IP Network eBook Series

Edge Computing-IoT Solution

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Release Date: 2021-7-10

Issue: 01

Preface

Author Introduction

Yunlong Cui: Serves as documentation engineer for Huawei data communication products. Since joining Huawei in 2015, he has been dedicated to developing documentation for a number of products, such as Huawei's Advanced Metering Infrastructure (AMI) Solution.

About This Book

This book outlines the features, advantages, architecture, and use cases of Edge Computing-Internet of Things (EC-IoT) technology. Throughout the book, you will also gain insights into Huawei's EC-IoT Solution across a broad range of industry scenarios.

Intended Audience

This book is intended for anyone with a general interest in EC-IoT; in particular, managers and sales personnel of enterprises in any industry who wish to gain an understanding of how to apply this emerging technology to their business.

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Chapter 1

EC-IoT Overview

Abstract

This chapter describes the background, definition, and benefits of Edge Computing-Internet of Things (EC-IoT).

1.1 Challenges Facing IoT

Rise of IoT

The Internet of Things (IoT) refers to a type of network where everyday physical objects are connected to the Internet, as shown in Figure 1-1.

Specifically, IoT leverages traditional communication networks and the Internet to enable common objects with independent functions to interconnect with each other, ultimately achieving the connectivity of everything.

The end devices that can be interconnected via IoT fall into the following categories:

- **Devices with built-in IoT capabilities**: sensors, mobile terminals, intelligent detection systems, etc.
- **Devices with add-on IoT capabilities**: assets with radio frequency (RF) modules attached, individuals and vehicles carrying wireless terminals, etc.

These end devices interconnect with each other over various wireless or wired communication networks that enable long-distance or short-distance transmission. In addition, they provide secure, controllable, and customizable management and service functions, such as real-time monitoring and tracing, intelligent scheduling, contingency plan management, and remote control, to implement connectivity of everything and integrated management and control.

Figure 1-1 IoT

With the rapid development of new technologies in recent years, IoT has become an important driving force for a new wave of technological revolution and industry transformation across the globe. Compared with the traditional Internet, IoT has several new and unique characteristics:

- **Comprehensive sensing**: Various types of sensors can be deployed using a broad range of sensing technologies so that an infinite number of everyday objects become IoT devices.
- **Intelligent processing**: By leveraging advanced technologies such as pattern recognition, IoT can analyze, process and filter valuable information from huge amounts of data obtained by sensors to meet the users' personalized requirements.
- **Reliable transmission**: IoT is a Field Area Network (FAN) built on the Internet. It integrates with the Internet through various wired and wireless communication networks and uses multiple communication protocols to ensure the correctness and timeliness of IoT data transmission.

Benefits and Challenges

IoT enables a massive, ever-growing number of industry terminals to be connected through networks, accelerating digital transformation across industries.

Huawei's Global Industry Vision (GIV) 2025 predicts that by 2025, the total number of connections around the world will reach 100 billion. Gartner also predicts that the economic value of IoT will reach US$11.1 trillion by 2025. As such, IoT will deliver significant benefits and value in two areas: network and data.

- **Network value**: It is estimated that IoT will bring hundreds of billions of terminal connections and devices online, and 50% of future network traffic will come from IoT. As such, the network value brought by this huge number of users and devices is immeasurable.
- **Data value**: With at least 23% of data having important analytical value, the value of data in unlocking new insights and business innovation for enterprises is critical.

There are many benefits of IoT, but there are also many challenges that go along with these benefits. IoT is a huge and complex system, with application scenarios varying according to industry. Independent analysts indicate that, by 2025, the volume of device data will reach 300 ZB (approximately 300 billion Terabytes).

In traditional data processing, all recorded data needs to be transmitted to the cloud for analysis. However, due to such a vast amount of data, cloud computing platforms face immense challenges: high network latency, a large number of devices to be connected, slow processing of complex data, insufficient bandwidth, and high power consumption.

1.2 Emergence of Edge Computing

Traditional cloud computing has the drawback of a high data processing latency and low real-time processing performance when handling massive amounts of terminal data.

This is where edge computing comes in.

What Is Edge Computing?

Powered by a distributed open platform that integrates network, computing, storage, and application core capabilities, edge computing provides intelligent edge services at the network edge, close to the things or data sources.

Edge computing opens up new opportunities for industrial digitalization in the areas of agile connections, real-time services, data optimization, application intelligence, as well as security and privacy protection. Serving as a bridge between the physical and digital worlds, edge computing enables smart assets, smart gateways, smart systems, and smart services.

What Makes Edge Computing Different from Cloud Computing?

Edge computing is a concept related to cloud computing.

In traditional cloud computing, all data is uploaded to the computing resource-intensive cloud data center (DC) or servers for processing, and all requests for access to the data must be sent to the cloud.

The explosive growth of data brought about by IoT magnifies these disadvantages of cloud computing:

- **Cloud computing cannot efficiently process increasingly massive volumes and sources of data.**

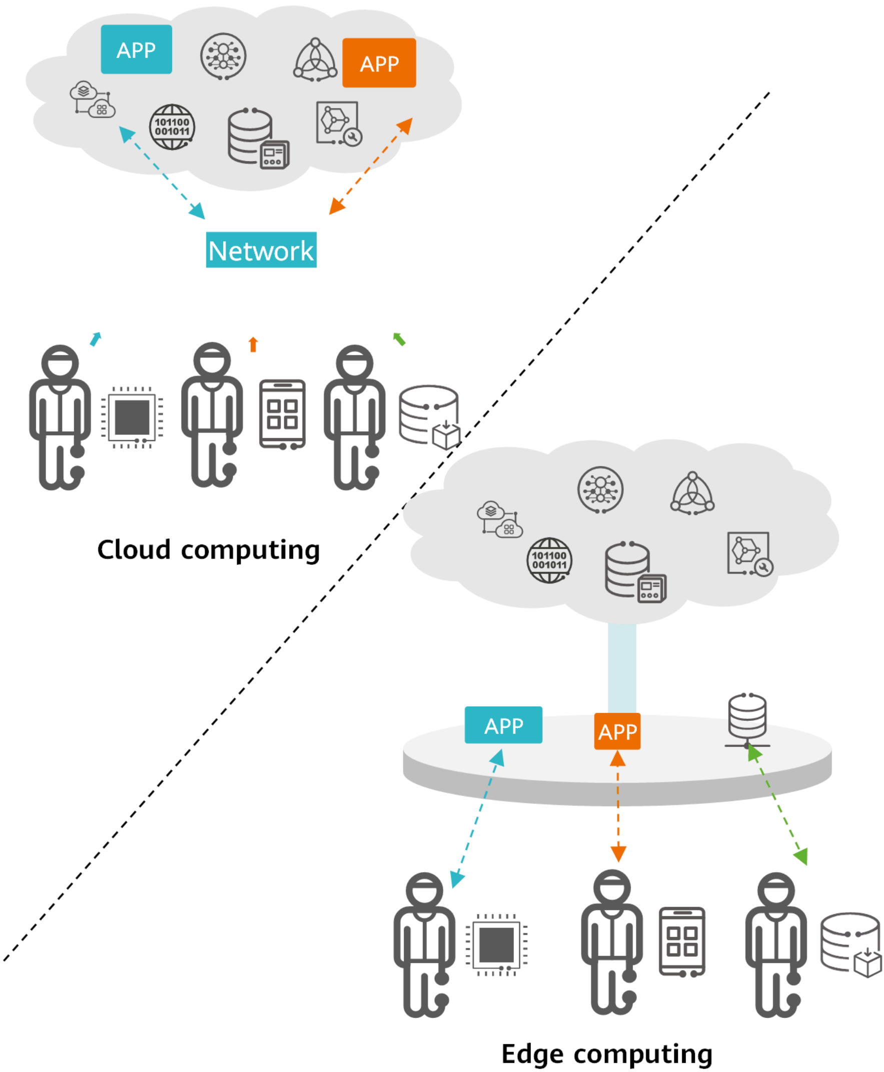
  With the popularization of IoT, the demand for computing power is increasing exponentially, which is beyond the current processing capability of the traditional cloud computing architecture.

- **Cloud computing cannot implement real-time data processing.**

  In the traditional cloud computing architecture, terminals collect IoT data and then transmit the data to the cloud computing cluster in a faraway DC. The computing cluster then sends back the result. This inevitably results in a long response time. However, some emerging application scenarios, such as unmanned driving and smart mining, have demanding requirements on the response time. As such, cloud computing is unsuitable for them.

Edge computing can solve these problems to some extent. As shown in Figure 1-2, data generated by IoT terminals does not need to be transmitted to remote cloud DCs for processing. Instead, data is analyzed and processed at the network edge, which is more efficient and secure than cloud computing.

Figure 1-2 Edge computing vs. cloud computing



What Are the Benefits of Edge Computing?

As a bridge connecting the physical world and the digital world, edge computing offers the following unique benefits:

- **Ability to handle massive number of connections**

  In many industrial scenarios, the number of connected devices increases sharply over time, posing great challenges to flexible network expansion, cost-effective operations and management (O&M), and reliability assurance. In addition, various industrial buses and industrial Ethernet of multiple standards coexist for a long time. Edge computing maintains compatibility with legacy connection standards and devices.

- **Real-time services**

  Some industrial scenarios have strict requirements for real-time performance, such as low latency, which may be 10 ms or even lower in specific scenarios. If all data analysis and processing is implemented on the cloud, the real-time performance requirements of services cannot be met, severely affecting user experience. Edge computing processes data at a place closer to the data source, minimizing the latency caused by the data transmission rate and bandwidth.

- **Intelligent data analysis**

  Not all data on the edge side needs to be uploaded to the cloud. Intelligent data analysis and optimization is required to extract, aggregate, and present data in a unified manner, so as to flexibly and efficiently serve edge applications.

- **Intelligent applications**

  Some intelligent analysis can be done at the edge to bring about business process optimization, O&M automation, and business innovation to unlock opportunities for new smart applications.

