A task can be woke up:
  - After an arbitrary event occurs.
  - After several events occur.
  - When the same event type is sent to a task multiple times, and is equivalent to sending the event type to the task only once.

Kernel Modules - Event Operation Mechanism

Queue | **Event** | Semaphore | Mutex



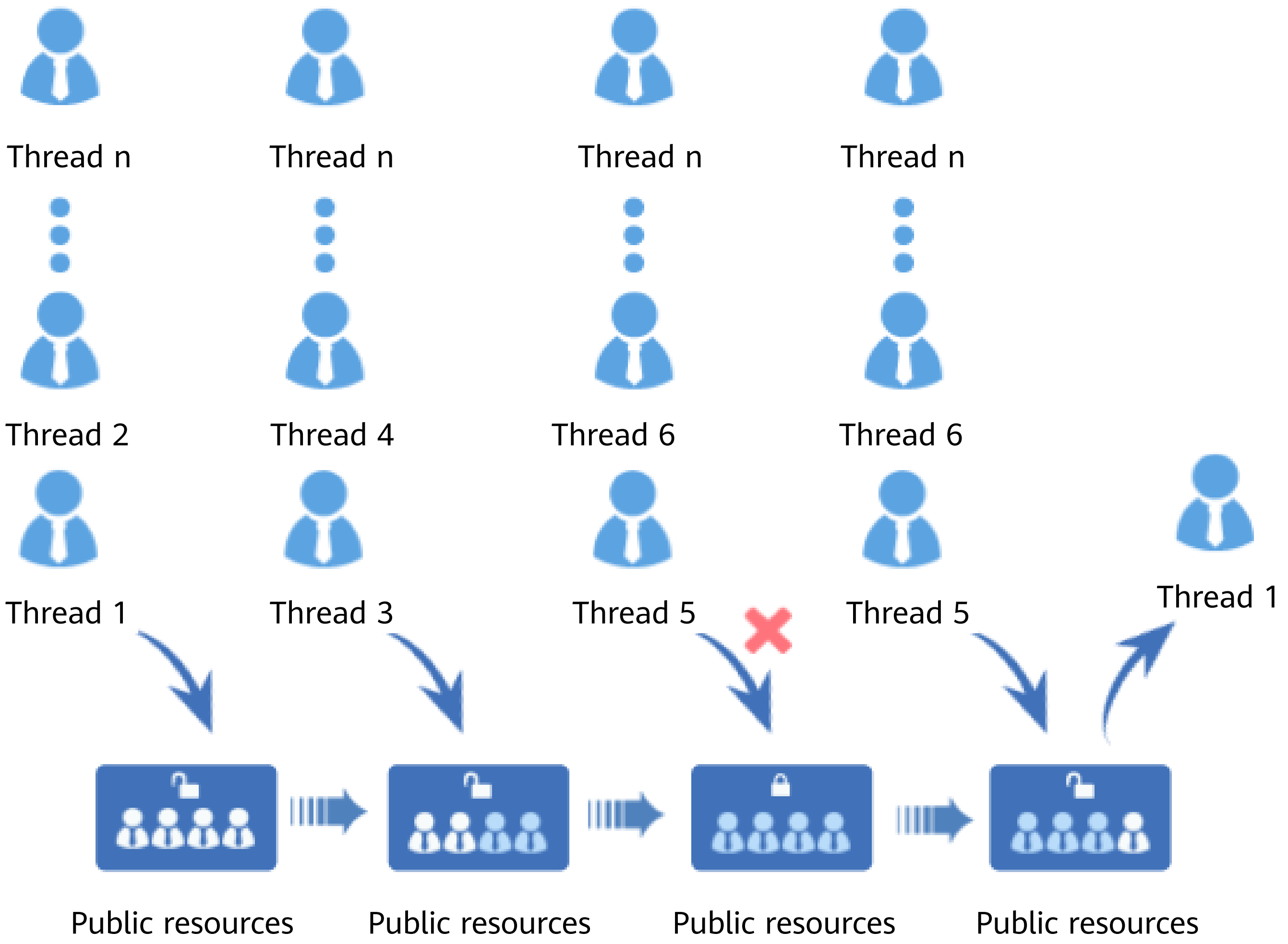
Kernel Modules - Semaphore

Queue | Event | **Semaphore** | Mutex

- A semaphore is a mechanism for inter-task communication, and enables tasks to access system resources synchronously or critical resources exclusively. Typically, a semaphore coordinates a group of tasks competing for critical resources.
- A semaphore limits the number of tasks concurrently accessing the same resource. When the number of tasks accessing the same resource reaches the maximum, the semaphore blocks other tasks from accessing the resource, until it finishes.

Kernel Modules - Semaphore Operation Mechanism

Queue | Event | **Semaphore** | Mutex



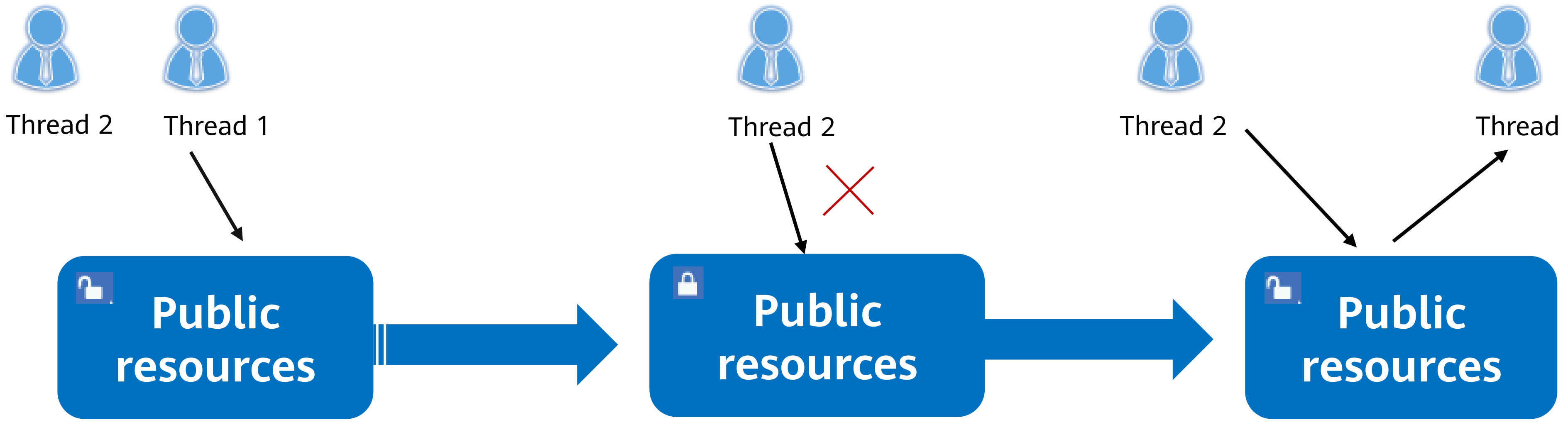
Kernel Modules - Mutex

Queue | Event | Semaphore | **Mutex**

- A mutex is a special binary semaphore used to exclusively process shared resources.
- A mutex has two statuses: locked or unlocked.
  - A mutex is locked when a task owns it. Other tasks cannot unlock the mutex during this time.
  - A mutex is unlocked when the task no longer owns it.

