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The Embedded Modules Solution of Household Internet of Things System and The Future Development

Chen-Zhuo-Er Li*[11], Zhi Wen Deng[2]

[1] No.24, Yi huan lu nan yi duan, Wuhou district, Chengdu City, China
[2] University of Sichuan, China

Abstract:

By analyzing the current situation of the Internet of Things, this paper realized that the household Internet of Things encounters many difficulties in many areas like electric appliances producing, consumers using, running and maintenance, control security. So this paper comes up with The Embedded Modules Solution of Household Internet of Things System, which is a household Internet of Things that allows all electric appliances been controlled by a single smartphone terminal. This system is able to be integrated, expanded, and optimized. And this paper comes up with the three stages of IoT in future which are "Internet of things with electrical appliances", "Internet of things with any appliance", and "Artificial Intelligence Internet of things"

Key words: Internet of Things, Embedded Modules Solution, Difficulties, Future Development

1 Introduction

With the development of modern technology and improvement of people's quality of lives, The internet has reached out to millions of users. At the same time, the Internet of Things (IoT) has also begun to enter the families. In 1999, is the concept of Internet of things were put forward. The Internet of things is still the basis of the Internet, it is usually people as a kind of extension and extension of the Internet[1]. IoT is an emerging technology which develops under the support of computer technology, but its functions are more outstanding. It breaks the limit of traditional network and unites multiple fields to establish a public information sharing platform[2]. As the important tools that can make people's lives become further intelligent, the development of the household IoT is facing many

[1] Corresponding Author. Tel.+(86) 18828058236
*Email : cdliwei111@sina.com

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difficulties and challenges today. As an extension of the Internet, IoT will extend the network from restricted network devices (such as mobile phones, computers, etc.) to physical communication. The household Internet of Things has the following characteristics: compatibility of different communication technologies, ubiquitous service, comprehensive perception，conveniently control[3]. In short, the household Internet of Things can improve modern family living environment to meet the increasing demands of life[4].However, compared with the more mature Internet that has been developed, the Internet of Things is still in the initial stage of development and faces many difficulties and challenges. This paper comes up with his own solution for the construction of the household Internet of Things and the projection of future development trend of the household Internet of Things, may discuss with colleagues from all walks of life.

2 The Origin and Development of the Internet of Things

The earliest network intelligence devices were discussed in 1982. Carnegie Mellon University (CMU) modified a Coke machine and make it enable to report whether the Coke inside the inventory was cold enough[5]. While the term “Internet of Things” (IoT) was come up with Kevin Ashton in 1999[6]. Today, IoT devices still maintain a 31% year-on-year growth rate, with global IoT devices already reached 8.4 billion by 2017[7]. IoT is expected to reach 30 billion devices[8] (Esmailian et al., 2000) and 7.1 trillion US dollars in global market value by 2020[9]. The Internet of Things currently has many applications in the fields of manufacturing, agriculture, energy management, and environmental monitoring. While in the household area, there are many home appliance manufacturers have made effort, but most of them failed to promote their devices and form large-scale effect.

3 The Current Difficulties that the Household Internet of Things Facing

Through the analysis of the status quo of the Internet of Things, this paper concluded that the Internet of Things is facing many difficulties in the aspects of home appliance manufacturing, user using, operation and maintenance, and control security.

3.1Manufacturer\ s Difficulties.

For the development of the Internet of Things, the biggest problem that manufacturers face first is the development of existing products. For any existed home appliance company, their product lines are very mature. If they decide to modify their products to be the IoT devices, they need to develop new product lines, and that also means a lot of investment in human resources, research and development is needed. A traditional home appliance company may have no human resources who familiar with the Internet industry, while the new recruitment of relevant personnel and re-training almost means an indefinite extension of the research and development cycle. In addition, the ecology of the Internet of Things has not yet been formed. No enterprise has the ability and capital to develop many kinds of new IoT appliances at the same time and to form an IoT ecosystem in a short period of time. Such challenges have made few mature home appliance companies willing to be pioneers in the home Internet of Things industry, and that also caused the development of the Internet of Things has been almost stagnant for many years since the concept of IoT been come up.

3.2 Users’ Difficulties.

The Internet of Things is also a new concept for consumers, and they are also facing many difficulties when choosing the IoT products. The increase in product prices is the most significant difficulty. If a company spends a lot of capital on the development of IoT products, while also there is not enough capital to support the company until the entire IoT ecosystem is mature that can make profit stable and continuous, then the company must reflect the expensive development cost on the product price in order to recover the cost in a short period. But for users who have never experienced the Internet of Things and don’t know what the Internet of Things can bring them, they may not be willing to pay for something that is half more than the price of ordinary goods or even twice as expensive as ordinary goods.

