2012 Fifth International Conference on Intelligent Computation Technology and Automation

Key Technologies and Applications of Internet of Things

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***Abstract*— Internet of Things (IoT) has been paid more and more attention by the government, academe and industry all over the world because of its great prospect. This article introduced the concept of IoT, the basic properties and characteristics. Then it discussed the key technologies of IoT in detail taking the wire-less sensor network as an example, and the application of IoT was illustrated by its typical use in environment monitoring.**

Key words: Internet of Things, Sensor network, RFID, System structure

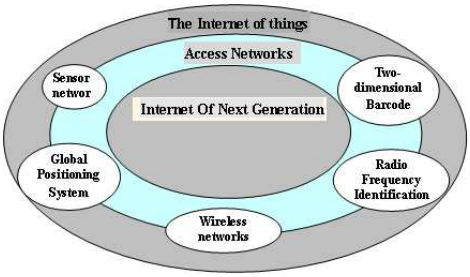
I. INTERNET OF THINGS AND ITS SYSYTEM STRUCTURE

A. The Cconcept of Internet of Things (IoT)

IoT is called the third wave of the world information industry after the computer and the Internet. Currently many countries have spent huge sums of money on in-depth study. IoT is a new technology system combined of the number of information technology.

The concept of "IoT" was proposed by MIT Auto-ID Lab in 1999[1]. November 17, 2005, World Summit on the Information Society (WSIS) was held in Tunis, the International Telecommunication Union (ITU) released the "ITU Internet Report 2005: Internet of Things", formally proposed the concept of "Internet of Things" [4]. In 2009, Samuel J.Palmisano, the CEO of IBM, proposed the concept of "Smart-Planet" [7].

That, "Internet of Things" refers to a variety of information sensing equipment and systems, such as sensor networks, RFID reading device, bar code and two-dimensional code equipment, global positioning systems and other short-range wireless ad hoc networks based on things-things communication model (M2M), through combining a variety of access network and the Internet to form a huge intelligence network. The model of IoT concept is shown in Figure 1.

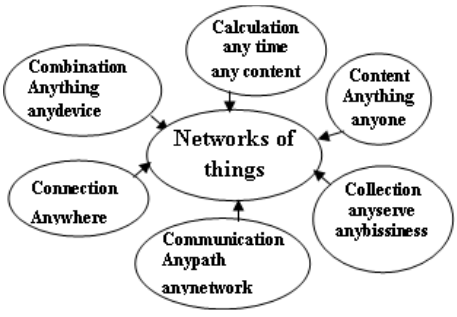


Figuer 1. The model of IoT concept

On the Two Sessions held in March, 2010, the government work report made clear that using the IoT technology to promote economic development pattern. IoT became one of strategy pillars of national economic and technological development [8].

B. Basic Properties and Characteristics

From the understanding of IoT above, we can see that IoT is the Internet's extending and expanding to the physical world and its related properties include focus, content, collection, computing, communications and connectivity scenarios. These properties show the seamless connection that between people and objects or between the objects and objects. The relationship between attributes is shown in Figure 2 [6].



Figuer 2. The basic properties of IoT

The objects of IoT play a role based on their ability. These capabilities include computing, network connectivity and available energy, also the scene situation (such as time and space) and other factors. According to

978-0-7695-4637-7/12 $26.00 © 2012 IEEE
DOI 10.1109/ICICTA.2012.56

the characteristics, effects and containment relationship of the part of IoT, its characteristics contain the following five parts [6]:

A. Basic features

The objects can be real-world physical or virtual objects;

·The objects have logo in a safe environment and can be identified automatically by the logo;

·The objects use the agreement to communicate with other objects and the IoT infrastructure;

·The objects exchange information between the real physical world and the digital virtual world.

B. *·General Characteristics of the Objects (Higher than the Basic Functional Characteristics)*

·The objects use the "service" as the interface to contact with other objects;

·A sensor attached to the objects, and it can interact with the environment.

C. Social Characteristics

·Between objects and between people and objects can communicate.

D. Autonomy Features

·Many tasks of the objects can be done automatically, and make judgments based on their reasoning ability; ·The objects can negotiate, understand and adapt their environment, and learn from other objects.

E. Self-Replication and Control Features

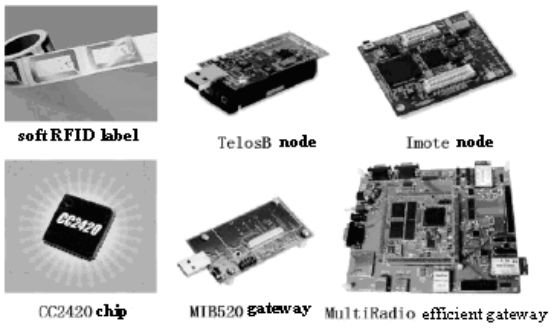
In summary, the Internet as a platform, IoT has integrated the sensor nodes, RFID tags and other information network with sensing capabilities to realize the interoperability between human society and physical systems.

II. THE KEY TECHNOLOGY OF SENSOR NETWORKS

The IoT is composed of the sensor networks, RFID reading device, bar code, two-dimensional code and other equipment and Internet [2]. The key content and key technologies that the sensor network contains mainly include data acquisition, signal processing, protocols, management, security, network access, design verification, intelligent information processing, information integration and support and application and other areas.

