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Research on Low-Cost IoT and Its Application in Improving Energy Efficiency of Distribution Networks

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Abstract. This paper introduces the global Internet of things (IoT) market in recent three years, analyzes the development direction and core obstacles of the IoT, expounds the latest relevant scientific research, compares the key technologies of low-cost IoT, and finally takes the digital management needs of electrical equipment in the headquarters building of Shenghui Holding Co., Ltd. as an example to create a model for energy conservation and emission reduction of manufacturing enterprises enabled by IoT technology.

Keywords. Low-cost IoT, 5G, intelligent buildings, energy saving.

1. Introduction

In the past three years, the total number of global IoT connections has continued to grow, with the number of connections exceeding tens of billions, and the market size has also expanded year by year, reaching a market value of hundreds of billions. In China, the number of IoT connections exceeds 4 billion, and the scale of the industry has exceeded 300 billion dollars. Smart home products account for most of the number of IoT devices, more than 40%, and these devices are consumer-oriented. Medical, industry, logistics, agriculture, public services and other fields do not account for a high proportion, belonging to the industrial IoT. Although the industrial Internet does not account for a high proportion, the demand is huge. The number of industrial Internet devices is not high, and the fundamental reason is that the cost remains high, resulting in low output ratio after deployment. In other words, the high cost of the IoT restricts the development speed of the Industrial Internet.

With the accelerated development of urban digitalization, the IoT has gradually become one of the important infrastructures of smart cities. Therefore, this subject intends to study the core technology of low-cost IoT and improve the application scope of IoT technology in the field of industrial Internet.

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2. Related Works

In recent years, the research on low-cost IoT technology has become more and more popular, because the progress of this research can promote the rapid development of the Industrial IoT [1].

In the field of smart lighting systems, Botero-Valencia, J. S et al.[2]presented a low-cost IoT multi-spectral acquisition device with wireless communication, which can be used for light source spectrum recovery and estimation of light quality and color rendering measures. The total cost of the device is below 130 USD, and customizability provides a great advantage over commercially available devices. Botero-Valencia, J. S et al. [3] also introduced a way that the sensors' data is recorded by an Argon development board from Particle, which is responsible for sending the data to the Internet through a WiFi connection.

In the field of environmental data monitoring, Ahn, J et al. [4] deployed IoT devices to detect the types of volatile organic compounds in the air. They exposed the fluorescent sensor to various organic compounds, and the changes in the photophysical properties that occurred created a unique fluorescent color pattern, and the compounds were classified according to the color pattern. Nwamaka U. Okafor et al. [5] used low-cost IoT sensors to collect environmental data, and then used feature selection algorithms to calibrate these data. Pasika, S et al. [6] used a microcontroller and basic sensors to construct a water quality monitoring system, and continuously sent real-time data such as pH, turbidity, water level detection, atmospheric temperature, and humidity to the monitoring station through wireless technology.

In the field of energy monitoring, Abate, F et al. [7] proposed a low cost smart electric meter for the measurement of electrical parameters. The meter is capable of adapting to the variability of the grid maintaining a high level of measurement accuracy. De Arquer Fernández et al. [8] proposed an open source solution for photovoltaic power station monitoring, connecting 24 inverters and 156 photovoltaic junction boxes to the grid. Rani, D. P. et al. [9] used the IoT to remotely monitor the performance of solar power plants, set the real-time angle of the solar installation and the sun's position to maximize output power, and assist in plant maintenance, problem diagnosis, and real-time monitoring.

In the field of intelligent buildings, Chih-Hao Yang et al. [10] incorporated the measurement of the characteristics of the IoT into the evaluation and determination of the intelligent building management system through the decision-making model of the IoT. Mehrzad Shahinmoghadam et al. [11] combined the IoT technology, building information modeling, and virtual reality technology to realize building monitoring visualization, using non-intrusive sensors to obtain the original thermal image stream to monitor the indoor surface temperature in real time. Arun Kumar et al. [12] proposed a safe and energy-saving intelligent building architecture, which uses limited application protocol (COAP) to transmit equipment related data, and reduces the energy consumption in the building by about 30.86%, which is lower than the telemetry transmission scheme of message queue. Kehinde Lawal et al. [13] concluded that the main research direction of IoT technology in the field of smart buildings is to analyze diverse, real-time high-resolution data generated by devices and sensors.

