

# Application of Android Mobile Platform in Remote Medical Monitoring System

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## **Abstract**

*Due to the actual demand of remote medical monitoring system, the overall framework of remote medical monitoring system which based on the Internet of things technology and cloud computing technology is designed. Put forward the application solutions of Android mobile terminal equipment in this system, and discusses the development methods of different types of the Android mobile terminal. First, the overall framework of remote medical monitoring system is introduced. Second, the development of data communication method of Android Bluetooth BLE and HTTP is discussed in detail, which is based on the Android framework. The Internet of Things and cloud computing technologies together to build a remote medical monitoring system. Android mobile terminal development on the medical applications of data processing centers and medical data display applications. Finally, the experimental results show that the system not only runs and transfers data stabilize, but also strong real-time, effective and feasible.*

**Keywords:** Remote medical monitoring, Android, GCM, BLE

## **1. Introduction**

With the arrival of an aging society, more and more elderly people, chronic patients whatever indoors or outdoors need to measure physiological data, They need to get more health care and doctor's professional advice when they feel unwell. Patients' family can't accompany them all the time and concern about their health. On the other hand, doctors hope to know patient's Personal Health Records (PHRs) in detail, but some are short-term survival data, and these important data need to be preserved in time. Therefore a Remote Medical Monitoring System family or community-oriented has gradually become a research hot-spot in field of remote medical technology [1-2].

In recent years, many research institutions have developed their own characteristics of Remote Medical Monitoring System. For example, Service Robot Technology Key Laboratory of ZheJiang Province in the ZheJiang University School of computer, the laboratory has developed a mobile remote medical monitoring system which including data acquisition module, monitoring platform and a terminal running on mobile phone, patient's physiological data collected by data acquisition module are transferred to monitoring platform via GPRS module, doctors can monitoring these data at mobile phone [3]. Institute of Computing Technology, Chinese Academy of Science (ICT) applied the Internet of things technology to the field of remote medical monitoring, and developed a Remote Medical Monitoring System which based on Internet of things. The homemade medical monitoring base station equipment and wireless dedicated sensor node are used to form a micro Medical Monitoring System in this system [4].

Homemade medical data acquisition devices and monitoring base station are used in the design process systems, the design improves the cost of the system in the implementation process, need a lot of funds for construction and maintenance. Android mobile devices as remote medical monitoring system data processing center and the data display device are used in this project, which not only reduces the cost, but also make the

system update and maintenance easier. Nowadays, most Android mobile devices already support Bluetooth BLE technology, which ensures compatibility of the system with other manufacturers of medical devices. This technology allows health equipment is simple, safe and effective medical and Android mobile devices interact with data, so Bluetooth BLE technology in medical care is also more promising.

This paper makes remote medical monitoring technology and the Android platform, Bluetooth BLE technology together which based on the analysis of demand of applications on remote medical monitoring system. On the basis of detailed analysis of Bluetooth technology and the Android operating system, and doing the research of how Android platform BLE Bluetooth technology, cloud push for application. Design and implement a set of data standards, secure and reliable, low price and easy to popularize the remote medical monitoring system

## 2. Android Mobile Platform

In this system, Data processing center and the data display device is Android intelligent terminal equipment. Android is a Linux-based open source and freely operating system. Now, use the Android operating system of intelligent mobile phone and tablet computer, is very popular in the global scope. The latest version of the system is 4.4. Since Android4.3 (API Level 18), the system introduces a Bluetooth Low Energy (BLE) support, which makes Android applications can communicate with a Bluetooth-enabled health devices better, such as heart rate monitors, blood pressure meter and so on.

Android system architecture is shown in Figure 1. Android system of top-down includes 5 levels: application layer, application framework layer, component library and the Dalvik virtual machine, the hardware abstraction layer and the kernel of Linux. The application layer (Applications) including email client SMS program calendar map browser contacts and other settings. Application framework layer contains a view manager resource manager content manager notifies the manager and event manager, and Java language application programming interface (API). Component library contains a set of application development in C/C++ library. Dalvik virtual machine is a Google for the embedded platform based on Java virtual machine registers. Hardware abstraction layer by calling the Linux kernel interface the realization of hardware abstraction. Linux kernel layer is the bottom of the Android operating system, operating environment to provide hardware drivers and system memory management, thread management network management.

