HUAWEI

Open & Standardized Smart Pole Proposal

Contributed by Huawei
Feb 2019

Contents

1 Executive Summary

1.1 Smart City and 5G Accelerating Smart Pole Industry Development

As the nerve endings of smart cities, smart poles are key carriers for data collection, information release, and information transmission of smart cities. Smart poles are the main force for smart city management.
The development of 5G requires municipal administration departments to plan and deploy urban communication infrastructure in advance. Smart poles are recognized as important carriers for 5G deployment, which will accelerate the deployment of smart poles.

1.2 National Policies Supporting Smart Pole Development

ICT competitiveness is a key indicator of national economic health. Global ICT powers, such as the US, China, South Korea, and Germany, have clearly set out the support for the development of smart poles and opened up related land and property resource Right-of-Way policies to support 5G infrastructure construction.

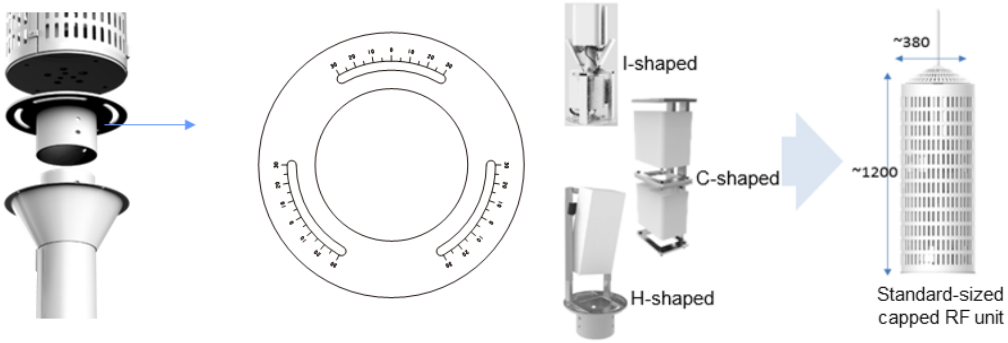
1.3 Device-Pipe-Edge-Cloud Architecture of Smart Poles Meeting Long-Term Evolution Requirements

Smart pole requirements vary from region to region. Long-term functional evolution in the next 10 to 15 years needs to be considered in the architecture design. The device-pipe-edge-cloud architecture of the smart pole solution is designed in terms of function decoupling, communication backhaul, intelligent processing, and unified cloud platform. This solution meets the requirements of flexible functional expansion and builds a long-term evolution platform for basic capabilities such as power supply, communication, and management.

1.4 Standardized Capped RF Unit of 5G Base Stations

This section describes the standardized physical ports of 5G-oriented smart poles for connecting 5G base stations. This enables smart poles to be ready for 5G and ensures that batch deployable site resources are available when 5G is coming.

Figure 1-1 Standardized physical ports for 5G base stations



2 Smart Pole Industry Trends

With the rapid development of global ICT technologies, smart city applications, such as smart lighting control, security monitoring, and Internet of Things (IoT), are emerging to improve urban efficiency and competitiveness. A variety of smart city projects have been launched in more than 40 countries and more than 300 cities around the world. Smart poles are part of the infrastructure required to implement smart city projects. They have become a common choice for various smart city projects.

Meanwhile, fifth generation mobile communications technology (5G) is being developed, and the world's leading countries have adopted 5G as the national strategic plan to create ubiquitous high-bandwidth coverage for the future Internet of Things, 5G will need many times more sites than 4G. Smart poles are the best site resources available to provide coverage everywhere.

Smart poles will be the first step of smart city reconstruction. They are the main hurdle to developing a smart city. Statistics of Huawei's marketing department indicate that more than 10 million smart poles will be deployed globally in the coming five years. Construction of smart poles will be part of a boom in the construction of cloud and communications infrastructure.

