INTEGRATION OF IOT WITH SMART GRID

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Abstract

In this paper, we studied the basic requirements of the smart grid. By applying Internet of Things (IoT) technologies, various intelligent services can be created. The development of most aspects of the smart grid would be enhanced by the applying IoT. Three-layer architecture of IoT for the smart grid in China is proposed. Various information and communication techniques of IoT applied on smart grid are discussed. Particularly, the IoT application solutions are provided in detail for power transmission line monitoring, smart patrol, smart home and electric vehicle management.

Keywords: Smart Grid; Internet of Things

1 Introduction

The smart grid was proposed to change the pattern of power grid in favor of obtaining economic efficiencies, robust control, and environmental benefits. Internet of Things has attracted much attention in China. Many countries have proposed state-level development strategies for IoT [1-5]. Moreover, IoT has been engaged into national strategies as one of the seven emerging technologies which will be focused in the future in China [4].

As one of the main scenarios of IoT, smart grid has gained wide attention throughout the industry. IoT can support the smart grid as one of the implementation techniques by providing telecommunication and information support [1,3,5].

When presented in 1999, the concept of IoT is simple: connect all the things with the Internet by sensing devices such as radio frequency identification (RFID), and hence realize smart identification and management. Wireless Sensor Networks (WSN), wireless communication and networking are categorized into IoT for a wider internet to resolve RFID's limitations of one-way communication and networking incapability [5-7].

WSN is composed by sensors and near field communication module. There are many kinds of sensors e.g. temperature and humidity sensor, pressure sensor and accelerometer. Rather than the sensor itself, current research in sensor network focuses on how to realize data transmission and processing with lowest power consumption, near field wireless transmission technology and MANET.

2 The architecture of IoT

IoT is mainly composed of sensors, RFID readers, cameras, machine to machine (M2M) terminals and various data collection terminals, which is responsible of the perception and collection of data in a way similar to how human sensory organs function. Telecommunication network transmission channel constitutes the network layer of IoT, including public 2G/3G mobile communication network, LTE network, cable broadband, PSTN, private network, WiFi, ZigBee, etc, which passes information to the processing and application layer, in the way like nervous system does to the brain. The application layer of IoT is the brain of the system, in charge of data processing.

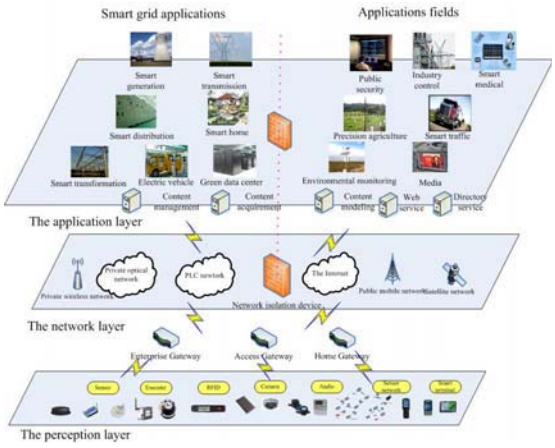

Figure 1 The architecture of IoT enables smart grid

3 Typical applications of IoT in smart grid

The characristics such as dynamic, intelligence, and integrativeness can provide technical support for smart grid construction. The main scenarios of IoT application in smart grid are as follows:

3.1 AMR with high reliability based on IoT

Auto meter reading system plays a significant role in smart grid. It is a system responsible for collecting, processing and real-time monitoring power consumption information intelligently. IoT supports the automatic collecting, abnormal measuring, electricity quality monitoring, and consumption behavior analysis. Moreover, the system also enables functions such as information release, distributed energy monitoring and information exchange between smart power devices.