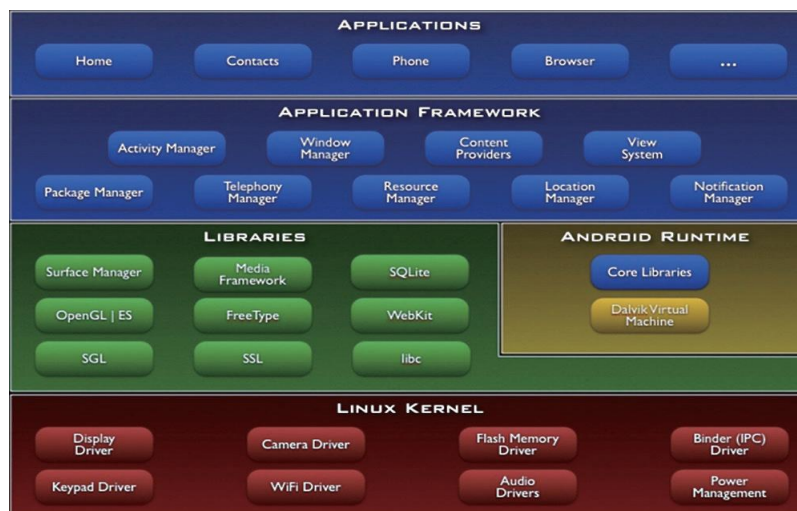
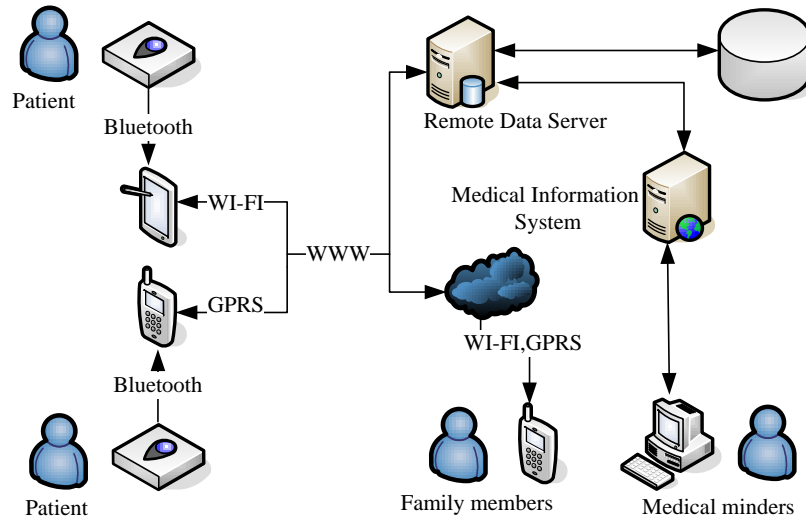


Figure 1. Android System Architecture

### 3. Design of Remote Medical Monitoring System

Here is the overall architecture design of the remote medical monitoring system. Remote medical monitoring system is divided into five parts: medical data acquisition devices, Android data processing centers, remote data server, Google Cloud Messaging server, Android data display device. Overall framework as shown in Figure 2.



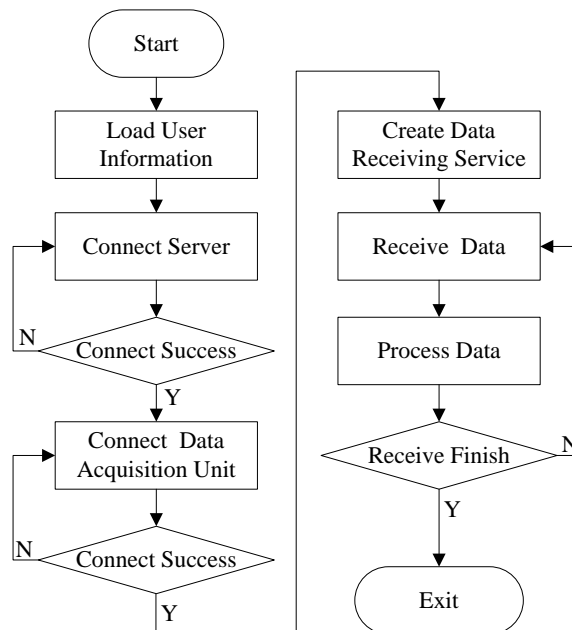
**Figure 2. The Overall Framework of the Remote Medical Monitoring System**

