Research on the Internet of Things Platform for Smart and Environmental Protection

Junyang Sheng[1,3], Xiaoqin Feng[2,3]

[1] Beijing Engineering Research Center for IoT Software and Systems, Beijing University of Technology, Beijing, 100124, China
[2] Xiaoqin Feng Beijing Engineering Research Center for IoT Software and Systems, Beijing University of Technology, Beijing, 100124, China;
[3] Beijing Advanced Innovation Center for Future Internet Technology, Beijing University of Technology, Beijing 100124, China
shengjuny@emails.bjut.edu.cn fengxqinx@163.com

Abstract: This article focuses on the research and implementation of an intelligent environmentally IoT platform and intelligently connects traditional environmental protection devices to the IoT Cloud platform.There are different types of environmental protection equipment,such as PM2.5, Pm10, water, sound and gas monitoring equipment.In this paper the environmental protection equipments connect to the IoT cloud platform through the smart gateway, and the communication mode of the network include 2G,3G,4G, Narrowband-IoT. The management platform supports intelligent access to devices, remote management, real-time monitoring and data analysis, prediction alarm. The vision of the Internet of Things (IoT) is a dynamic global network based on standard and interoperable communication protocols where physical and virtual things have identities, physical attributes, and capabilities and are seamlessly integrated into the existing internet infrastructure. This paper descripes the intelligent environment project which is based on Smart Environmental Gateway Management Platform. It's function position is to build a smart environmentally aware network of omni-directional interconnections between the environment and society and to realize the modernization and intelligence of environmental monitoring and control The experimental results show that the IoT platform is stable, scalable, high performance.

Keywords: Internet of Things;3G/4G/NB-IoT; Environmental Monitoring IoT Platform; Data management.

1 Introduction

In the era of Industry 4.0, IoT developed rapidly. All things in the world could be interconnected via the Internet, including some high-speed services (such as video services, etc.), and some low-rate services (such as meter reading services, etc.). According to incomplete statistics, low-speed services account for more than 67% of IoT services, and low-speed services do not have good cellular technologies to provide sufficient support [1][2]. The demand for intelligentization and industrial upgrading is becoming more and more urgent in various industries and NB-IoT technology has emerged as the times require.

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It is a cellular network-based communication technology with features such as wide-area coverage, massive access, and low power consumption. Low-rate NB-IoT technology will be mainly used in municipal applications that are less sensitive to low communication delays [3][4] . With the country's emphasis on the environmental protection industry in recent years,China's environmental protection industry has entered a new stage of development [5]. It is of great significance to understand, study and use the new generation of information technology [6].Due to the wide variety of monitoring equipment in the environmental protection industry, which involves sound, lignt, Gas, odor, water and other aspects of the monitoring index and the transmission protocols are diverse too. As a result the islands of information are formed between various IoT platform , and data sharing cannot be achieved [7].

Huawei's OceanConnect platform takes the lead in the NB-IoT field. Therefore, this article refers to the the ideal of SSD in OceanConnect platform and designed an IoT cloud platform which supports access of NB-IoT and 4G LTE. Without changing the functions and design of the original environmental protection equipments, different types and multifunctional environmental protection devices can be accessed on the platform to realize the modernization and intelligence of environmental monitoring.

This paper analyzes the functional requirements of the intelligent environmental cloud platform based on the B/S architecture. For the characteristics of environment protection equipment and its data transmission difference, On the one hand , We choose to adopt smart gateway to support multiply devices which function is the same as the DTU on the terminal side and on the other hand, open TCP port is used to support the access of 3GPRS and 4G LTE; The data communication protocol refers to the data transmission of pollutant on-line monitoring system adopted by the Ministry of Environmental Protection of the People's Republic of China; The platform is adopting the Netty framework based on NIO non-blocking technology package and mature Web development technology and it realizes the project based on B/S architecture which is of greate

practical significance.

2 Environmental platforms requirements

The IoT device management cloud platform is an intelligent environment-friendly IoT cloud platform system. The smart environmental protection platform is divided into four layers, which are the perception layer, network layer, application layer, and user layer in Figure1.

The application layer consists of two parts, divided into an access platform and a management platform. The access platform connects to the environmental protection equipments from the south, receives and saves the data reported by the equipments, conducts command interaction with the equipments, and connects to the management platform from the north. The management platform south connects to the access platform , connects users from north and provides open data interface to relevant enterprises and government departments. This platform is to assist users in connecting environmental protection devices of different models and manufacturers to a smart environmental management platform, providing environmental monitoring and early warning, intelligent analysis of big data, tracing the origin of illegal emission points, and inquiring about the surrounding pollution.

