Data Acquisition and Analysis from Equipment to Mobile Terminal in Industrial Internet of Things

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Abstract. Internet of things (IoT) has become more and more popular in the new information technology era. It is also an important stage that supplies development of the information age. The aim of the IoT is to shorten the distance between objects and objects through the information system. This paper constructs an application model of the IoT and mobile terminal to realized human-machine interaction management, based on Android APP and ThingSpeak cloud platform to achieve the data signals' communication between intelligent mobile terminal and the different environments of device at anytime or anywhere. The model with Arduino development board as the underlying controller by the ESP8266 serial wireless WiFi module is linked into the Internet. In this way, the acquisition signal from the bottom control terminal will be sent to the cloud platform. Writing control program for the mobile terminal and the collection of real-time temperature or humidity parameter information, through be linked into 3 G/4 G network or WiFi router network to access cloud platform for data query and monitoring equipment.

Keywords: Android · Cloud platform · Mobile terminal · IoT

1 Introduction

The rapid development of Internet of Things (IoT) is considered to be a significant progress and opportunity in the field of information technology. IoT aims at assisting human to realize human-computer interaction and artificial intelligent [1].

Reference [2] summed up two major themes in Industries 4.0: smart factory and intelligent production that is a group consisting of machines will be self-organize, and the supply chain will be automatically coordinated. However, Ref. [3] pointed out that the current theoretical research of IoT is still in development stage, there some network should be accurately called Intranet of things at present, which be used to link to objects without the ubiquitous connectivity of internet. Recently, cloud computing is an emerging technology for improving inter-connectiveness of things via assistance of clouds. The platform of cloud will be a critical factor in the intelligentization of IoT.

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Based on the above research, in this paper we constructed a model, which adopt the cloud platform as hub center for information interchange, and the cell phone as mobile terminal to access cloud platform to simulate the mobile IoT which has the characteristic of the Internet, so as to reflect the application of a feature of industrial 4.0.

The rest of the paper is organized as follows: In Sect. 2, mainly introducing the application and research of cloud computing and mobile terminal in the field of IoT in recent years. The overall architecture and enabling technology for mobile IoT model is introduced in Sect. 3. Following that, the design method and phase of mobile IoT model is described in Sect. 4. In Sect. 5, the result of experiment that this model is presented. Finally, Sect. 6 concludes the paper.

2 Related Works

2.1 Related Research on Cloud Computing in the IoT

The IOT as a typical information and communication system, not only existing the ability of the Internet to store and transmit the information, but also can automatically collect and process the information of things. Therefore, the IoT must have the functional characteristics of the Internet for constructing the global information infrastructure to link to objects [3]. With the development of cloud computing, cloud platform [4] can provide an excellent environment for massive data qualitative analysis processing, and form a visual, intuitive and provide decision reference data set [5].

Cloud computing is a computing mode based on the Internet. By this way, the sharing of software/hardware resources and information can be available to the computers and other equipment on demand. Therefore, the IoT' structure and application will have big development based on the technology introduction of cloud computing. Reference [6] pointed out the advantages of the function and flexibility by the means of the smart home based on cloud computing compared with the traditional home automation system. The intelligent community management and control system based on cloud computing is introduced in the [7]. Reference [8] proposed that the system based on cloud computing system for realizing the intelligent community management and control; the authors design the manufacturing service model based on cloud; Reference [9] proposed sensor cloud concept and technology; Reference [10] designed the cloud services of the reservoir scheduling automation system transformation and upgrading, discusses the cloud computing in the Internet of things as a comprehensive information processing platform. Therefore, comparing to the traditional IoT, cloud computing makes IoT more intelligent, scalable, stability, but also make its application management more transparent and convenient.

2.2 Related Works on the Mobile Terminal in IoT

Development of information technology is to using the Internet application as the basement to realize the interaction of terminal equipment [11]. With the rapid development of science and technology, the intelligent mobile terminal change to a comprehensive information processing platform from a simple communication tools [12]. Just as the

mobile terminal equipment with the functions of data collection, processing and transmission, etc., so the development of mobile terminal equipment will enable to achieve the interaction between people and things in IoT. Such as Ref. [13] exhibited that the design of network remote monitoring and control system for aquaculture Android platform based on Internet; And the application of the mobile terminal in the logistics information system based on IoT is described in Ref. [14]; Reference [15] discussed that the mobile terminal in the IOT application role; Reference [16] pointed out that the needs of development of mobile terminal in environment of IoT, etc., through these application forms of mobile terminal in IoT, these papers discusses it as a communication medium or carrier between people and things for the information exchange.