In this system, the monitor who is monitored wearing Bluetooth BLE medical equipment, After being collected by the sensor medical devices whose objective physiological data transfer via Bluetooth to the Android data processing center. Android data processing center to an Ethernet router via WI-FI or 3G network data sharing to remote data servers and Microsoft Azure server. The data will be parsed after through the Android data processing center of healthcare data manager, and storing the data to the SQLite database, ensures the normal storage of information; the data will be analyzed further in the system, display and alarm. After receiving the medical data by remote data server, store it to the medical information database, the remote data server can also be shared with the hospital information system, storage and analysis for medical institutions Doctors can check the monitored person's personal information, medical information, physiological data and monitors location etc. And Microsoft Azure Mobile Services is responsible for comprising the monitored physiological data and normal data values, when there exists abnormal data will remind attention by means of Google Cloud Messaging cloud push to the doctor or a patient's family, it is convenient for the followers to deal with timely. The patient's physiological data can be monitored by the Android data display device in time, the alarm tips will appear when patients get abnormal physiological data value. The Android client in remote medical monitoring system is mainly used Bluetooth BLE, message processing, SQLite, network programming and animation and other technology.

#### 3.1 Android Data Processing Center

Android hardware data processing center performs in the form of tablet or smart phone application with Android system, which is connected via Bluetooth by those monitors who carry medical data acquisition instrument. The features of Android data processing center including: user login and registration; Bluetooth connection; Remote server connections; GPS positioning; medical equipment information management ;such as

medical data reception and analysis, real-time medical data monitoring, data upload, data storage, *etc.*, user information query, such as the user's personal information query, historical medical data query; alarm settings. Android data processing center business processes shown in Figure 3.



**Figure 3. Android Data Processing Center Business Processes**

Data center business processes can be described as follows: Create and login user, connecting to a remote server via 3G or WIFI + Ethernet. Connecting a Bluetooth device to establish data reception service, receiving data and sending medical data to a remote data server. Parsing medical data, storing data and sending data to Microsoft's Cloud Services. Comparing data with the alert range, out of range alarm turned to Microsoft Azure Mobile Services transmission GPS positioning.

Microsoft cloud server which receiving the alarm information and GPS sending the data information to the families or doctors monitored through Microsoft's cloud push way .The data being processed information will be displayed in their end Android data and display.

**3.1.1 Android Bluetooth BLE Data Transmission:** The patient's personal health equipment should have Bluetooth transmission of medical data in this telemedicine system. After the patient's physiological data were collected via Bluetooth to your Android phone or Android data processing centers. With the development of Bluetooth technology, medical devices on the market today, there has been a lot of medical health data transmission devices based on the Bluetooth 4.0 specification equipment, which is to ensure the health facilities and the Android platform compatibility and security, therefore when choosing Android mobile device must be equipped with Bluetooth 4.0 module. The most important feature of the Bluetooth specification 4.0 is the low power consumption. BLE allows Bluetooth devices to be operated by a button battery dimension for several years to continue to work. BLE allows Bluetooth devices in the healthcare market more prospects. Bluetooth 4.0 Bluetooth difference between classical shown in Table 1.

