Sensors & Transducers, Vol. 180, Issue 10, October 2014, pp. 16-21

Sensors & Transducers

Optic Fiber Sensing IOT Technology and Application Research

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Received: 25 July 2014 /Accepted: 30 September 2014 /Published: 31 October 2014

Abstract: The growth of the Internet of Things (IOT) industry has become a new mark of the communication domain. As the development of the technology of the IOT and the fiber-optical sensor, the combination of the both is a big question to be discussed, and the fiber-optical IOT also has a good development prospect. This article first introduces IOT's current status, the key technology, the theoretical frame and the applications. Then, it discusses the classification of the optical fiber sensor as well as the development and its application's situation. Lastly, it puts the optical fiber sensing technology into the IOT, and introduces a specific application which is used in the mine safety based on the fiber-optical IOT. *Copyright © 2014 IFSA Publishing, S. L.*

Keywords: Fiber-optical sensor, Internet of Things (IOT), Fiber-optical IOT, Machine to Machine (M2M), Mine Safety Monitoring.

1. Introduction

Internet of Things (IOT) is an important part of China's strategic emerging industries, it is a new round revolution in information technology after the computer, the Internet and mobile communications, it is driving a new round of information wave on information technology, and it has deeper applications in all walks of life. On the basis of the computer Internet, through radio frequency identification, infrared sensors, global positioning systems, laser scanners and other information sensing device, according to the agreed protocol, anything are connected with the Internet, information exchange and communication are realized to achieve intelligent identify, locate, track, monitor and manage in a network, the Internet is still the core and foundation, but for an extension and expansion of the Internet, it is possible to interconnect with a variety of networks and communicate seamlessly with multi-networks.

Optical fiber sensing technology is developed rapidly in recent years, it is new technology, and it has been widely applied in the fields of energy, health care, aerospace, chemicals, environment, etc. Compared to traditional detection technology, optical fiber sensing technology is with remote transmission, multi-parameter, multiplexing capability, ease of networking, real-time online, interference, intrinsic safety, etc., it is facilitated to analyze comprehensively all aspects of the information, it can greatly enhance the existing security monitoring and production automation. In recent years, various special features of fiber, active devices, passive devices have come out in the international community, and it has been greatly improved in terms of performance, the price is reduced accordingly, thus the fiber optic sensor technology is greatly promoted

in the information transmission and sensing aspects, and it has a wide range of applications.

In the development of the Internet of Things (IOT), the fiber-optic communications network is capable of carrying higher bandwidth, and t is suitable for long distance transmission, it is very suitable for expanding IOT applications, it has been applied in network layer of IOT (the Internet of Things). A large variety of sensors are used in the bottom layer of IOT, initial information is provided for IOT perception layer, the rapid rise of the optical fiber sensor has integrated a great achievement which has achieved in many fields, such as fiber optic technology, laser technology and optical detection, the optical fiber sensor has many advantages in promoting the development of IOT, it is widely used in various fields of national economy and people's lives.

2. Things Technology

IOT is defined by radio frequency identification (RFID), infrared sensors, global positioning systems, laser scanners and other information sensing device, according to the agreed protocol, anything is connected with the Internet, information exchange and communication are realized to achieve intelligent identification, positioning, tracking, monitoring and management in a network [1].

2.1. Architecture of Things

In the system study, the system architecture is a primary premiseto guide specific design, the architecture design is also expected to decide on the technical details, application patterns and trends of things. At present, when the domestic researchers describe the architecture of things, USN high-level architecture will described as a basis in ITU-T recommendations, which is divided into five levels for bottom-up, such as sensor networks, access network, backbone network, middleware and application platforms. In addition to ITU, other international standardization organizations describe and research IOT architecture from different sides, such as the European Telecommunications Standards Institute and the Technical Committee of the machine, they present a simple M2M framework from the perspective of end-to-end, network domain is formed by M2M core network, the M2M application domain will be is connected with the M2M devices domain. This is a simplified architecture of USN.