Therefore, with the development of information communication technologies, IoT mobile terminals will become more and more popular in industrial field.

3 Key Enabling Technology

This paper according to the model of "bottom controller—cloud platform—mobile terminal" to research and discuss the relevant techniques of IoT information interaction [17], and to simulate a data exchange format from Fig. 1, namely the process of from data acquisition to mobile terminal data displays: sensor—Arduino development board + ESP8266 WiFi module—ThingSpeak cloud platform—smart phone. The technology and facilities involved in this process are: network resource access technology, ThingSpeak cloud platform, WiFi module mode setting and mobile terminal development system selection.

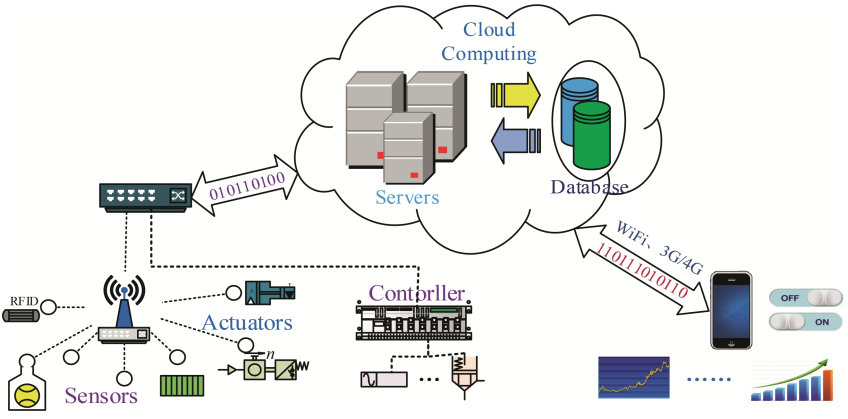


Fig. 1. Application model diagram

3.1 Network Resource Access Technology

In the IoT, each kind of resource is relatively independent, with independent access address and life cycle. This paper considered heterogeneous resources interoperability problems are caused by the information of different devices producing, processing and

receiving [18], therefore, combining with the conclusion of literature [19], introducing the semantic web technology to the model of information interaction among. Each of the "resources" generated by this model is an addressable entity, the Uniform Resource Locator (URL) provide an abstract identification method to the location of the resources, so used this method to determine the location of the resources. Therefore, between the application-systems can rely on the resources location method for data transmission.

There are three elements for data transmission between the application-systems: transmission mode, transmission protocol, data format.

3.1.1 Transmission Mode

Transmission methods use the Socket method, it is the simplest way of interaction, and is a typical C/S interaction mode. The client terminal connects to the server through the IP address and port designated for the message exchange.

In this paper, the bottom controller timing sampling data and on time to upload, so according to the equipment type and the real time of the data transmission by socket method makes the underlying control terminal through the WiFi module to connect to the cloud server platform.

3.1.2 Transport Protocol

Transmission protocol, this paper considers the use of TCP/IP protocol and Http protocol. TPC protocol is a transport layer connection oriented, and end-and-end data packet transmission protocol. It's mainly used for solution how to data transmission in the network. Comparing with the non-connected oriented of UDP protocol, the TCP protocol transmission data reliability is higher. However, HTTP is the application layer protocol, mainly to solve how to pack data, mobile terminal applications program can be achieved access to cloud platform resource interface through the use of POST, PUT, GET, DELETE operations of HTTP.

3.1.3 Data Format

This paper adopts the JavaScript Object Notation (JSON) data format for retrieving data from web services. JSON which is a lightweight data interchange format based on the JavaScript programming language, data format is relatively simple, and easy to read/write. JSON is mainly used for with server data exchange, due to its format is compressed and occupy bandwidth is small, and easy to parse, and support multiple languages.

3.2 ThingSpeak Cloud Platform

Cloud platform in the field of IoT as a network hub center is used for the exchange of information [20]. Cloud platform provide the API address to share software and hardware resources and information to other devices. Therefore, this paper uses ThingSpeak cloud platform to carry on the experiment.

ThingSpeak cloud platform is an open source cloud IoT platform for constructing IoT applications and provides specialized services for user, the user can create multiple

channels in this platform, and each channel provides eight fields to the same terminal for acquisition of eight different data. ThingSpeak can handle HTTP requests, and store and process data. The key features of this open data platform include: open API, real time data collection, location data, data processing and visualization, device status messages and plug-ins.

