# WSN Data Acquistion System for Mobile Service Based on IoT Gateway

**Ge Li**

*Northwestern Polytechnical University,*
*Xi'an 710072, Shanxi, P. R. China.*

Abstract
Under the background of Internet of Things, the information perception and acquisition is the premise of implementation in wide fields. IoT gateway plays important role as a belt between perception layer and network layer. This paper analyzes the key problems in mobile information acquisition system based on IoT and designs the whole frames of system. Then it provides an implementation scheme in software and hardware, supporting ZigBee, 3G, GPRS, etc, to be connected to the gate way. The intelligent mobile device can access the gateway by WiFi to obtain the perception information of wireless sensor network at bottom. So it will be suited to a large number of application scenarios like surrounding monitoring and intelligent home furnishing. Finally our scheme if used to make a test in remote access and monitoring functions, which verifies its feasibility and stability in actual case.
Key words: IOT GATEWAY, WSN, ZIGBEE, MOBILE, 3G

## 1. Introduction

IoT integrates information sensing network with Internet to form a network for information exchange and communication and to make intelligent recognition, location, tracking, monitor and management. It has been a hot spot in communication industry and embedded system development to develop communication equipment supporting 3G [1-3]. The key of this technology lies in service and IoT is a very important application. When constructing IoT structure, the gateway is very essential. Because it is the bridge to connect sensor network with internet or other intelligent devices. Generally to say, the main functions of IoT gateway contains the following aspects: The first is accessing capability [4]. In IoT environment, one terminal access to sensor network while the other one is selectively accessing to public network such as internet in multi-way; The second one is protocol conversion which is the most fundamental function in gateway. After data in sensor network is performed protocol conversion, it can be effectively and quickly sent to public network through wired or wireless way. The last is the management control function and security. As acquired entrance in IoT information, while management access in sensing network is provided, accessed users are effectively controlled. At present, in technical perspective, the pattern of wired access is relatively mature. However, for the direction from sensor network to 3G, wireless access such as WiFi has always been in the stage of study and experiments [5]. For the combination between sensor network and telecom network, China mobile published business design in IoT-oriented TD-SCDMA module in 2010 IoT Peak Symposium. China telecom also published sensor network terminal management-oriented MDMP protocol. In foreign, 3GPP and IEEE802.15, etc, are formulating relative standards [6-8].

For currently various kinds of IoT perception equipment, also with large acquiring information, undetermined data type, different format, various stimuli-presenting modes, difficult processing and analysis, this paper designs a mobile terminal-oriented IoT data acquisition and analysis platform. At first, it analyzes the key problems of IoT-based mobile information acquisition system, further designs the overall composition framework, and provides software, hardware design scheme supporting ZigBee and 3G to access IoT gateway. Therefore, intelligent mobile equipment can access the gateway via WiFi and obtain perception information at the bottom of wireless sensor network. Finally, this paper objectively analyzes the needing improvements of the obtained research achievements based on data acquisition and analysis platform in IoT gateway by testing, and provides corresponding prospect in future research.

**2. System structure**

In particular, the system is mainly made up by sensor network node, gateway and mobile terminal. However, system function realization and sensor network node focus are communicating with specific sensor equipment. Thus, from usual perspective, this paper focuses more on illustrating from gateway and mobile terminal.