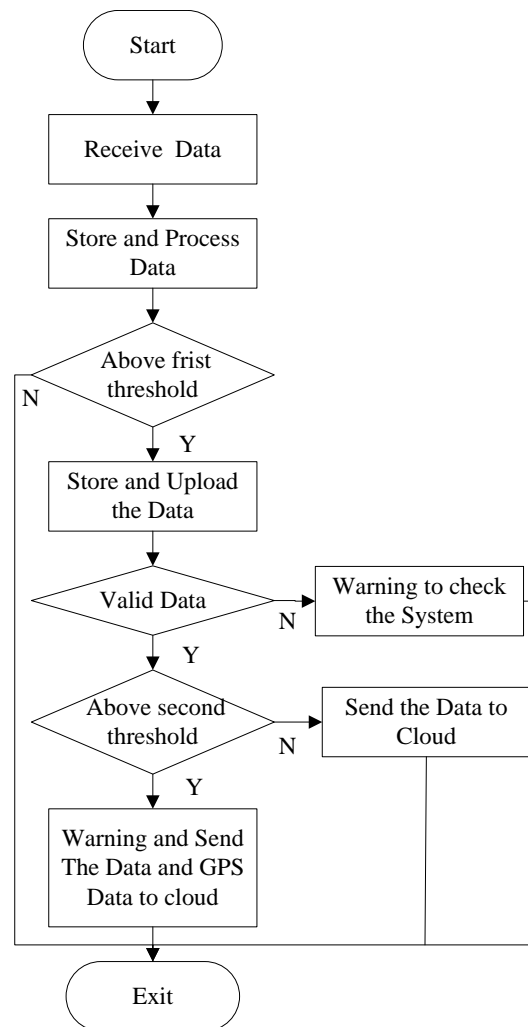
**Table 1. Classic Bluetooth and Bluetooth Low Energy Parameter Comparison**

| Technical Specifications            | Classic Bluetooth (2.1 &3.0 ) | Bluetooth Low Energy (4.0 ) |
|-------------------------------------|-------------------------------|-----------------------------|
| Radio Frequency                     | 2.4GHz                        | 2.4GHz                      |
| Distance                            | 10m/100m                      | 30m                         |
| Data Rate                           | 1-3Mbps                       | 1Mbps                       |
| Application Throughput              | 0.7-2.1Mbps                   | 0.2Mbps                     |
| The total time of transmitting data | 100ms                         | <6ms                        |
| Power consumption                   | 1                             | 0.01~0.5                    |
| The maximum operating current       | <30mA                         | <15mA                       |

Bluetooth SIG application scenarios based on different definitions of the different Bluetooth profile, which contains some of the medical application of norms related to health facilities. Heart a Rate Profile (HRP) positioning and medical / health-related scenario, which allows Bluetooth devices to interact with the heart rate sensor. Similar health practices as well Glucose Profile (GLP, regulate blood sugar), Blood Pressure Profile (BLP, regulate blood pressure BLP), Health Thermometer Profile (HTP, health thermometer specification).

When Android mobile devices and health equipment for data transfer via Bluetooth, the Bluetooth Android end business process can be described as the following steps: firstly, Creating BluetoothAdapter, which corresponds to the local Bluetooth module Android device, BluetoothAdapter is a single example throughout the whole system. By BluetoothAdapter to judging whether a device with Bluetooth and be turned on. Secondly, Searching BLE devices by calling BluetoothAdapter of startLeScan (). BluetoothAdapter. LeScanCallback need to pass parameters when calling this method. At this point the need to achieve BluetoothAdapter.LeScanCallback interface, BLE device search results will be returned by the callback. The search for the specified UUID peripherals, which can call startLeScan (UUID [], BluetoothAdapter.LeScanCallback) method. UUID specified array which your application supports the UUID GATT Services. By specifying supported UUID GATT Services for searching.Finally, you first need to establish a connection of GATT when two devices communication via BLE, Android device as a client in this system to connect GATT Server. Called BluetoothDevice of connectGatt () method. device.connectGatt (this, false, mGattCallback); function succeeds, the return BluetoothGatt object, which is GATT profile package. With this object, we will be able to carry out related operations GATT Client side. BluetoothGattCallback is used to pass some connection status and results.

**3.1.2 Android Data Management:** The data management functions of Android data processing center including: medical data storage, query and display, function of data storage and query are used in SQLite. SQLite is a lightweight, embedded, relational database, because of the reliable and efficient portability of the SQLite, Android, iPhone and other mobile systems has been used now. The function of data display is mainly achieved by the SurfaceView in Android dynamic drawing. Because of the double buffering mechanism of the SurfaceView, which provide good support to draw a line graph data quickly. Medical data refresh rate is very fast and requires real-time monitoring of medical data values in medical information systems, so choosing Android dynamic graphics to display medical data is very suitable. The data processing shown in Figure 4.