In other fields, Rourab Pual et al. [14] researched IoT security access control technology and used blockchain technology to ensure the security of urban IoT systems. Ahmad Shabani et al. [15] proposed a chip virus detection method to prevent

IoT devices Send fake information to the application layer. ZhihengZhao et al. [16] studied a set of manufacturing logistics tracking system, using Bluetooth modules and edge gateways to automatically track the location of manufacturing resources in air-conditioning manufacturing companies. Neha K. Nawandar et al. [17] researched intelligent irrigation systems, using MQTT and HTTP protocol technology to let users know the situation of crops at any time. H.Aguirre-Jofré et al. [18] designed a low-cost fleet operation management system for medium-scale mining scenarios to optimize the comprehensive performance of trucks and mining products.

3. Application Scenario Analysis

Table 1 introduces the IoT protocols commonly used in the field of intelligent buildings, and compares the characteristics, applicable scenarios, and prices of each protocol module. Among them, the characteristics of the modules mainly reflect the optimal transmission distance and transmission rate. The scenes mainly include specific applications in intelligent buildings and related fields. The price mainly introduces the purchase price of each module in the past two years when the conventional functional components are included. According to this table, we can easily select the appropriate IoT communication module according to the specific application scenarios in smart communities, smart parks, smart agriculture, and smart factories, and design the best low-cost IoT solutions.

Table 1. Comparison of IoT Protocol Features in Smart Buildings

Protocls	Bluetooth	NB-IoT	CAT1	5G	Zigbee	LoRa	WiFi
Features	Within ten meters	Hundreds of meters, low speed, low power consumption	Hundreds of meters, medium speed	Hundreds of meters, high speed	Hundreds of meters	Several kilometers	Tens of meters
Scenarios	Indoor and corridor lighting control system	Remote meter reading, manhole cover monitoring, smart lock, street lamp monitoring, smart smoke sensor	Wearable devices, charging piles, industrial sensors, security monitoring	Smart factory, remote control	Smart lock, indoor lighting system, housework electrical assistant	Temperature sensor, harmful gas sensor, logistics tracking, shared bicycle, parking space management	Large data-consuming devices such as mobile phones, computers, TVs, etc.
Unit Price (RMB)	6~15	15~36	35~60	1300~2100	9.5~30	15~40	9~50

4. Case Background and Technical Architecture

Next, take an industrial park as a case to illustrate the understanding of the IoT protocol in this study and the choices in specific application scenarios. The headquarters of Sunfly Holding Co., Ltd. is composed of a factory area and an office area, with a total construction area of 59000 square meters. It is a comprehensive service building integrated with scientific creation, intelligent manufacturing and related personalized service. The building is equipped with electrical system, water system and intelligent office system. Based on environmental factors, suitable IoT modules are selected here, and the core parts of the three systems are connected to the local area network, so that managers can fully grasp the company's water and electricity consumption in the whole area, and then control energy saving and emission reduction. As shown in figure 1, this topic uses industrial gateways and wireless access technology to connect the key devices of the three systems to the network, including medium-voltage, low-voltage box, quality control set, power distribution box, voltage transformer, power generation conversion set, storage battery, central control screen, electric box, miniature circuit breaker, equipotential box, multimedia, electrical control cabinet, pressure stabilizing pump et al.