Kernel Modules - Mutex Operation Mechanism

Queue | Event | Semaphore | **Mutex**



When thread 1 accesses public resources, the mutex is locked and thread 2 is suspended.

When thread 1 releases the mutex, thread 2 can access public resources.

Kernel Modules - Time Management

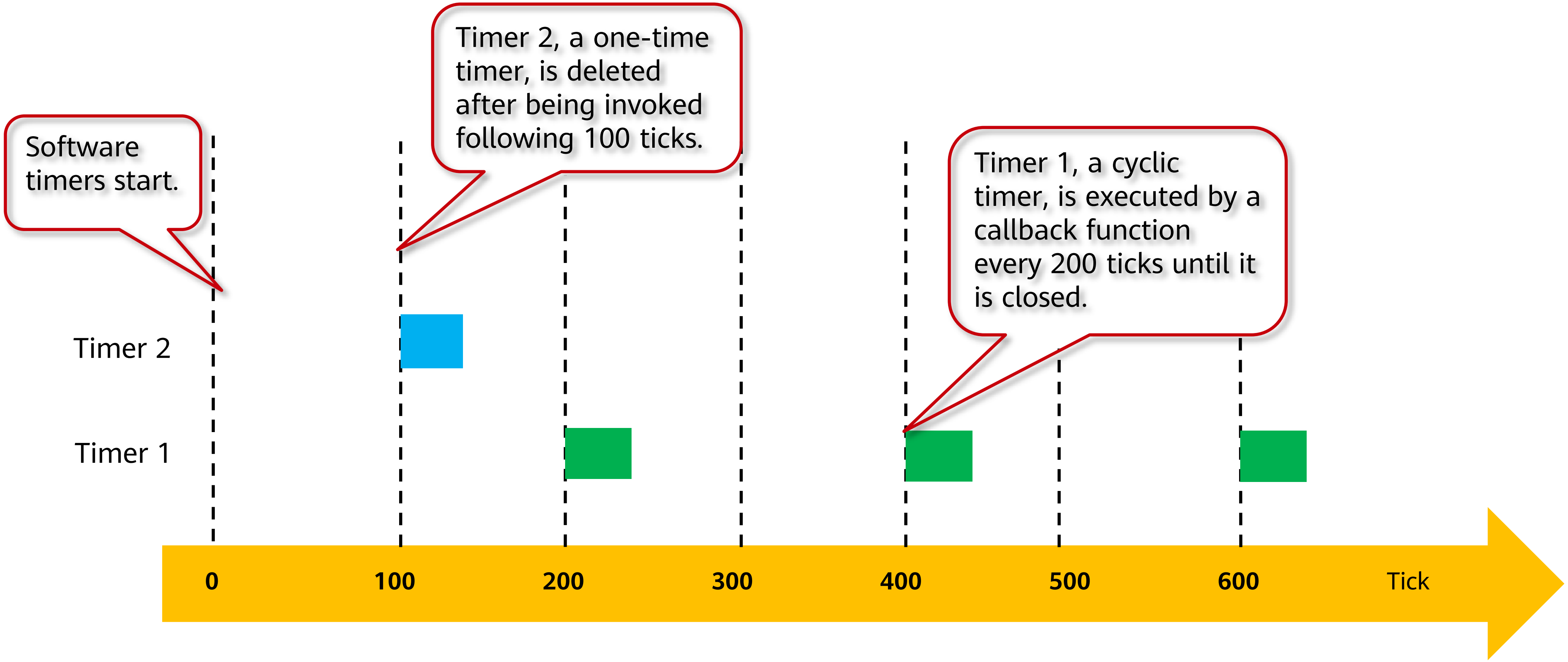
Time Management | Timer

- Time management is based on the system clock, and provides all time-related services for applications.
  - When the output pulse generated by the timer or counter triggers an interrupt, the system clock is generated. The system clock is generally defined as an integer or long integer, and the period of the output pulse is called a "clock tick". The system clock is also referred to as time scale or tick, and the duration of a tick can be configured statically.
  - The clock measures in seconds or milliseconds, while that of the chip CPU is tick. When a user needs to perform an operation on the system, for example, task suspension or delay, they input a value in seconds, which then needs to be converted by the time management module.

Kernel Modules - Timer

- Hardware timers are limited, and are unable to meet user requirements. As such, Huawei LiteOS provides a software timer.
- The software timer is a timer simulated by software, depending on tick. After the configured tick counts are reached, a user-defined callback function is invoked. The timing precision is related to the period of the tick.
- The software timer is unlimited and can be created as required.