- **Robust security**

  As the edge of the network is closer to the connected devices, it is crucial to build a security line of defense at the edge. Edge-side security mainly includes device security, network security, data security, and application security. In addition, the integrity and confidentiality of critical data, and the protection of large amounts of production or personal privacy data are key concerns in security protection.

1.3 Huawei's EC-IoT Solution

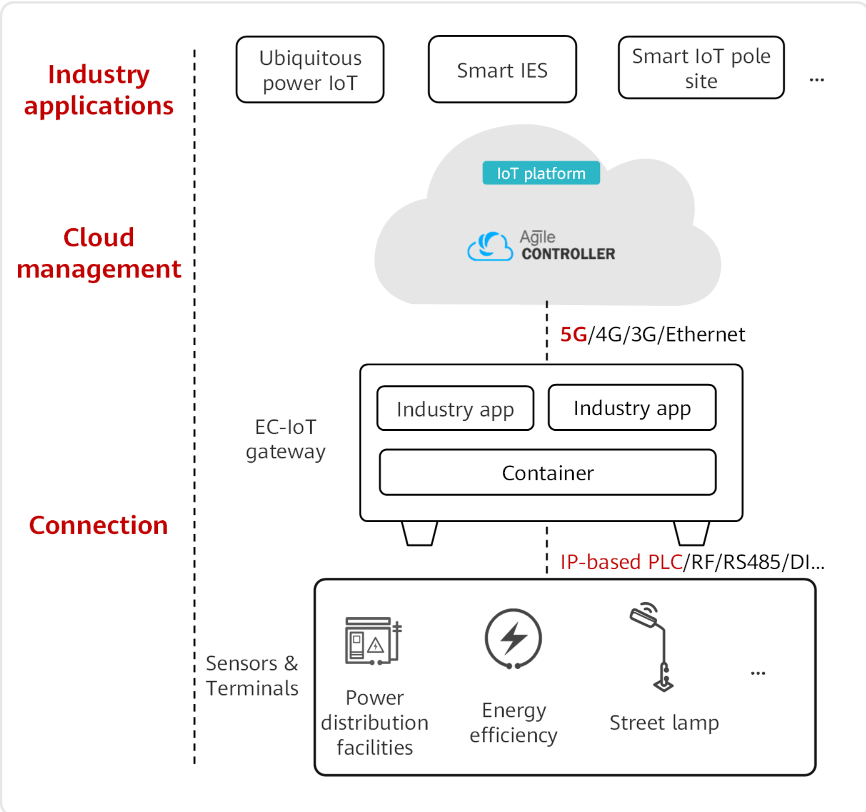
To quickly respond to the requirements of intelligent data processing at the edge and enable industrial digital transformation, Huawei introduces the edge computing architecture to the IoT field and launches the innovative Edge Computing-Internet of Things (EC-IoT) Solution.

Deeply integrating edge computing with IoT, Huawei's EC-IoT Solution deploys IoT gateways with edge computing capabilities (known as EC-IoT gateways) near network edge nodes to provide device management and control services, resolving the "last mile" problem of IoT communication. This solution implements smart connection and efficient management for IoT devices.

Figure 1-3 shows the architecture of Huawei's EC-IoT Solution. Designed for the industrial IoT field, the solution supports a wide range of industrial protocols and IoT interfaces, making it ideal for device connection scenarios across industries. The open edge computing capabilities and cloud management architecture meet the intelligent data processing requirements of different industries:

- **Connectivity**: EC-IoT gateways offer diverse IoT interfaces, for example, IP-based Power-line Communication (PLC), radio frequency (RF), RS485, and RS232, for connecting to sensors and terminals, enabling massive numbers of terminals to connect to IoT networks.
- **Cloud-based management**: Using cloud computing technologies and Agile Controller-IoT — Huawei's IoT platform, customers can implement centralized cloud-based management of edge IoT resources (such as networks, devices, containers, and applications). Additionally, Agile Controller-IoT offers open northbound application programming interfaces (APIs) to support flexible integration with other industry application systems.
- **Customization of industry applications**: The IoT platform provides standard open APIs for integration with partners' industry application systems, extending its adaptability across industries and enabling in-depth customization.

Figure 1-3 Huawei's EC-IoT Solution



Chapter 2

Advantages and Benefits

Abstract

This chapter describes the key advantages and benefits of Huawei's EC-IoT Solution, including: in-depth open edge computing, unified cloud management of massive devices, and construction of an open EC-IoT ecosystem.

2.1 In-depth Openness

Based on the "edge intelligence + cloud-based management" architecture and open edge computing capabilities of EC-IoT gateways, Huawei's EC-IoT Solution quickly adapts to various industries' requirements for intelligent data processing at the edge. This enables a rapid response to key services in milliseconds, local data aggregation and optimization, and proactive backhaul of high-value data to the cloud. The cloud-based IoT platform provides open northbound APIs to interconnect with industry application systems. In addition, the EC-IoT Solution provides integrated PLC-IoT communication modules and offers deep integration via software and hardware interfaces and APIs. Industry partners can perform secondary development to integrate the modules into IoT terminals.

IoT Platform Openness

In the EC-IoT Solution, Agile Controller-IoT uses cloud computing technologies to implement unified cloud-based management of networks, devices, containers, and applications. In addition, through open northbound APIs, Agile Controller-IoT supports flexible interconnection with industry application systems, as shown in Figure 2-1.

- **Open architecture, quickly adapting to diverse industry scenarios**

  In the northbound direction, the IoT platform uses open standard RESTful APIs to interconnect with industry application systems, providing value-added application services together with partners. In the southbound direction, the IoT platform can flexibly connect to various gateways through protocols such as Message Queuing Telemetry Transport (MQTT).

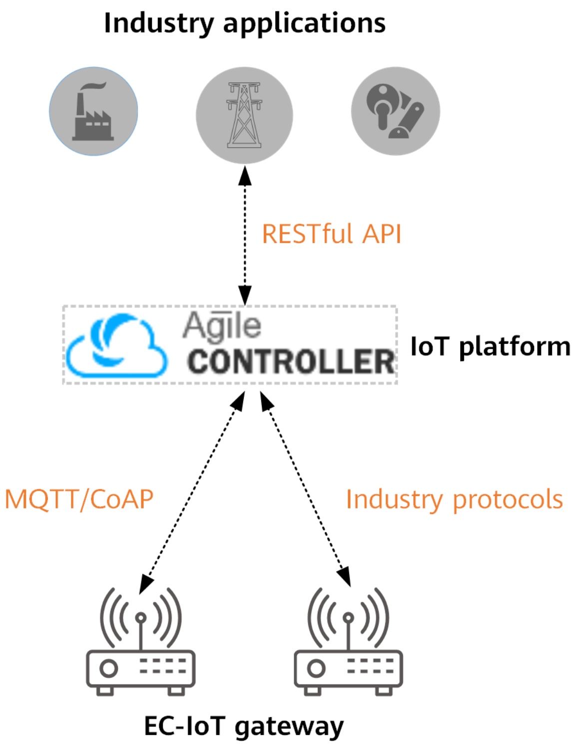
- **Service integration, enabling flexible expansion of service functions**

  The IoT platform implements full-lifecycle management of devices, containers, applications, and networks, and supports on-demand deployment of service apps.

- **Cloud-based deployment, enabling flexible capacity expansion**

  The IoT platform supports distributed cluster deployment, enabling seamless expansion and implementing centralized management of a large number of IoT gateways.

Figure 2-1 IoT platform openness



Gateway Openness

The EC-IoT gateway is designed on the concept of "platform-based hardware and app-based service". Terminal functions are defined using app software, enabling users to develop customized apps based on basic service interfaces and flexibly deploy the EC-IoT gateway to quickly adapt to IoT scenarios with complex service requirements.

Figure 2-2 shows the gateway openness. The EC-IoT gateway supports the deployment of containers, where users can install service apps. In addition, the gateway provides various eSDK interfaces for containers and applications to invoke resources.

Figure 2-2 Gateway openness

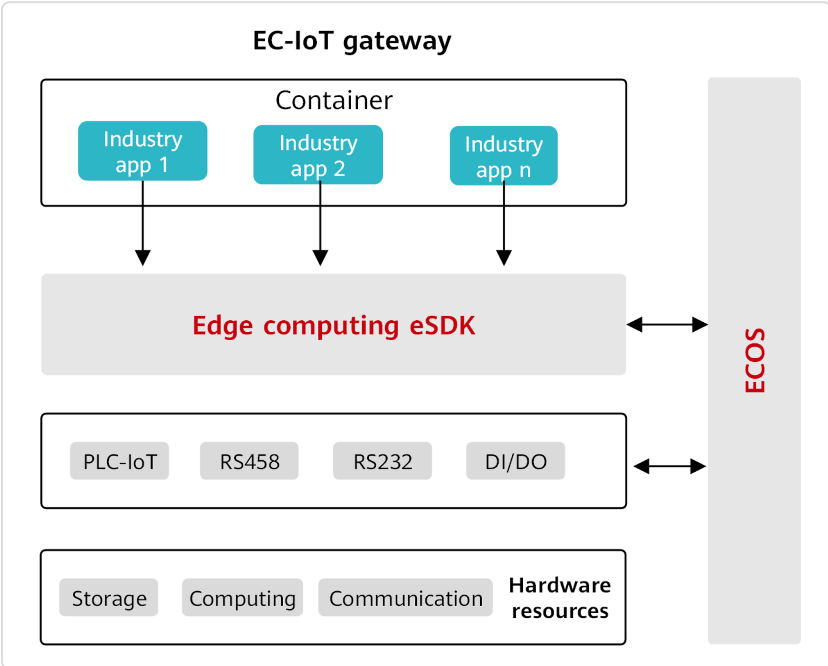


Table 2-1 Component description

Component	Description
Container	The EC-IoT gateway provides containers for users to install and deploy third-party industry apps.
Industry app	Partners can develop industry apps based on service requirements.

Component	Description
Edge Computing Operating System (ECOS)	Huawei ECOS provides the network and management functions.
Hardware resources	Hardware resources of the gateway can be opened to third-party service apps to obtain data of devices connected to the gateway.