3.3 WiFi Module Mode Settings

ESP8266 WiFi module has two patterns: AP pattern and the STA pattern [21], the AP pattern is the wireless access point pattern, the WiFi model is a creator of wireless network, also is the center node of the network, under this pattern. General office and home use wireless router as an AP. And STA pattern for the site pattern, STA is refers to each terminal which is connection to the wireless network (such as notebook computers, PDA and other networking terminal) can be called a site.

In this paper, the model of experiment is use of WiFi ESP8266 module to connect the wireless router, and the data which is collected by Arduino development board will via the Internet to upload to ThingSpeak cloud platform. Therefore, in the needs of experiment, the WiFi ESP8266 module is set to STA mode.

3.4 Mobile Terminal Development System Selection

Using mobile terminal access to the IoT to achieve mobile Internet, it is necessary to carry on personalized mobile application software development. Currently, the system for mobile application software development is mainly divided into iOS and Android in the market.

The iOS originated in the Apple Corp OSX, it's based on the UNIX system. The iOS and the revaluate equipment are closely integrated, the current point of view that the integration of the iOS device and drive optimization comparing with similar products is the most outstanding. But the drawback of IOS system is controlled strictly by apple. In most cases, the other party application is unable to get the iOS' entire API, and its development environment must be the Mac operating system, developed application cannot be applied to the other products equipment. Therefore, using iOS in this paper' development conditions of mobile terminal model design are relatively harsh.

Android is a open source operating system base on the Linux and JAVA, although its performance is not as flexible and stable iOS, but this difference will be more and more small with the improving of Google. Due to the openness of the Android platform, it can do much more than iOS. Therefore, this model mobile terminal development using Android phone as a client terminal, and using Eclipse IDE to develop the android app which with links of ThingSpeak cloud platform corresponding API addresses, and download to the cell phone, through the friendly user interface, and guide the user to select the interface of corresponding parameters for related data query [22].

4 Design Methods

In this paper, the experimental model design is divided into three parts: (1) Arduino development broad communicates with cloud platform, (2) Android mobile phone communicates with cloud platform, and (3) Data display. Through these 4 designs, to describe the experimental model as an IoT model with function of the Internet, this can be used to reflect the function features of this model.

4.1 Communication Between Arduino Development Board and Cloud Platform

Using the Arduino development board to upload sampling data to ThingSpeak cloud platform through the ESP8266 WiFi module, this process need to meet two conditions: 1. Calling the ThingSpeak data channel address API; 2. ESP8266 WiFi module serial mode setting.

4.1.1 Calling the ThingSpeak Data Channel Address API

The Arduino IDE software programming need to call data channel write-API addresses of ThingSpeak cloud platform (GET/update? api_key = Write_API_KEY STRING & FIELD_NAME = VALUE), in the program by write data to the VALUE, and combined with the API send the VALUE to the ThingSpeak server corresponding storage area.

4.1.2 ESP8266 WiFi Module Serial Mode Settings

Due to this IoT model need to communicate with cloud platform, therefore, the WiFi module needs to be set to STA pattern by connecting the wireless router, and then access to the Internet for data communicate with cloud platform. Due to ESP8266 WiFi module access object is the cloud server, so the port type is the client and the module adopt the TCP transmission [23]. In this paper, experiment with in ThingSpeak cloud platform for model design, so the remote server IP address settings is 184.106.153.149 or api.thingspeak.com,and the port number of the remote server is 80, in the WiFi module.

4.2 Communications Between Android Mobile Phone and Cloud Platform

When using a cell phone to query the data which collected by ThingSpeak cloud platform, it is required to use the Http protocol to access the corresponding website of ThingSpeak to send GET request to get the data. Because of the user terminal access network is a time-consuming process, in order to prevent the UI thread is blocked lose response to user actions, Android provides an abstract class AsyncTask<Parma, progress, Result>, and makes network access process can be a simple asynchronous processing. Therefore, in terms of network communications programming by using of inheriting the AsyncTask class to handle issues that the user's cell phone access ThingSpeak cloud platform.

Due to ThingSpeak cloud platform have simply store and analysis for these sampling information (for example, averaging or accumulating the sampling data at a certain period of time, etc.), therefore, users only need to call its API addresses that can be queried the

corresponding results. Such as the API address of the real time data acquisition (https://api.thingspeak.com /channels/ ThingSpeak_CHANNEL_ID/feeds /last?api_key=Read API_KEY STRING) and the API address of the historical data aquisition (http://api.thingspeak.com/channels/ThingSpeak_CHANNEL_ID /feeds.json? api_key=Read API_KEY STRING&average= T &start= Ts UTC &end= Te UTC), and then read the data to JSON data analysis [24].

