Development of Internet of Things in the field of smart home security

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Abstract. With the rapid development of the Internet of Things and the constantly breakthrough of sensing technology, the Internet of Things has been further applied to the field of smart home security. The progress of the Internet of Things in the field of smart home security not only improves the efficiency of civil home security, but also improves people's life experience. This paper first introduces the security range of the Internet of Things technology applied in the field of smart home security, and then introduces Zigbee, a typical communication network of the Internet of Things. Then it introduces the sensors involved in environmental monitoring and intelligent door lock in the Internet of Things. In the end, it summarizes the content of this paper.

1   Introduction

Intelligent security on the basis of traditional security, the integration of Internet of Things、 cloud computing、 artificial intelligence、 big data and other new generation of information technology, improve the image perception、 data processing、 information analysis、 correlative fusion capabilities, to achieve pre-prevention、 in-process detection and post-processing[1].The application of Internet of Things technology in the field of smart home security has many advantages and a wide range of coverage, which can greatly protect people's lives and property.

2   The range of smart home security based on Internet of things technology

2.1   Environmental Monitoring

Environmental monitoring mainly provides real-time environmental monitoring and alarm processing for home environment. Data of gas、 flame、 smoke、 temperature, humidity and so on, which is related to living safety and comfort are collected through sensors. Dates are collected and are transmitted to the remote control system in real time. Then the remote control system analyzes the data and compares it with the safety data values. If abnormal data is found, the alarm will process.

2.2   Smart home door lock

With the continuous development of Internet of Things technology, the traditional key unlocking has been unable

to satisfy people's requirements for convenience and security. There are much unlocking ways based on intelligent locks now, such as fingerprint recognition、 face recognition、 wireless remote lock and unlock password, people can according to their own needs to choose a right way of unlocking, or combine several unlocking ways. It can solve the problems of traditional key security and is more conducive to preserve people's life and property security.

3   Zigbee Communication Network

3.1   Introduction to Zigbee wireless network technology

Zigbee is an open、 low cost、 low power、 low delay、 large network capacity、 high reliability、 high safety factor of the new short-distance wireless communication technology. Zigbee generally adopts the combination of IEEE802 transceiver and Zigbee protocol station, it form a wireless data transmission network platform. Within the range of the entire network, each Zigbee network data transmission module can communicate with each other. These Zigbee nodes need very little energy to work. Data transmission between nodes is carried out through radio waves in the way of relay, so Zigbee communication efficiency is very high. Zigbee is a good communication network solution for smart home security technology and the technical characteristics of Zigbee will be analyzed below.

3.2   Zigbee Layered protocol

Zigbee protocol from bottom to top are the physical layer (PHY)、 media Access Control layer (MAC)、 network

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layer (NWK)、 application layer (APL). The hardware layer is PHY and MAC defined by IEEE802.15.4, and the software layer is NWK and APL defined by Zigbee Alliance. See Figure 1 below. In addition, it can be intuitively seen from Figure 1 that the Data transmitted by the user-defined APL can pass through two relatively independent but actually closely related wireless channels, namely Data Server and Manage Server [1].
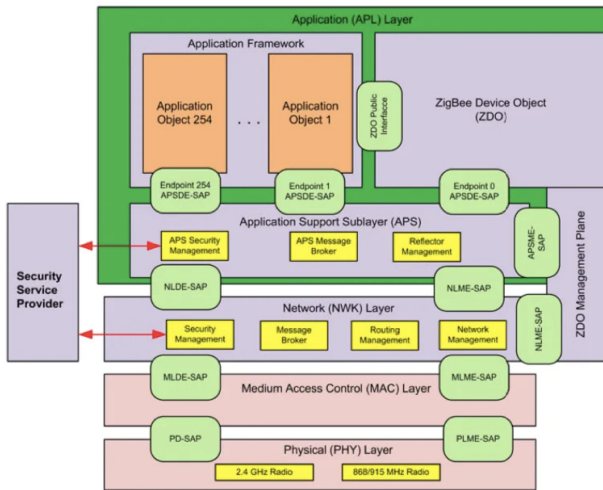