Kernel Modules - One-time and Cyclic Software Timers



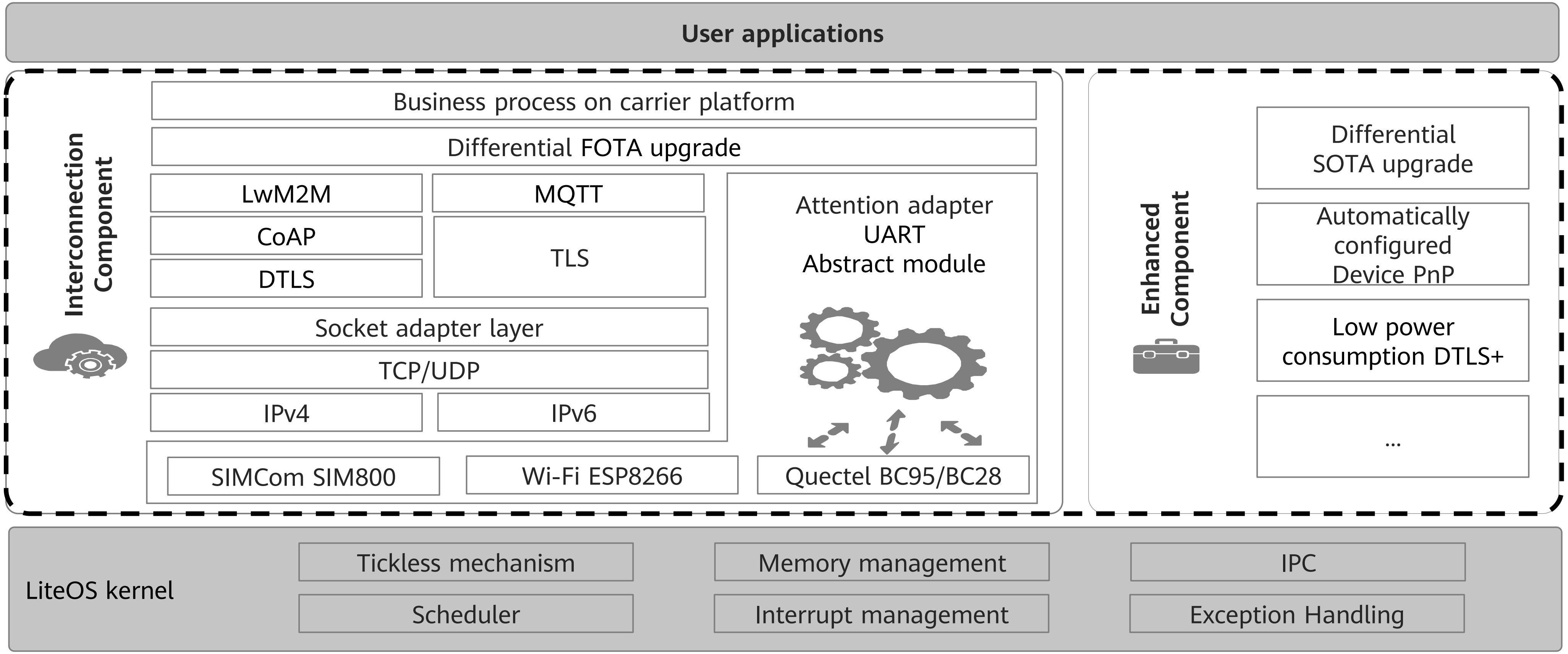
Huawei LiteOS Kernel Features

- Low power consumption, strong performance, and high stability.
- Ultra-small kernel of less than 6 KB.
- Dynamic and distributed loading.
- Static tailoring.

Contents

Huawei LiteOS SDK

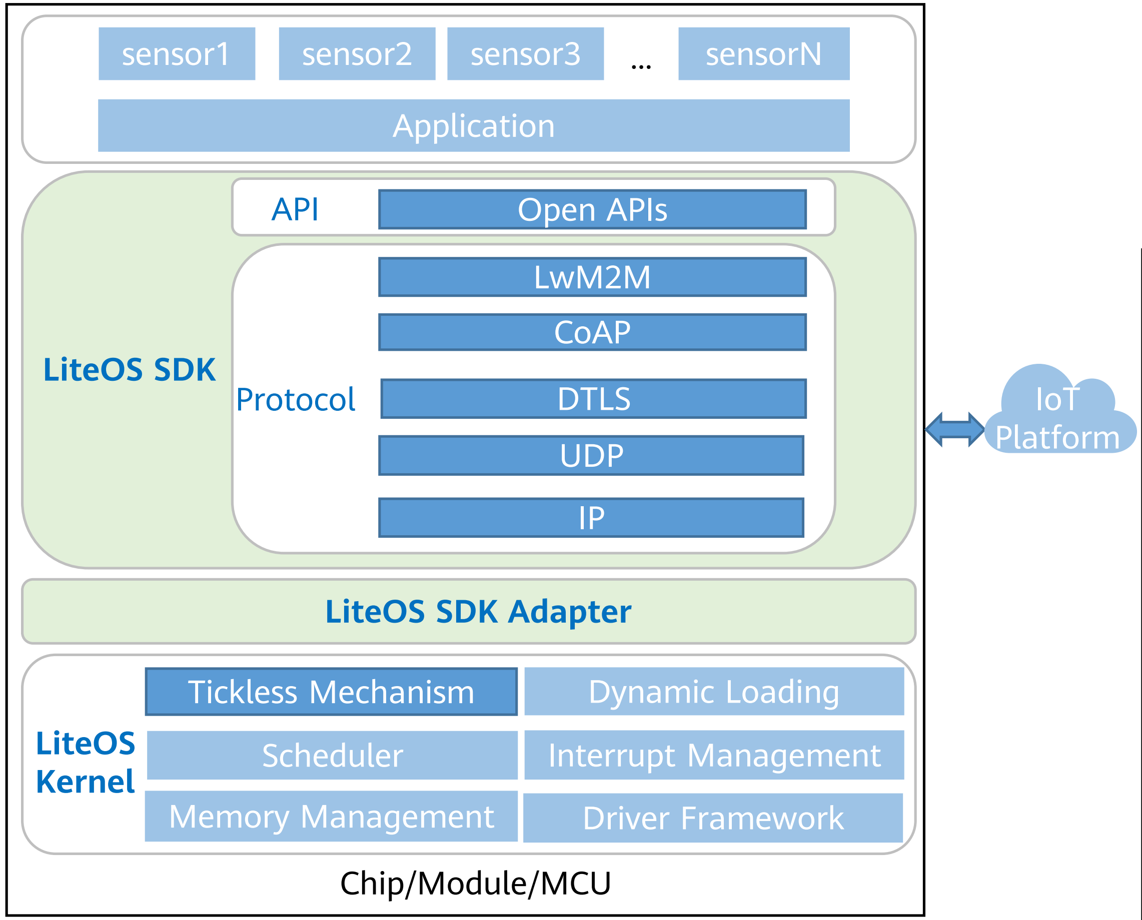
- Huawei LiteOS software development kit (SDK) comprises device-cloud interconnection, JS engine, and smart sensing framework.