4.3 Data Display

Data display need to develop an android APP software, the software is used for the user can access information in the database of server via the Internet using mobile communications tool. The software interfaces consist of a main interface and four graphical display interfaces. The jump between the interfaces is performed by triggering the event of the corresponding button. As shown in Fig. 2.

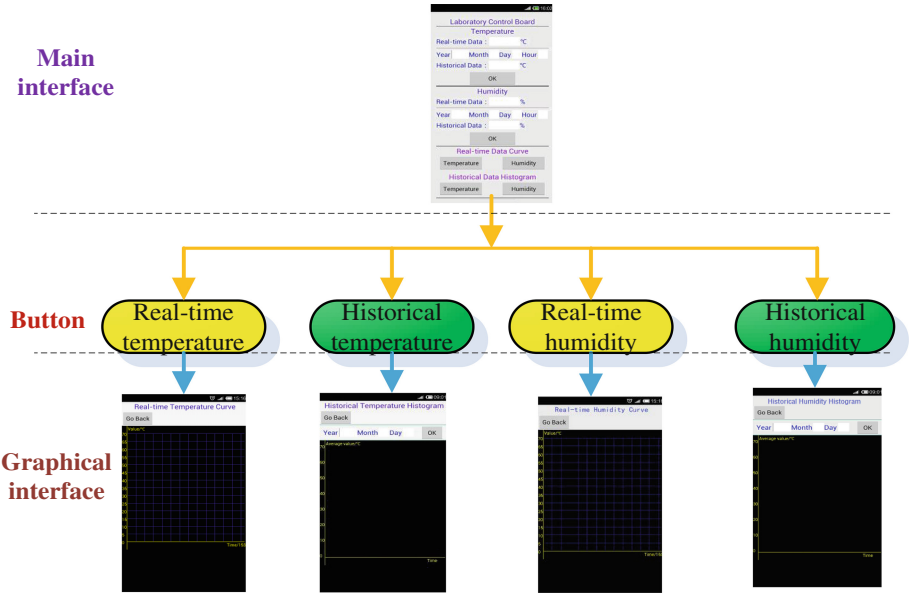


Fig. 2. Overall interface design

The design of data display program is divided into two mainly parts: 1. Real-time data display; 2. Historical data query & display.

4.3.1 Real Time Data Display

The Real time data display that the cell phone per 10 s sends instructions to ThingSpeak server to obtain real time update of data for digital display or graph shows. The real-time data acquisition program has mainly three threads, namely the UI thread and timer timing processing thread and network communication thread.

The UI thread is mainly responsible for handling user event which is user' operation and interface display, and so on. Considering the Android UI thread is not safe, which means that if there are multiple threads to manipulate a UI component, it may lead to thread safety issues. Therefore, in this program adopt the Handler message transfer mechanism, using a timer timing to send a message to a message-queue and Handler from the message-queue gets the message, and triggering Asynctask' subclass for the network data acquisition, so as to achieve the purpose of real-time data updating. Details of the process are shown in Fig. 3.

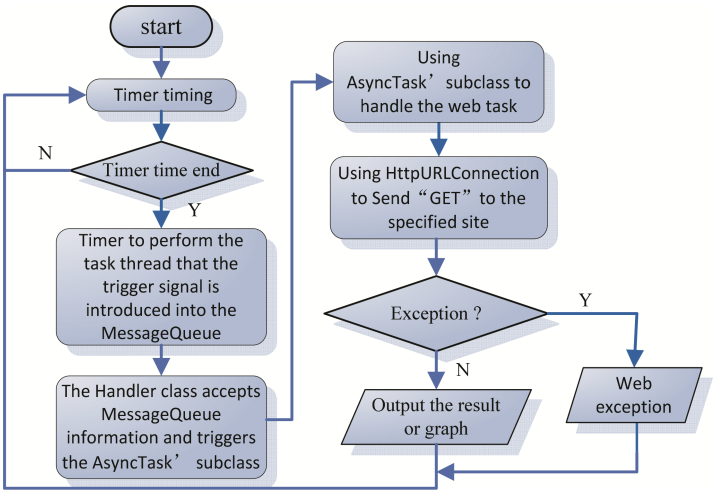


Fig. 3. Real time data display program flow chart

4.3.2 Historical Data Query and Display

Historical data query & display that according to the information of time setting (the time must be in the data sampling of the total time range) send instructions to the ThingSpeak server to gets that it in a set time period the average value of sampling data for digital display or bar graph display.