Gateway openness offers the following benefits:

- **Quick application development**: Partners can invoke network services, interface services, message services, and container basic service libraries based on the standard Linux programming environment and open interfaces (such as eSDK). This shields the complexity of underlying hardware and basic protocols, and enables partners to focus on service requirements to quickly develop service apps, implementing intelligent management of connected IoT terminals.
- **System resource isolation**: Different system resources (such as CPU and memory resources) can be allocated to apps installed in a container. Each app has its own virtual interface and network address, preventing apps from interfering with each other.
- **Security permission isolation**: Each app does not have the highest permission of the system. Instead, they exchange information only through standard message interfaces, enhancing service security.

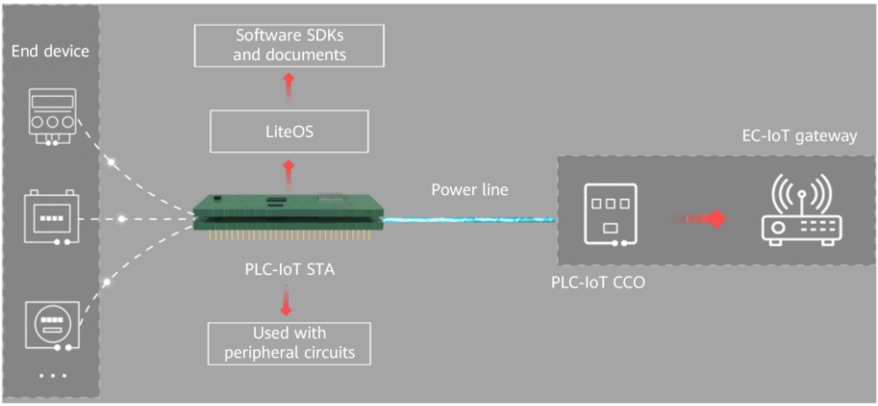
Communication Module Openness

The communication module is located at the connection layer of the Huawei's EC-IoT Solution. It is installed or integrated on IoT terminals to connect to the EC-IoT gateway through PLC-IoT to implement communication between control data and service data. The communication module is a key component for interconnection between terminals and the EC-IoT gateway.

Huawei provides two types of communication modules: central coordinator (CCO) and station (STA), which provide open software and hardware resources for secondary development.

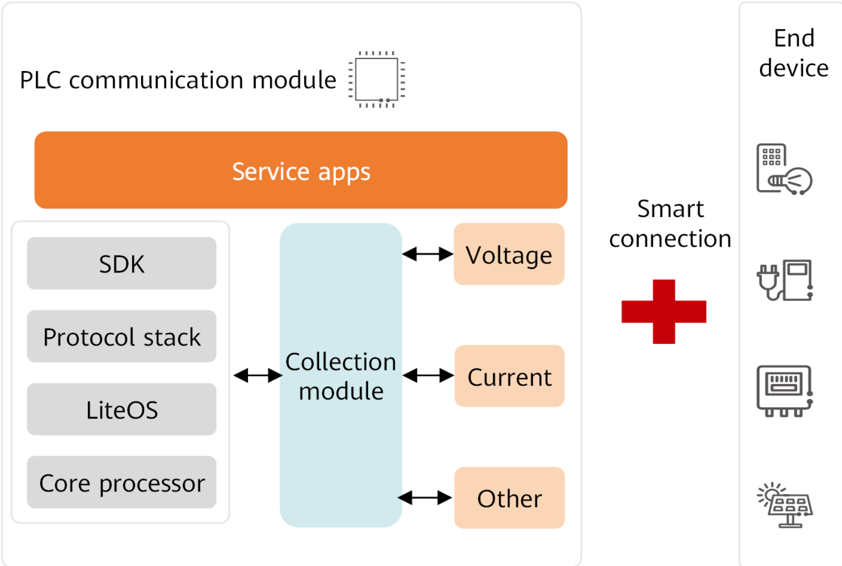
- **"Being integrated" for hardware**: PLC-IoT communication modules provide open hardware interfaces for third-party vendors to perform secondary integration of terminals, as shown in Figure 2-3. This allows a variety of terminals to access the IoT network. Installing or integrating communications modules into end devices overcomes hardware differences between end devices, facilitating quick deployment and management, and enabling quick, reliable, and cost-effective connections of a large number of sensors and smart terminals across industries.

Figure 2-3 "Being integrated" for hardware of PLC-IoT communication modules



- **Secondary development for software**: PLC-IoT communication modules provide open software interfaces for third-party vendors to invoke. As shown in Figure 2-4, the PLC-IoT communication module runs on LiteOS and provides SDK interfaces. Partners can develop customized service apps through the open APIs to implement intelligent end devices.

Figure 2-4 Openness of the PLC-IoT communication module software

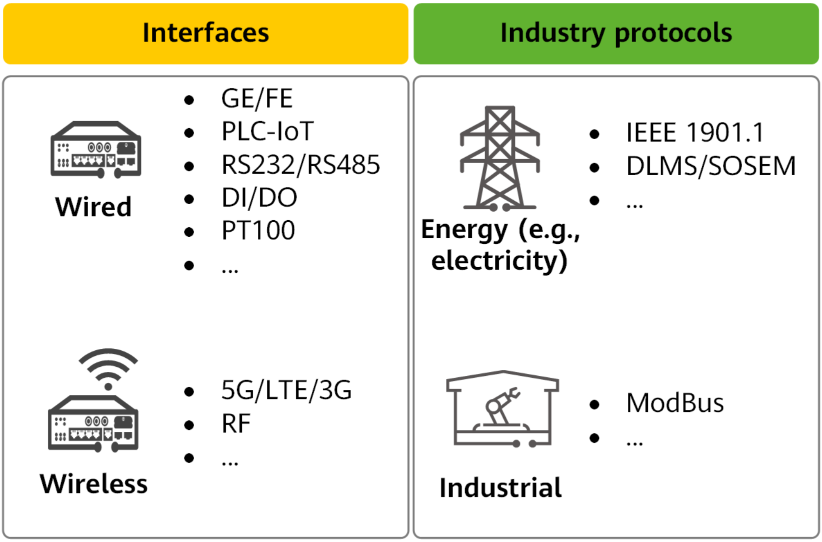


2.2 Centralized Management of Numerous Terminals

With EC-IoT gateways and Agile Controller-IoT, Huawei's EC-IoT Solution implements intelligent connection and visualized management of end devices, solving the problem of difficult management of a large number of devices in the traditional IoT.

- The EC-IoT gateway provides extensive connection modes and supports more than 17 types of industrial interfaces and industry protocols, as shown in Figure 2-5. Diverse industrial terminals, such as elevator sensors, electricity meters, transformers, water meters, and gas meters, can connect to IoT through the EC-IoT gateway.

Figure 2-5 Abundant interfaces and industrial protocols



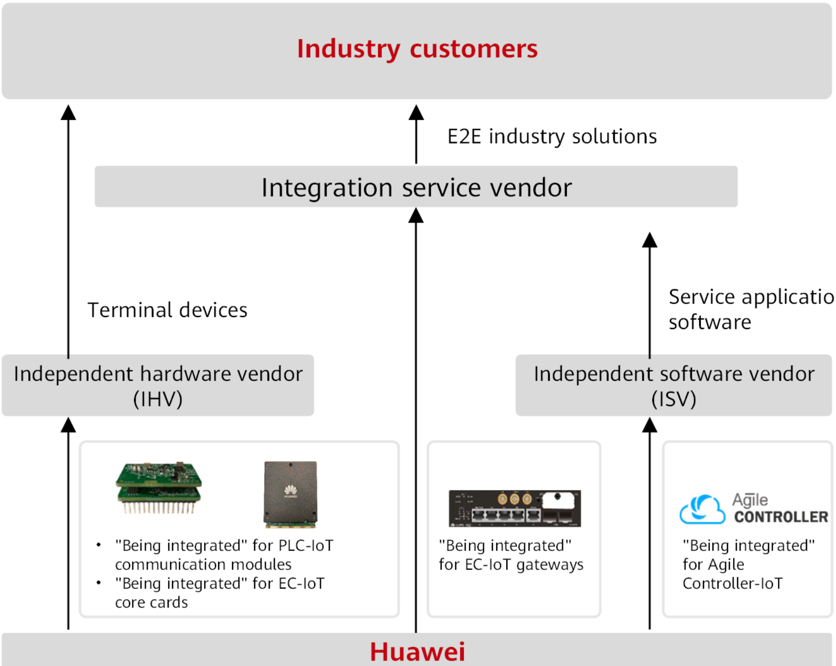
- Agile Controller-IoT supports cloud-based management of a large number of IoT terminals, full lifecycle management ranging from deployment to O&M, as well as real-time network-wide status monitoring (implemented together with the visualized management component).

2.3 Building an Open EC-IoT Ecosystem

As shown in Figure 2-6, Huawei's EC-IoT Solution supports the "being integrated" mode, which facilitates the integration and use by independent hardware vendors (IHVs), independent software vendors (ISVs), and innovation labs.

Huawei provides comprehensive development and test guidance for partners, who can then develop innovative applications based on the open capabilities of edge computing and cloud management, implementing end-to-end industry service and business model innovations and facilitating industry digital transformation. This, in turn, helps industry customers achieve business success and win-win outcomes.

Figure 2-6 Open EC-IoT ecosystem



- **"Being integrated" for Agile Controller-IoT**: Agile Controller-IoT provides open northbound APIs for connecting to third-party industry software vendors, so that the third-party industry software can integrate the Agile Controller-IoT capabilities.
- **"Being integrated" for EC-IoT gateways**: Solution integrators can use EC-IoT gateways together with industry application software that integrates the Agile Controller-IoT capabilities to meet industry customers' EC-IoT requirements.
- **"Being integrated" for EC-IoT core cards/PLC-IoT communication modules:**

- IHVs can integrate Huawei EC-IoT core cards into their devices.
- IHVs can integrate Huawei PLC-IoT communication modules into terminals (such as street lamps, sensors, and electricity meters) to transmit terminal data over power lines.