3.3 Running' Difficulties.

The operation of the Internet of Things devices is also facing difficulties. If each enterprise develops its own products for the Internet of Things, designs the products and accesses the network with its own standards, the IoT products from different enterprises will have different specifications and interfaces, which will not be compatible with each other. This means that if a user intends to build their own home Internet of Things system, he can only choose the IoT products from one company and cannot be compatible with other companies' products. However, since the development of the Internet of Things is still in its infancy, the scope of coverage is also very wide, no single company has the ability to develop every kind of IoT products that covers all aspects. The result is that no single company can form its own complete IoT ecosystem. While users can neither complete the construction of their family Internet of Things system with one enterprise's products, nor choose multiple different brands to form their household Internet of Things system due to the incompatibility of different brands of products. In the end, consumers can only abandon the consumption of IoT products, and enterprises will also abandon the development of IoT products and switch back to the production of traditional products.

3.4 Maintenance' s Difficulties.

Even if the ecology of the Internet of Things can be built, who is responsible for the operation of this Internet of Things is another question. There will be a large amount of IoT data transmitted over the network, and there must be someone to manage these data. However, if every enterprise only builds servers for its own IoT products, the result is that products from different enterprises cannot communicate with each other, and information is difficult to interconnect.

3.5 Security' s Difficulties.

After the Internet of Things ecology been built, it will also face challenges from security aspect.

For example, if a user chooses to use an ordinary household router to connect an IoT device to the network, there is a risk of being attacked at any time, especially when many families have weak passwords or even do not have the habit of setting a password for their wireless network environment. In this case, the attacker can easily control the entire IoT system of the home by invading the router. The current Internet mainly serves virtual content, and usually only the data is lost when suffering the hacker attacks. However, the Internet of Things connects the network to actual objects. Once it is illegally controlled, it may cause material damage or even threaten personal safety. Therefore, it is also important to find out who is responsible for ensuring the security of the Internet of Things.

4 Household Internet of Things with embedded PLC module solution

In view of the above difficulties faced by the household Internet of Things industry, this paper proposes an embedded module solution for the construction of the home Internet of Things.

4.1 Overall Structure.

The home IoT embedded module solution consists of three sections: user household IoT System, Enterprise Servers Center, User Cellphone Terminal. The main structure is to use the enterprise server as a relay to complete the communication from the user cellphone terminal to the user household IoT system. (Fig. 1.1)

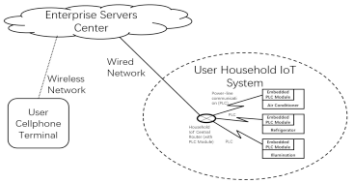

Figure.1. Household Internet of Things with embedded PLC module solution Structure

3.1.1 User household IoT system. User household IoT system is the most important section of the entire solution (Fig. 1.2). The user household system is divided into two sections: the household IoT Central router and the embedded IoT modules. The Power-line Communication technology (PLC) is used as the basic principle in this system, which based on the IEEE Std 1901-2010. The household IoT Central router and the embedded IoT modules communicate through the home electrical system. The user household IoT system can be responsible for communicating with all IoT devices and appliances within the home LAN. The household IoT central router is responsible for communicating with the enterprise server center in the WAN to receive and send data.

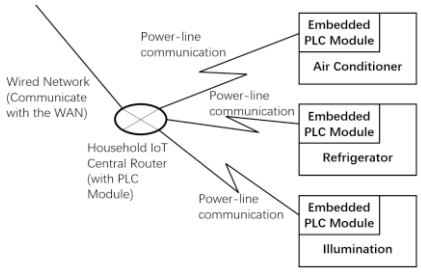

Figure.2. User household IoT system Structure

Power-line communication (PLC). The basic principle of power-line communication (PLC) consists in superimposing a high frequency signal that is message signal (1.6 to 30 MHz) at low energy levels over the 50 Hz electrical signal[10]. It can be remotely received and decoded through power infrastructure transmission, and the PLC signal can be received by any PLC receiver on the electrical grid.

In this system, we use the IEEE Std 1901-2010 as a design specification and use power-line communication technology for data transmission in the household IoT central router and embedded PLC modules in various appliances within the scope of the home LAN.