Historical data acquisitions program mainly rely on the user to the cell phone screen text edit box enter the value of query time, and by clicking the query button to trigger the AsyncTask' subclass for network data acquisition. With the cell phone APP program in the history of the temperature value query as an example, ThingSpeak cloud platform timing for data collection, and provides the different API key of data processing. Therefore, when connected to the platform by the use of HttpURLConnection class, according to the characteristics in the use of the API key, to obtain specific data value, such as a certain period of time the average value, maximum value. Details of the process are shown in Fig. 4.

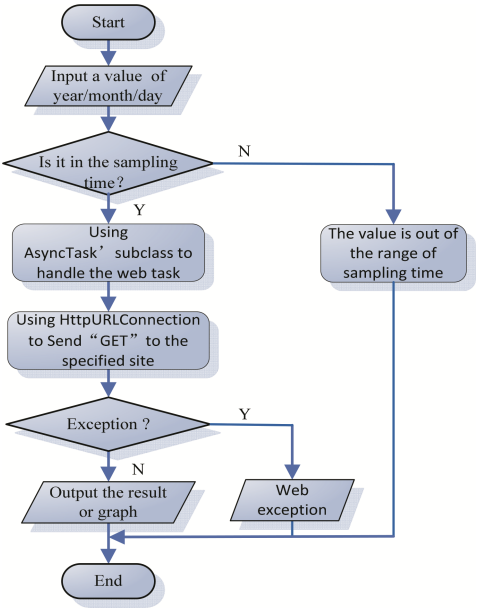


Fig. 4. Historical data query display flow chart

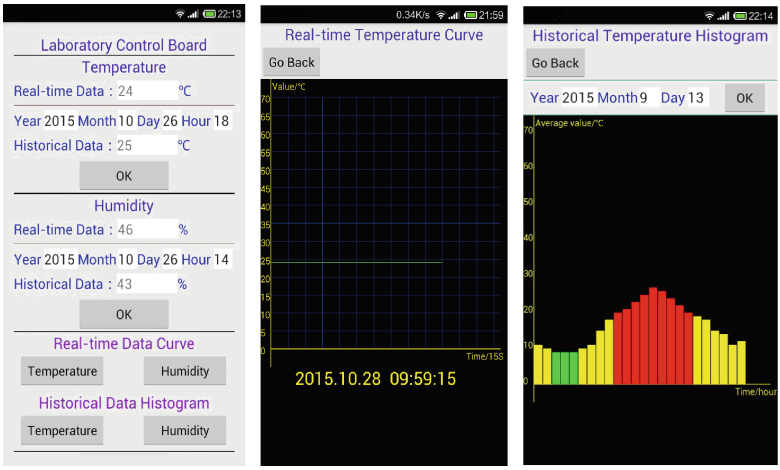
Through these above methods can display digital information, dynamic data graph and image information for user, so that users can clearly understand the operation of the things that they are concerned about.

5 Experimental Results

Based on temperature query as an example, the processing results of cell phone app as shown in Fig. 5, figure (a) is the main interface of numerical display, figure (b) is real-time temperature curve, and figure (c) is historical temperature histogram.

In the model designed in this paper, the cell phone can use WiFi or 3 G/4 G signals for information query at anytime or anywhere, cloud platform can be applied to the data processing and transmission of multiple models, the bottom controller can be flexibly using wireless technology for information exchange. By analogy, this model can be added more new functions to be improved, through the data mining technology in the IoT generated huge amounts of data to extract hidden information, analysis and modeling, and be applied to industrial production management [25]. The mobile terminal' design of interface program is on-demand, and the cloud platform by industrial production model can be flexibility customized, and the bottom control equipment according to the function module to be distinguished, these flows of information are gathered to upload to the cloud by using the wireless communication technology, combined with the industrial model setting and enterprise management personnel adjustment measures, so the cloud platform will automatic provide feedback information and

assign production task to other equipments in factory [26, 27], that to achieve the wisdom of plants, intelligent production and the mobile Internet.



(a).Main interface (b).Real-time chart (c).Temperature histogram

Fig. 5. Data processing results

6 Conclusions

Based on cloud platform and intelligent cell phone, this paper realized the mobile Internet with the Internet function: a model of the interaction between human and things information. However, to realize the automation and intelligence of the true meaning of IoT, still need further theoretical innovation and research, searching for common characteristics from the various fields of IoT applications, refining cloud computing application category, so that it can be used to flexibly make decisions and offer intensive application platform for industries in the fields of management, production sales, and so on.

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