Chapter 3
Solution Architecture

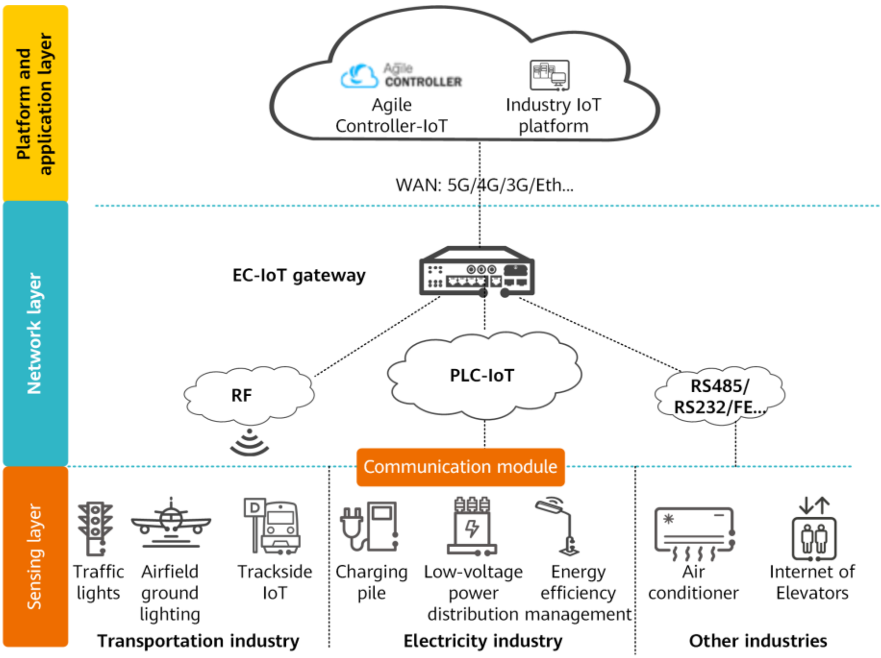
Abstract

This chapter describes the architecture of the EC-IoT Solution, which uses open edge computing and industry-leading PLC-IoT technologies to build an intelligent industry IoT.

Figure 3-1 shows the architecture of Huawei's EC-IoT Solution, which consists of the platform and application layer, network layer, and sensing layer.

- **Platform and application layer**: This layer includes the industry IoT platform and Agile Controller-IoT.
  - **Industry IoT platform**: performs analysis and computing, generates policies, and displays results based on the received IoT data.
  - **Agile Controller-IoT**: centrally manages a large number of terminals, networks, and data, enabling upper-layer IoT applications.
- **Network layer**: This layer provides an extensive range of functions such as network connection establishment and maintenance; data collection and front-end processing; on-demand local analysis and decision-making; and backhaul of required data to the cloud.
- **Sensing layer**: This layer is responsible for connections to huge numbers of sensors and smart terminals.

Figure 3-1 Architecture of Huawei's EC-IoT Solution



Chapter 4
Key Technologies

Abstract

This chapter describes two key technologies used in Huawei's EC-IoT Solution: PLC-IoT and container.

4.1 PLC-IoT

Concept

Power-line Communication (PLC) is a communication mode that uses power lines to transmit data and media signals. Although PLC was first developed in the 1920s, due to technical problems such as signal attenuation and severe noise, it was not widely applied until the 21st century. With the development of smart grid and PLC technologies, PLC has been widely used in many fields such as smart grid, industrial control, IoT, and home networks.

Huawei's PLC-IoT is a mid-band PLC technology specifically designed for industrial IoT scenarios to transmit data over power lines.

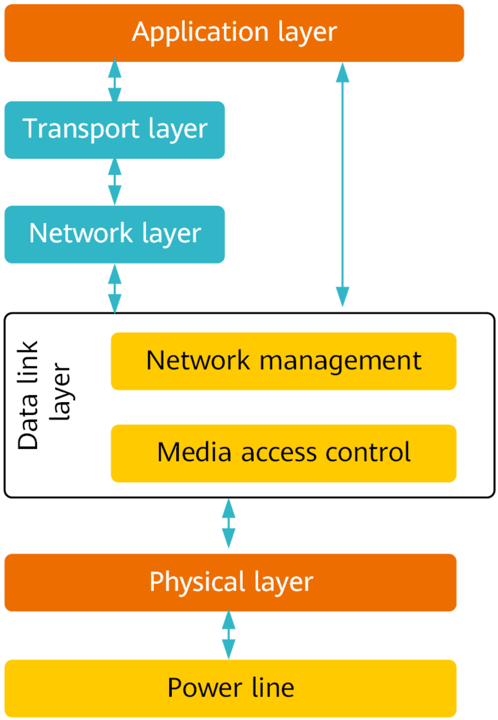
PLC-IoT has the following advantages over PLC:

- Powered by HPLC/IEEE 1901.1, PLC-IoT introduces the IPv6 over Low power Wireless Personal Area Networks (6LoWPAN) technology, which enables IPv6 to seamlessly run on low-speed networks.
- PLC-IoT operates in the frequency band ranging from 0.7 MHz to 12 MHz, featuring low and stable noise and good channel quality.
- PLC-IoT uses the orthogonal frequency division multiplexing (OFDM) technology, which has high frequency band utilization and strong anti-interference capability. By modulating digital signals in high-frequency carriers, PLC-IoT transmits data at a high speed across a long distance over power lines.
- PLC-IoT delivers an application-layer communication rate in the range from 100 kbit/s to 2 Mbit/s and can extend the transmission distance to several kilometers through multi-level networking. With IPv6, abundant IoT protocols can run over power lines, enabling intelligent end devices and implementing full connection of devices.

Network Model

Based on the Open Systems Interconnection (OSI) model, the PLC-IoT network architecture is divided into five layers: physical layer, data link layer, network layer, transport layer, and application layer, as shown in Figure 4-1. PLC-IoT aims to interconnect with standard TCP/IP to implement standard IP network communication, transmit data over power lines, and enable different types of PLC terminals to communicate with each other based on IP networks (also known as IP-based PLC). This enriches the application scenarios of PLC-IoT.

Figure 4-1 PLC-IoT network architecture



Application Scenarios

PLC-IoT enables high-speed, reliable IoT communication over power lines, with almost no major roadworks, reducing the communication construction and deployment costs by over 50% and greatly shortening the deployment period. PLC-IoT-capable smart devices have the following characteristics:

- **Wired power supply**: Devices in all scenarios of power generation, transmission, distribution, and consumption in the AC power grid system are included. Digitalization, automation, and intelligence transformation of the power grid system cannot be achieved without the networking digitalization of power generation devices, distribution and transformation terminals, and power consumption devices.

- **Grouped**: Terminals of the same type or with similar functions share the same energy network cable and have the group or cluster feature, as typically found in three types of energy network topologies: bus topology, tree topology, and star topology. Typical devices that have this characteristic include: power supply equipment under a transformer, power-consuming equipment under a power distribution box with carrier isolation, and power-consuming terminals connected to the DC power bus under an isolated power module.
- **Non-mobility**: Terminals basically have fixed locations (for example, electricity meters and street lamps) or move within a limited range (for example, elevators).

Due to the preceding characteristics, PLC-IoT has been widely used in the following fields:

- **Power energy**: intelligent meter reading, charging piles, energy efficiency management, switchgear, and medium- and low-voltage intelligent power distribution.
- **Transportation**: smart traffic lights, smart street lamps, etc.
- **Smart building**: Internet of Elevators, smart firefighting (visualized smoke detectors, emergency lights, and networked indicators), etc.
- **Smart home**: smart lighting, smart control, etc.

Benefits

PLC-IoT delivers the following key benefits to help industry customers build smart edge connections:

- **IPv6**

  By introducing 6LoWPAN, PLC-IoT not only implements slice-based transmission but also reduces the IPv6 packet header size from 40 bytes to 4 – 12 bytes. This enables IPv6 to seamlessly run on a low-speed network and more IoT protocols to be carried over TCP/UDP.
- **Shared PLC network**

With the open standard IPv6 technology, different types of end devices can share one PLC network, as can applications on the IoT gateway and applications in containers. This enables applications to access managed end devices independently without affecting each other, improving the concurrency capability and communication efficiency of the PLC network.

- **Secure and reliable data**

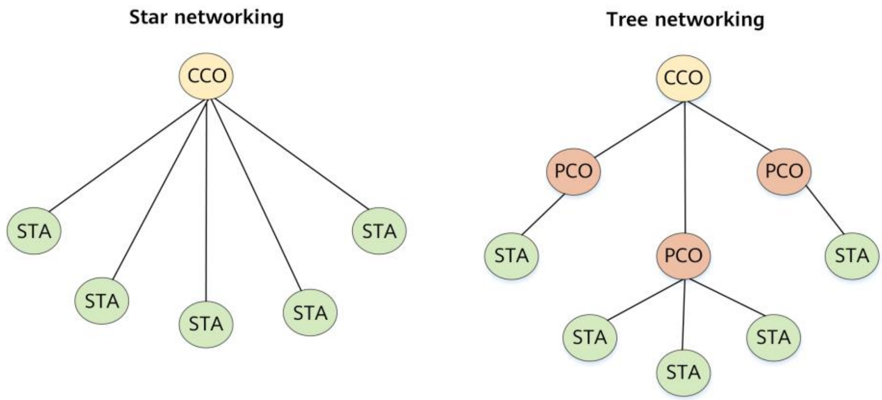
  PLC-IoT supports extensive link-layer security mechanisms:

  - Data encryption secures data confidentiality.
  - Integrity check prevents data tampering, enhances link security, and prevents network attacks.
  - Datagram Transport Layer Security (DTLS) is used to implement digital certificate-based access authentication for PLC nodes, and the DTLS encryption channel is used to transmit the negotiated link-layer encryption key, implementing encrypted transmission of link-layer data and providing basic security assurance for applications.