Figure 2-1 Global smart city market forecast

Source: *frost&Sullivan, Markets& markets, Navigant Research, Extreme network report.*

3 As-Is of the Smart Pole Industry Ecosystem

3.1 Diversified Business Models

Large-scale smart pole deployment requires an industry ecosystem that is healthy, and a win-win business model. Currently, the Public Private Partnerships (PPP) operation modes are favored, including Engineering Procurement Construction (EPC), Build Operate Transfer (BOT), and Build Own Operate (BOO). In EPC model, the government funds the construction and operates the project. In BOT model, the government harnesses social capital to construct and operate networks. In BOO model, enterprises invest in network construction and operation. These models have been adopted in different areas, but they are still in the exploratory stage.

3.2 5G-driven Policy Support

Global ICT leading countries are actively planning and guiding the deployment of smart poles. In addition to public functions such as intelligent lighting and video surveillance, more and more countries require smart poles to integrate 5G functions in long-term planning.

China: More and more local governments are aware of the important role of smart poles and accordingly promote the healthy and orderly development of the smart pole industry at the policy level. Provincial governments, such as Guangdong, have issued a three-year action plan for information infrastructure construction, which clearly requires promotion of multi-purpose urban smart lamp poles. At the same time, Shenzhen is the first to organize the industry to introduce the technical and engineering specifications for multi-purpose smart pole systems, accelerating the development of the smart pole industry at the standard level.

Germany: In *5G Strategy for Germany*, the Federal Government of Germany clearly mentioned the multi-purpose pole integrating the function of 5G mobile communications: "The co-use of existing carrier infrastructures will play a key role in terms of the development of small cell networks in city centers. Road infrastructure which already has power connections today, for example traffic lights and street lamps, can be used for the cost-effective development of Pico cells."

South Korea: The article "Better utilization of 5G equipment and facilities" issued by the Ministry of Science and ICT wrote: "Furthermore, 17 local governments and national facility management agencies have to provide more equipment than before so that repeaters and communication cables can be installed in street lights, transportation structures, etc."

4 Applications

Smart poles are the embodiment of next-generation smart city construction. They represent the beginning of new smart city construction. They provide new applications for smart city communications, energy, transportation, and security protection, generating social and economic benefits. As smart industry scenarios proliferate, cross-industry and 5G collaboration will produce more intelligent, more diverse smart city applications. In terms of services, smart poles are mainly used for smart connection and smart sensing.

Smart connection

Traffic control: Vehicles can be networked and automated by deploying devices such as the roadside units (RSUs) and smart gateways on smart poles. This is an important part of smart transportation and automated driving. Smart transportation is:

- Safer: More reliable automated driving and smarter networks, roads, and people, in combination with vehicle sensing and prediction, reduces accidents.
- More efficient: The data of vehicles, roads, networks, and surrounding environment is monitored and calculated in real time so that people and vehicles can move more efficiently.
- More comfortable: Vehicle functions will be more oriented to entertainment, leisure, business, life, and convenience.

The video surveillance system on smart poles and the magnetic based parking detection systems allow parking to be accurately monitored for smart parking.

Lighting energy saving: There are two types of street lamp IoT solutions, PLC-IoT and NB-IoT, each with different types of networked lighting control. Unlike traditional street lamp management, these new solutions allow for remote control of street lamp switches and brightness based on a schedule, allowing for on-demand lighting in different regions and at different times. In addition, the energy consumption management, energy saving management, and fault management of the lamps can be remotely performed in a visualized, manageable, and controllable way.

Smart sensing

City security protection: Cameras and emergency help buttons are deployed on poles and connected to a remote surveillance system. They have become an indispensable part of city security. The integrated video surveillance system provides an end-to-end solution, consisting of cameras, video surveillance, and video analysis. Its core value is in criminal deterrence, remote visualization, front-end analysis, and post-event evidence collection. The video surveillance system deployed on a smart pole boasts:

- Intelligent warning: They allow for real-time monitoring of exceptions, and quick detection of video exceptions using technologies such as defining forbidden areas and establishing detection lines; identifying abandoned or removed objects, loitering, and the detection of crowd formation.
- Whole-city surveillance: They allow for quick, accurate identification of target locations through license plate recognition (inspection and surveillance deployment), facial recognition (blacklisted personnel identification and alerting), panoramic video splicing, and linked operations of box and PTZ cameras.

