Research and Application of Intelligent Street Lamp Platform Based on Ubiquitous Internet of Things

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Abstract. In order to meet the needs of smart cities for intelligent infrastructure, the intelligent street lamp platform is developed based on ubiquitous Internet of Things. This paper introduces the structure and application scenarios of the platform in detail. It provides solutions for communication support, IoT management and people's livelihood services. The platform has been put into use in the Italian style district of Tianjin, which has considerable economic and social benefits.

1. Introduction
The national "Thirteenth Five-Year Plan" clearly proposes to build a smart city that focuses on intelligent infrastructure as well as facilitation of public services, making full use of modern information technology and big data.

With the advent of the 5G era, traditional 3G/4G wireless base station selection methods cannot meet the needs of high-density deployment of 5G [1]. According to the data released by the National Bureau of Statistics, the density of various poles and towers in the city is one base pole per 20 square meters, and the phenomenon of "single pole and single use" is serious [2]. Professional data resources such as municipal administration, transportation, emergency response cannot be used comprehensively, and the level of delicacy of people's livelihood services is low [3-4]. Traditional street lights have single functions and lack of profitability in operation [5].

To solve these problems, this paper uses intelligent perception and edge computing to combine the street lamp platform with ubiquitous power Internet of Things (IoT), aiming to build it into an urban-management infrastructure platform.

2. Intelligent street lamp platform
2.1. Communication support platform
Through the optical fiber network of intelligent street lights and 4G/5G base stations, it provides a network foundation for urban data transmission and convergence. The intelligent street lamp passive optical network (PON) is a broadband access network built on the optical distribution network (ODN). Combining Ethernet technology and high-speed optical transmission technology, it can realize the integrated access of multiple services of voice, data, and video, providing a new solution to the problem of "the last kilometre".

At the access layer, the optical line terminal (OLT) is first responsible for connecting to the convergence layer to complete the upstream access of the PON. It connects to the optical network unit (ONU) of the client through the ODN, and then connects to the pole side to realize its control. The
access layer adopts single-fiber two-way transmission technology. When downstream, the OLT performs continuous broadcast transmission, and the ONU performs selective reception. When upstream, time division multiplexing multiple access is used, and distance confirmation technology is used to ensure that data does not conflict.

The access layer adopts a secondary optical splitter structure, the first class adopts a 1:32 optical splitter (1:64/1:128 optical splitter can be considered according to the later development needs), and the second class adopts a 1:8 or 1:16 optical splitter to ensure fiber usage rate. On the basis of fully meeting the needs of use, the total length of the optical fiber is effectively reduced, and the pole side is basically the same as the internal structure. The optical fiber passive network structure diagram is shown in figure 1.

2.2. Service platform for people's livelihood

The research and development of intelligent street lamp is based on the carrier of urban public resources, which perceives the needs of citizens and provides a complete public service system, including: smart lighting, information release, Wi-Fi, monitoring, one-click help, charging piles and other service functions.
2.2.1. **Smart lighting service function**
   The road lighting is divided into five levels from the upper limit to the lower limit. Using road importance level and traffic composition as static parameter, vehicle speed, traffic flow and environmental brightness as dynamic parameter input, this paper establishes a new dimming model to realize dynamic on-demand dimming of road lighting and ensure secondary energy saving.

2.2.2. **Information release service function**
   The LED display of the light pole can update the release content in real time, actively convey public welfare information, timely convey traffic information, and effectively convey commercial information to ensure the maximum value of information.

2.2.3. **Charging pile service function**
   Currently, the competition among charging pile operators is fierce, and the barriers between industries make it difficult to collect big data. The street lamp charging pile realizes the "Internet +" charging pile, which is convenient for data collection and sharing. In addition, the reduction of AC and DC conversion links greatly improves the charging efficiency of the charging pile.

2.2.4. **Wi-Fi service function**
   As Wi-Fi covers urban administrative areas, users can access the best network at any time, building a convenient, safe, and rapid access to the information world for citizens.

2.2.5. **One-click help service function**
   In case of emergencies or emergencies, citizens can press the one-click help terminal button on the intelligent street light pole to talk to the rescue centre personnel. At the same time, information such as the help location is automatically sent to the management platform, so that rescuers can rush to the scene in time.

2.3. **IoT management platform**
   The platform has basic functions such as connection management, device management, data management, and capability opening, and supports the rapid access of a variety of Internet of Things terminal devices and the rapid integration of applications in various industries. In addition, it also supports customers to focus on application and business innovation. The platform has been applied in two scenarios.

2.3.1. **Hidden danger warning function on cable channel**
   Intelligent street lights can perform real-time monitoring and dynamic analysis of the surrounding environment of the cable, as shown in figure 2.

![Figure 2. Schematic diagram of danger warning function on cable channel](image-url)
The intelligent cable warning peg installed along the cable channel uses audio recognition technology to initially identify the hidden danger of external damage, then it uploads the abnormal data to the smart street lamp for edge calculation and gives immediate warning. Various sensors installed in the well upload the collected internal environmental information and the safety status of the well to the smart street lamp, and then it uploads them to the data center in a unified manner to improve the effectiveness of environmental monitoring. At the same time, when each monitoring terminal finds an abnormal state, it will automatically call the monitoring device of the smart street lamp to record, which uses image recognition technology to automatically determine and classify the hidden dangers, providing the basis for judgment for operation and maintenance personnel.

2.3.2. Inspection drone charging and storage platform
The platform is equipped with a drone apron, which is divided into two modules: drone storage and drone charging. It provides functions such as drone storage, drone charging, and drone take-off and landing guidance.

2.4. Comprehensive management system
The system can realize the coordination of multiple services such as lighting, security, and transportation. In addition, it can uniformly control intelligent sensing devices such as sensors, cameras, and charging piles, and analyse and process data.

3. Application Cases
In 2019, in order to build a night economic demonstration block, Tianjin took the lead in adopting the intelligent street lamp system in the Italian style area. Among them, the function distribution points configured on Minzu Road are shown in figure 3.

![Figure 3. Schematic diagram of Minzu road function layout](image)

According to the calculation of the six industries used by the project, namely, security, transportation, communication, environmental protection, and electricity, the current cost of personnel inspections for 100 kilometres of facilities has been reduced by at least 52.35%. By optimizing the staffing configuration, the manpower input is reduced by more than 50%, as shown in table 1. What’s more, through the time-sharing and zoned lighting control method, the life of the lamp can be extended by 2.5 times, and each base pole can save about 20% of the electricity bill each year.

| Project     | Lamp | Security | Transportation | Communication | Environment Protection | Electricity | Total | Reduction Ratio |
|-------------|------|----------|----------------|---------------|------------------------|-------------|-------|-----------------|
| Previous Cost | 2.5  | 0.5      | 0.5            | 1.5           | 0.1                    | 3           | 8.1   | 1               |
| Current Cost  | 3    | 0.1      | 0.1            | 0.15          | 0.01                   | 0.5         | 3.86  | 52.35%          |
In terms of social benefits, as a smart city IoT management platform, it can help multiple industries improve service levels. Taking the State Grid Tianjin Electric Power Company as an example, the use of smart street lights for cable channel management can reduce 41 power outages each year, which improves power supply reliability, increases users’ satisfaction, and enhances corporate image.

4. Conclusion
The paper combines the concept of street lamp platformization with the ubiquitous power Internet of Things to create a new mode of smart IoT management. As an important infrastructure platform for urban management, it provides solutions for communication support, IoT management, and people's livelihood services.

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