PLC-IoT Networking

Depending on the cabling environment and terminal connection mode, the PLC-IoT network supports the star or tree topology, as shown in Figure 4-2. The tree topology supports up to 8-level networking, which further extends the carrier transmission distance.

Figure 4-2 PLC-IoT networking



The PLC-IoT network supports the following roles:

- **CCO**: The CCO is responsible for the access of end devices as well as the receiving and sending of data.
- **Proxy Coordinator (PCO)**: The PCO is supported only in tree networking and is a site that relays and forwards data between the CCO and sites or between sites.
- **STA**: The STA receives and sends PLC signals and provides terminals with unified access to the PLC-IoT network.

To implement fast networking, the PLC-IoT network has the following characteristics:

- Fast level-by-level convergence and proxy authentication, enabling a large number of sites to quickly connect to the network.
- Fast path evaluation and optimal path selection, improving the STA communication success rate after network access.
- Dynamic timeslot management and self-adaption upon multi-phase imbalance in transformer districts, maximizing bandwidth utilization.
- Up to 512 nodes supported by a single gateway and up to 8-level networking, extending the coverage of transformer districts.

4.2 Container

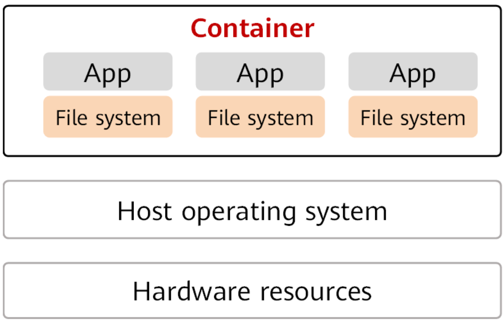
In the EC-IoT Solution, containers can be deployed on the EC-IoT gateway to provide isolated virtual environments, where users can install their service apps to implement different service functions.

Concept

A container is a type of lightweight virtualization technology. Virtual machines (VMs) require a complete virtualized operating system (including the CPU, memory and disks) before they can be used in a manner of physical machines. In contrast, a container requires only a lightweight virtual environment that is isolated from the host operating system.

As shown in Figure 4-3, installing service apps in containers enables independent service functions, mitigates the impact of external environment differences (such as development environments), and minimizes conflicts between different software running on the same infrastructure. A container encapsulates all the resources, including dependencies, class libraries, other binary files, and configuration files, required for running apps into a container image package. In this way, images can be flexibly migrated from one environment to another.

Figure 4-3 Container



Categories

In terms of architecture, the container technology comes in two major forms: Linux Container (LXC) and Docker container.

- **LXC**

  LXCs are based on Control groups (Cgroups) and namespace isolation, which are Linux kernel functions. An LXC is an operating system-level lightweight container offering a virtual operating system environment with lightweight virtual isolation processes and resources.

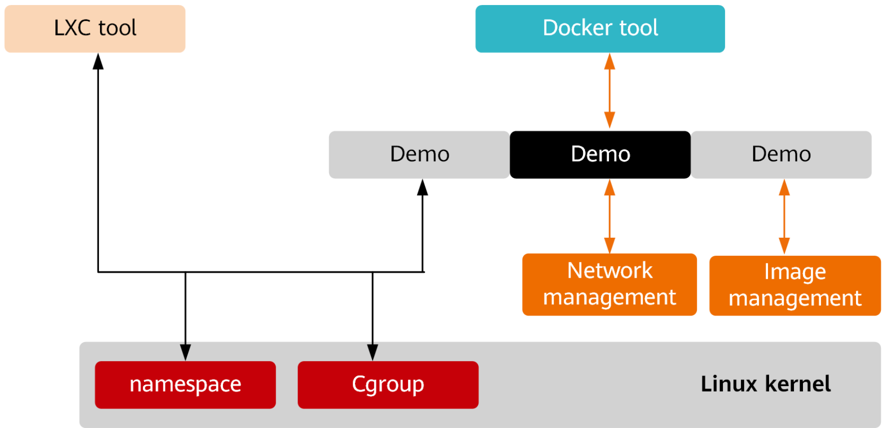
  - An LXC packs an application software system into a software container, which contains the code of the application software and the required operating system core library.
  - Hardware resources of different software containers are allocated by using a unified namespace and a shared API, to create an independent sandbox runtime environment of application programs. This eases creation and management of system or application containers for Linux users.

- **Docker container**

  A Docker container, also called an application container, is an application-level container that is further encapsulated based on LXCs. Each Docker container is an independent application, which is packed into an image. To use this application, you only need to obtain the image. This facilitates application deployment and installation.

Both LXC and Docker provide containers based on Linux kernel namespaces and Cgroups, as shown in Figure 4-4.

Figure 4-4 Docker and LXC containers



Docker provides more powerful functions as enhancements based on LXC, including:

- **Portability**

  In terms of portability, LXC only implements sandboxed processes and cannot be migrated across machines. Docker, in contrast, defines a new format of containers and packs applications and their dependency environments into a single object. This object can run on any device where Docker is installed with the same results upon execution, thereby improving the portability of containers. Docker abstracts all configurations of an application and integrates them into a container for improved portability. To put it simply, an app is a container in the Docker architecture. Unlike Docker, LXC supports a maximum of four containers, in each of which multiple apps can be deployed.

- **Application-centric**

  Docker optimizes application deployment in terms of APIs, user interfaces, and design principles.

  - **Automatic construction**

    Docker supports Dockerfiles. All dependencies, build tools, and packages of an application are written in a Dockerfile as source code.

Then, Docker can build an image based on the Dockerfile. This image runs on any machine with the same effect.

- **Version control**

  Docker provides version control functions, such as version rollback. In addition, Docker supports incremental upload and download, saving bandwidth resources required for upload and download.

In the EC-IoT Solution, Huawei enhances the container function of EC-IoT gateways on the basis of LXC technology. By leveraging Docker advantages, Huawei EC-IoT gateways support more container construction modes, and provide new functions such as version control, management of apps in LXCs, and container signature verification.

Chapter 5
Use Cases

Abstract

This chapter describes the use cases of Huawei's EC-IoT Solution across industries, including smart charging piles, smart Integrated Energy Service (IES), IoT pole sites, and ubiquitous electric power IoT.

5.1 Smart Charging Pile

Pain Points

The number of electric vehicle charging piles around the world has increased exponentially in recent years. With millions of charging piles connected to the power grid, the charging of electric vehicles has had a significant impact on power grid services:

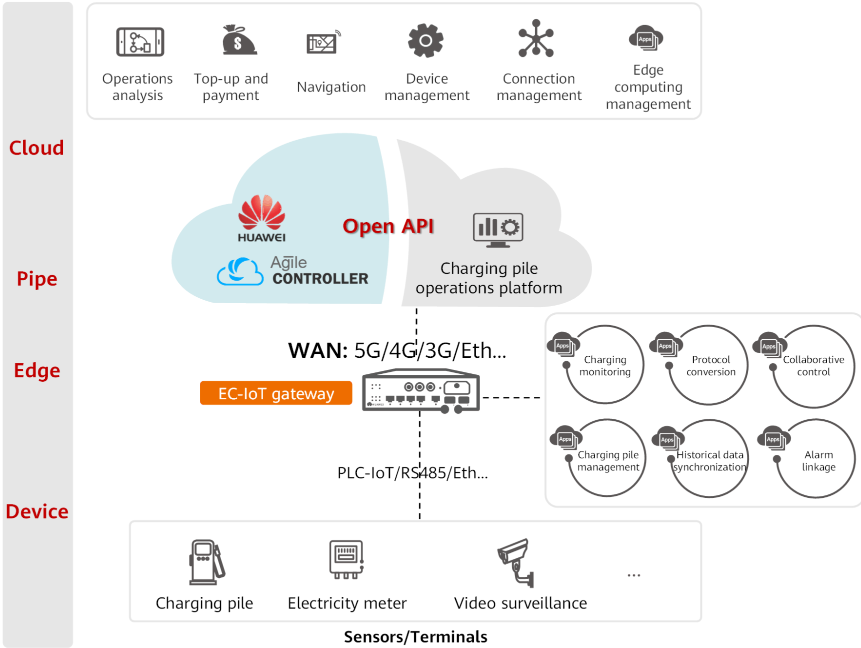
- **High operating risks**: During peak hours for electricity demand, if coordinated charging is not implemented for electric vehicles, transformers will be overloaded, which threatens the safe and stable operation of the entire power grid.

- **Low O&M efficiency**: Charging piles have a high fault rate and poor interoperability due to different companies using different standards. No unified network management system is available, making it difficult to manage a large number of terminals. If a fault occurs, engineers need to travel onsite to diagnose the fault and upgrade the application.

EC-IoT-powered Smart Charging Pile

To cope with the challenges faced by charging piles, Huawei launches the EC-IoT-powered Smart Charging Pile Solution. As shown in Figure 5-1, this solution integrates edge computing, wired communication, and wireless communication technologies to digitalize the charging pile infrastructure and transform it towards higher intelligence, simplicity, and efficiency.

Figure 5-1 Smart Charging Pile solution



- **Cloud**: As an IoT management platform, Agile Controller-IoT provides abundant southbound access capabilities of a broad range of protocols as well as access and management functions for terminals. In addition, Agile Controller-IoT provides open northbound APIs to collaborate with the charging pile operations platform, enabling flexible expansion and upgrade of charging services and various value-added services for industry customers.
- **Pipe**: Sensors and terminals use wired and wireless communication technologies such as PLC-IoT and Ethernet to deliver high-reliability and low-latency access for terminals at charging stations. In addition, the wireless (5G, LTE, or 3G) backhaul network or Internet private line backhaul network provides high-reliability and high-bandwidth network channels for remote intelligent management of charging stations, ensuring real-time services and optimal user experience.
- **Edge**: The EC-IoT gateway is designed based on the concept of "platform-based hardware and app-based software". It enables service apps to be deployed on demand and helps partners flexibly develop and expand apps

for coordinated charging, charging monitoring, and video linkage. The EC-IoT gateway can also collaborate with other intelligent edge modules to implement remote O&M of charging piles, intelligent management of charging stations, load prediction, and intelligent fault analysis.