The main technical features of NB-IoT include wide coverage, strong links, low power consumption and low cost[8]. Here are the specific introductions.

2.1 Wide coverage

In the same frequency band, NB-IoT covers a wider area than existing wireless technologies and can be expanded to 100 times. Due to the adoption of mechanisms such as retransmission and low-order modulation, its penetration performance is better. The same applies to applications such as in-building, underground pipe networks, and well covers that require deep coverage.

2.2 Strong links

Compared with existing wireless technologies, NB-IoT can provide more access in the same base station. A sector of NB-IoT can support 100,000 NB-IoT terminal connections.

2.3 Low power consumption

The NB-IoT consumes 1/10 of the power of 2G. it's terminal module has a long standby time of up to 10 years.

2.4 Low cost

NB-IoT can reuse site infrastructure and can reuse radio frequency and antenna, so the deployment cost can be reduced. In addition, for the NB-IoT chip, low-speed, low-power, and low-bandwidth technologies can also reduce the cost of related modules. According to NB-IoT's main technical standards, it has the following key attributes: low-rate attributes, high-latency attributes, low-frequency sub-attributes, and weak mobility attributes [9].

3 Design for smart environmental platforms

3.1 Design Principles

The design of IoT platform should support variety bussiness needs, not only meet the common needs of different business but also support the individual needs of different business [10]. In addition, the system design of the platform should also follow the following principles: safety principles, practical principles, scalability principles and standard principles. The design of the platform takes into account the different access devices, different transmission data formats, and different communication protocols. Smart gateways are used to support access to different devices. Unified data transmission standards and platform management are based on grading device.

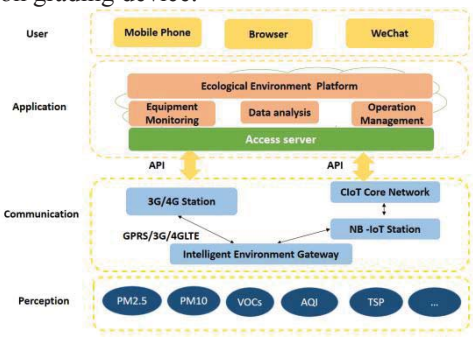

Figure 1 Ecological IoT architecture

3.2 Data format

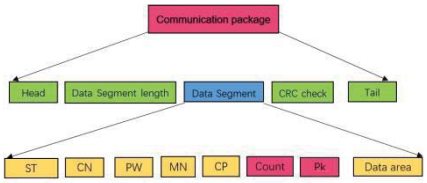

Figure 2 Communication protocol data structure

All communication packets are composed of ASCII characters (excluding Chinese S characters, using UTF-8 code,8 bits, 1 byte). The data structure of the communication protocol is shown in The communication between the device and the platform mainly includes the following four aspects: the information transmission between the user and the platform; the device actively reports the data; the platform issues the command to the device and the device responds to the platform command [11].

Terminal reporting format:

##0131ST=22;CN=2011;PW=123456;MN=781703664AM0001;CP=&&DataTime=20150811151200;PM10-Rtd=89.59,PM10-Flag=N;TSP-Rtd=133.71,TSP-Flag=N&&C241

Parameter Description:

(1) Header: Fixed as ##;

(2) Data segment length: the number of ASCII characters of the data segment, for example: length 255, then written as"0255". The data packet length is calculated from the first system number "ST=" and the data length up to the last newline character "\r\n";

(3)ST:212 System number of the agreement, "22" for air quality monitoring; 39 for site dust

(4)CN:212 The order number of the agreement,“2011” represents uploading real-time data of pollutants

(5) PW: There is no practical use, and it can be fixed as "123456";

(6)MN: It is used for device identification, a total of 15 digits, the first 9 digits are the device manufacturer's organization code, and the middle 2 digits are the device type codes (for details, see "Table 2: Device Type Codes"). Bit 4 is the unique code for this device as determined by the device manufacturer

(7) CP: (CP=&& data area &&) Please refer to the description of the data area defined in the environmental protection 212 protocol. The final format is shown in the above example.

(8) Data area: PM10 parameter is PM10; PM2.5 parameter is PM25; TSP parameter is version: V1.0 Release date: 2017.08.11 TSP; Wind direction parameter is WD; Wind speed parameter is WS; Temperature parameter is TEM; The parameter is PA; the humidity parameter is RH; the rainfall parameter is RI; the coding, measurement units, and data types are listed in the “Table 1 Gas Monitoring Factor Code Table”.

(9) Convert the CRC returned by the data from the beginning of the ST to the last two && to a hexadecimal string, added to the end of the packet. Precautions A newline character "\r\n" must be added at the end of each packet.