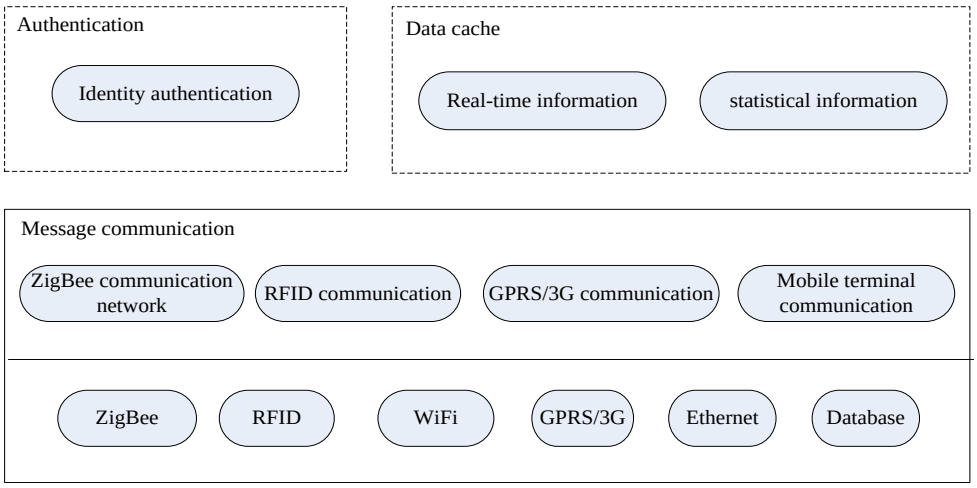


**Figure 1.** Main Function of Gateway

(a). IoT Gateway: gateway of IoT-based mobile information acquisition system should offer sensing network flexible access mode and selective internet access model. Meanwhile, it should guarantee security authentication of information cache and access.

(b). Intelligent Mobile Terminal: The intelligent mobile terminal plays a part as real-time information checker and information acquisition in this system. Meanwhile, it will be directly applied in popular mobile equipment so common mobile phone users can conveniently operate them. As the representative intelligent terminal in Android system, it quickly analyzes gateway transmitting ZigBee network data information and simply as well as clearly realizes environment information, sensor network information and specific application of information browsing.

The design of this paper is started from the constructed ZigBee network. Meanwhile, the ZigBee information convergence function of converging nodes in gateway has obtained the perceptive information of network from ZigBee nodes. Mobile terminal has possessed the functions such as WiFi communication connection, identity authentication, information check and acquisition [9]. WiFi communication connection completes mobile terminal and quickly stable connection of gateway and it has mobile characteristics to adapt to mobile terminals. The gateway is an IoT one which has many kinds of access modes to be suit to changing system demand and practical application needs. Therefore, the adopted module hardware design can increase and reduce functional modules such as GPRS, 3G, Bluetooth, etc. ZigBee convergence node module communicates with gateway by serial port. In software function, the gateway should have the functions of information communication, identity and data cache. Its information communication should contain necessary protocol conversion and unified data format. Gateway plays a part in connection link and it is the key part of this system to make smooth and constant adaption for other requirements

**3. Hardware Design Project**

**3.1. Overall architechture**

According to characteristics of IoT gateway, its overall hardware design is shown as figure 2. The principle hardware is microprocessor module and local storage module. On this basis,

combining with ZigBee communication module, WiFi communication module can adapt to mobile information acquisition in this paper. In order to enhance coordination between gateways and real-time information browsing in mobile terminal at any time, GPRS/3G communication module needs to be increased. In order to further increase patrol and supervise mobile terminal users, it needs increasing Bluetooth communication module or RFID reader module. Meanwhile, increasing LCD display module can helps to enhance human-computer interaction. This paper is based on verifying multi-way access IoT gateway, the adaptive system needs should provide corresponding functions tailoring such as main processor module, SDRAM, NAND FLASH module. SDRAM offers sufficient reading space for project operation. NAND FLASH module power down stores the firmware program [10]. The smallest core system is system control core. It is the base to guarantee the normal work in the whole system, which directly determines the function and performance in the whole system.