M2M is machine-to-machine abbreviation, i.e. "machine to machine" abbreviation, it was understood that human-to-machine (man-to-machine), machine-to-human (machine-to-man), etc., communication technology is used to achieve intelligent and interactive link seamlessly between human, machine and system. M2M device is able to answer the data request in some equipment or apparatus to automatically transfer the data contained in these devices. M2M communication is consistent with the core idea of things, the difference is the concept of things, technology and applications which are used in a broader scene. And then M2M focus on wireless communication network applications, it is a major way of IOT applications. Things architecture is now widely considered to be divided into three things, such as the perception layer, network layer and application layer [2]. As is shown in Fig. 1.

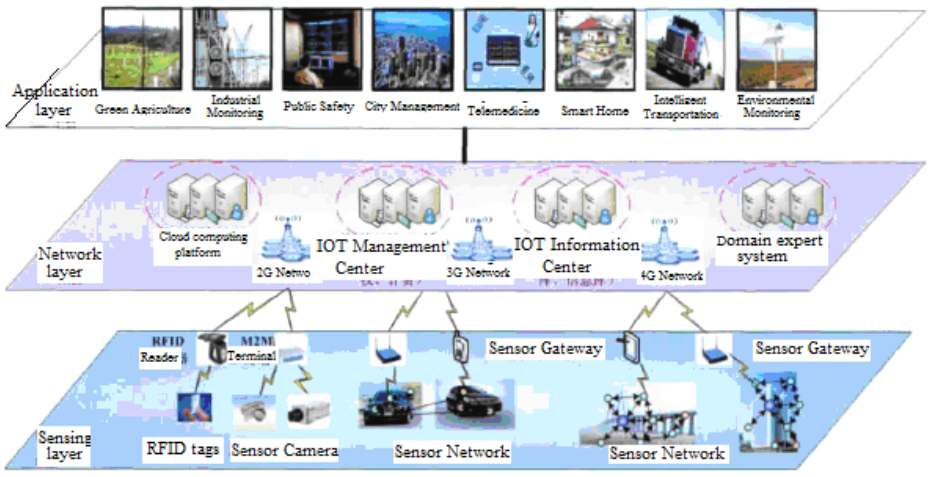

Fig. 1. Architecture of Things.

Sensing layer consists of various types of acquisition and control modules, such as RFID tags and readers, sensor networks, temperature, sound, vibration sensor, two-dimensional bar code, a variety of terminals. The underlying information is mainly collected in the perception layer, the data acquisition and device control functions is completed in IOT applications. it is the basis of IOT applications and

development. Sensing layer typically comprises a data acquisition and short-distance transmission, information and data are collected by sensing devices, they are passed to the gateway via bus or short-distance wireless transmission technology, the information is submitted to the upper layer.

Network layer is built on the basis of existing networks, the existing network integration and expansion are made, a network is the formed by which multiple heterogeneous networks coexist with a variety of organic integration networks, the functions of data transmission are primarily assumed, there is the ability to transmit data in the perceived layer with accessibility, high reliability, high security, especially long-distance transmission. Meanwhile perception layer also includes part of the perception of data management and processing techniques [3].

Application layer is the driving force and purpose of the development of things. The main function of the application layer is the perception and transmission information to be analyzed and processed, the correct control and decision-making, intelligent management, applications and services are made. This layer solve the problem of information processing and human-machine interface. Specifically, the data coming from the network layer is to be processed by various information systems, and they interact with people through a variety of devices. It can be divided generally into two sub-layers: the application layer and the layer of the terminal devices.

2.2. The Key Technology of Things

IOT is a comprehensive body of information technology, communications, sensors and automatic control and other technologies, IOT technology can be divided into three levels with the application layer, network layer and perception layer. In the perception layer, the key technologies involve in sensor technology, RFID technology, wireless communication, self-organizing networks, middleware and embedded systems. At the network layer, it mainly includes heterogeneous network convergence, M2M, cognitive radio technology and network context-aware technology. At the application layer, according to the architecture, the main techniques have to take into account the massive data storage, data sharing, data mining, cloud computing, resource virtualization, software architecture, etc. [4]. Things technology architecture is shown in Fig. 2.

