Layered Structure and Management in Internet of Things

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Abstract

The development for Internet of Things and RFID technology is described in this paper. A feasible scheme and layered structure is proposed for Internet of Things. Its management is presented according to the demand for Internet of Things in China. The general system contains two parts: computer information subsystem and RFID terminal subsystem, the latter of which is the main focus. The management protocol for Internet of Things explored in the paper includes SNMP and RFID managing protocol (RFID-MP).

1. Introduction

Radio frequency identification (RFID) is a wireless automatic identification technology, which identifies objects and exchanges information via RF mode. RFID technology has numerous advantages such as contact-less, speediness, multi-objects identification, etc. RFID develops fast with potentially wide application in the fields of traffic, transportation, security, anti-counterfeiting [1-2], etc.

Figure 1 shows a typical RFID system mainly composed of computer information subsystem and RFID terminal subsystem. The RFID terminal subsystem includes RFID readers and RFID tags which are used for data collection and object's properties storing. Readers work as information collecting terminals to identify tags and communicate with computer information subsystem [3]. With the technologies of RFID and Internet, we can install readers anywhere needing data collection and achieve track-and-trace through Internet, all the things based on the Internet form a net-Internet of Things [4-6]. EPC (Electronic Product Code) [7] and UID(Ubiquitous ID Center) are the two typical systems with their large-scale production implementations.

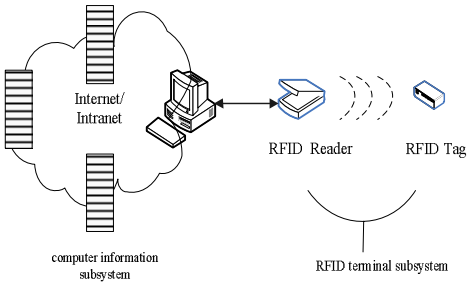

Fig.1 Typical RFID system

The EPC [8] is a globally unique serial number that identifies an item in the supply chain. This allows enquiries to be made about a single instance of an item, wherever it is within the supply chain. For EPC system, with a database, we can get Universal Resource Identifier (URI) via Object Naming Sever (ONS), and obtain object information from RFID sever through internet，as shown in figure 2. While a production is produced or transported, the readers that equipped in the factory, on the road or in the vehicle identify the object to achieve auto-management and track-trace. With the large-scale applications, a global, an open identification standard for Internet of Things becomes necessary.

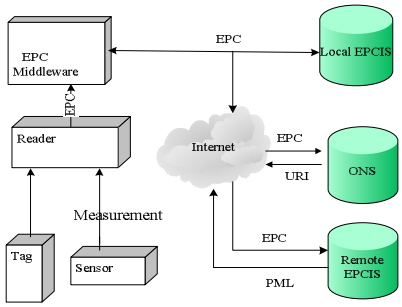

Fig.2 EPC system for Internet of Things

Research on Internet of Things is progressing quickly [9-11], here we propose an original layered structure for Internet of Things according to the state idiographic conditions, and discuss its management solution.

2. Layered structure for Internet of Things

The structure for Internet of Things introduced is consisted of four levels, shown in figure 3.

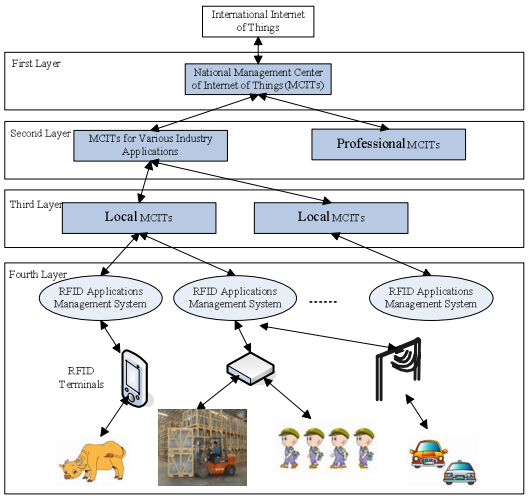

Fig.3 Layered structure for Internet of Things

State administrator as the primary management center, designs overall standards, manages the level downwards, and communicates with international system.

Industry net (such as management of food safety and medicine anti-counterfeiting) and some special net (management of military and customs, etc) constitute the second level. Statistics information of various fields is concentrated separately on this level, industry manager can get access to the database with corresponding grant to acquire information.

Local manager, as the third level, manages the transportation in an enterprise, establishes its own database to effectively capture and transfers logistics information. It can monitor the overall processing of the products distribution, maintains the safety and the qualification of the products.

The basic level composes of various RFID application terminals, referring to front-end information collection, information writing/reading, and the simple management. RFID terminals send the collected information to computer or the server upwards via internet.

The manager on each level has its own grant for data transportation, information storing and publishing, maintains data security and the normal working state to keep the net safe and smooth.