**Figure 4. Data Processing Show**

Physiological data processing: receive physiological data collection terminal via Bluetooth data collection, storage, physiological data to determine whether the data exceeds remind threshold, the threshold set by the doctor, if not exceeded, if the data continue to deal with the next hop beyond. Whether through alignment algorithm to determine whether a valid physiological data, if the data is invalid, then the expectation remind patients to check the data acquisition system connected properly. If it is valid physiological data to determine whether further beyond the alarm threshold, the threshold is exceeded, the cloud server will send GPS data and physiological data, and alarm. If you do not exceed the reminder message is sent to the cloud and physiological data. Setting the alarm threshold setting mode, and setting the data processing, the doctor may recommend changes.

**3.1.3 Android Network Data Transfer:** Android data processing center server or Microsoft cloud data transfer medical data to a remote server via Http protocol and programming interface HttpClient to obtain additional data information. The medical or other data will be custom protocol encapsulated during transmission, data processing center Android ensure that the process of the transmission data when abnormal exits, the server returns response information can be obtained through the HttpResponse way, the

information includes type of exception, After receiving this information by Android data processing center and taking the appropriate action according to the type of exception.

### 3.3 Android Data Display Device

Android data show that the manifestation of the Android terminal hardware is the Android smart phone; it visits Microsoft Azure Mobile Services through Ethernet or WI-FI + 3G Wireless network and gets relevant information. The main function of Android data terminal of display includes: patient concerns; medical data in real-time display; alarm information management; patient GPS positioning; patient information inquiries. Android data show end business processes can be summarized as follows:

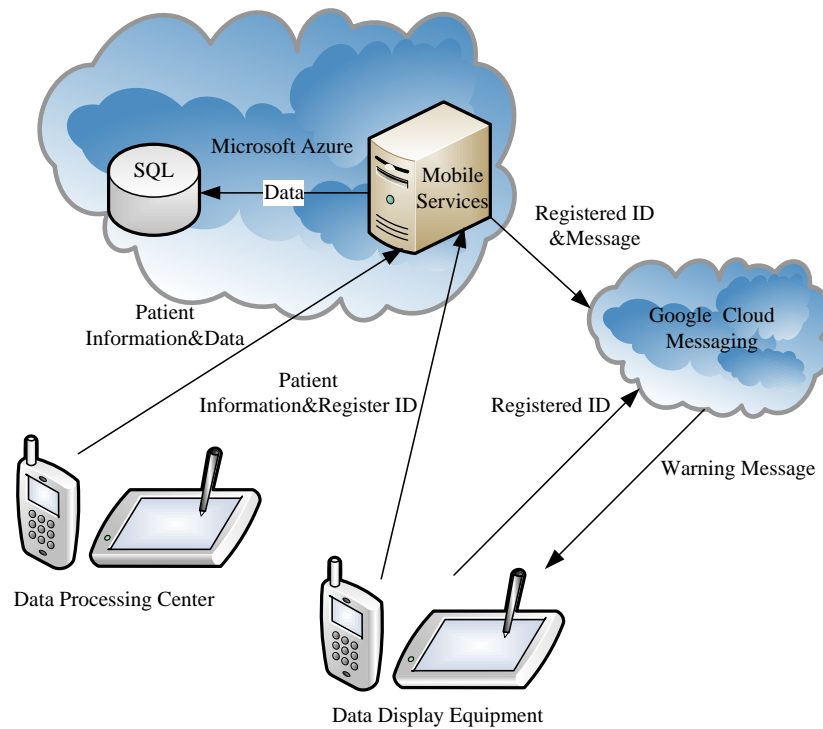
- 1).Connecting the monitored medical data server.
- 2).Getting the monitored medical data by means of Http request and display in real time line chart.
- 3). Receiving push alarm notification information and displaying the information in detail by Microsoft Azure Mobile Services.
- 4). By the Baidu map service to locate the source of the alarm information.

### 3.4 Emergency Medical Service

Emergency medical systems (EMS) are among the most crucial ones as they involve a variety of activities which are performed from the time of a call to an ambulance service till the time of patient's discharge from the emergency department of a hospital and are closely interrelated so that collaboration and coordination becomes a vital issue for patients and for emergency healthcare service performance.

In this remote medical monitoring system, to build a hybrid cloud with a push function of medical information through health information private cloud and two public cloud, and the establishment of Emergency medical Service by Microsoft Azure Mobile Services and Google Cloud Messaging.