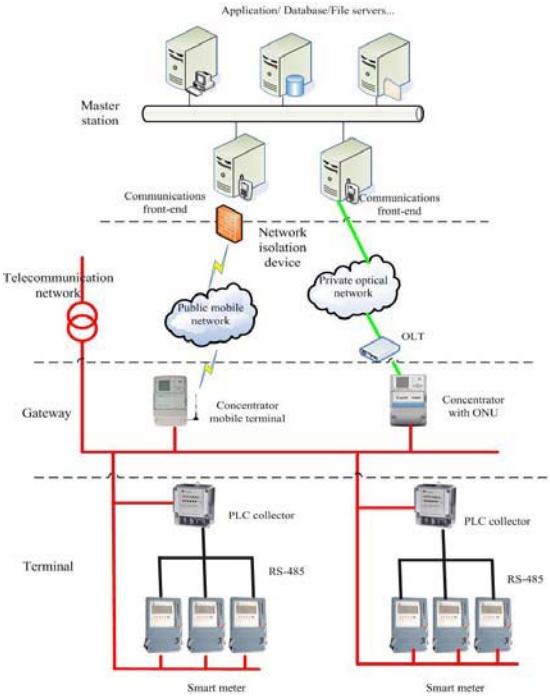

Figure 2 The architecture of AMI based on PLC and OPLC

Traditionally, power consumption information was collected on site manually over a period of time, which leads to inadequacy of timeliness, accuracy and applicability. The remote meter reading system based on the integration of WSN, power line communications (PLC) and optical PLC (OPLC) collects electricity data and other useful real-time information with high reliability through private power line communication network and public communication network, and hence achieves power consumption statistics, analysis and state of use via advanced communication technologies, computing technologies and electric energy metering technologies. The significance of such a system lies in its real-time, accuracy and efficiency in terms of electricity quality statistics and monitoring. The proposed system would greatly enhance the stability and accuracy of traditional AMR system.

People can enjoy the benefits from this system as well. They can adjust their behavior of using electricity to save money according to the statistics and analysis of power consumption as well as the implemented price ladder.

3.2 Smart home based on IoT

As the key part of smart grid, smart home is an important means of realizing real-time interaction between users and the grid, enhancing the capacity of integrated services of the grid, meeting the demand of interactive marketing and improving the quality of service.

Smart home service is widely used in daily power consumption. For instance, residents can switch on his washing machine and chargers in the middle of night when the electricity price is relatively lower. They can turn on air conditioners and electric water heaters remotely before coming home by telephoning or through a text message so that they may enjoy the air conditioning and a hot red bath without waiting. And they can monitor the status of their homes at any time they are not at home and call the police when there is a hacking.

By shifting residential load peak, the demand for transmission and distribution capacity can be reduced, and therefore reduce the investment on power system. Meanwhile, selling the shifted residential peak load to industrial and commercial users helps increasing grid enterprises' revenue without increasing generation capacity.

The components of smart power service system are illustrated in Figure 3.

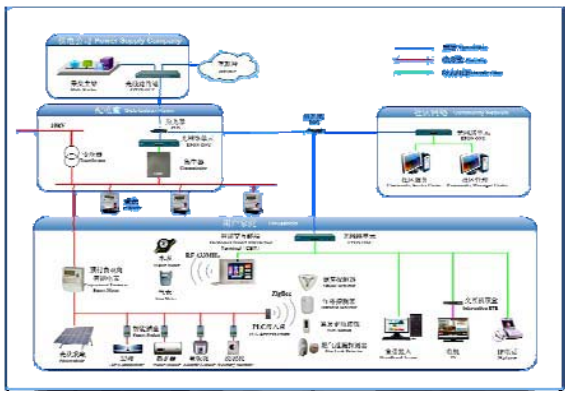

Figure 3 Components of smart home

IoT can be applied to various aspects of smart grid. It can be used in general home sensor LAN protocol of smart home service system, which provides smart appliances control, multi-meter reading, power consumption (including electricity, gas, water, heat, etc.) information gathering, home sensitive load monitoring and control, renewable energy access, user interaction, information services, etc. It can also be adopted to develop generalized platform, on which researches of wireless sensor, PLC, power line composite cable, and the integrated networking technology of next-generation broadband wireless communication could be conducted.

Ultimately, the applications of IoT would accelerate the development of digital, information city, and AMR, analysis and expert decision system. Consequently, we will meet the goals of saving energy and using various resources effectively.