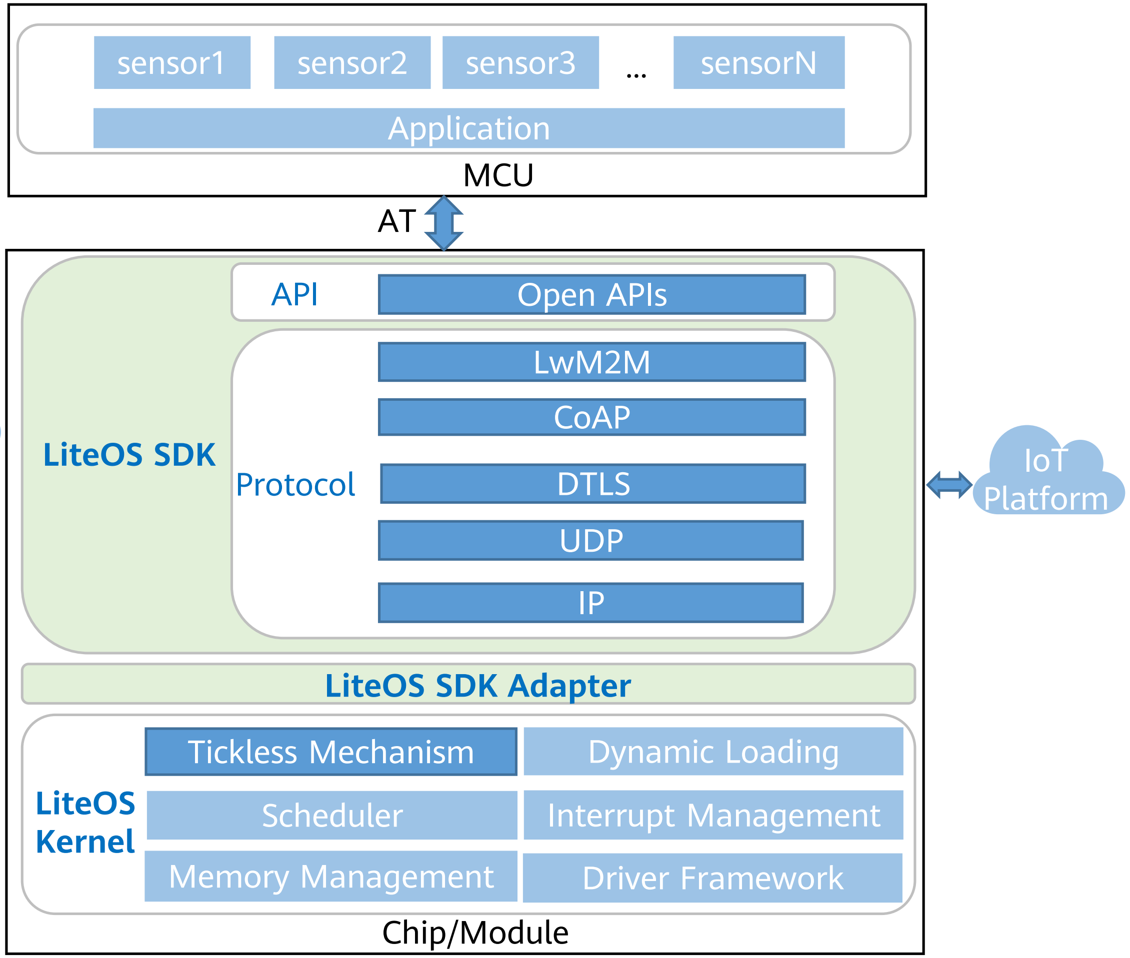
Device-Cloud Interconnection Component

- The LiteOS SDK device-cloud interconnection component does not depend on specific chip architecture or network hardware type and can be easily integrated into various communication modules, such as the Narrow Band Internet of Things (NB-IoT) module, enhanced Machine-Type Communication (eMTC) module, Wi-Fi module, Global System for Mobile Communications (GSM) module, and Ethernet hardware.
- The device-cloud interconnection component provides device-cloud collaboration and integrates a full set of IoT interconnection protocol stacks such as Lightweight Machine-To-Machine (LwM2M), Constrained Application Protocol (CoAP), mbed TLS, and Lightweight IP (LwIP).