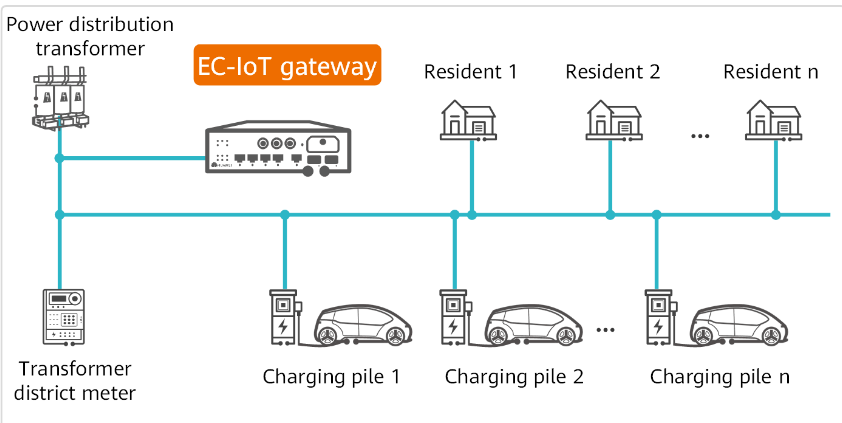
- **Device**: Sensors and IoT terminals connect to the EC-IoT gateway in various access modes.

Application Scenarios

- **Power grid load control**

  As shown in Figure 5-2, the EC-IoT gateway can collect the load of power distribution transformers in real time, and control the charging mode (immediate charging, scheduled charging, restricted charging, and load balancing) through service apps installed on it. This prevents power distribution transformers from being overloaded, intelligently controls the charging and power consumption load, and eliminates the need of capacity expansion.

Figure 5-2 Power grid load control



- **Charging and discharging monitoring**

Based on scheduling instructions, the EC-IoT gateway implements bidirectional charging and discharging control between electric vehicles and the power grid according to the preset charging and discharging control policies. In this way, the EC-IoT gateway responds to power grid requirements in real time and achieves peak load shaving.

- **Parking space management**

  Leveraging edge computing apps as well as wireless and wired sensors, the EC-IoT gateway offers diverse functions such as vehicle detection, intelligent management of parking locks, license plate recognition, and charging pile startup/shutdown, intelligent alarms upon occupation of electric vehicle charging spaces by fossil fuel-powered vehicles, and automatic management of charging parking spaces.

5.2 Smart IES

Pain Points

Integrated Energy Services (IES) is a new energy service mode that enables diversified energy production and consumption for end users and covers energy planning and design, engineering construction, multi-energy operation, as well as investment and financing services. Driven by the rapid development of IoT, IES is in urgent need of a digital platform to solve the following problems:

- **Diverse access scenarios and complex environments for energy devices**
  - Collection terminals, such as electricity, water, and gas meters, and sensors, involve diverse access scenarios and use different interfaces and protocols, complicating device management.
  - The onsite energy environment is complex, and reconstruction is difficult.
- **Complex management of numerous terminals and high O&M costs**

  No unified management platform or remote management method is available for massive energy terminals, resulting in difficult fault locating and low O&M efficiency.

EC-IoT-powered Smart IES

Leveraging EC-IoT, Huawei launches the Smart IES IoT Solution. As shown in Figure 5-3, the Smart IES IoT Solution integrates edge computing, wired communication, and wireless communication technologies to build an open digital IES platform for electric power enterprises, accelerating industry service transformation.

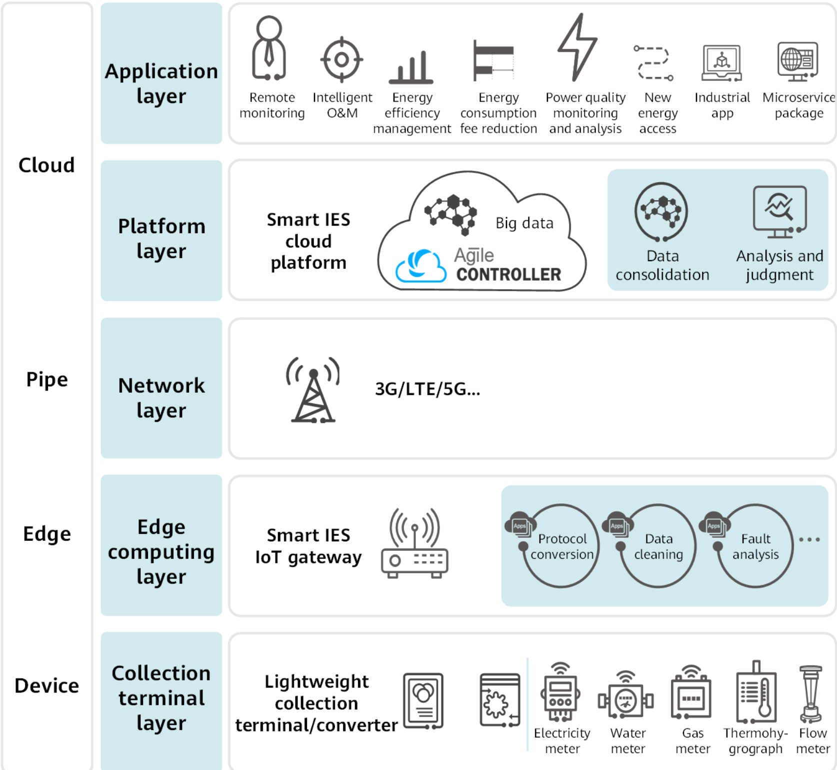
- **Cloud**: consists of the platform layer and application layer.
  - **Platform layer**: The smart IES cloud platform consists of components such as Agile Controller-IoT and big data analytics. Powered by the cloud managed architecture, the smart IES cloud platform implements remote visualized management of numerous terminals across their full lifecycle and analyzes and processes massive amounts of energy consumption data.
  - **Application layer**: Agile Controller-IoT flexibly interconnects with industry applications at the application layer through open northbound APIs.
- **Pipe**: communication network layer between the cloud and edge.

  The smart IES IoT gateway supports both wired and wireless communication to suit all kinds of onsite conditions, extending application scenarios.
- **Edge**: edge computing layer.

  Edge computing redefines energy gateway devices and empowers them with intelligence. Just like the way of smartphones, functions are implemented for the smart IES IoT gateway through service apps, which can be customized and loaded on demand. Furthermore, data can be flexibly shared to connect to different service ecosystems. In this way, one device can be used for multiple purposes, eliminating the need to repeatedly develop hardware systems.
- **Device**: collection terminal layer.

  PLC-IoT makes lightweight collection terminals and converters plug-and-play and networks available over power lines. This allows campuses, public buildings, and residential areas to connect to networks over power lines, and energy consumption information to be collected efficiently and reliably, providing basic data for IES services.

Figure 5-3 Smart IES



Application Scenarios

- **Full collection of electricity, water, gas, heat, and cooling data**

  Meters and sensors monitor and collect statistics on energy data such as electricity, water, gas, heat, and cooling data. External environment and production data can be imported, including weather, environment, production capacity, and people flow data.

- **Real-time monitoring**

A unified monitoring and management center is built to achieve real-time communication with the instruments, relay protection devices, sensors, and automatic control devices in the energy and related systems. Advanced data processing and analysis technologies are used to process site monitoring data and control instructions of the energy system accurately in real time. If a fault occurs, customers can quickly locate the faulty circuit according to surveillance images, facilitating troubleshooting.

5.3 IoT Pole Site

Pain Points

The development of smart cities leads to a large number of new services emerging. For example, a city usually has a vast number of traditional street lamps, which need to transform towards intelligence. Effectively utilizing advantages of power supply, network, and pole resources can significantly improve city management efficiency and promote smart city development.

Traditional lamp pole scenarios face the following challenges:

- Costly public lighting and maintenance and inefficient troubleshooting
- Unknown street lamp status, wasting resources
- Decentralized management of street lamps, resulting in high management and maintenance costs

EC-IoT-powered IoT Pole Site Solution

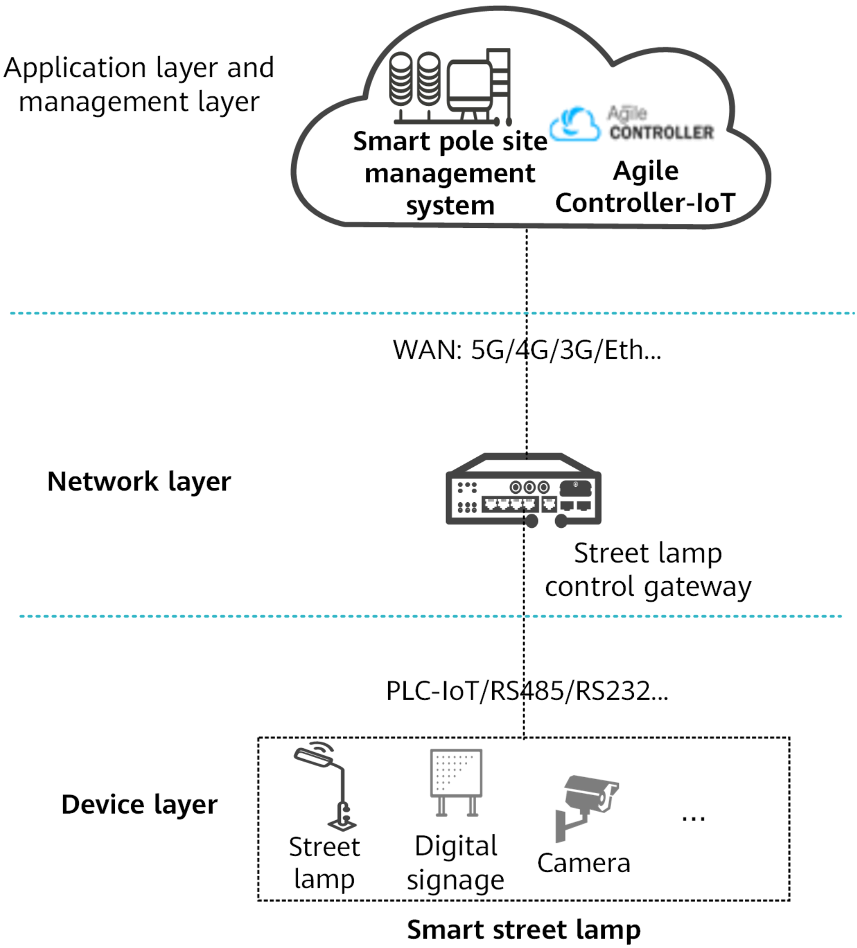
Leveraging the EC-IoT architecture and PLC-IoT technology, Huawei launches the IoT Pole Site Solution. As shown in Figure 5-4, this solution reuses the power lines of the street lamp system to transmit data and adopts intelligent lighting policies, reducing energy consumption.