When the device reports other information, it also reports through this format, but the identifiers will be different. The following is the reporting of GPS coordinate information.

3.3 Platform Core Business Process

3.3.1 Add device node

The registration of devices on the platform are the core steps of the management platform. The specific registration process is as shown in the figure3.

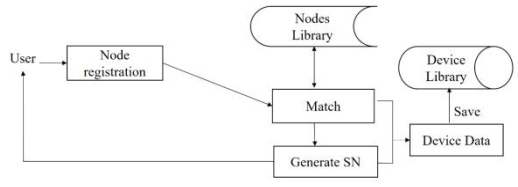

Figure 3 Add device node information to the platform

The user inputs information such as Dev_ID, Pro_ID, DevName, Manu_Name, Created_Time, and so on. When registering first, the device node will be attached to a certain project. After receiving the registration information, the operation management background will first determine whether the node is already registered. If it is registered, it will return the prompt information. If it is not registered, the user will be prompted to improve the information. After the selection is completed, the system generates an SN and saves it to the device node library.

3.3.2 Device node data adaptation

The data adapter is the process of converting the device node data into the platform's standard data format and persisting it into the database. The communication between the platform and the device can use NB or 4G mode and may also support the extension of Lora. Uploaded data is received through data interfaces such as Socket and Http. The data transmission format mainly includes JSON strings, hexadecimal strings, and so on. There are at least two different communication method in the platform, so the data analysis service needs to support them.

1) *Send via 4G format*

If data is reported by the device,the platform could determines which device by the data comes from by the BoardID, and extracts the device ID. According to the identifier of 4GLTE, the reported 4G information would be extracted, and then the network signal strength and IP address of the device would be obtained.

If the command is delivered by the platform, the server can send the command to the specified device based on the channel saved by the platform. The device can receive the message according to the command name and parameters and respond accordingly.

2) *Send data through NB*

The device Quectel_BC95 can send data to the UDP server through UDP. It only needs to provide the server port and IP.

The device Quectel_BC95 through the AT command for UDP communication.

(1) AT+NSOCR=DGRAM,17,4587,1 //Create a socket

(2)AT+NSOST=2,120.24.86.104,50000,3,AB3045

// Send data 2 is the socket number ,3 is the data length

(3) +NSONMI:0,4 // Receive data

(4) AT+NSORF=0,4 //Read data

0,192.53.100.53,5683,4,60A041C7,0 (The last 0 indicates the length of data that has not been read yet)

(5) AT+NSOCL=0 //Close a socket

3.4 Device data storage

Device data storage is divided into gateway data including temperature, GPS, and network signals. These data are stored in the database in the form of key-value pairs, and the primary key and index are used to speed up the query. In addition, the device data of GPS is stored in the FTP server . On the server, for other units to query and record.

3.5 Database Relational Model

project：

pro_id,pro_namepro_address,created_time,pro_creator,creator_phone

device：

device_id,pro_id,device_name,device_address,status,manu_name,created_time

device information：

device_id,sate_num,cur_time,longitude,latitude,board_tem,chip_tem

Environmental Data:DeviceId,PM2.5,PM10,SO2,CO,O3

User：user_name,user_pwd,user_phone,role_id

Role：role_id,role_name,role_desc,role_status

Authority：aut_id,role_id,aut_desid,aut_url,aut_des

4 Platform implementation

The platform system consists of two parts: the access server ,management platform. The function module of platform is shown in the figure4 below. There are five modules in the platform, including device monitoring, data analysis, and operations Management, server management, Statistical report.

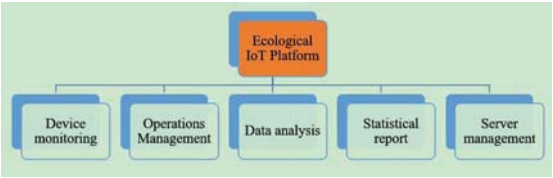

Figure 4 Function module of platform

Equipment monitoring:

Displays the engineering-equipment-gateway three-level menu. The user can perform positioning operations on the project or equipment, display the real-time geographic location of the equipment through the three-dimensional map, and the environmental status of the site.

Operation Management:

1) Effective management of the terminal equipment of the access platform:

It can display the status of the equipment in real time, including the equipment online status, temperature information, Beidou satellite quantity information, network signal strength and other status; it can add and modify the basic information of the equipment, including the equipment name, the equipment engineering, the equipment address, and equipment belonging Information such as vendor and device type; ability to delete devices

2) Ability to manage the project, including addition, deletion, modification, and inspection of the project, configuration of the sampling action of the device, remote update procedures, and remote restart of the system.

3) Ability to add, delete, modify, check, grant, and deprive users of rights to users and roles, corresponding to different projects and resources.