In the perception layer, the perception layer technology includes data collection techniques, short-distance communication and collaborative information processing technology [5]. In data acquisition techniques, sensor can feel the measured information, and according to certain rules, the detect information can be converted into electrical signal or other forms of the required information, which are output to meet the information transmission, processing, storage, display, recording and control requirements. RFID technology achieves non-contact transmission of information by the radio frequency signals and space electromagnetic coupling, and the object is identified by the information conveyed. RFID technology can be seen as device identification technology and can also be seen as one of short-range communications technology. In the short-range communication technology, a common ZigBee technology is a short-range and low-power wireless transmission technology, it is suitable for carrying data traffic in small business.

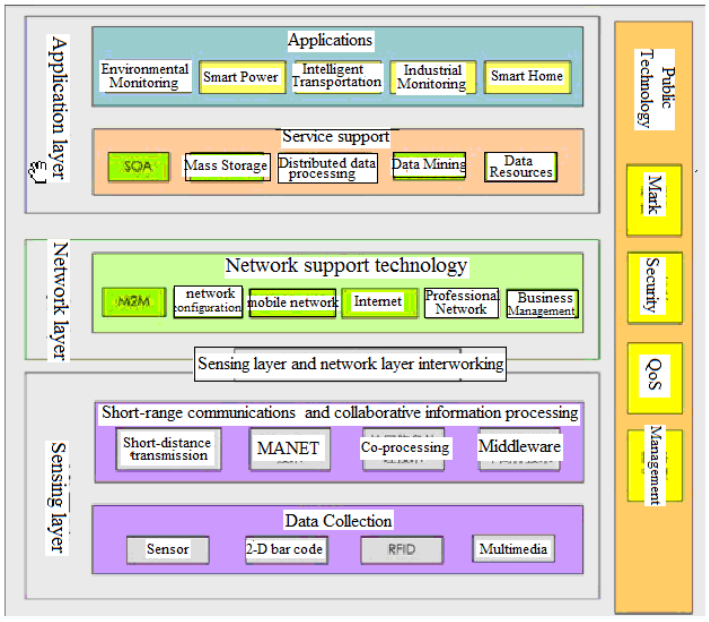

Fig. 2. Things technology architecture.

At the network layer, we mainly consider the networking and communications technology. Network is infrastructure of the IOT information transmission and support services, through ubiquitous connectivity features, perceptive Informatics is achieved and transferred in high reliability and high security. In addition to considering traditional mobile communication networks, the Internet and other technologies, our main consideration is heterogeneous network convergence technology, a variety of wireless and wired networks are organically fused to form a unified information exchange network, the information silos are excluded, a global information is integrated.

In the application layer, compared with the general network, there is massive computing and processing sensory information, a major problem is considered after the application of large-scale development of things, data fusion, efficient storage, semantic analysis, parallel processing and data mining and other functions are realized in the mass information [6].

In addition, IOT public administration and support technology is the most important issue, which are considered in the construction of things, because things have openness, inclusiveness and autonomy, so we have to study the new management model and key technologies of IOT, as well as security technology is more optimized to ensure the normal development of IOT [7-13].

3. Development and Application of Optical Fiber Sensing Technology

3.1. Fiber Optic Sensor Characteristics and Classification

Fiber optic sensor not only has the basic technology with traditional sensors, but also has many unique advantages. When the optical fiber sensor uses the light transmission through the optical fiber, its phase, polarization, wavelength and other parameters change with external factors, the corresponding changes are sensed in the external physical quantity, the sensing measurements are realized. The basic working principle of the optical fiber sensor is that the light from the light source is fed to the modulator via an optical fiber, after the measured parameter is interacted with the light which enters modulation region, the optical properties of light (e.g., light intensity, wavelength, frequency, phase, Modifier state, etc.) are resulted in change, it is referred to as the modulated signal light, then which is fed to the light detector through the optical fiber, after demodulation, the measured parameters are obtained [14]. Fiber optic gyro sensor principle is shown in Fig. 3.