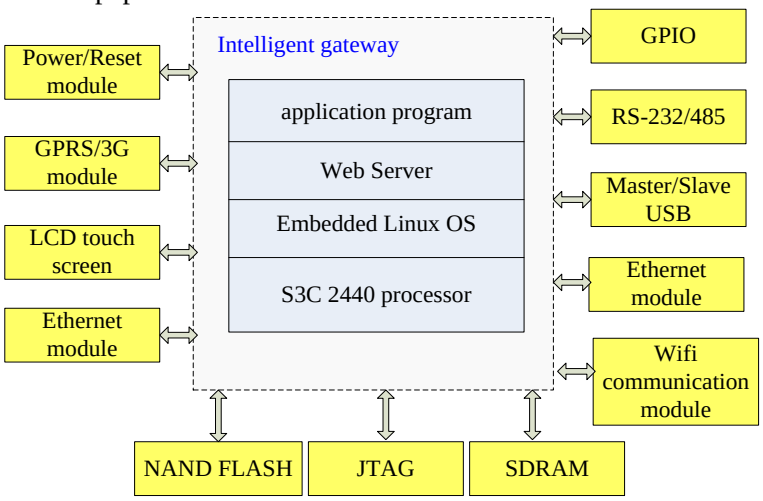


**Figure 2.** Hardware Structure

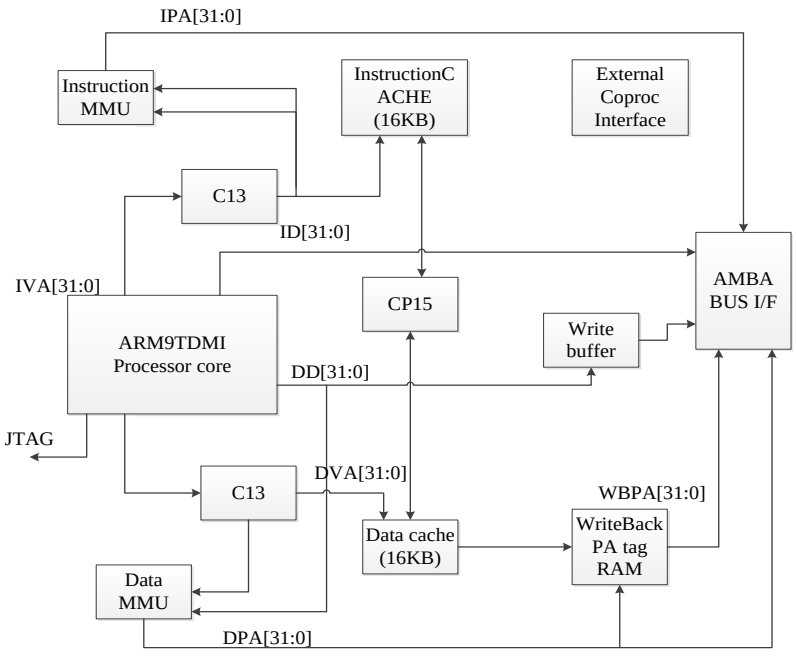


**Figure 3.** Internal structure of ARM920T

### 3.2. Controling core

The system chooses ARM9 S3C2440 processor of SAMSUNG company as main control chip. It is a chip designed for handheld devices which has advantage in operating speed and low energy consumption. S3C2440 is a complex of standard unit with 0.13um cmos and storage unit based on ARM920T. Its priority in consumption, simplity and stability is very suited to the products having higher demand for powers. It adopts novel

bus architecture AMBA and provides excellent feature beacuse of its advandance processor whose kernel is 32bit. ARM920T makes MMU, AMBA bus and Havard architecture, and the frequency can get 400MHz. Next, Internal structure of ARM920T, AHB bus and related devices, and APB bus and related devices are shown in figure 3 to figuire 5.