Software Architecture of the Device-Cloud Interconnection Component

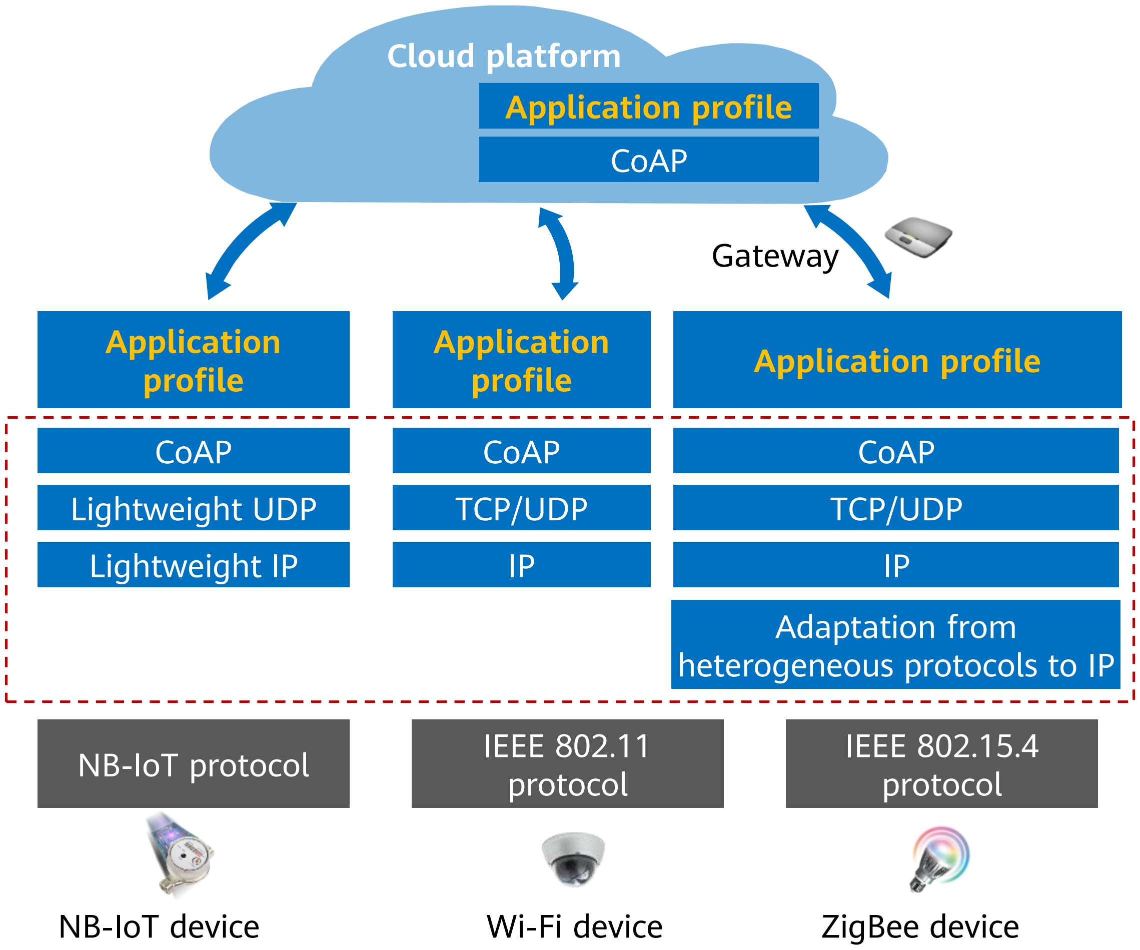


Single Module/MCU

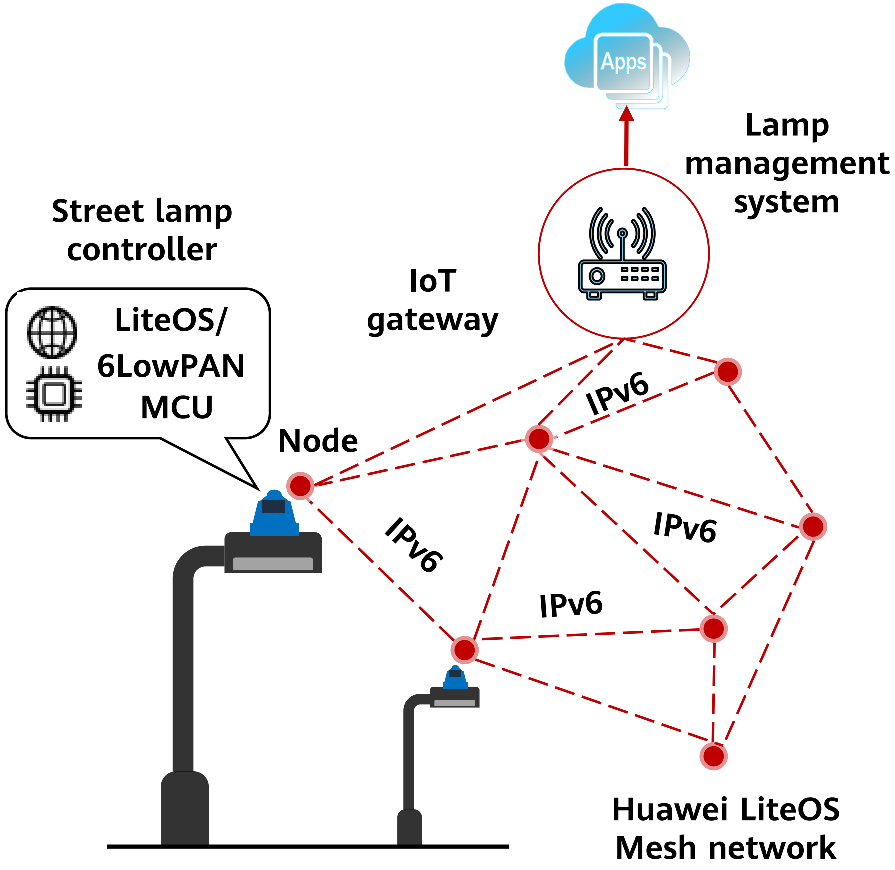


MCU + Chip/Module

Interconnection Framework



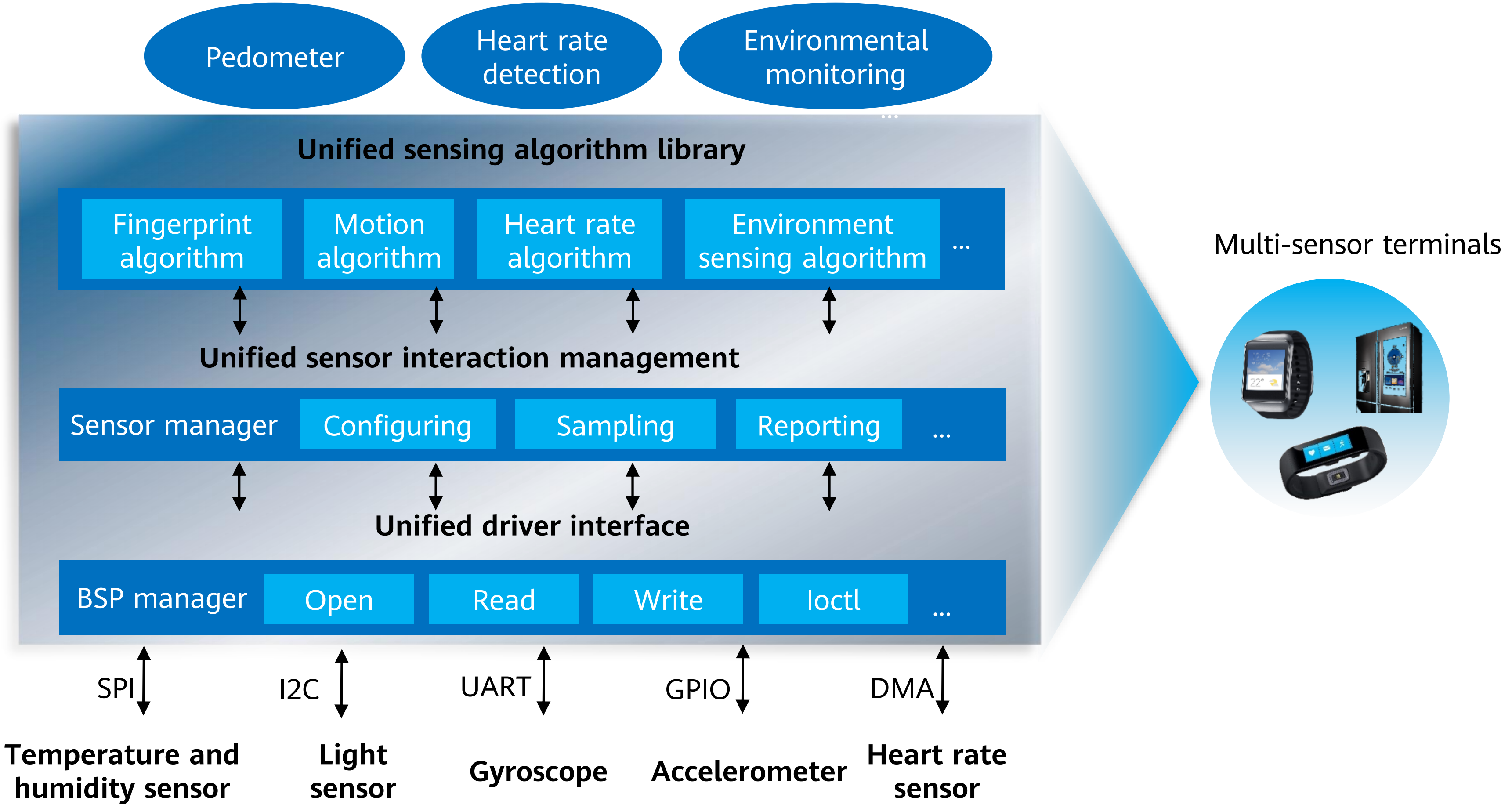
Interconnection framework ensures terminals run different protocols.