- Emergency button: The pole provides the function of one-button police calling. The public security department can accurately determine the target position and provide responsive services.

Meteorology and environmental protection: Data can be collected based on densely distributed meteorological environment monitoring points of smart poles and analyzed through a cloud platform. This enables both local and remote environment information push services as well as environment pollution and noise detection services. The video surveillance system provides comprehensive environmental services, delivering more convenience.

Information release: The electronic display and the broadcast system let smart poles publish timely information, such as weather reports or emergency warnings, and provide people with handy service information.

5 Challenges

At the macro business level, smart poles have changed traditional lamp pole deployment, affecting multiple government departments and cross-industry entities. Investment, operations, management mechanisms, and multi-party business models are still being explored. The lack of a unified smart pole infrastructure operation party has become an important factor hindering the construction and development of smart poles. At the technical standard level, smart poles lack effective, unified planning. Construction is often repeated and resources wasted. For example, in today's cities, there are many different types of poles serving many varied purposes and roads are excavated repeatedly. Smart poles also lack unified technical specifications and reference, which introduces some constraints on function evolution and makes interconnection and data sharing between service components difficult.

Figure 5-1 Many different types of poles serving many varied purposes on the street

Smart poles need a "cloud-edge-pipe-device synergy" solution driven by cross-domain standards.

6 Technical Proposal for Smart Poles

Smart poles are used in the following two scenarios:

- Road scenario: The pole height ranges from 9 m to 12 m, meeting the requirements of urban road lighting, intelligent transportation, intelligent monitoring, wireless communication, and intelligent IoT.
- Campus scenario: The pole height ranges from 6 m to 9 m, meeting the requirements of digital intelligent campus applications such as central business district (CBD), campus, and industrial park.
- (Do you want to include a bit about electric poles... these might be especially important for RSU (Road-Side-Unit) for V2X applications.

The smart pole architecture needs to be unified regardless of road scenarios or campus scenarios. Considering the commercial use time, function requirements, and investment pace of different application scenarios, smart poles must support long-term function evolution in terms of the device-pipe-edge-cloud architecture.

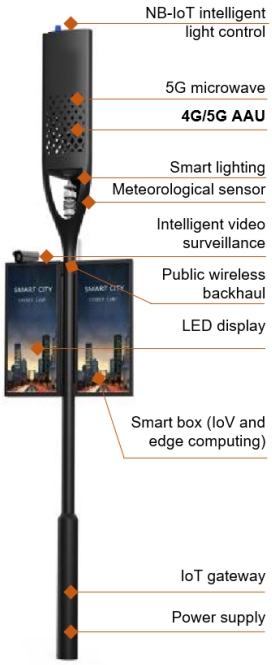
6.1 Technical Proposal for "Device"

6.1.1 Smart Pole Device Layout

Based on the device usage and mounting requirements, the recommended device layout on the smart pole is as follows: It is recommended that ICT devices such as transmission devices, power devices, and edge computing devices be placed in the bottom compartment of a pole. It is recommended that smart units such as cameras, displays, and sensors be mounted to the middle of a pole. It is recommended that base stations and wireless backhaul devices be placed on the top of a pole.

Figure 6-1 Smart pole device layout

(a) Road scenario



(b) Campus scenario

6.1.2 Capped RF Unit

The smart pole capped RF unit is a scenario-based 5G ready solution. By opening standard capped RF unit interfaces, the devices of different pole manufacturers can quickly and flexibly interconnect with each other, ensuring that smart poles meet the 5G ready requirements.