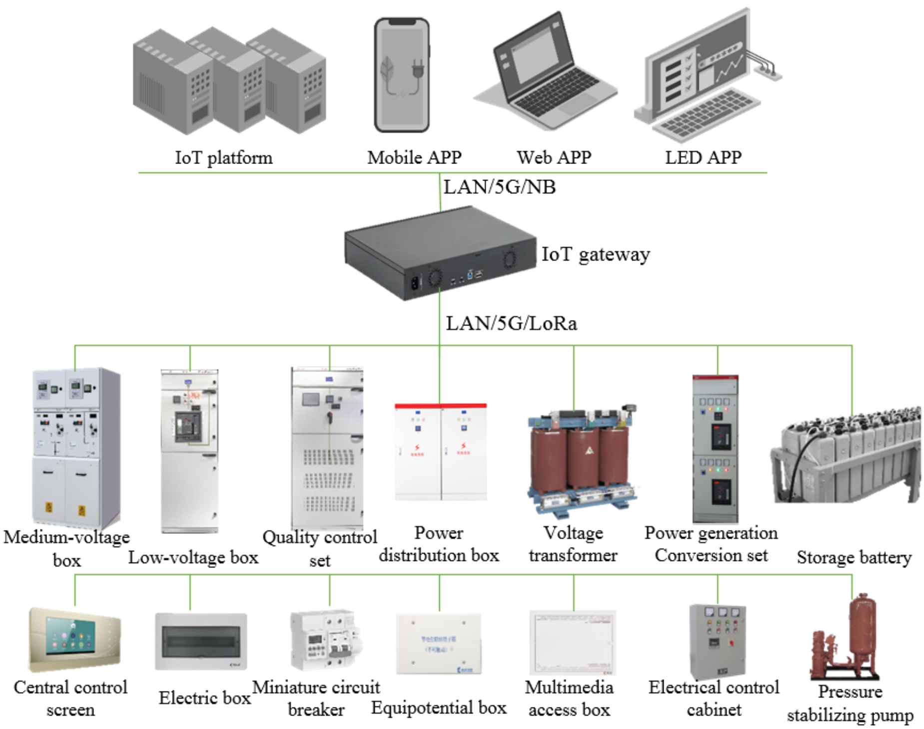

Figure 1. IoT architecture of the headquarters building

5. Introduction to Energy Monitoring System

We have developed an energy detection system based on the above-mentioned IoT architecture, which can monitor and analyze the water and electricity consumption of each floor in the building. Figure 2 shows the 24-hour power consumption of a certain floor, and figure 3 shows the health status of the electricity meters, water meters, and industrial gateways on each floor.

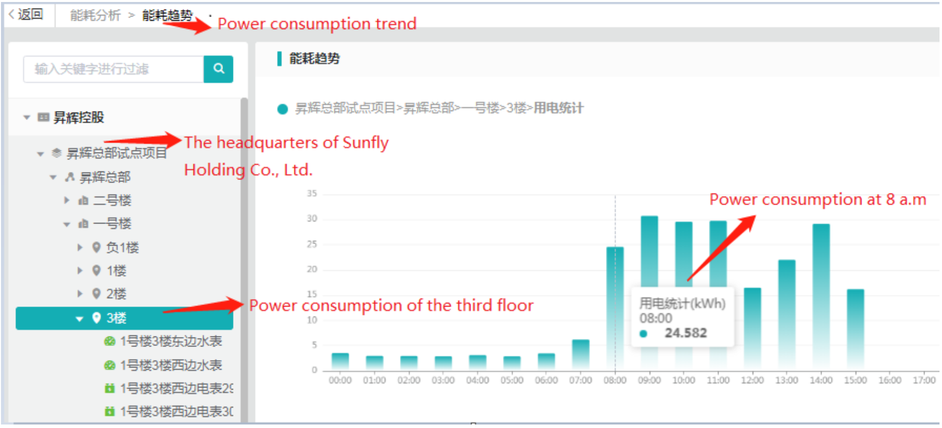

Figure 2. Trend analysis of water and electricity consumption

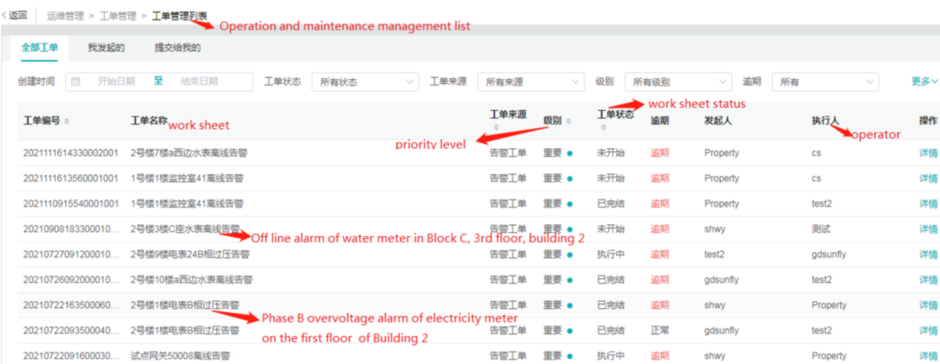

Figure 3. Fault and abnormal warning

6. Conclusion

The national policy level promotes the rapid growth of the number of IoT connections. 5G, artificial intelligence (AI), block-chain and other technologies will be deeply integrated with the IoT, and breakthroughs have been made in industrialization. On the one hand, IoT chips, sensors and related data must be traceable, monitored, and controlled. On the other hand, the networking of massive devices will inevitably generate massive amounts of data, and AI is an important tool for forming data assets. These will promote the rapid progress of the research and application of the block-chain IoT and the AI-IoT.

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