Research and Application of a New Encryption Transmission Technology of Internet of Things Based on PLC Power Line Carrier Communication

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Abstract- Information transmission is an important part of the Internet of things. At present, the different devices produced by IOT (Internet of things) manufacturers give rise to the various connection modes, such as infrared, Wi-Fi, network cable, Bluetooth, ZigBee, VB IOT, Lora and LTE, making the market in chaos. In view of the above situation, this paper proposed a new way of IOT communication by using PLC power line carrier for encrypted transmission. It covered the IOT network to all power supply terminals by using wires in the unit of the area. In this way, the IOT devices can be powered, solving the problem of the last kilometer of network signal transmission.

1. Introduction
The Internet of things is the backbone of the third wave of information industry revolution and the fourth industrial revolution. Based on the agreed protocol, it connects any item with the Internet to exchange information and communicate through radio frequency identification, infrared sensors, global positioning system, laser scanner and other information sensing devices, so as to realize the intelligent identification, positioning, tracking, monitoring and management of items. It represents the
reappearance of the spiral development of human society. Its development will inevitably lead to industrial, economic and social changes and restructure our world. Seizing the opportunity in the era of IOT development will drive China’s development. Therefore, at the fifth session of the Eleventh National People’s Congress, the IOT was written into the government work report for the first time. Since then, general secretary Xi Jinping, Premier Li Keqiang and other government leaders have made important instructions on the IOT for many times to make the IOT better promote production, enter our life and benefit the people. In February 2013, the State Council issued the Guidance on promoting the orderly and healthy development of the Internet of things. And in February 2014, the State Council held a national teleconference on the work of the IOT. The IOT enjoys a fast growth thanks to top-down high attention and policy support.

As an important part of the IOT, information transmission network is also implemented in various ways, such as infrared, Wi-Fi, network cable, Bluetooth, ZigBee, VB IOT, Lora and LTE. At present, there are technical obstacles in these connection ways, such as blocking of wireless signal, weak current wiring difficulty, incompatibility of equipment from different manufacturers, and high independent Internet access cost. How to effectively solve the above-mentioned problems has become the research focus of this project.

2. Methods

2.1 Disadvantages of PLC power line carrier
Power line carrier - PLC communication is a special way of voice or data transmission by using power line as information transmission medium. It is also the only way of wire communication without additional line investment. The power line carrier communication technology can carry out duplex transmission of digital information, carrying the characteristics of convenient installation and cost saving. However, power lines are used to transmit electric energy to electrical equipment rather than data, so there are many limitations and disadvantages in data transmission.

(1) Power line itself has inevitable pulse interference. The frequency of alternating current used in China is 50 HZ, thus there are two peaks in each AC cycle, and the two peaks will bring two pulse interference, that is, there is a fixed 100 HZ pulse interference on the power line, and the interference time is about 2 ms.

(2) The electric load will lead to highly reduced carrier signal. In practical application, when the power line carries no-load, the point-to-point transmission distance of carrier signal can reach several hundred meters or more; but the heavy load on the power line means that the line impedance reaches less than 1 Ω, which can only transmit tens of meters or less, resulting in the high reduction of carrier signal.

(3) Electrical current and electromagnetic interference. The current and electromagnetic interference generated in the process of opening, closing and using all kinds of high-power electrical appliances will cause high noise and high distortion of carrier signal.

Therefore, the high interference, high reduction, high noise and high distortion of the power line make the power line not ideal as a communication medium, greatly limiting its application field and using effect.

2.2 Encryption transmission method of information internet of things
In order to effectively solve the problems of PLC power carrier signal, including high reduction, short transmission distance and easy interference, our team propose a new PLC power carrier long-distance encrypted transmission communication technology based on OTN technology. Through the establishment of IOT special exit in the area, the network signal is covered to all power terminals by wires, and the unified monitoring and management of all kinds of items on the IOT cloud platform is realized, and the technical barriers such as blocking of wireless signal, weak current wiring difficulty, incompatibility of equipment from different manufacturers, and high independent Internet access cost are moved. This method lays a solid foundation for the popularization of PLC power carrier technology in civil field.
The technology is mainly composed of the IOT cloud platform, data base station, relay module and IOT terminal: (see the flow chart for the working principle)

1. The system adopts series networking mode, and all data frames are amplified and transmitted by relay module.
2. Each relay module has an IP address. Only the data frame with the key is amplified and forwarded to the upper module based on the OTN relay strategy issued by the system.
3. The IOT terminal on the user side is connected to the relay module (≤ 100 m) nearby according to the key access mode, so as to realize two-way communication with the IOT cloud platform.
4. When users need to adjust the opening condition or query working status of household appliances in each room, they can access the IOT cloud platform through mobile phone or web page for remote operation.

2.3 System business mode
Both the long-distance power line carrier encrypted transmission communication system and IOT export are public facilities. A certain amount of manpower and material resources are needed from construction to daily use each year. Therefore, it is feasible for operators to charge a certain network maintenance fee according to the number of IOT devices connected, but the charging standard must be supervised by the government and society, and the pricing should be kept within the scope of users’ economic bearing capacity.

3. Results
In order to test the practical application effect of the new project in the IOT, our team authorize the technology to the “intelligent management system of electric heating current limiting control” for free. We have conducted an experimental test on 293000 square meters of large, medium and small electric heating buildings for three years. There is almost no error in the information data collection and remote management of equipment. And we haven’t witnessed too low heating temperature due to communication system failure. All these results demonstrate that the communication system of power line carrier long-distance encrypted transmission can withstand the test of time, and the test work has achieved a complete success.
4. Conclusion
In the process of matching the usage with the “intelligent management system of current limiting control for electric heating”, the IOT network is covered to all power terminals by wires, so we can realize the unified monitoring and management of temperature sensing equipment, and save more than 2 million yuan for the construction cost of weak current generic cabling. This method has laid a solid foundation for PLC power carrier technology to be popularized in a wider range in the civil field. Besides, it has been highly praised by users and power departments, and achieved remarkable economic benefits.

In the future, with the large-scale promotion of this technical products in the whole country, it will establish industry alliance with various IOT equipment manufacturers, integrate various short-range wireless technologies such as “radio frequency, Wi-Fi, Bluetooth” based on power line carrier communication technology, and realize the systematic compatibility of various communication protocols; therefore, the IOT devices purchased by users are no longer differentiated by manufacturers and models. They are managed by the cloud platform of the IOT in a unified way. When they are powered on, they can be connected to the Internet. This eliminates the technical barriers such as weak current wiring difficulties, wireless signal occlusion, incompatibility of equipment from different manufacturers, and independent Internet access costs, truly making a comprehensive transformation to the era of seamless IOT communication.

Project fund
This scientific research project does not belong to any fund project

References
[1] Sheng Zhanshi, Zhang Donghua, Yang Nianfa, Liang Jun. (2011) Relay strategy of power line carrier communication. Automation & Instrumentation, 1: 32-35.
[2] Qi Jiajin, Liu Xiaosheng, Wu Di, etc. (2008) Study on power line communication routing for
low-voltage distribution. Chinese Journal of Electron Devices, 3: 1033-1038.

[3] Yao Tao, Niu Bin, Wang Congchun, Mu Qiongjing. (2019) Application of low voltage PLC technology in ubiquitous power Internet of things. Telecom World, 12: 192-193.

[4] Zhou Xia. (2010) Study on the application of Internet of things based on power line communication, 9: 002.