3. Protocol structure and Management for Internet of Things

Network management (NM) usually includes data acquisition, data processing, and data analysis and reporting to the administrator. The NM should guarantee the network normal, economical, and reliable. A common RFID system contains the RFID terminal subsystem in front and the computer information subsystem behind. The layered structure for Internet of Things described here is divided into four levels, three above relates to the computer information subsystem management, the bottom involves the RFID subsystem management. The protocol proposed based on the structure contains two parts, SNMP applied for information management and RFID-MP used for front-end RFID terminals. As shown in figure 4.

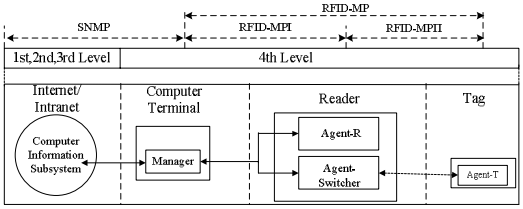

Fig.4 Management structure for Internet of Things

We can apply SNMP into computer information subsystem management. The current network management protocols include two main components: CMIP (Common Management Information Protocol proposed by the International Organization for Standardization /Open Systems Interconnection (ISO/OSI)) and SNMP (Simple Network Management Protocol) designed by the Internet Engineering Task Force Network (IETF). SNMP has advantages of simplicity, flexibility, etc. It has been acquainted by manufacturers and got broad support of many academic institutions [12]. Computer information subsystem mainly relates to the computer terminal management, applying SNMP can make it integrated into the existing network systems rapidly and effectively.

RFID terminal subsystem mainly relates to the management of the RF terminals, management protocol for RFID application network on international is still in development stage, lacking unified standard. In this paper, we propose RFID-MP to manage RFID terminal subsystem.

For Internet of Things, each item has a unique ID which will consume enormous bandwidth and computing resources, moreover, its structure and scale

should have dynamic changes with the development of the national industry. To address these problems, we propose a top-down uniform standards and distribution management method to supervise the network. Distribution management model can reduce the transmission flow of the network to avoid congestion, and adapt the expansion of the network size for it is scalable. In addition, the distribution management model can reduce the complexity of network management, and resolve the problem closer to the issue of it, which will save network bandwidth and decrease the processing time.

4. RFID-MP

4.1 Structure and design for RFID-MP

Figure 5 shows the general structure of RFID-MP introduced based on the RFID terminal subsystem (Computer, RFID Reader and RFID Tag)

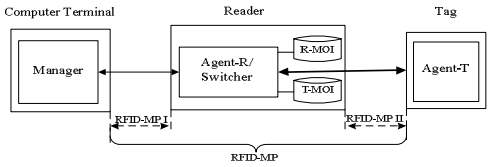

Fig.5 Structure of RFID terminal subsystem management

RFID-MP mainly composes of communication protocols (RFID ─ MP I and RFID ─ MP II) and management modules, which reside in Computer, RFID Reader and RFID Tag).

RFID─MP I RFID─MP I is responsible to the communication between Manager and RFID Reader, realizing data exchange.

RFID-MP I is designed on the basis of TCP / IP communication protocol, including: decision for communications commands, such as Get Msg, Set Msg, Response Msg and Trap; and decision for transmission format.

The significations of communication commands as follows:

•GetMsg operation: Manager acquires MOI (Object Management Information) value from Agent-R/Switcher.

•SetMsg operation: set (or change) MOI value in the Reader.

•ResponseMsg operation: return MOI value as the response from Agent-R/Switcher.

•Trap operation: Agent-R/Switcher issues the information actively to inform the Manager with certain abnormal incidents.

The message transportation form as shown in figure 6.

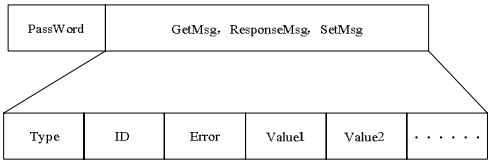

Fig .6 Message transportation form for RFID-MP PDU

•PassWord: the passwords between the Manager and Agent-R/Switcher;

•Type: identify GetMsg, SetMsg, ResponseMsg, Trap and so on;

• ID: ID for the inquirer or the receiver;

•Error: give the abnormal information acquired from MIO;

•Value: acquired information from MOI value.

RFID─MP II RFID─MP II is responsible to the communication between RFID Reader and RFID Tag, realizing data exchange. RFID-MP II communication protocol design is based on RFID technique, microwave wireless communication protocol. The design is similar to RFID-MP I and not detailed here.

MOI R-MOI (Reader- Management Object Information), which contains all the names and attribute information of the readers, such as reader frequency, temperature and voltage information; T-MOI (Tag- Management Object Information) which includes all attribute information of the managed objects, such as tag's working state, product origin, date and other relevant information.

4.2 Module functions and principle in RFID─MP system

Manager module Manager module acts as a computer management terminal, communicates with computer information subsystem upwards through SNMP connecting with the internet/intranet, manages RFID Reader and RFID Tag downwards through RFID─MP, offering human-computer interaction.