Figure 6-2 Smart pole capped RF unit

The key elements of the capped RF unit are as follows:

- 360° direction adjustment
- Internal cabling: two optical fibers and two cables
- Quick assembly: Directly insert it and tighten screws.
- Unified wind load for 5G capped RF units operating on different frequency bands

The typical configuration specifications of the capped RF unit are as follows:

- Dimensions: diameter: 380 mm; height: 1300 mm
- Weight: 20 kg (excluding modules) or 45 kg (including devices)
- Configuration: 1 x relay/microwave+1 x RRU/AAU/BTS or 2 x book RRU/AAU/BTS
- Natural heat dissipation: –40°C to +45°C
- Antenna mechanical vertical tilt + –7 degrees, horizontal + –30 degrees

New deployment scenario: The smart pole has no base station. The smart pole supports base station installation and is 5G ready. There are two scenarios: new single-sector 5G and new two-sector 5G.

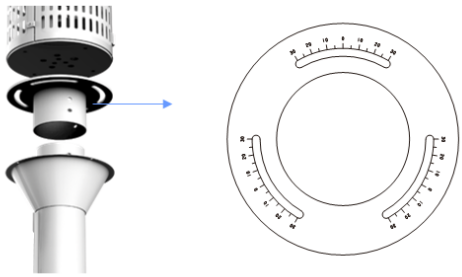
No.	Scenario	Configuration	Frontal Area	Interface
1	New single-sector 5G	1 x 5G BTS/AAU	0.45 m^2	M18 (screw hole) x φ290 (hole) x 60° (angle) x 3 (number of holes)
2	New two-sector 5G	2 x 5G BTS/AAU	0.49 m^2	M18 (screw hole) x φ290 (hole) x 60° (angle) x 3 (number of holes)

Capacity expansion scenario: 4G base stations have been deployed on smart poles, and 5G ready is required.

No.	Scenario	Configuration	Frontal Area	Interface
1	4G expansion+5G	1x 4G RRU+1 x 5G BTS/AAU	0.49 m^2	M18 (screw hole) x φ290 (hole) x 60° (angle) x 3 (number of holes)

The interfaces on the capped RF unit are unified. The standard interface design is as follows:

Figure 6-3 Standard 5G base station interface design



6.1.3 Power Supply Technology

- Integrated "MIMO" power supply design

  Smart poles integrate various devices such as cameras, environmental sensors, Wi-Fi, and wireless base stations. The power supply voltage, power, input, and output of the devices are different. Smart pole power supplies must meet the "Multiple-Input Multiple-Output (MIMO)" and intelligent management design requirements. They support high-voltage direct current (HVDC) and 220 V AC input. When the load on the power supply is high and a remote connection mode is used, an HVDC power supply is used to reduce cable loss and save energy. The output supports 12 V DC, 24 V AC, and –48 V DC to supply power to different loads.

- Intelligent monitoring and management

  The development of 5G demands a large number of smart pole sites. This presents challenges for maintenance and management of smart pole sites. The power supply of smart pole sites needs to support intelligent management, monitor their own running status, including input, output, and faults; and report the information to the element management system (EMS) to implement unified remote aerial management and reduce O&M costs.

- Low current requirements for smart poles

  The modular design of the power supply supports low current requirements for all smart pole devices. The LED light and screen input

use DC, and heavy current is not applied to smart poles, reducing the risk of electric shock.

6.2 Technical Proposal for "Pipe"

6.2.1 Wired Transmission

- Unified access of multiple services

  Smart poles require network aggregation devices so that multiple services can be accessed over the 10GE/GE/STM-N ports. They also need dedicated interfaces for base stations, interfaces like eCPRI/CPRI, which reduce the investment required for aggregation and access to devices mounted on the poles.
- Large bandwidth, hard pipes, and high security

  The line bandwidth is 100 Gbit/s. The OTN hard pipe supports physical service isolation to ensure service security.
- Network-level lossless transmission

  The delay compensation technology can be used to implement 50 Gbit/s 1+1 lossless protection switching.
- Configuration-free, commissioning-free, easy maintenance

  Line- and customer-side online bit error and performance monitoring facilitates fault demarcation
- Industrial-grade protection

  IP65 rated transmission devices must be provided.