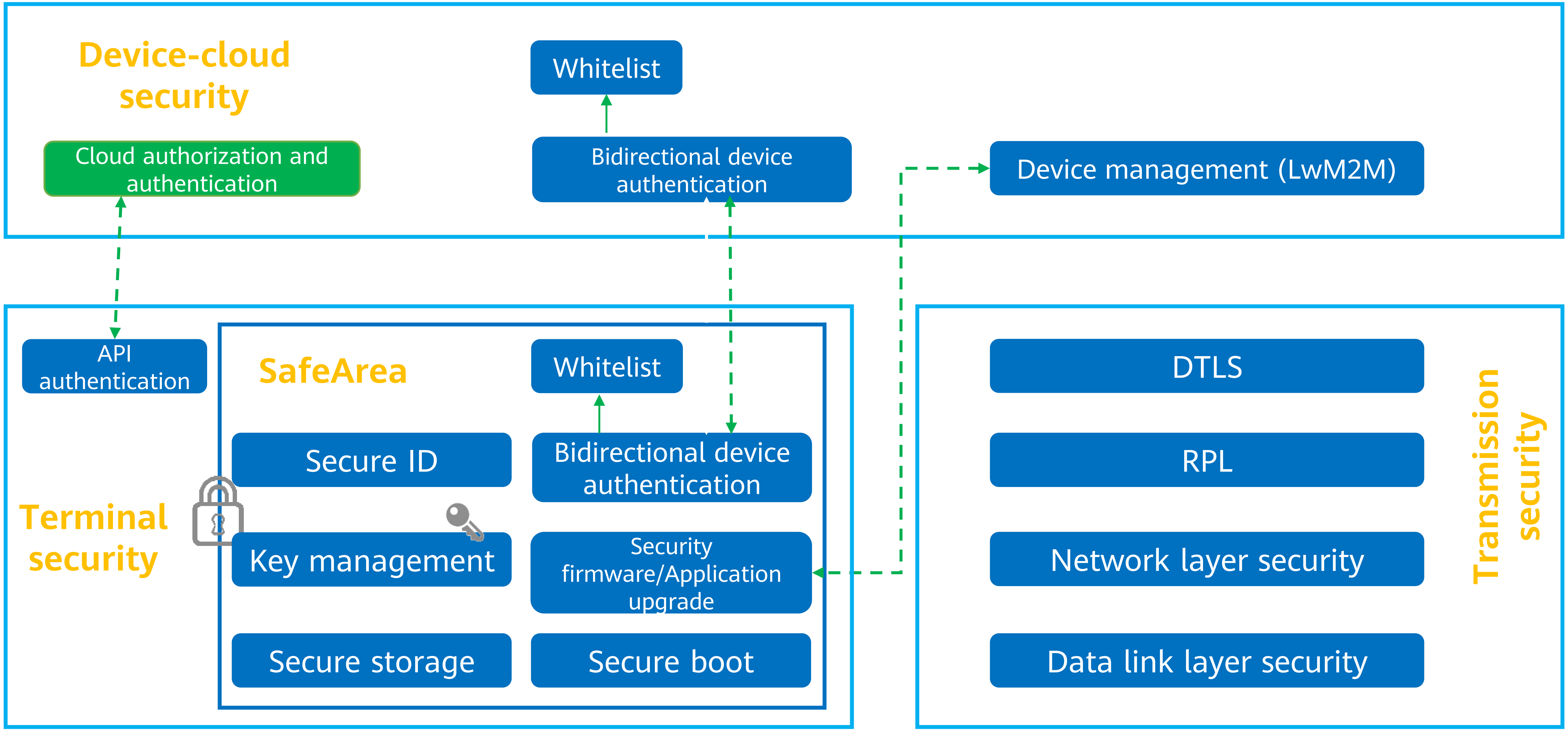
Optimized Mesh network (self-networking) connects a large number of terminals.

Smart Sensing Framework

- The smart sensing framework provides unified management of sensors.