Fig. 1. Zigbee protocol architecture

3.2.1 Physical Layer (PHY).

The physical layer offers the ports between MAC and the wireless physical, the channel mainly provides management services and data services. For example: checking and evaluating whether the channel is free and the channel connection status, which directly determine whether the signal can be transmitted successfully. The CSM-CA algorithm can be used for idle channel evaluation (CCA), which simply means that the underlying hardware detects whether a certain carrier exists in the space, and whether its energy is higher than a defined value. There are three methods as follows: first, energy detection (ED) is carried out in the current channel. If the energy of a channel exceeds a certain value, the channel is considered occupied; Second, carrier detection (CS). CS is more intelligent than ED monitoring. ED monitoring can only monitor whether the channel can be used, while CS monitoring can judge whether the signal of the current channel is the same as its own IEEE802.15.4 signal according to the carrier characteristics, if not, the channel will be considered busy. Third, it is determined by the above "and" "or" "nor" logic of ED monitoring and CS detection. According to different countries and regions, three different frequency bands are provided, 868MHZ, 915MHZ and 2400MHZ, which provide 1 channel, 10 channel and 16 channel respectively. The center frequency of each channel can be calculated by Equation 1:[2]

$$\begin{cases} f_c = 868.3MHZ & k = 0 \\ fc = 906 + 2(k-1)\,MHZ & k = 1,2,\ \ldots,\ 10 \\ fc = 2405 + 5(k-11)MHZ & k = 11,12,\ldots,26 \end{cases} \quad (1)$$

3.2.2 Media Access Control Layer (MAC).

As can be seen from Figure 1 Zigbee protocol stack structure diagram, MAC is located between PHY and NWK and mainly provides data transmission service and management service. MAC Common part Molecular layer Service Access point (MCPS-SAP) is mainly responsible for receiving data from network layer、 transmitting data through peer entity keys and reporting data from other devices to the upper layer. The MAC Management Entity (MLME) provides MAC management functions such as channel scanning、 network association、 disassociation、 beacon synchronization and so on. It is also responsible for maintaining MAC management object database, namely the PAN Information Base (PIB).

3.2.3 Network Layer (NWK).

NWK is a protocol layer between APL and MAC, which is the most important part of Zigbee protocol stack. The main task is to provide functions to ensure the correct operation of IEEE802.15.4-2003 MAC, and to provide appropriate service interfaces for APL. The NWK consists of two service entities, namely Network Layer Data Entity (NLDE) and Network Layer Management Entity (NLME). The NLDE provides the following data transmission services: 1. After receiving the APL protocol data unit, the NLDE adds the NWK layer frame header to generate the NWK layer protocol data unit (NPDU).2. The NLDE can send data to the target device or the next-level device on the path to the final target. NLME provides management services: 1. Configure a new device.2. Start a new network.3. Connect or disconnect from a network;4. Search and record services such as valid transmission of information.

3.2.4 Application Layer (APL).

The APL is the top layer of the Zigbee protocol stack, It includes Application Support (APS)、 Zigbee Device Objects (ZDO) and Application Framework (AF). APL is mainly developed by users according to specific applications to maintain functional attributes of nodes, discover the work of other nodes in the workspace of this node, and make multiple nodes communicate with each other according to service and demand. AF is the working environment of device application objects. About maximum of 240 application objects can be defined. APS provides an interface between the NWK and the APL, which contains a set of objects that can be agreed upon by ZDO and devices for use through the Service Access Point (SAP). The Zigbee device object ZDO sits between APS and AF and provides an interface for both. Customized by different manufacturers according to different needs. AF interacts with ZDO through ZDO public interface.

4   Hardware

4.1   Sensor

Sensor or Transducer is a monitoring device. It can sense and measure information. Sensor also can convert and output electrical signals or other required information forms. Sensor has miniaturization、 digital、 intelligent、 multifunctional、 systematic、 network and other characteristics. Basing on perception function, sensor can be divided into: thermal sensitive element、 photosensitive element、 gas sensitive element、 force sensitive element、 magnetic sensitive element、 sound sensitive element and so on. Here are two typical smart home detectors.

4.2   Environmental Detecting Sensor

4.2.1 Gas sensor.

Gas is a general term for gas fuel, which plays an indispensable role in modern household life. It can release heat through combustion for the use of residents and enterprises. Common fuel gas is natural gas, gas, petroleum, biogas and so on. This paper mainly introduces the sensors for monitoring natural gas. The main component of natural gas is alkanes, of which methane accounts for the majority. Methane is a highly toxic gas, mild poisoning, patients will appear dizziness、 headache、 fatigue and other symptoms, severe poisoning, patients will feel chest tightness、 breathing difficulties and even life-threatening. So gas leaking can be detected by monitoring the concentration of combustible gases such as methane, such as MC226A catalytic combustion gas sensor. MC226A catalytic combustion type gas sensor bases on the principle of catalytic combustion effects work, it consists of monitoring unit and compensating element matching bridge of one arm. When meeting combustible gas, its monitoring components resistance increases and the bridge circuit output voltage changes, the voltage variation as gas concentration increases in proportion to increase. The MC226A operates at a voltage of 2.5V±0.1, with a sensitivity of 20%LEL, methane: 15-40mV、 20%LEL, ethane: 10-30mV, and a measurement range of 0-100%LEL. Beyond this value, the intelligent home control system will send alarm signals, so as to achieve the purpose of protecting family life and property safety.