Embedded PLC module. The module is implanted in the home appliance to directly obtain control rights of various control interfaces in the appliance (directly taking over the circuit of the control button and panel on the appliance for example), and it works on any kind of electric appliances. Through the power-line communication, receiving instructions from the household IoT central router, turning it into control commands to achieve remote control of the electrical appliances (Fig. 1.1, Fig. 1.3). At the same time, the embedded PLC module will collect various working data of the electrical appliances (such as the temperature of the air conditioner, monitoring screen, etc.), and send to the household IoT central router by PLC. The central router transmits data to the user's cellphone terminal through the traditional Internet to achieve the purpose of real-time monitoring and control of the electrical appliance. In addition, these IoT modules embedded in each home appliance can also exist as wireless access points (APs) of the central router, significantly extending the wireless coverage capability of the original router, and realizing coverage of signals with no blind area in the home range as the result.

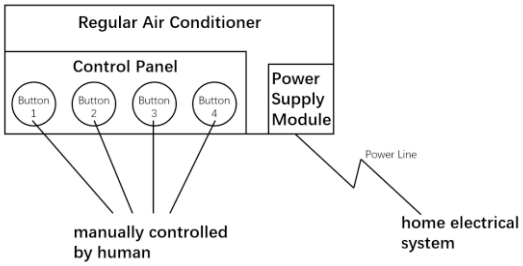

Fig.ure.3. Regular Air Conditioner

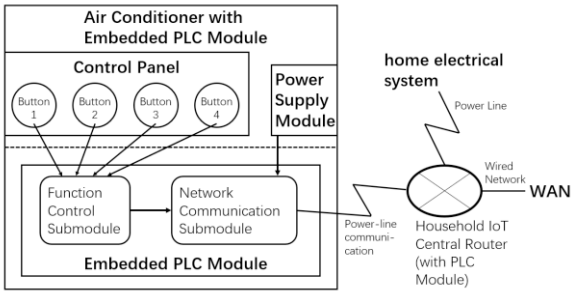

Figure..4. Air Conditioner with Embedded PLC Module

Household IoT Central Router (with PLC Module). The household IoT central router is the core module in the user household IoT system. This module communicates with the IoT modules embedded in each electrical appliance through the power line by power-line communication technology, performs data processing and send command to all electrical appliances that connected to the household IoT system. At the same time, the user uses the personal account to log in to the enterprise server center through the central router, make the router be able to communicate with the enterprise server center, so that the user can implement the purpose of accessing, viewing, and controlling the household IoT system through the cellphone terminal.

Enterprise Servers Center. Enterprise Server Center is the back-end data center for the entire household IoT system. At present, most network users do not have individual public IP addresses, so it is not realistic for users to conduct point-to-point communication from their cellphone terminals to their household IoT central routers. Besides, this method faces many difficulties like high technical requirement for users, high security risks, and difficult to make scale deployment. So in this solution, a new role is needed: the Internet of Things Service Provider (IoTSP). The IoTSP in this system will establish the data server center, and the data server center will work as a relay site between the user's cellphone terminals to the user’s household IoT central router. By registering a personal account, the user can make his cellphone terminal and their household IoT central router to log in to the account and simultaneously connect to the enterprise server center, and then remotely control his household IoT system.

User Cellphone Terminal. The user cellphone terminal is a control program used by the user to control his household IoT system, exists in the form of an application on the user's mobile phone, and logs into the enterprise server center through the user’s personal account. The terminal allows the user to send commands and acquire data at the remote end if there is any network. In addition, the control terminal in the form of an application makes the entire household IoT system scalable and programmable. Any control commands can be programmed or linked to other functions in the phone. For example, the wake-up alarm clock triggers the coffee machine to work automatically, or the user will arrive home soon and his location information triggers his air conditioner to start working, etc.

5 Advantages of the Embedded Modules Solution of Household IoT System

In view of the difficulties faced by the current household Internet of Things, this paper proposed the embedded modules solution of household IoT system has significant advantages in technology research and development, product price, ecology construction, convenient installation and scale deployment.

There is no need to lay additional network cables but directly use the existing home power lines as the transmission medium. The amount of modification required for the user's existing housing environment is minimized, which significantly reduces the technical requirement, financial cost, time cost, and will be more easily accepted by users.

The module embedded in the household electrical appliance is universally applicable. By directly acquiring the authority of each control interface in the electrical appliance and adding a corresponding mapping interface on the cellphone terminal, this kind of embedded PLC module is applicable to any brand, any kind, any function of the electric appliance, and is convenient for quickly establish an IoT ecosystem in a variety of electric appliances. This module can be directly modified on existing electrical appliances, so the electrical appliance manufacturers can continue to produce products according to their original designs. It is not necessary to modify their original design

specifically for our embedded IoT devices. This can minimize the cost of home appliance manufacturers producing their products with our embedded IoT modules.