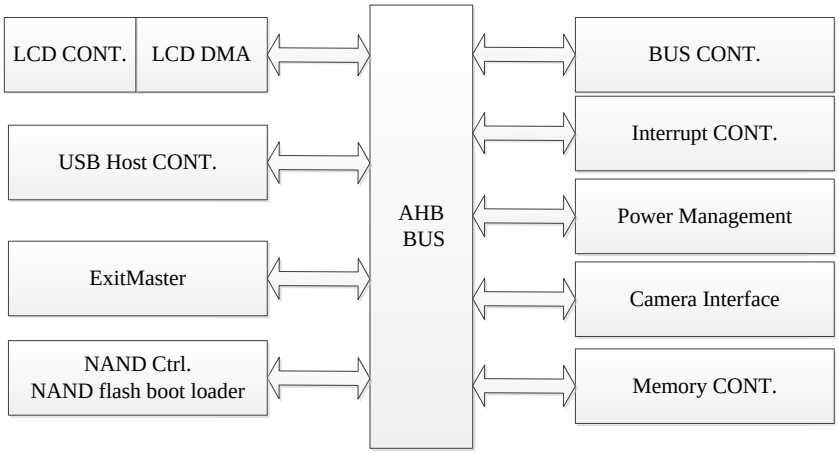


**Figure 4.** AHB bus and related devices

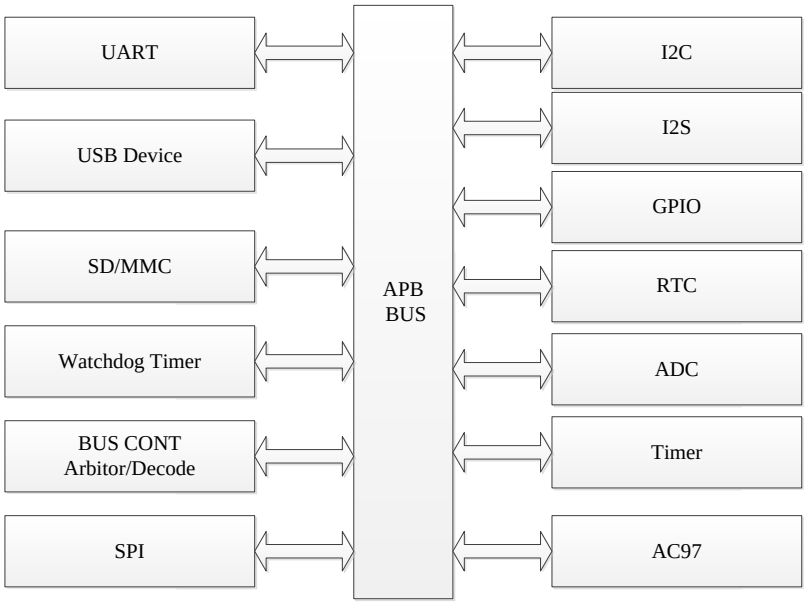


**Figure 5.** APB bus and related devices

Analyzing from the demand for runing space of the comprehensive program in our system, we choose two SFRAM chips K4S561632H whose capacity is 32 MB and can provide 64MB reading and writing space for system. In addition, the chips offer special NAND FLASH controller and easy NAND FLASH chips. So HY27UF081G2M chips of HYNIX corporation with 128MB memory are adopted. The Ethernet modules connect the gateway to Internet for the user, to make convinient remote control and management. Since the amount of data transmission is large and it should support breaking data transfer or burst access with high speed, the working frequency of master chip should get 200MHz and its bus width should be 32 bit to support Ethernet data transfer with 100Mbps. Therefore, the system chooses 10/100M adaptive Ethernet controlling chip DM9000A.

### 3.3. 3G communication module

The 3G communication module LC6311 adopted by IoT gateway is HSDPA/EDGE dual mode wireless moduleIndustrial grade of industrial grade. It adopts board to board connector with 0.55mm distance and 60 feet, which can be easily embedded in wireless application system. Such product has the feature of low consumption, high performance and low cost. It is generally applied in the field like intelligent mobile phone, data card, video monitoring, scheduling and navigation instrument etc. LC6311 module also supports TD-

SCDMA and its working frequency band is 2010-2025MHz, withe manual and automatic switching mode. LC6311 supports standard AT instructors and intergrates TCP/IP protocol. Its modules contains sleeping mode, standby mode, business model, three normal working modes totally. The main application interfaces include DART, USB, SIM card, controlling signal etc. The structure of LC6311 is shown in figure 6, including the part of radio frequency, simulated band, digital band, NAND FLASH and SCRAM.