Data processing center send the parsed data and the monitored patient identity validation information to the Azure Mobile Services through Rest API; When the medical application installed on the Data Display Equipment execution OnCreated() method, it will be issued to Google Cloud Messaging to get Registered ID, After the guardian entered the monitored patient identity validation information is transmitted along with the Registered ID to Azure Mobile Services; Azure Mobile Services will receive the data stored in the SQL database for later viewing, and to detect the data when receiving data, when the data exceeds the alarm value, to retrieve all the subscribers of Registered ID with the alarm information sent to Google Cloud Messaging, Then Google will push the information to all Data Display Equipment. Shown in Figure 5 below, we put the Mobile Services into our system.



**Figure 5. System with Mobile Services**

Microsoft Azure Mobile Services is an Azure service offering designed to make it easy to create highly-functional mobile apps using Azure. Mobile Services brings together a set of Azure services that enable back-end capabilities for apps.

GCM (Google Cloud Messaging) is a free cloud service provided by Google for Android. Users can send their physiological data to any Android device via a server with this service, which also can restore the message from the user's device to the cloud service. This is a lightweight messaging service. Users can get real-time data server in a new Android application as needed by the message way. Data can also be transmitted via the messaging service, Payload carried data on the line is 4Kb. It is between the server and the mobile device side provides a simple lightweight communication mechanism that enables mobile devices to the server side can receive notification contacts and establish direct contact with the server-side, so as to realize the receiving server-side push data. Compared to the third-party push technology services, GCM can receive messages directly. It has good practical, and low energy consumption, simple to implement relatively. In addition to the GCM, the usual way to push the message follows: XMPP, MQTT, HTTP polling mode, the third party pushing service. The difference between them, as shown in Table 2.

**Table 2. Common Push Service Comparison**

| Method | Advantages                                                                 | Disadvantages                                                                                              |
|--------|----------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|
| GCM    | Service provided by Google, simple, no need to implement and deploy client | Version limit. Android 2.2 above                                                                           |
| XMPP   | Examples of protocols mature, scalable, open source java version later     | Protocol complexity. Redundancy. High traffic. High power consumption. The high cost of deploying hardware |
| MQTT   | Simple and compact protocol, scalable, provincial traffic, low power       | Not mature enough. Complex. Server operation is not open source.                                           |



|       |                                                                             |                                                                                       |
|-------|-----------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|       | consumption, has been used in the corporate sector police                   | Hardware deployment cost is high.                                                     |
| HTTP  | Simple, controllable, low deployment costs                                  | Poor real-time. High power consumption.                                               |
| Third | Stable, mature, saving development time and related applications to improve | A program embedded concerns, privacy, scalability, quality of service there are risks |

### 3.5 The Remote Data Server

The remote data server of this system is that the data of medical information system server with data access interface, medical data and other information of the monitored patient is more suitable for upload to the relevant medical institutions data server, and the guardian can obtain personal information and medical data monitored by data interface of the server. In the system implementation process, construction of remote data server based on REST service model. REST defines a set of system framework, Developers design to system resources as the center of the Web service according to these principles, including the use of different language of the client through the HTTP processing and transmission resource state, one of the main features of the REST Web service is to follow the RFC 2616 protocol defined by the way of explicitly using the HTTP method. REST service simplifies the external client calls, in the Android mobile platform and PC terminal can obtain the service resources through the standard HTTP interface, consistent access to the REST service API changes will not affect the implementation and client program.

## 4. System Implementation

Figure 6 shows a screenshot of the data processing center remote medical monitoring system, the data processing when the received data is valid physiological data, and the data exceeds the maximum threshold, the physiological data and the GPS latitude and longitude coordinate data by the data processing center uploaded to the Microsoft cloud, Microsoft's cloud push this information to the target mobile device.