6.2.2 Wireless Transmission

Compared with wired transmission, wireless transmission is applicable to scenarios where no optical fiber is available. Currently, the wireless transmission solution for smart poles can use the eLTE or small-capacity microwave solution. In typical cases, the eLTE-U solution is recommended for small bandwidth scenarios where video backhaul has mobile requirements. If a large bandwidth is required for fixed video backhaul without mobile requirements, the small-capacity microwave solution is recommended.

6.3 Technical Proposal for "Edge"

Edge computing is a system architecture that integrates connectivity, computing, storage, control, and applications on network edge nodes close to terminal devices or data sources to meet user requirements for real-time services, intelligence, security, and data aggregation.
Edge computing has the following advantages over cloud computing:

- Real-time services: millisecond-level real-time data analysis and event response
- Edge intelligent analysis and processing: service edge deployment, flexible adjustment, and automatic network O&M
- Data aggregation: no data fragmentation, interference shielding, and data uploaded on demand.
- Private security domains: data security, node security, and network security

Edge computing is not simply connecting personal computing to the network and establishing connections with cloud services. It is a system architecture that extends cloud computing centralized on the data center (DC) to network edge devices.

6.3.1 Edge Computing Gateway

An edge computing gateway is an edge computing entity running on a smart pole. It needs to provide a wide range of local ports, such as wired and wireless WAN ports, Ethernet LAN ports, RS232, RS485, RF, PLC, DI, and DO ports. It must provide wired and wireless backhaul and a wide range of wired and wireless IoT interfaces.
The RF and PLC modules of a mesh network support IPv6 and evolution to IP-based IoT. ECC certificates (preconfigured before delivery) can be used to ensure IoT network security.

6.3.2 Edge Storage/Computing

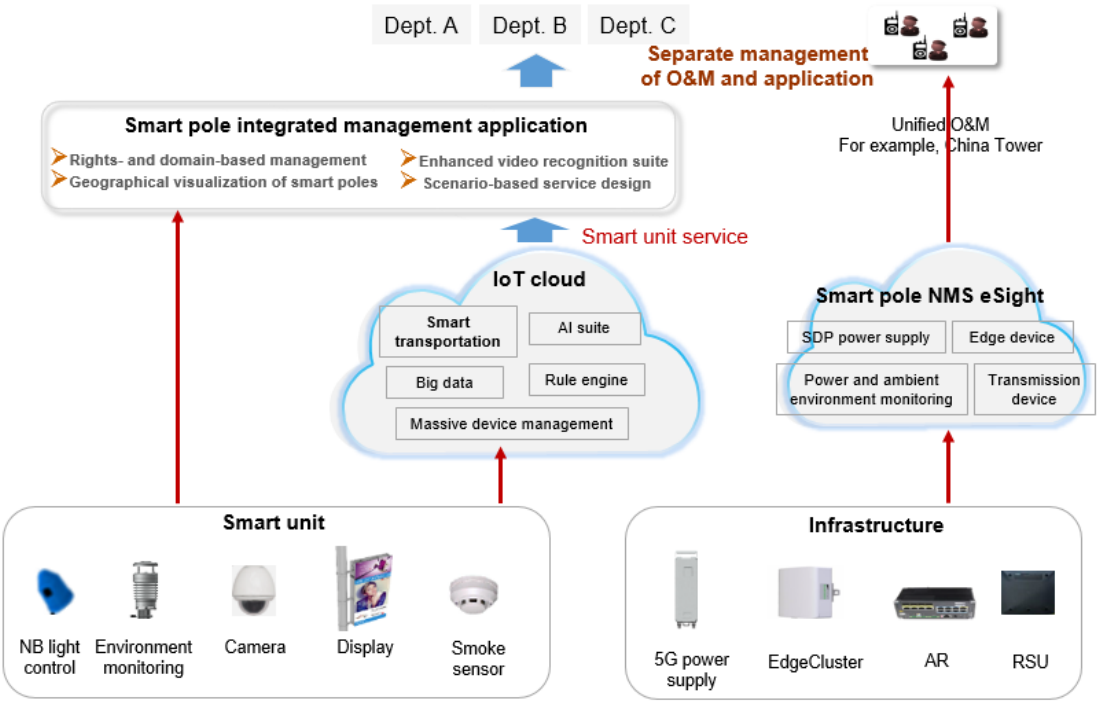
Edge storage/computing devices can manage front-end sensors and cameras and provide services for the management platform. The upper-layer domain is the management platform, the parent node is the intelligent computing gateway, and the child nodes are function devices.
Edge storage/computing devices must provide the following functions:

- Cloud-edge collaboration: Supports collaboration with the central cloud management platform to remotely manage, maintain, and exchange data with edge intelligent computing gateways.
- Open platform: Containers are supported, and multiple algorithms and applications can be deployed together.
- Storage and retrieval of videos, images, and structured data.
- Secondary analysis and comprehensive application of videos and checkpoint images.
- Traffic flow detection and traffic law enforcement.

6.4 Technical Proposal for "Cloud"

Based on different types of access devices, the smart pole cloud is classified into the smart pole management application (application cloud), IoT management platform (IoT cloud), and device O&M system (O&M cloud). The smart pole management application is mainly used for smart unit service applications such as cameras, displays, and sensors. The IoT platform is mainly used for access management of IoT devices in smart units and common application enablement capabilities of devices. The O&M system is used for O&M management of infrastructure devices such as power supplies, transmission devices, and edge computing devices.

Figure 6-4 Smart pole cloud architecture



6.4.2 Smart Pole Management Application

Geographical Visualization of Smart Poles

The smart pole management platform supports geographic information system (GIS) mapping of all connected front-end devices, visualized display of O&M device details on the GIS map, and search functions for streets, neighborhoods, and devices. The platform also supports viewing of alarms, fault details, signal strength, switch statuses, and dimming levels of all connected front-end devices.

Cross-Industry Scenario Linkage

The smart pole management platform links multiple service scenarios. In addition to management of smart multi-purpose pole devices, the platform can manage other smart city devices, such as smoke sensors, well covers, or garbage bins. For cross-industry scenarios, rules can be set to link different IoT services and devices. For example, a smoke alarm can be set to trigger a specific camera aimed at the area where the sensor is located.

Rights- and Domain-based Management

The smart pole management platform supports rights- and domain-based management. You can set different roles and users to implement region-, device-, and function-based rights management.

In addition, the smart pole management platform can create customer groups to manage the permissions of these customers. Authorized customers can view, control, and manage specified devices based on their permissions. This function enables the system management party to provide the services of the smart pole sub-module to its customers in software as a service (SaaS) mode.

6.4.3 IoT Management Platform

The IoT platform provides functions such as device access, application access, data integration, capability integration, and system maintenance. It provides comprehensive management of data collection sensing devices deployed at different sites for various IoT upper-layer applications, and stores, analyzes, and shares collected raw data.

Application Enablement

The smart pole management platform provides open interfaces. Ecosystem partners can invoke interfaces to obtain the service and operation data packaged on the platform and develop their own applications after obtaining permissions from the data owner.

Seamless Network Security

To ensure system security, transmission over the interfaces between the cloud platform and peripheral systems is encrypted. Devices connect to the cloud platform through a cloud gateway, or an IoT protocol agent is embedded in the devices so they can connect to the IoT platform. Interface protocols between the devices and cloud platform depend on the access technologies used or on the industries using them. NB-IoT devices use the Constrained Application Protocol (CoAP), which is a Datagram Transport Layer Security (DTLS) based secure transmission protocol.

Public Cloud-based SaaS

The IoT platform is deployed based on the public cloud and accordingly can provide public cloud-based SaaS services. With the rights- and domain-based management feature, this platform provides services for multiple users in the industry at the same time.