4.2.2 Fire detection monitor.

In people's daily life, fire is a common major disaster. It often threatens people's safety and social development, which has attracted great attention. The main function of the fire detector is to monitor the home environment. If the fire is detected by the sensor, the alarm signal will be sent immediately. Common fire detectors include smoke sensors, flame sensors, temperature sensors, special gas sensors and so on. In the early stage of a fire, there will generally be a lot of smoke, and the temperature around the ignition point will rise sharply. The combination of smoke sensor and temperature sensor can effectively detect the fire, predict the size of the fire, alarm the fire, and provide information about the fire, and reduce the loss caused by the fire. MQ-2 smoke monitor and DS18B20 temperature detector will be introduced next[3].

MQ-2 smoke detection has wide range、 high sensitivity、 fast response、 high stability、 long life and other characteristics. Its working principle is built-in tin dioxide semiconductor photosensitive material, the material is Surface ionic N-type semiconductor. At 200~300 ℃, tin dioxide adsorbs oxygen from the air and form negative ion adsorption of oxygen, which reduces the electron density in the semiconductor, thus increasing its resistance value, so that the electrode cannot generate an electrical signal. So MQ-2 can judge whether a fire occurs.

DS18B20 is a common temperature sensor and output digital signal. It has the characteristics of small size、 low hardware overhead、 high precision、 strong anti-interference ability and so on. It is suitable for various kinds of narrow spaces. DS18B20 temperature detector operating voltage range of 3.0V-5.0V, measuring temperature range of -55℃ to +125℃, can be set according to the actual conditions of the temperature threshold. For example, assumed the temperature threshold is set to 40 ° C, if the sensor detects that the temperature exceeds this range, it will alarm.

4.3   Smart home door lock

4.3.1 Introduction of smart home door lock.

With the progress of science and technology and the improvement of people's living standards, people attach more importance to the safety of life and property. The traditional security door device has simple design principle and low safety factor, which has been hard to satisfy people's needs. Because of the continuous development of information technology, smart home door locks based on the Internet of things have entered people's daily life [4]. Smart home door lock mainly completes two functions: 1. Monitoring function;2. Unlock function.

4.3.2 Monitoring function of smart home door lock.

As it name implies, the monitoring function is monitoring the surroundings of the user's home. The user's family needs to input biological information, such as fingerprint、 voice and appearance into the database of the smart home system. When an outsider approaches, the surveillance camera will first capture the person's biological information and compare it in the database. If there is no information about the person in the database, the user will be alerted. Users can check the alarm information, decide whether the external person is a visitor and open the door.

4.3.3 Unlocking function of smart home door lock.

4.3.3.1 Unlocked by user Biometric Authentication.

The system collects the user's fingerprints, voice, facial features and other biometric data and stores them in a database. When entering the door, the biological data of visitors will be collected through cameras、 microphones、 fingerprint collectors and other devices, then compared in the database. If the comparison result is determined as a family user, the door will be opened. Users can also set the type of authentication mode and choose one or multiple biological information [4] to authenticate.

4.3.3.2 RFID verification unlock.

RFID (Radio Frequency Identification) is a kind of automatic identification technology. It can fast exchange and store information through radio waves without contact. Connecting database through wireless communication and data access technology, it can realize non-connect two way communication. During identification, the electronic label can be read, written and communicated by electromagnetic wave.The access control system uses RFID reader to identify the electronic tag. If the electronic tag matches the set value, it is regarded as successful matching and the door lock is opened [5].

5   Conclusion

This paper first describes the structure of Zigbee protocol stack in the communication network of intelligent home security system. And then introduces how to realize the environment monitoring module and intelligent door lock module in the intelligent home security system. In the environment monitoring module, the sensor used in the gas monitor and fire detection monitor and its working principle are analyzed. In the intelligent home door lock, there are two ways to verify the lock, respectively biometric verification and electronic tag verification.

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