- **Application layer and management layer**: includes the smart pole site management system and Agile Controller-IoT.

- As the central controller, the smart pole site management system manages IoT terminals and network devices, and summarizes, analyzes, converts, processes, and displays data.
- Agile Controller-IoT interconnects with the smart pole site management system through open northbound APIs.

- **Network layer**: transmits information for smart street lamps. Functioning as the bridge between the application layer and terminal layer, the network layer is responsible for transmitting information about end devices to the application layer securely and reliably. The street lamp control gateway supports the PLC-IoT technology and reuses power lines for communication to offer a point-to-multipoint, stable, and reliable wired smart lighting control mode. This avoids secondary trenching and cable burying, reducing construction costs.
- **Device layer**: consists of various hardware terminals, which are fundamental for the smart pole site management system. Smart pole sites involve various environmental sensors, cameras, information release devices, public addressing devices, and emergency call devices. The device layer collects various types of information and obtains static and dynamic information such as material properties and environment status, which are used for feedback and processing after transmission through the network layer and decision-making by the application layer.

Figure 5-4 IoT pole site scenario



Application Scenarios

- **Planned light control and adjustment based on time and longitude/latitude, conserving energy and reducing emission**

Users can formulate lighting control plans to automatically adjust the switch-on or switch-off status and brightness of street lamps, implementing on-demand lighting and minimizing energy consumption. For example, when there are many pedestrians and vehicles after sunset, the brightness of street lamps is automatically set to 100%; when there are few pedestrians and vehicles at night, the brightness is automatically adjusted to 50%.

- **Visualized management and proactive maintenance of massive numbers of street lamps**

  The smart pole site management system centrally manages a large number of street lamps, visualizing the street lamp status and reducing O&M costs.

- **Multi-purpose poles, building ubiquitous connections**

  Smart street lamp poles offer functions such as smart lighting, environment monitoring, and information release, integrating city information sensing and collection with public services.

5.4 Ubiquitous Electric Power IoT

Pain Points

The explosive growth of new energy requirements and services drives traditional power grids to evolve towards the Energy Internet. Against this backdrop, to centrally manage power distribution and utilization devices and cope with emerging scenarios such as distributed photovoltaic (PV) and new energy vehicles, transformer districts urgently require automation and intelligence. As the "last mile" of the power supply service, the low-voltage power distribution network is directly oriented to users. The entire power grid has up to 4.8 million low-voltage power distribution networks, which connect more than 400 million terminals. The result is a complex network topology, on which the following problems need to be resolved urgently:

- **Insufficient service monitoring methods**: The power supply quality cannot be fully controlled because there is no automatic method for monitoring the power supply reliability.
- **Lack of data for service decision-making**: Service faults cannot be predicted, and no technical support is available.

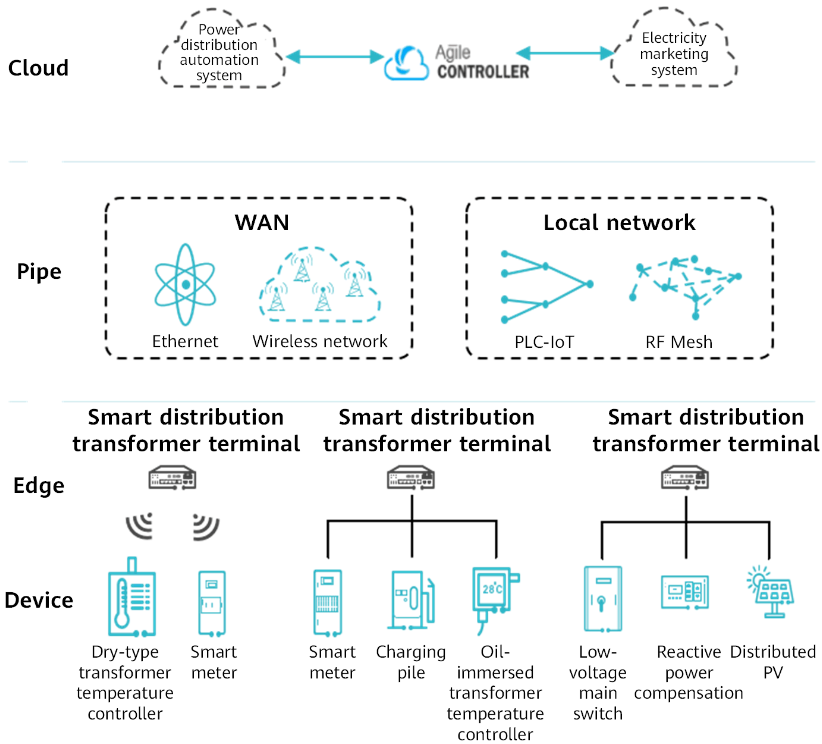
- **Low operational efficiency**: Faults cannot be predicted in a timely manner, resulting in low customer satisfaction. Worse yet, it is difficult to connect terminals to the network, leading to difficult management.

EC-IoT-powered Ubiquitous Power IoT

To address the challenges faced by low-voltage power distribution networks, Huawei introduces EC-IoT into low-voltage power distribution networks to offer comprehensive power IoT, implementing IoT-powered marketing and distribution.

As shown in Figure 5-5, Huawei's Ubiquitous Power IoT Solution incorporates the "cloud-pipe-edge-device" architecture into the traditional power distribution and utilization network to implement converged marketing and distribution as well as unified management, greatly improving operational efficiency.

Figure 5-5 Ubiquitous electric power IoT



- **Cloud**: consists of the power distribution automation system, power marketing system, and Agile Controller-IoT, which is developed by Huawei based on the SDN cloud architecture. The power distribution automation system and power marketing system are provided by third-party vendors. These components collaborate to implement service functions such as power distribution terminal management, online device monitoring, power outage repair, asset management, and big data.

  Agile Controller-IoT provides open northbound APIs for interconnection with the power distribution automation system to share information. It also provides northbound APIs for ubiquitous electric power IoT apps to invoke general-purpose basic service resources such as information processing and computing, implementing massive device management, connection management, computing management, and application management.

- **Pipe**: refers to communication pipes.
  - WAN communication pipes (including Ethernet and wireless networks): mainly transmit data between the cloud and edge.
  - Local communication pipes (covering Huawei PLC-IoT, RF Mesh, and other communication technologies): mainly transmit data between terminals and the edge.
- **Edge**: As the core of the edge side, smart distribution transformer terminals that use the edge computing architecture in transformer districts transmit information about devices on the edge side to the pipe side through multiple communication modes such as WAN and local networks.

  Smart distribution transformer terminals in transformer districts provide services such as precise management and control of low-voltage power distribution and consumption devices, refined O&M, and power quality operation indicator analysis through apps, improving the regional energy management capability, meeting the requirements of distributed energy access and diversified load control, as well as implementing flexible and fast deployment of power distribution services. Based on the local decision-making and cloud-based collaboration mechanism of transformer districts, the low-voltage power distribution network transforms from passive management to proactive management, achieving refined management for transformer districts.
- **Device**: Low-voltage distribution devices use intelligent core communication modules to implement communication between intelligent terminals and EC-IoT gateways.

  Huawei provides intelligent core communication modules that provide open interfaces for third-party vendors to perform secondary integration of low-voltage devices. In addition to standard PLC and RF communication technologies, these modules support the built-in IPv6 protocol stack to meet various communication service requirements. Huawei also provides standard module management, which minimizes hardware differences and helps to build an intelligent ecosystem for low-voltage devices.

Application Scenarios

- **Low-voltage fault warning and real-time power outage alarm**

- Predicts aging lines or potential risks based on the topology of the low-voltage power distribution network and the loop impedance measurement principle.
- Monitors the low-voltage switch-on/off status, voltage/current, active/reactive power, and alarm events to automatically detect power outages of residents, branches, and transformer districts, and reports the results to the power distribution automation master station in real time.

- **Proactive and accurate fault rectification, improving customer satisfaction**
  - Obtains power outage information in real time.
  - Proactively detects the trip fault of the low-voltage switch.
  - Automatically predicts faults, shortening the mean time to recovery.
- **Efficient management of mass low-voltage terminals**
  - Enables industrial devices using diverse protocols to connect to the power distribution network, implementing efficient management of a large number of terminals.

Chapter 6

Deployment Suggestions

Abstract

This chapter describes the deployment suggestions for each component in the EC-IoT Solution.

The EC-IoT Solution opens up software and hardware capabilities to partners for secondary development.

Table 6-1 lists the suggestions for deploying components in the EC-IoT Solution.

Table 6-1 Deployment suggestions

Component	Deployment Suggestions
Agile Controller-IoT	• < 300 gateways: Deploy Agile Controller-IoT Lite to reduce costs. • > 300 gateways (especially in scenarios with tens of thousands of gateways): Deploy Agile Controller-IoT of the standard edition.

Component	Deployment Suggestions
EC-IoT gateway	• **AR502H series EC-IoT gateway**: Users can directly use the service functions provided by AR502H series EC-IoT gateways. If the PLC-IoT function is required, the AR502H series EC-IoT gateways can only be used together with iCUBE-PLC100 (CCO). • **Edge computing core card**: Customers can integrate edge computing core cards that are in the form of printed circuit boards (PCBs) into their devices to extend service functions.
PLC communication module	Huawei provides PLC communication modules with various sizes and functions. They offer open hardware interfaces and pins and can be integrated into diversified low-voltage end devices. CCO modules must be used with together with STA modules.