Compared with the conventional sensor, optical fiber sensor has many advantages, such as that the broadcast information is transmitted, electromagnetic interference is immuned, corrosion resistance, anti-hypertension (high pressure). By using a phase-coherent technology, it has high sensitivity, and light weight, small size, and applicability. And its frequency is bandwidth, there is the wide dynamic range, the reliability and accuracy are improved on the measurements, in addition, fiber optic sensors can also detect various physical quantities, this research is a major breakthrough within the range of the sensor.

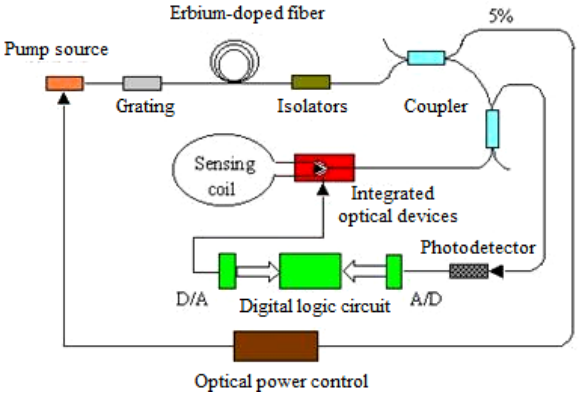

Fig. 3. Fiber optic gyro sensor principle.

Fiber optic sensor can be divided into two categories by sensing principle, one is called as functional sensors, the optical fiber role are both the signal transmission and its sensitive, it has a unity of sense and mass characteristics. Another is known as non-functional sensors, which only serves as an optical fiber transmission, and the feeling of the signal is to use the other to complete the optical sensor. By modulation principle of light in the fiber, fiber optic sensors can be divided into several forms, such as light intensity, phase modulation, polarization modulation and wavelength modulation, etc.

3.2. Applications and Developments of Optical Fiber Sensors

Fiber optic sensor is used to measure the magnetic, acoustic, pressure, temperature, acceleration, gyroscope, displacement, surface, torque, photoacoustic, current, physical strain [15]. It has wide range of applications, it is mainly in the following areas.

1) Interferometer gyroscopes and Grating Pressure Sensors applications in urban construction, such as bridges, dams, oil fields. Fiber optic sensors can be embedded in the concrete, carbon fiber reinforced plastic and various composite materials for testing stress relaxation, stress of construction and dynamic load stress, in order to assess the performance of the bridge structure of short-term

construction phase and long-term operation state. FBG settlement sensor application is shown in Fig. 4.

Fig. 4. FBG settlement sensor application.

2) The temperature, current and other parameters need to be determined in the power system, such as the inside detection of high-voltage transformer and large motor stator and rotor temperature, because electromagnetic type sensors is susceptible to electrical interference, which can't be used in such occasions, only fiber optic sensors can be used. Distributed fiber optic temperature sensors are developed in recent years, it is a high-tech for real-time measurement of space temperature field distribution. Optical fiber temperature sensor application in on-line monitoring of power high-voltage switch is shown in Fig. 5.

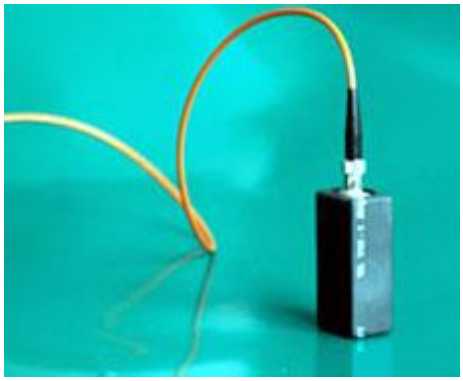

Fig. 5. Optical fiber temperature sensor application in on-line monitoring of power high-voltage switch.