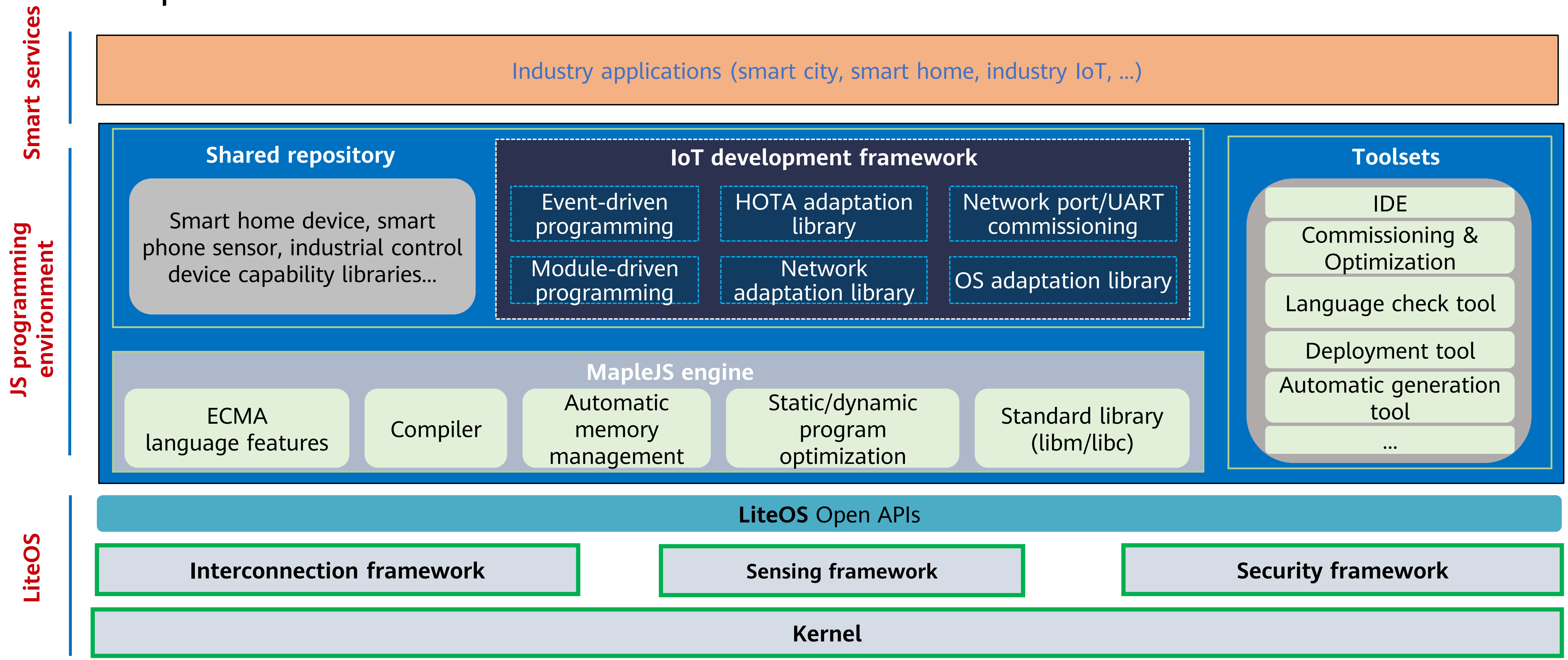


Security Framework



JS Running Engine - MapleJS

- MapleJS: advanced IoT dynamic languages help developers focus solely on application development.



JS Running Engine

- High-Performance and Lightweight JS Virtual Machine (VM)
  - Optimized design for devices with severely limited resources
  - The JS framework, JS VM, and OS work together to boost performance and reduce power consumption.
  - Provides independent user space and application isolation to ensure application security.
- Advantages of the JS Framework
  - Applications decoupled from the OS and upgraded without burning
  - Simplified system integration across hardware platforms and middlewares
  - Cross-compatibility with third-party libraries
  - High-level language abstraction conceals some programming details

Contents

Huawei LiteOS APIs

- Open APIs bridge the gaps between applications, allowing developers to focus on application development.
- User-friendly compatibility enables developers who are already familiar with application development on the Linux system to switch smoothly to Huawei LiteOS. In addition, the simplified kernel of Huawei LiteOS is easier for developers to understand.
- For example, based on APIs provided by the device-cloud interconnection component, developers quickly implement secure and reliable connections to Huawei IoT platform OceanConnect with only a few steps.

Quiz

1. Which of the following functions belong to Huawei LiteOS kernel? (Choose more than one)

   A. Task B. Process C. Time management D. Memory management

2. (True or false) Data in the read-only memory (ROM) does not disappear after a power failure.

3. In the MCU architecture, which of the following modules is used to read instructions and control the entire system? (Choose only one)

   A. Memory

   B. Processor

   C. Bus

   D. I/O

Summary

- This document describes the development process related to the sensing layer, including hardware development and software development.
  - In hardware development, it mainly introduces the basic concept of single-chip microcomputer as well as the sensing technology and related sensors.
  - In software development, it describes the architecture of Huawei LiteOS and its components, including the kernel, framework, and APIs.

Thank you.

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HUAWEI

AT Commands for Communication Modules

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Foreword

- Attention (AT) commands are used for connection and communications between terminal equipment (TE) and PC applications. They are sent from TE or data terminal equipment (DTE) to a terminal adapter (TA) or data circuit terminal equipment (DCE). AT commands are used to control the functions of mobile terminals (MTs) to implement interaction with network services.
- This course describes AT commands used for NB-IoT and Wi-Fi networks involved in the end-to-end (E2E) IoT service experiments.

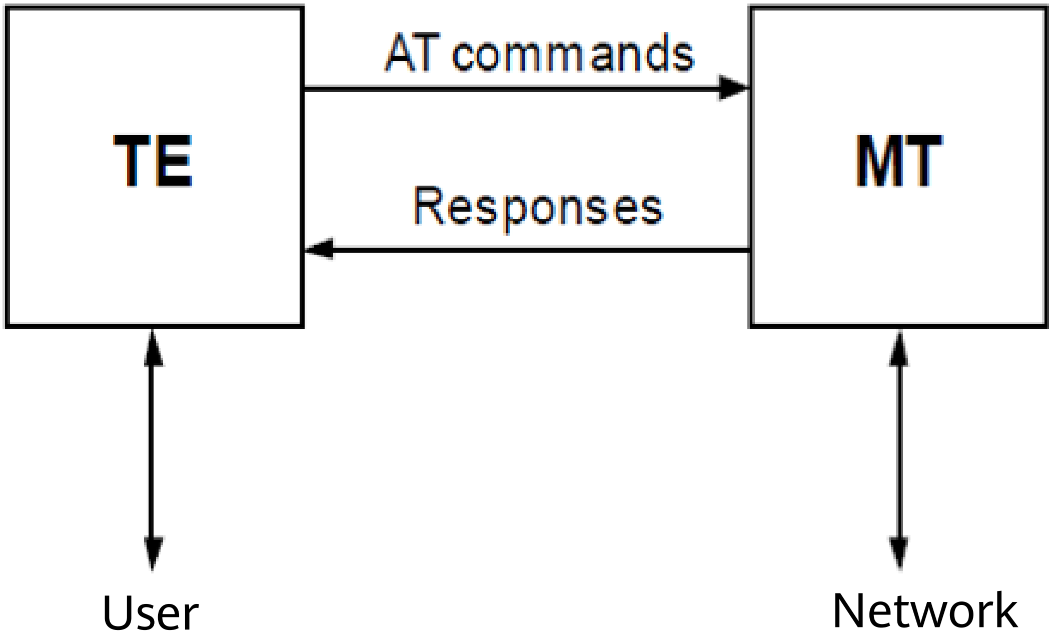
Objectives

- On completion of this course, you will:
  - Know how to distinguish AT commands for NB-IoT, Wi-Fi, and Huawei certified communication modules.
  - Have a good command of the process of accessing NB-IoT and Wi-Fi networks.