Chapter 7
Product Portfolio

Abstract

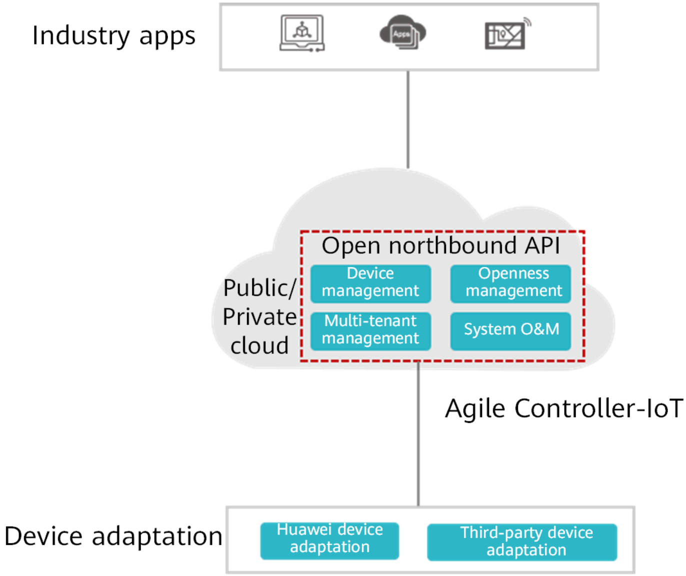
This chapter describes the components provided in Huawei's EC-IoT Solution, including: Agile Controller-IoT, Edge computing devices (AR502H series EC-IoT gateways and AR-CORE series core cards), as well as PLC-IoT products.

7.1 Agile Controller-IoT

Agile Controller-IoT is a management platform developed by Huawei for the EC-IoT Solution. As shown in Figure 7-1, it uses cloud computing technologies to implement unified cloud-based management of networks, devices, containers, and applications, and supports flexible interconnection with other industrial application systems. This platform helps enterprises reduce O&M costs and accelerate digital transformation across industries.

Agile Controller-IoT comes in two editions: standard edition and lightweight edition (Agile Controller-IoT Lite), both of which provide the same GUI and operation experience. Customers can select the appropriate edition based on their deployment environments and requirements.

Figure 7-1 Agile Controller-IoT architecture



Agile Controller-IoT has the following highlights:

- **Open software architecture, quickly adapting to industry scenarios**

  Agile Controller-IoT provides extensive standard northbound APIs for interconnecting with application systems in different industries, for example, elevator management systems in elevator scenarios, management and charging systems in electric power scenarios, and traditional power distribution master stations in low-voltage power distribution scenarios. Furthermore, Agile Controller-IoT uses southbound protocols such as NETCONF and MQTT to communicate with terminals, quickly adapting to industry scenarios such as elevator, electric power, and power distribution network scenarios.

- **Unified management, enabling flexible service expansion**

  Agile Controller-IoT supports edge computing management, such as full lifecycle management of containers and applications. It can also flexibly deploy industry apps based on service requirements, facilitating rapid service development.

- **Cloud-based deployment**

  Agile Controller-IoT uses a cloud-based management model in which resources are physically shared and logically isolated. It supports distributed cluster deployment and seamless expansion, and will support centralized management of millions of IoT gateways in the future.

7.2 AR-CORE Series Edge Computing Core Card

The AR-CORE-220E is a next-generation edge computing core card launched by Huawei. As shown in Figure 7-2, the AR-CORE-220E integrates management, computing, and communication functions, which can be leveraged by other equipment vendors to develop their own devices. As such, the AR-CORE-220E can be widely used in fields such as electric power, transportation, and industrial manufacturing.

Figure 7-2 AR-CORE-220E

The AR-CORE-220E offers the following advantages:

- **Open architecture**
  - Supports deployment and management of LXC and Docker containers.
  - Deploys service apps on demand.
  - Provides opens software and hardware resources and supports the standard Debian development environment and secondary development.
- **Extensive interfaces**
  - 5G, LTE, and 3G interfaces; expansion to Gigabit Ethernet interfaces supported.
  - Industrial interfaces: PLC-IoT, RS232/RS485, DI/DO, etc.
- **High security and reliability**

  Supports container disk encryption and app signature verification, ensuring user service data security.

7.3 AR502H Series EC-IoT Gateway

The AR502H series EC-IoT gateway — Huawei's next-generation IoT gateway — has powerful edge computing capabilities and is purpose-built for IoT scenarios such as smart IES, smart pole sites, smart power distribution rooms, smart campus, and smart water conservancy.

The AR502H series EC-IoT gateways come in two models: AR502H and NetEngine AR502H-5G models, as shown in Figure 7-3 and Figure 7-4, respectively.

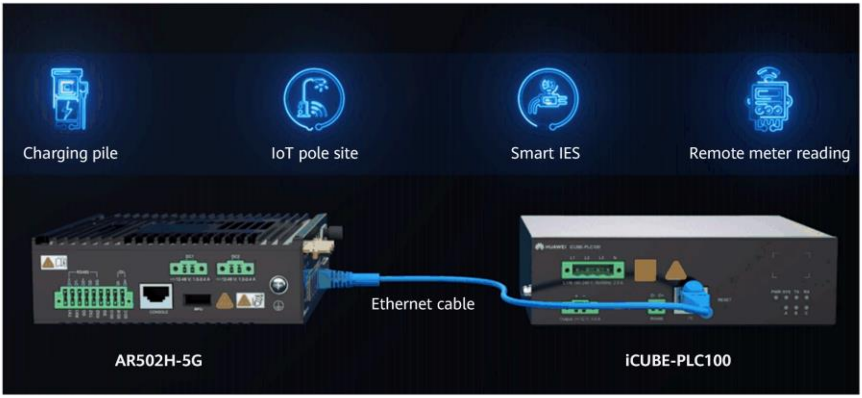
Figure 7-3 AR502H

Figure 7-4 NetEngine AR502H-5G

The AR502H series EC-IoT gateway stands out with:

- **High-quality, industrial-grade design**
  - Fan-free design, wide operating temperature range, from –40°C to +70°C
  - Resilient to strong magnetic interference, IEEE 1613 compliant
- **Edge IoT, enhancing security and reliability**
  - Open software and hardware resources based on the edge computing architecture
  - Multi-container management, enabling on-demand app deployment
  - Standard Debian-based development environment, providing SDKs to flexibly invoke computing, storage, and network resources
  - Data encryption, enhancing device security and reliability
- **Extensive interfaces, enabling flexible expansion**
  - Diverse industrial bus interfaces: gigabit Ethernet, RS232, RS485, DI/DO, etc.
  - Support for 5G, LTE, and 3G.
  - Support for all global positioning systems: BeiDou, GPS, Galileo, and GLONASS.
  - Extensible IP-based PLC module, which can be combined with iCUBE-PLC100 in a building block manner to implement PLC-IoT communication, as shown in Figure 7-5.

Figure 7-5 AR502H used together with iCUBE-PLC100 to implement PLC-IoT communication



7.4 PLC-IoT Products

Huawei's PLC-IoT products enable innovative open business models and promote interoperability, cooperation and win-win across the ecosystem, making them ideal for a broad range of fields such as electric power, transportation, and industrial manufacturing.

Huawei provides a full lineup of PLC-IoT communication modules, as shown in Figure 7-6. The modules include: PLC head-end communication unit, PLC head-end communication module, compact PLC tail-end communication component, and PLC tail-end communication module, which are described in Table 7-1.

Figure 7-6 PLC-IoT products

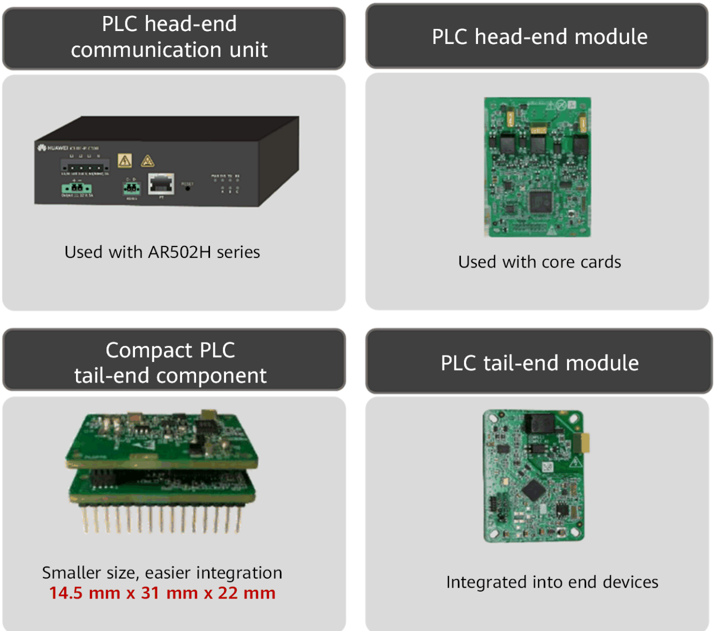


Table 7-1 Huawei PLC-IoT products

Model	Description
iCUBE-PLC100	IP-based PLC head-end communication unit, which is used together with the AR502H series routers. Operating temperature: –40°C to +70°C
PLCh-Power-1	IP-based PLC head-end communication module, which is used together with Huawei's core cards. Operating temperature: –40°C to +70°C
PLCe-Power-1	IP-based PLC tail-end communication module. Operating temperature: –40°C to +70°C

Model	Description
iMOD-PLC121	Compact IP-based PLC tail-end communication component. Operating temperature: –40°C to +70°C
PLC-IH-1	IP-based PLC head-end communication module, which is used together with Huawei's core cards. Operating temperature: –40°C to +70°C
PLC-IS-1	IP-based PLC tail-end communication module. Operating temperature: –40°C to +70°C

IP Network

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