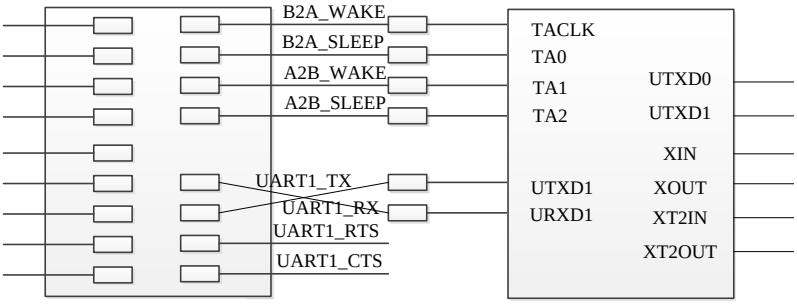


**Figure 6.** LC6311 Structure

### 3.4. ZigBee WSN module

The WSNs based on ZigBee are widely used, so we choose ZigBee module of C51RF-3 as the WSN coordinator node of gateway floor. The module adopts CC2430 of TI corporrtion as the core chips, with 8K RAM, 128K Flash, strenthened 8051 kernels, serial ports and JTAG simulated interfaces. CC2430 scheme supports the communication between IEEE802.15.4 an d ZigBee. It can improve the performance can be used in ISM wave band of 2.4GHz based on ZigBee, showing low power comsumption and cost. It integrates 8051 controller and DSS radion frequency transceiver core with high performance. There anre many function modules are integrated inside CC430, so we just need fewer components to configure the outside, to constiture a ZigBee module and make signal transceiver.

## 4. Software Design and Realization of Gateway Module

### 4.1. Software running environments

IoT gateway needs heterogeneous network ability for access and this may need to design special hardware module drive. However, Linux operating system offers driver source code of various hardware modules and can assist users to compile proprietary hardware drive through these source code at this time. As data transmitting system, IoT gateway must send data at perception layer by means of external network. At this time, selective remote transmission method can be in the form of Internet but Linux has excellent network performance and TCP/IP protocol is internally embedded. In specific application, IoT technology does not highly need real-time data under partial environment. Although Linux real-time is not enough, it can usually satisfy the requirement of other applications [11]. This disadvantage is acceptable in comparison with lots of excellent performance of Linux so this paper selects Linux as operating system of embedded IoT gateway equipment. Linux operating system porting is usually divided into three steps: Bootloader porting, kernel porting of Linux system and file system transplanting:

Bootloader is a small program which is operated before operating system kernel startup. This program can implement hardware equipment to bring software and hardware environment in system to an appropriate status, and to prepare an accurate environment for kernel in final operating system.

During kernel porting, the isolated codes which are related to hardware in memory management, process management and equipment management need to be changed. Since Linux kernel supports various kinds of hardware, if all of them are totally selected, the compiled kernel is very large. The manually tailored can allocate kernel according to system platform characteristics and application requirements, delete unnecessary functions and transplant kernel image to embedded gateway board through USB access, which is similar to Bootloader.

This paper adopts yaffs root file system because S3C2416 supports this file system format and this is an embedded file system, which is specially designed for NAND FLASH suitable for storage equipment in large capacity. It is log-structured file system and offers loss balance and power failure protection so it can effectively avoid influence of accidental power failure on porting and complete file system. Based on this software system, this paper develops specific application program of IOT gateway according to specific requirements. In application program research, it

will be based on practical conditions to apply kernel and root file system to finally reach the function of operating hardware realizing purpose. It is also the classical embedded system and this development mode has been broadly applied in specific equipment realization in IoT.

### 4.2. Message communication module

Information exchange between gateway and internal sensor network is realized by self-defined frame. The frame refers to the frame at application layer and it is different from other frames at other layers. We divide one frame into five parts, as is shown in figure 7. Packet head and packet tail is the boundary to separate a data frame. Node number designates where this information is from or is directing to ZigBee node. Data type indicates whether this frame is order frame, data frame or other special type of frame. Finally, the real meaning of data is defined by frame type. It can be either pure data or the parameter to control command. The whole information frame length is not large because ZigBee sensor has adapted to frequent and small information exchange condition. Thus, this design has satisfied basic requirement.