Manager module sends searching or setting commands to the Agent-R/Switcher module, receives the return messages from the Agent-R/Switcher to obtain object information of RFID Reader or RFID Tag and responses to the trap information. For instance, Manager can obtain the reader's voltage value by sending searching command to Agent-R, or get the tag's ID information by Switcher. When the tag or the reader is malfunctioned (or abnormal), such as over hot or beyond detecting, Manager will take actions instantly after the trap information responded from the Agent-R/Switcher.

Figure 7 shows the working principle.

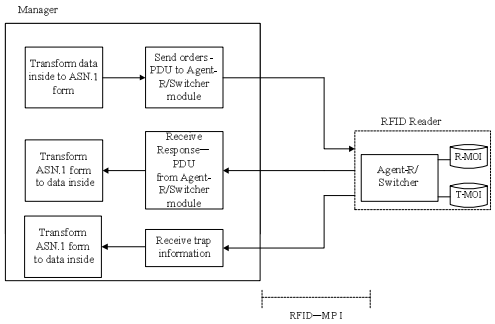

Fig.7 Manager module working principle

Agent-R/Switcher module The Agent-R module in the RFID reader acts as an agent, receives commands from Manager through RFID－MP I, analyses and searches Reader-Management Object Information (R-MOI), then gets the corresponding object information and returns it to Manager; trap information is also sent to Manager module.

Switcher is an agent in charge of switching, receiving commands from Manager through RFID－MP I, analyzing and searching the Tag-Management Object Information (T-MOI), getting the corresponding object information and returning it to Manager; it exchanges data with Agent-T at intervals through RFID－MP II, gets the tags' properties and renews the T-MOI; sends monitoring data to the Manager module at the mean time.

Working principle is shown as figure 8.

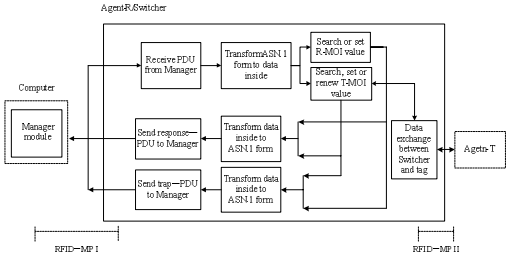

Fig.8 Agent-R/Switcher module working principle

Agent-T module The Agent-T module in RFID tag, sends information correlated to the Switcher (Switcher as a transfer agent) through RFID－MP II, and renews T-MOI, realizing the Manager's indirect managing.

5.Conclusion

The layered structure for Internet of Things is proposed in this paper, each level introduced has its corresponding authority. The network management based on this structure contains two parts, SNMP for computer information subsystem management and RFID － MP for RFID terminal subsystem management. The design details about RFID－MP and the security mechanism which is not discussed in the paper will be extended in the future work.

6. References

[1] YANG H P, MA Z Z, NING H S. "The dual-band RFID Tag upgrades the freeway online charge system"[J]. Smart Cards and Lables.2006, (5): 36-38.

[2] LIU F L, NING H S, et al. "RFID-based EPC System and Information Services in Intelligent Transportation System"[A]. 2006 6th International Conference on ITS Telecommunications Proceedings[C]. Chengdu: IEEE Press, 2006.26-28.

[3] YU Z Q, et al. "*RFID Theory and Application"*[M]. Beijing: Publishing House of Electronics Industry, 2005.

[4] Yi Zhi ZHAO, Oon Peen GAN. "Distributed Design of RFID Network for Large-Scale RFID Deployment". 2006 IEEE International Conference on Industrial Informatics, Aug. 2006. 44 – 49.

[5] Andreas Heil, Mirko Knoll, Torben Weis. "The Internet of Things – Context-based Device Federations". Proceedings of the 40th Hawaii International Conference on System Sciences. 2007. Jan. 2007. 58 – 58.

[6] Juhan Kim, Dooho Choi, Inseop Kim and Howon Kim. "Product Authentication Service of Consumer's mobile RFID Device". 2006 IEEE Tenth International Symposium on Consumer Electronics. 2006. 1 – 6.

[7] EPCglobal, "RFID & EPC Essential", version 01.

[8] EPCglobal, About the EPCglobal Network, http://www.epcglobalinc.com/about/about_epc_network.html.

[9] YANG H P, et al. "Introduction of Bar Code and EPC Code"[J]. Cards Tech & Security,2006,（4）:21-25.

[10] WANG S M, NING H S, et al. "SNMP managements the RFID system efficiently" [J]. Smart Cards and Lables.2006,(8): 47-49.

[11] Beijing University of Aeronautics & Astronautics. RFID reader network management based on SNMP protocol [P]. China Patent: 2006100790481. 2006.

[12]William Stallings. *"SNMP Network Management "*[M] Beijing: China Electronics Publishing House, 2001.