3.3 The online visual monitor platform of smart grid transmission line

Traditionally, the site operation of high voltage line construction is facilitated by pictures and voice information, which are not real-time. As the integration of visualization, wireless broadband and satellite communication technology, the comprehensive visualization program applied to high voltage line construction can monitor the transmission line, discover, diagnose, and eliminate fault and hidden problems. This magnificent effect of visualization was successfully proved in the 1000kV Yellow River Span and the 1000kV Hang River Span projects[4]. The video monitoring and environmental data gathering of the key points or the whole transmission line can realize the sending back of high voltage line live video and important data. Moreover, the real-time monitoring of the swinging, icing, bird hazard and man-caused disaster can support safe running of transmission line with visualization. The smart grid transmission line online monitor system network structure is illustrated in Figure 4.

Figure 4 The online monitor device

The bearer network of video monitor is mainly based on ground fiber optic network and supplemented by power line broadband wireless network. Now the video monitor system is widely applied to substations and converters, and is aimed to take step towards digital, platform and integration of multi-technology/system.

3.4 Smart patrol based on IoT

The patrol of the power transmission, substation and distribution equipment is mainly conducted manually at a regular time. Limited by objective factors like climate and environment, the quantity and quality of patrol are not always satisfactory. In this case, smart patrol would be a better alternative. It is based on IoT enabled wireless sensor network, and can help positioning equipment by identifying labels, thus improve the standardization and regulation of patrol work. Smart patrol has played an essential role in improving patrol quality and efficiency, guaranteeing power system stability and enhancing power supply reliability. The applications of smart patrol mainly includes patrol staff positioning, equipment environment and status sensing, state maintenance aiding and standard operation guiding, etc.

3.5 EV assistant management system based on IoT

In order to reduce CO2 emissions, State Grid takes vigorous action in constructing EV charging stations [4]. With IoT, GPS, and wireless communication technology, we have realized smart sensing, interconnection and high interaction of Evs, batteries and charging stations. This enables customers to know the availability and usage of resources, and thus realize unified distribution of resources and quality services.
EV assistant management system consists of EV, charging station and monitor center. As is illustrated in Figure 5, there could be two-way information interaction between Evs and charging stations through EV sensor system. With GPS navigation system, users could examine nearby charging stations and their parking information. The GPS navigation system will automatically plan and lead drivers to the most suitable charging station. Through the monitor center, we can realize integrated management and control, including management of car batteries, charging equipment, charging stations, resources optimization, and life cycle management of equipment. Meanwhile, we can also realize an overall management of charging process, billing and integrated services.

Figure 5 EV charging management system based on IoT

The system contains batteries and unified coding system of EV. Each EV has a unique ID which carries information of manufacturer, production date, city, owner, purchase date, usage and related information of production, selling, maintenance, usage, etc.

EV has great significance in resolving the increasing concern of oil resource and environmental issues. At present, one of the major problems facing EV is the convenience of charging. With the help of IoT, EV drivers can manage their batteries more efficiently. And through the information of charging station positioning, automatic navigation, and waiting length provided by GPS, drivers can save the labor of finding a suitable charging station. Plus, the system also helps drivers with charging pile guiding and charging process monitoring.

3.6 IoT applications in green smart computer room management

The power consumption of computer room and data center is highly considerable. With IoT enabled temperature monitoring of servers and network equipment, administrators could have the precise knowledge of the running conditions of equipment and switch to hibernation machines to reduce computing load of over-heated machines accordingly. As a place with extremely high security requirements, computer room needs a sound security solution. With the help of IoT positioning technology, video monitor technology and powerful calculated tracking technology, we can realize seamless link between computer room and data center and the combination of operation environment sensor and equipment running status. Meanwhile, IoT also provide solid technique support to power environment sensor, power consumption analysis, information system interaction and joint offices.

4 Conclusions

As an ever emerging technology, IoT has revolutionized information and telecommunication, and brought the possible integration of building, power line, tower, chip, and network. Currently, the power grid is transforming towards smart grid in China, the requirements of automation and intellectualization would lead to deep integrations of IoT with smart grid.The concept of IoT meet the demand of smart grid development. In this paper, application forms of IoT in smart grid have been studied. The applications of IoT in power grid are far more than what has been mentioned in this paper. As IoT improves, it can provide the smart grid with more solid and diverse technique support.

Acknowledgments

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