Contents

AT Commands

- AT commands are used to control the rules of interaction between a TE and a mobile terminal (MT).



AT Command Types

- Set command, =XX, is used to set the attributes carried in the AT command.
- Test command, =?, is used to display valid parameter values set by other AT commands.
- Read command, ?, is used to query attributes set by other AT commands.
- Execution command, is used to instruct a module to execute a specific function.

Category	Syntax	Example
Set command	AT+<x>=P1	AT+NNMI=1
Test command	AT+<x>=?	AT+CMEE=?
Read command	AT+<x>?	AT+CMEE?
Execution command (with parameters)	AT+<x>=<...>	AT+CMEE=0
Execution command (without parameters)	AT+<x>	AT+NRB

NB-IoT AT Commands

- The MCU uses AT commands to control the communication module. Terminal manufacturers must develop software that invokes AT commands to control communication modules in addition to developing corresponding service functions.

Purpose	AT Command
Disabling a function	AT+CFUN=0
Checking the software version	AT+CGMR
Querying the international mobile equipment identity (IMEI)	AT+CGSN=1
Setting the platform address	AT+NCDP=xx.xx.xx.xx
Configuring an access point name (APN)	AT+CGDCONT=1,"IP","xxxx"
Rebooting the module	AT+NRB
Enabling a function	AT+CFUN=1
Querying the IMSI of a SIM card	AT+CIMI
Notifying the terminal of connecting to the base station	AT+CSCON=1
Notifying the terminal of connecting to the core network	AT+CEREG=2
Notifying the terminal of downstream data transmission	AT+NNMI=1
Notifying the terminal of successful data transmission	AT+NSMI=1
Attaching to a network	AT+CGATT=1
Querying the terminal status	AT+NUESTATS
Querying the IP address assigned by the core network	AT+CGPADDR
Transmitting data	AT+NMGS=1,11
Querying the sending buffer	AT+NQMGS
Querying the receiving buffer	AT+NQMGR

Wi-Fi AT Commands

- As a non-3GPP short-range wireless communications technology, Wi-Fi involves different AT commands from GPRS and NB-IoT network environments. The Wi-Fi AT commands are mainly used to interact with the gateway and access the network through the gateway. Carrier data related to SIM cards, wireless networks, and core networks are not involved.

Purpose	AT Command
Resetting the module	AT+RST
Querying the version	AT+GMR
Scanning available access points (APs)	AT+CWLAP
Connecting to an AP	AT+CWJAP
Disconnecting from an AP	AT+CWQAP
Querying connection information	AT+CIPSTATUS
Resolving the domain name	AT+CIPDOMAIN
Establishing a connection	AT+CIPSTART
Starting transparent transmission	AT+CIPMODE
Transmitting data	AT+CIPSEND
Querying the local IP address	AT+CIFSR
Using the ping operation	AT+PING
Restoring factory settings	AT+RESTORE
Querying the available memory space of the system	AT+SYSRAM

AT Commands for Huawei Certified Communication Modules

- For modules with Huawei compatibility certification, the AT commands and format specifications are similar to general specifications. Modules from some manufacturers may be implemeted slightly differently, due to their AT channel limitations. These differences will be stated in the special description by module manufactures.

Purpose	AT Command
Obtaining the Huawei SDK version	AT+HMVER
Setting MQTT connection parameters	AT+HMCON
Disconnecting from the HUAWEI CLOUD IoT platform	AT+HMDIS
Sending MQTT data to a topic	AT+HMPUB
Transmitting data received by the module to an external MCU	+HMREC
Transmitting the module connection or disconnection status to an external MCU	+HMSTS
Subscribing to a custom topic	AT+HMSUB
Unsubscribing from a custom topic	AT+HMUNS
Setting a server or client certificate	AT+HMPKS

Contents

NB-IoT Terminal Connection Process

- Power on the terminal, and run the **AT+NRB** command to reset the terminal. If **OK** is returned, the terminal is running properly.
- Run the **AT+NTSETID=1,*Device_ID*** command to specify the device ID. The device ID is the terminal IMEI. If the command is executed, **OK** is returned.
- Run the **AT+NCDP=*IP*,*Port*** command to set the IP address and port for connecting to the IoT platform. The port is 5683. If the command is executed, **OK** is returned.
- Run the **AT+CFUN=1** command to enable the network access function. If the command is executed, **OK** is returned.
- Run the **AT+NBAND=*Frequency_band*** command to specify the frequency band. If the command is executed, **OK** is returned.
- Run the **AT+CGDCONT=1,"IP","APN"** command to set the IoT core APN. If the operation is successful, **OK** is returned. To obtain the APN, contact the carrier or OpenLab owner.
- Run the **AT+CGATT=1** command to connect the terminal to the network. If the command is executed, **OK** is returned.
- Run the **AT+CGPADDR** command to check whether the terminal has obtained the IP address assigned by the IoT core network. If it has, the terminal has accessed the network.
- Run the **AT+NMGS=*Data_length*,*Data*** command to enable the terminal to send upstream data. If the upstream data is sent, **OK** is returned.
- If the IoT platform sends downstream data to the terminal, obtain downstream data by running the **AT+NMGR** command.

Wi-Fi Terminal Connection Process

- Power on the terminal, and run the **AT+CWMODE=3** command to reset the terminal. If **OK** is returned, the Wi-Fi mode has been configured on the terminal.
- Run the **AT+CWJAP=SSID,Password** command to connect to the router. If the command is executed, **OK** is returned.
- Run the **AT+CIFSR** command to query the IP address of the ESP8266. If the command is executed, **OK** is returned.
- Run the **AT+CIPSTART=TCP,IP,PORT** command to set the IP address and port for connecting to the IoT platform. The port is 5683. If the command is executed, **OK** is returned.
- Run the **AT+CIPSEND=<length>** command to send data. After **>** is returned, input the data. If the command is executed, **SEND OK** is returned.

Quiz

1. (Multiple Choice) Which of the following are AT command types?

   A. Test command B. Read command C. Set command D. Execution command

2. (True or False) AT commands are used to control the rules of interaction between a TE and an MT.

3. (Single Choice) Which of the following types does the **AT+CMEE?** command belong to?

   A. Test command B. Read command C. Set command D. Execution command

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Summary

- This course covered the general concepts and classification of AT commands, and describes the AT commands for NB-IoT, Wi-Fi, and Huawei certified communication modules. It also describes the process for accessing NB-IoT and Wi-Fi networks.

Thank you.

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