6.4.4 Device O&M System

Infrastructure devices on smart poles, including base stations, transmission devices, power supplies, enterprise gateways, and edge computing devices, have their own O&M systems. These O&M systems can be deployed based on customer requirements.

Intelligent O&M and Remote Real-Time Monitoring

The O&M system can remotely monitor devices on smart poles in real time and manage data configuration to implement intelligent O&M, avoid secondary and multiple visits. It also provides electronic door locks to enhance the anti-theft capability. It checks for slant, water damage, and electricity leakage of the pole body and reports alarms.

Diversified and Multi-dimensional Report Analysis Capability

The O&M system provides data reports by hour, day, month, and year, and supports multiple display modes, such as bar chart, curve, and pie chart. The power module on the smart pole supports the sharing of multiple services. Therefore, the O&M system needs to collect statistics on the power consumption of each service in multiple dimensions.

7 Case Study

7.1 Smart Lamp Poles in Country S

Background: Country S is located in a desert area. The current urban lighting system is outdated. The power consumption of each pole is 400 W. The average life cycle is 1–2 years. The street lamp operating expense (OPEX) is high. The demand for energy saving reconstruction of municipal lighting is strong. However, traditional street lamp reconstruction has a high CAPEX, and the government's public finances cannot afford it. At the same time, mobile operator Z in the same city also encountered the bottleneck of site addition. Difficult site acquisition and the long deployment period hinder the development of operator networks.

Solution: Based on the 2030 strategy of country S, Huawei worked with operators to communicate with the government about smart city solutions and proposed a smart pole solution with smart street lamp sites as the prototype. This solution was recognized by the government. Finally, the government and street lamp partners agreed on the PPP cooperation mode. Street lamp partners helped the government reconstruct the lighting system free of charge. The government now shares revenue with partners in pay-as-you-sell (PAYS) mode. Smart street lamps also provide smart city services such as video surveillance and digital advertising, maximizing the value of the infrastructure. In addition, the government works with operators to use street lamps for installing base stations. This helps operators to obtain site resources in batches and reduces the TCO of the street lamp poles.

Figure 7-1 Smart poles in country S

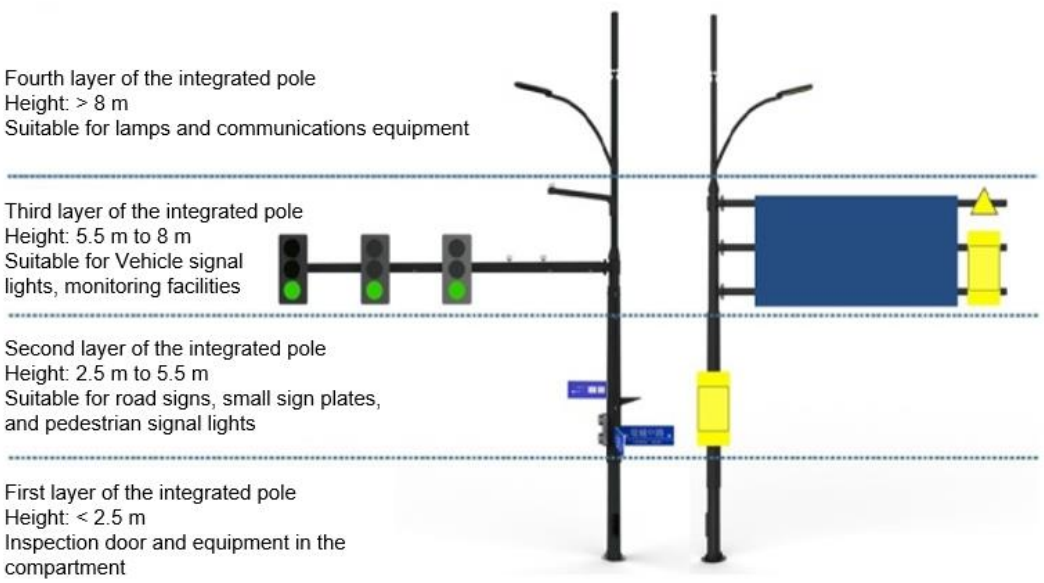
Effect: The new smart city business model not only reduces the power consumption of street lamps to 200 W per pole, but also increases the lifespan of new light bulbs to more than 10 years, significantly reducing the OPEX of municipal street lamps. In addition, deploying radio base stations on smart poles improves urban radio signal coverage, and reduces the operator's TCO in five years by 38%, achieving a win-win situation.