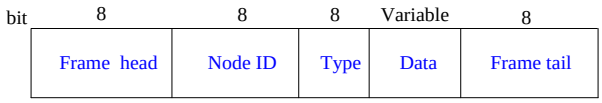


**Figure 7.** Application layer structure of ZiBee

Information exchange between gateway and external access is based on Web server and realized through HTTP protocol. Therefore, gateway needs to open httpd process on server to wait for connection request of hand-held terminal and make functions by connecting parameter analysis in request. Server sends command request to gateway by background script.

There are mainly two parts to realize the specific program. One of them is QT-based embedded gateway program development. This program will make one user control the interface and all sensor nodes management from read and write serial port of gateway, to receive and send self-defined frame. The main codes of this program are gateway operation on serial port. Serial port operation in Linux is very simple. In fact, in a Linux system which has been ported, operating serial port is similar to read-write common file. It is enough to use system call function open(), read() and write(). The use of QT packaging serial operates serial port and the essence of these packaging is the call of above functions. The second part is to construct http server at gateway. From general embedded development, common apache server is usually not used, boa server or httpd will be used instead. These two servers are single process servers and they can only process next user response without supporting development after completing response of one user. But boa server supports CGI at the same time and it can singly establish a process for CGI program. Main task of CGI program is to operate the commands from terminal users, which is based on GET request in http protocol.

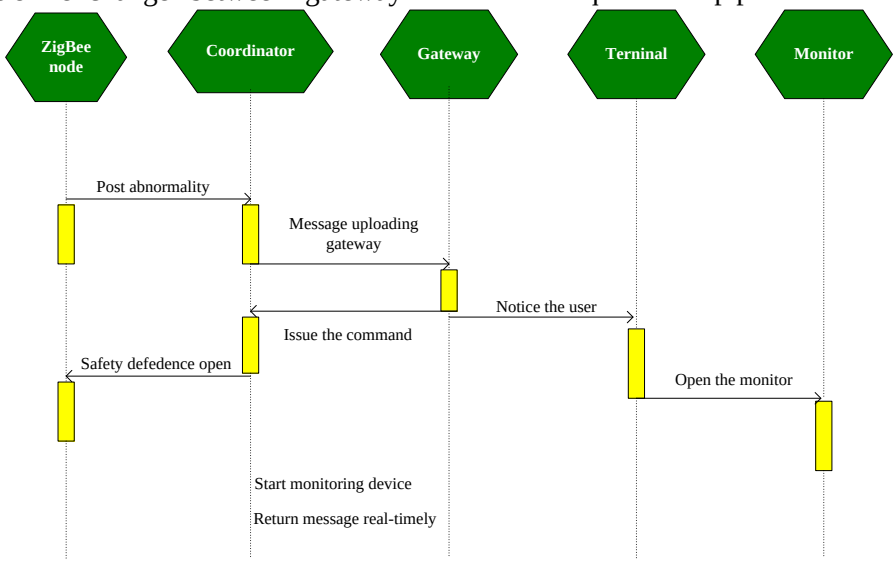


**Figure 8.** Gateway Monitoring Process

### 4.3. System test and analysis

With rapid development of intelligent home technology, the study of home energy management system becomes a hot spot. It can monitor electricity consumption real-time at home and provide referential basis for adjusting home

energy consumption structure. IoT data acquisition and analysis platform are applied into energy management field. To get related energy data measured by intelligent socket uploads to mobile service platform via Web Services access. The visual data processing promotes users to intuitively understand home electricity consumption so users can more intelligently and effectively consume electricity.