Data analysis:

Including monitoring data query, tracing the source, and environmental pollution warning. According to different business needs, different operations can be carried out. According to single or multiple equipment to view the environmental data, we can use large data technology and weather related algorithms to trace the source and give the corresponding evidence; the pollution level will be judged and alarm information will be issued in the future.

Statistical report and server management are support the common business of the platform.There is not much space to draw the details.

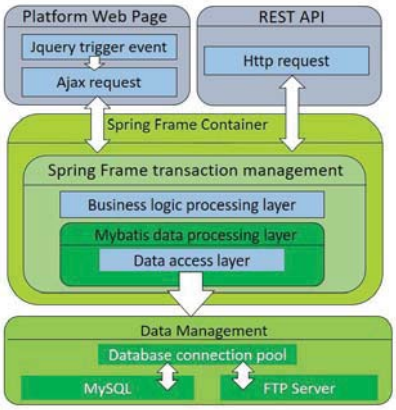

Figure 5 Technical architecture of system

The management platform and access server adopt Java Web based on the B/S architecture and use Spring+ SpringMVC+ Mybatis, The technical architecture is shown in Figure5. The access platform uses Netty4.x as the middleware to implement message communication.

For the hardware platform, the development board adopts the Zynq7010 FPGA board, the programminglanguage is the C language, and the IoT gateway device is responsible for receiving the data of the acquisition equipment and communicating with the platform and the acquisition equipment. Then report the collected data to the cloud platform through 4G or NB network. We can see the environmental monitoring equipments clearly from the intelligent environmentally IoT platform in the picture6 below. So far we have accessed a total of 30 devices.

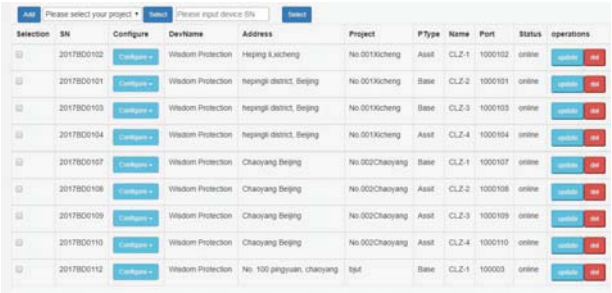

Figure 6 Device detail of platform page

5 Platform testing

The smart environmental protection equipment management platform is to achieve the access of environmental protection equipments, environmental protection equipment monitoring and data sharing. In the course of use, a large number of devices are accessed at the same time, and device communication and data query speed will affect the user experience. To understand the throughput of the platform and the response time of the data query interface, various performance tests were performed on the platform.

5.1 Data access concurrency test

Through the device access testing and concurrency testing of the platform, the results show that. The real-time performance of the device can be monitored in real-time within 15 minutes and the device is notified to the platform. When the number of accesses to the device is less than 100, the error rate is 0; the data throughput is 2725, which satisfies the concurrent requirements.

Table 1 Fest report of platform concurrent capability

Link number	Error rate%	Thread throughput per second/KB	Data throudput/KB
10	0	321.1	1025
100	0	724.2	2725
1000	3.12	902.2	3542
10000	12.2	1231.1	4020

5.2 Response speed test for platform data query

Currently, the platform can provide real-time data query interfaces for single devices, real-time data query interfaces for multiple devices, and historical data query interfaces. In order to test the response speed of the data server interface, this paper uses the real-time data of one device node, the real-time data of 10 device nodes, the historical data of one device for one month, and the historical data of one device for 12 months as the test cases, and the test cases are every 100. The test yielded the average historical response time for the standard. The test results are shown in Table 2. The query speed of real-time data is slow, and the query speed of historical data increases with the increase of data volume. After optimizing the index, the query speed of historical data is obviously improved.

Table 2 Result data query response speed

Link number	cycle number	Response time /ms
Single-device-real-time	1	1321
multi-device-real-time	<100	50.6
small-scale historical	<1000	2230.6
large-scale historical	<10000	5002.2

6 Conclusions

This article mainly realizes the intelligent smart environmental protection equipment intelligently accessing the IoT cloud platform. The environmental protection equipment supports a variety of different types of equipment including PM2.5, Pm10, water and acoustic monitoring equipment etc. The transmission network uses 4G LTE and NB network technologies. The smart environmental gateway device reports various types of environmental protection data information to the equipment service management platform through the 4G LTE network or the NB-IoT network. The management platform supports intelligent access, remote management, real-time monitoring, analysis of acquired data to display and predictive alarms.

However, it is still necessary to continue research and practice in the intelligent of management platform and data transfer security in order to achieve IoT platform that is efficient, safe and convenient for marketing.

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