The IoT module embedded in each electrical appliance can also be used as a wireless access point for the household IoT central router to extend the signal coverage, can achieve the coverage of signals with no blind area in the home range.

Using the Enterprise Server Center as a relay site, users only need to log in to their accounts on their cellphones and their household IoT central routers to complete the connection. Compared to let users conFig. point-to-point connections by themselves, this solution does not require the user to master any professional skills, nor does it require the user to hold an independent public IP address, which is user-friendly. The standardized connection method is more suitable for large-scale layout and unified management. In addition, the network data channel designed, operated and maintained by professional technicians can better ensure the user's data security.

Due to the embedded PLC modules is universally applicable, the only configuration is needed at the software level, which significantly reduces the cost of IoT service providers and appliance manufacturers, and reduces the price of IoT appliances in general.

An electrical appliance manufacturer cannot produce all types of electrical appliances, and consumers will not choose products from only one electrical appliance company. Therefore, manufacturers who try to build the IoT ecosystem on their own devices have all failed. In this solution, the IoT service provider provides standard certification for appliances equipped with this kind of embedded IoT modules. Any appliance that has this certification can be used throughout the IoT ecosystem and connect with all other appliances that have the certification. This solution can form an IoT ecosystem in various electrical appliances and various fields in a short period of time, which has obvious advantages over the existing IoT ecosystem establish solution led by a single electrical manufacturer.

The IoT service provider installs the household IoT central hub router for the user free of charge, informing the user that the system is compatible with all appliances on the market that have the IoT embedded module standard certification. Relatively flat prices make users more willing to accept these IoT products. At the same time, users who choose a large number of appliances with the certification in this scheme will have a strong impact on the electrical appliances that have not yet joined this IoT embedded module standard certification, forcing them to add the embedded PLC module to their products to restore the market. This will enable the ecology of the IoT to continue to develop and form a benign ecology in a short-term and rapid manner.

6 The Future Development of the Household Internet of Things

Regarding the future development of the Internet of Things, this paper believes that it should first develop from the household Internet of Things ecosystem, and then from small to large, gradually drive the construction of the Internet of Things in industry, commerce and even the entire city, and finally complete the construction of the Internet of Things. Here, this paper makes the projection about the future development direction of the household Internet of Things and proposes three major stages of future development:

6.1 Internet of Things with Electrical Appliances.

To complete the basic ecological construction of the household Internet of Things, users can use the cellphone terminals to control the household electrical appliances, and remotely complete the controls (such as turning on the lights, turning on the air conditioner, etc.), and implement the remote control be programmable. And add low-level intelligent modules to implement some basic ability to make decisions. For example, make warning when the heater is working but no one at home, have the fire detection function, and even automatically power off the heater if necessary.

6.2 Internet of Things with Any Appliance.

Expand more non-electrical appliances into the Internet of Things ecosystem (such as allowing windows to access the IoT to be opened or closed remotely). Further, enrich the Internet of Things ecosystem, and begin to make human life fully enter the IoT era in all aspects. Gradually eliminate traditional items. Strip the IoT ecosystem from the traditional Internet ecosystem, and IoT transmission would not depend on existing Internet devices.

6.3 Artificial Intelligence Internet of Things.

Artificial intelligence is fully integrated into the Internet of Things. The household IoT system gradually transforms into the identity of the smart housekeeper by the identity of simply processing data, receiving instructions, and controlling each embedded PLC module, and can perform many daily tasks intelligently and programmatically. Artificial Intelligence Internet of things has the learning ability and can understand the user's life habits (such as starting the automatic cooking before the user arrives home, etc.). The artificial intelligence Internet of Things has the ability to self-check (such as notifying the user in advance of an item's working condition is abnormal, may be damaged), ability to self-perception (such as the refrigerator can automatically detect each item placed, automatically set the shelf life, automatically remind users when near the expiration date, etc.). With the high development of material science and artificial intelligence technology at that time, a sensing circuit similar to the neural network principle is implanted in the object material. At this point, human life will enter an era of high integration with Internet of things and artificial intelligence.

7 Conclusion

The Internet of Things has a very bright future, but the industry is still in an almost undeveloped state. The one who seizes the opportunities of the Internet of Things, regulate the industry, and form an ecosystem, will hold the lifeline of the future IoT development.

And the development of the Internet of Things will directly change people's lifestyles, extend the current virtual Internet to all aspects of life, make the virtual network become reality, truly integrate into our lives, and change our lives, and make us live in a more convenient and intelligent world.

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