This paper selects electricity information which can detect electricity consumption power, electricity flow, voltage and power etc., and relative surroundings. It is based on LC-DT01 digital transmission module for device alteration, which connects the RS232 interface of In-Home Device. The data detected by Intelligent socket sends to common IoT analysis platform through In-Home Device to store into database in node form by smart_socket type. Before intelligent socket connects platform, manager newly establishes a content type named Smart Socket as data model of intelligent socket, as is shown in figure 9:

| Label | Machine Name | Field |
|---|---|---|
| Title | Title | Node module element |
| Date | Field_date | Date(Unix time stamp) |
| Current | Field_ Current | Float |
| Voltage | Field_ Voltage | Float |
| Power | Field_ Power | Float |
| Temperature | Field_ Temperature | Float |
| Active Energy | Field_ Active Energy | Float |
| Caron Emissions | Field_ Caron Emissions | Long Text |

**Figure 9.** Editing Interface of Smart Socket

The mobile phone terminal program running in Android OS can receive input information of user after the network communication is established with intermediate service program. The information acquisited by sensors can be displayed on mobile phones. Simultaneously, the client can operate the Buzzer of remote sensor network and the resource such as LED lights. The communication process at mobile phone user terminal software is the same to that of PC client software. It has functions with similar PC client terminal. The difference lie in that this part connects through wireless network.

**5. Conclusion**

At present, 3G technology and IoT develop quickly and they bring huge changes to our lives and work. By 3G technology, ZigBee technology and GPRS technology, this paper integrates the design principle and requirement in IoT gateway system to construct a general IoT gateway model, and proposes a mobile users-oriented IoT data acquisition and analysis platform. Based on lots of embedded gateway design and application examples for reference, we put forward ARM9 32-bit microprocessor S3C2440 as CPI of IoT gateway. Zigbee technology-based CC2430 chip is used to make wireless assembling at perception layer of IoT and the inner set TCP/IP protocol-3 G module, LC6311 module and GPRS module 6600 are used for upper access mode of IoT. For software design, we adopt Linux system as basis platform. To implement the embedded software framework of IoT gateway, this paper specifically designs the content of bottom guide, kernel and file system. Finally, the effectiveness and stability of this IoT gateway are proved by tests.

**References**


1. Essbach Jan (2012). An approach to a decentral mobile payment system using NFC and the German eID-Card. *Proceedings of IEEE 1st International Symposium on Wireless Systems-Within the Conferences on Intelligent Data Acquisition and Advanced Computing Systems*, p.p.67-71.
2. Chen Yourong, Zhou Junhua, Yu Lizhe (2014) Grid-based Lifetime Optimization Algorithm for Mobile Wireless Sensor Networks. *Journal of Electronics & Information Technology*, 36(10), p.p.2370-2373.
3. Cheng Jizhong, Peng Zhen (2011) The Study of Protocol Conversion Gateway Based on IPv6 Network and ZigBee Wireless Sensor Network. *Public Communication of Science & Technology*, p.p.115-118.
4. Furfari Francesco, Girolami Michele, Lenzi Stefano, (2014). A service-oriented ZigBee gateway for Smart Environments. *Journal of Ambient Intelligence and Smart Environments*, 6(6), p.p.691-705.

5. Li Zhenwei, Zhang Xing, WANG Lei, (2013). Design of wireless sensor network gateway based on ARM9, *Modern Electronics Technique*, 36(9), p.p.1-4.
6. Mair Andrew (2009). Big numbers and small screens: Challenges and opportunities of the mobile web for national statistical offices. *Statistical Journal of the IAOS*, 26(1), p.p.47-54.
7. Manzoor Farhan, Linton David, Loughlin Michael (2012). RFID based efficient lighting control, *International Journal of RF Technologies: Research and Applications*, 4(1), p.p.1-21.
8. Papadopoulos Petros, Tianfield Huaglory, Moffat David (2013). Decentralized multi-agent service composition. *Multiagent and Grid Systems*, 9(1), p.p.45-100.
9. Turner Kenneth J. (2011). Flexible management of smart homes. *Journal of Ambient Intelligence and Smart Environments*, 3(2), p.p.103-109.
10. Wan Shuqin, Wei Bin, Chen Zifeng (2012) The Design of Gateway of Wireless Sensor Network. *Electronics & Packaging*, 108(4), p.p.38-40.
11. Wang Wei, Zhang Sheng, Shan Huiyang (2014) Design and Implementation of Communication Gateway for Wireless Sensor Network and Fieldbus. *Measurement & Control Technology*, 10(7), p.p.109-111.