7.2 Multi-Purpose Poles in Shanghai

Background: In the old urban area of Shanghai, dense aerial cables are often seen, as well as various monitoring poles, communication poles, utility poles, and road sign poles at intersections, which seriously affect the appearance of the city. In 2018, under the auspices of the municipal government, by taking the opportunity of China International Import Expo (CIIE), the construction committee took the lead in officially initiating rectification actions to bury aerial cables into the ground and integrating poles, gradually eliminating "black pollution."

Solution: According to *Technical Guide to Roadside Pole Integration and Rectification in Shanghai*, the principle of "multi-pole integration", "multi-box combination", and "multi-head integration" is adopted. All kinds of poles are integrated based on the principles of "multi-pole integration", "multi-box integration", and "multi-camera integration." Integrated poles with lamp poles as carriers are constructed, and all the abandoned poles are removed. Integrated poles are uniform in color and are made of high-strength steel or aluminum alloy profiles, and have different layers.

Figure 7-2 Multi-purpose pole design solution in Shanghai



Effect: The first phase of multi-pole integration in Shanghai has been completed. Hundreds of new "multi-pole integrated" smart poles have been constructed on the roads around the CIIE exhibition hall and in Lujiazui/Bund, achieving good results. These poles will be gradually extended to the whole city in the next phase.

Figure 7-3 Multi-purpose poles in Shanghai

Roads around the CIIE exhibition hall

Inner-ring roads in Shanghai

8 Smart Pole Development Prospects

With the advent of 5G and new smart city construction, the progress of government policies, industry standards, and industry showcases of smart poles will be accelerated. We believe that smart pole construction and 5G deployment will complement each other to build a new smart city foundation.

To achieve this goal, we will accelerate the establishment of unified standards for smart poles, build smart pole showcases with a certain scale, and verify business models and cross-industry value-added services in the market. This will be the focus of the next stage of smart pole industry development.

Huawei will work with global industry partners and government organizations to improve smart pole standards and explore business models, helping the smart pole industry to develop.

9 Acronyms and Abbreviations

Acronym or Abbreviation	Full Name
BOO	Build Own Operation
BOT	Build Operate Transfer
CPRI	Common Public Radio Interface
DTLS	Datagram Transport Layer Security
EPC	Engineering Procurement Construction
GIS	Geographic Information System
IoT	Internet of Things
LED	Light Emitting Diode
MIMO	Multiple-Input Multiple-Output
NB-IoT	Narrow Band Internet of Things
OTN	Optical Transport Network
PLC	Power line Communication
PPP	Public Private Partnership
SaaS	Software as a Service

10 Reference Documents

1. "5G Strategy for Germany"
   https://www.itu.int/en/ITU-D/Regional-Presence/Europe/Documents/Events/2018/5G%20Greece/Session%201%20Franziska%20SchillGERMANY%20-%20Making%205G%20Sa%20success%20in%20Germany.pdf
2. "Better utilization of 5G equipment and facilities"
   http://www.businesskorea.co.kr/news/articleView.html?idxno=21584
3. "Technology and engineering construction specification"
   http://www.sohu.com/a/277353818_468661
4. Three-Year Action Plan for Information Infrastructure Construction in Guangdong
   http://zwgk.gd.gov.cn/006939748/201805/t20180523_766069.html

Huawei Technologies Co., Ltd.
Huawei Industrial Base
Bantian Longgang
Shenzhen 518129,P.R.China
www.huawei.com