3) Fiber optic sensors can be used to temperature measurement on flammable materials production processes and equipment. Fiber optic sensor is essentially a anti-fire and anti-explosion device, it does not require the use of explosion-proof measures, and it is very safe and reliable. Compared with electrical sensors, both costs are reduced and the sensitivity can be improved [16].

In addition, fiber optic sensor is also possible to monitor the railway, rocket propulsion systems, and application of well testing, etc., fiber optic sensors have a variety of the application, it can be applied to all sectors of our country, we believe that optical fiber sensing technology has great market potential.

4. To Investigate the Optical Fiber Sensing Technology in the Internet of Things

4.1. Optical Fiber Sensing Technology Application in Sensing Layer

A wide variety of sensors are used in the Internet of Things, fiber optic sensors are different from the traditional sensors and has a lot of advantages, the application of the Internet of Things will be unparalleled. In the application of Things perception layer, on the one hand, fiber optic sensors can be used to detect a wide variety of environments, they bring things more timely detection information, and they are not impacted by the detect environment. On the other hand, the entire network can be brought to a higher detection sensitivity, the accuracy and the reliability of the network information are ensured. Also, its sense unity characteristics is suitable for a distributed sensing system, the continuous sensing detection and transmission are realized over long distance lines, which is very necessary in IOT network, it is suitable to build network architecture of things [16].

4.2. Application Case Study

In the connectivity platform cloud technology research of the mine fiber IOT, we focus on mine safety detection problem, we propose a universal fiber optic sensor IOT interfaces, a fiber-optic sensor IOT is built [17]. System is connected by the user, the Internet, cloud platform, and fiber optic sensors, wherein the optical fiber sensor is a main way to collect information for monitoring mine gas concentration, temperature, level, vibration, humidity, dust concentration, harmful gases, etc. In the cloud connected platform, the collected information is acquired with a wide range of the optical fiber sensors and its different parameters, and through signal conversion, unified transport protocol and data format are uploaded ultimately to the control room or the Internet on Inoue, but also the terminal control command is accessed, the command is converted to the instruction format, which can be identified in terminal device, that is sent to the device control terminal for device to be controlled. Internet function is to transmit information. This system of coal mine safety provides a more effective solution, the ability and level of coal mine safety testing have been to greatly enhanced [17]. Fiber optic ring network transmission of security monitoring system is shown in Fig. 6.

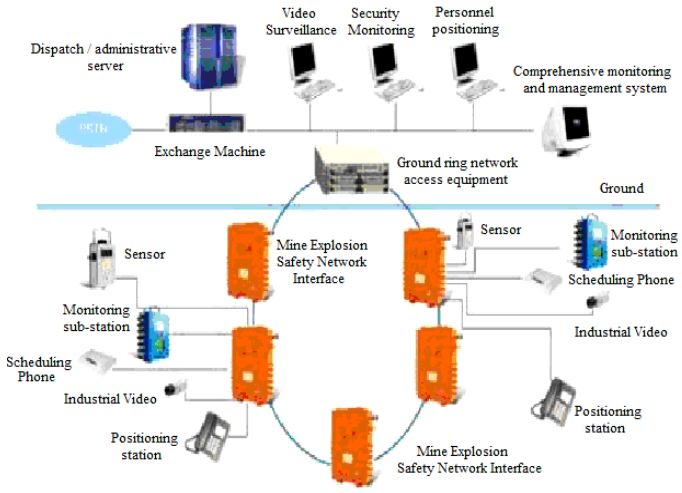

Fig. 6. Fiber optic ring network transmission of security monitoring system.

5. Conclusions and Outlook

IOT framework technology and fiber optic sensing technology has been studied in this paper, the optical fiber sensing technology applications are analyzed in IOT perception layer, and the specific applications of the optical fiber sensing things are studied in mine safety testing, that fiber-optic sensor network is found to provide greater protection for mine safety, based on this, we can predict that the fiber-optic sensing things will have the greater development and application space in the future.

Acknowledgements

This paper is sponsored by Hunan Provincial Education Science "Twelfth Five-Year" plan project (No. XJK014BGD046).

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