A. IntelliSense Technology

Data collection is the foundation of IoT to achieve "objects linked and the interaction between people and objects". Collection devices generally have MCU controller. It is generally embedded systems because of the cost constraints. The regulatory of IoT requires the terminal equipment must be intelligent [3], so the information collection devices generally have the operating system. In order to obtain a variety of physical quantities in objective world such as temperature, humidity, illumination and so on, and sensor technology is a key of data acquisition technology. Therefore, the data acquisition technology of IoT includes sensor technology, embedded systems technology, collecting equipment and core chips. Some typical hardware of IoT is shown in Figure 3.



Figuer 3. The related equipment and devices of IoT

B. Intelligent Signal Processing Technology

Intelligent signal processing will make a necessary treatment to a variety of original data obtained by the collection equipment to get information relevant to target things. Firstly, obtain measurements of various physical quantities, namely the original signal. Then filter the useful signals through signal extraction technology, and improve signal to noise ratio by conditioning. The signal of high signal to noise ratio can be made signal feature extraction in the mapping space through various signal transformation. By means of signal analysis technologies such as feature comparison, classification, various feature signals can be mapped to a class of physical events.

Here, "signal processing" encompasses signal interference, signal separation and signal filtering technology. These technologies have on the nodes and on the base station two implementations. But the difficulty is how to reduce the data traffic within the network and the energy consumption during the transmission, and minimize the increased network costs by the server as possible. Thus, in the signal processing techniques of IoT,

more physical testing, signal extraction, signal conditioning, signal conversion and signal analysis are core and key technologies. The CC2420 in the Figure 3 is the second-generation RF chip of IoT introduced by TI, and it has digital modem and other features. The consistency of the chip has been improved through digital signal processing technology.

C. Network Access

Taking the terminal-sensor network as antennae, the program running on the large server as brain, IoT achieves the favorable perception and effective control to the objective world. Which connect the terminal-sensor network and the server are various types of network access technology, including GSM, TD-SCDMA and other cellular networks, WLAN, WPAN and other private wireless network, Internet and other networks. The network access of IoT is done by the gateway. MultiRadio high-performance gateway in Figure 3 is developed by Sensor Network Laboratory of Calculation of the Chinese Academy of Science, which can support the operation of two embedded WiFi modules.

D. Information Processing and Information Integration

As IoT has a clear requirement and feature of "intelligence", and intelligent information processing is a key technology to protect the characteristic, so the related key technologies and research basis of intelligent information processing is important to the development of IoT.

Information integration is an important stage as well a method of intelligent information processing. Information integration is a multi-level, multi-faceted process that makes the data processing to multiple data source (or multiple sensors) from sensor networks. It can get higher accuracy than a single sensor, and the reasoning that more effective and easier to understand. At the same time, it is a method that deals with the data from different nodes in a joint, as well as architecture of tool. Thus, we will require using this technology in perception, access, and Internet and application layer.

E. Intelligent Interaction and Collaborative Sensing

Intelligent interaction of IoT is mainly reflected in the key technology of situational awareness. It can explain the physical signals and biochemical signals of perception, and make decisions to different events of outside world and adjust their own monitor behavior, so intelligent interaction has become an integral part of the application system of IoT. Meanwhile, situational awareness can make some data in IoT processed on the local resource constrained sensor node with the method of low power consumption, so that minimize power consumption and communication bandwidth of the entire network.

Collaborative sensing technology is a focus of the IoT research. A physical phenomenon is generally caused by a variety of factors; also the information observed by the devices in different time and space has complementary. The data of multiple sensing nodes must be together, so co-perception mechanism is very important [5].

II. TYPICAL APPLICATIONS OF IOT

Take the environment monitoring as an example to show the application system of IoT. The environment monitoring is an important application area of IoT; the features of automatic and intelligent of IoT are suitable for monitoring environment information. In general, the environmental monitoring system structure of IoT includes the following sections:

Perception layer: The main function of this layer is to get environment monitoring information by the sensor nodes and other sensing equipment, such as temperature, humidity, light and so on. As the perception of environment monitoring required relatively large geographical area, contained the relatively large amount of information, the device in this layer requires using the wireless sensor network technology to form an autonomous network, and adopt the way of collaborative work to extract useful information, and realize resource sharing and exchanging through the access devices and other devices of Internet.

Access layer: The main function of this layer is to send the information from the perception layer to the Internet through the existing public communication networks (such as a cable Internet network, WLAN network, GSM network and TD-SCDMA network) and satellite network and other infrastructure.

Internet layer: The main function of this layer is the Internet platform built IPv6/IPv4 as the core. It integrates the information resources within the network into a large intelligent network that can be interconnected, and establishes an efficient, reliable and credible infrastructure

platform for upper service management and large-scale environmental monitoring applications.

Service management layer: The main function of this layer is to make real-time management and control for the vast amounts of information obtained of environment monitoring within the network through the large-scale center computing platform(such as high-performance parallel computing platform, etc.), and provide a good user interface to the upper application.

Application layer: The layer integrates the function of system underlying and built up the industry for the practical application of environment monitoring, such as the real-time monitoring of ecological environment and natural disasters, trend forecasting, early warning and emergency response and so on.

By the above parts, the IoT of environment monitoring can achieve collaborative sensing environment information for trend analysis and forecast the development trends.

III. CONCLUSION

The Internet of Things is a new technology system made from a variety of technology. IoT has potential and significant technical value and application requirements in many applications. The development of IoT will promote the construction of information society of objects linked and the interaction between people and objects. The key problem of affecting large-scale application of IoT is the various technologies and they need interoperability, so IoT has a huge room for further development and upgrading.

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