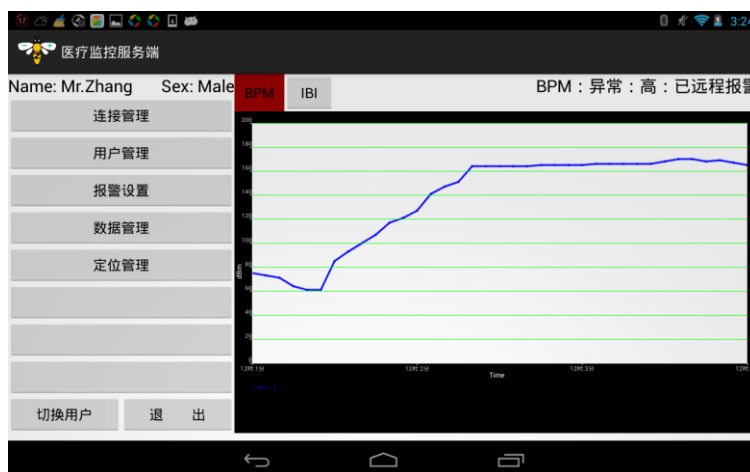


Figure 6. Data Processing Center Screenshot

Figure 7 shows the data of the remote medical monitoring system display side shots, data display terminal, received notification from the Microsoft cloud exception information, you can view the notice, you can also view notifications original position by Baidu Maps API.

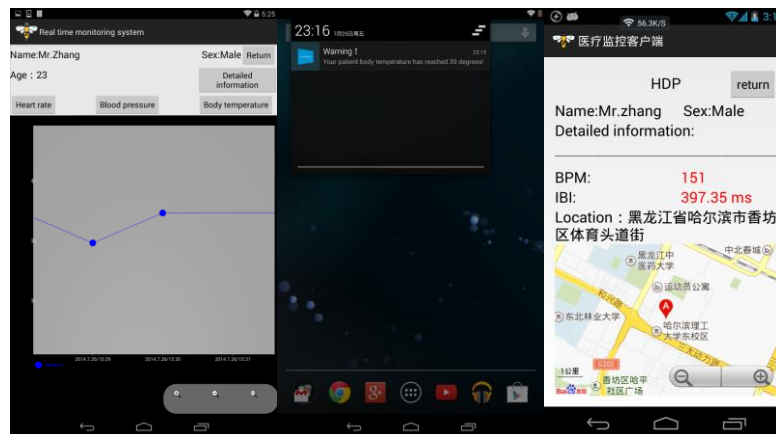


Figure 7. Data Display Device Screenshots

## 5. Related Work

In 2011, Ping Li Design the Medical Remote Monitoring System Base on Embedded Linux. In the System, design a remote wireless monitoring terminal, using ARM microprocessor as its core controller, the whole software system runs on an embedded Linux environment, they developed the Blood Pressure Module, Blood Oxygen Module, ECG (Electrocardiogram), and respiration [5]. In the next year, Deepshikha Goyal designs the low cost patient monitoring device and remote health monitoring using tablet PC. They provide a system that is effective in remote monitoring of the patient and full management of the medical resources like assigning duties to the doctors, nurses etc. They developed a Low cost patient monitoring device that can measure the temperature, blood pressure and pulse rate of the patients and transmit this data to the Low cost tablet PC and generate an alert message, When emergency [6]. In 2013, Mordhwaj Patel and Rounak Singh Narde design and develop a remote medical health monitoring system. The project relates to a health monitoring system comprising of a medical diagnosis done by a medically-qualified person in relation to a patient who is being monitored remotely via a communication system. The project is characterized in such a way that the medically- qualified person links medical data to health actions in a server using surveillance rules. The server programs a remote terminal which is located close to the patient, such that the remote terminal uses an automatism which applies the surveillance rules to the medical data supplied to the terminal by at least one sensor which is associated with the patient by a machine interface. Article focuses on the hardware environment of the project [7]. Studied the characteristics of these outstanding projects, on this basis, the design and implementation of this remote medical monitoring system. This system is more focused on project implementation, low-cost investment, facilitate the expansion, good compatibility, real-time good, these is a feature of the project.

## 6. CONCLUSIONS

Based on the analysis of actual demand of the basic health care system, combined with networking and cloud computing technology, based on the Android platform and the design of the overall framework of HDP technology medical care system. Development of remote data acquisition, medical data analysis, the application data of the alarm. Experiments show that the system is compared with the traditional health care system, significantly reducing investment of health care resources, to make health care more efficient and more practical. Experiments show that the system compared with traditional

medical monitoring system, significantly reducing medical resource inputs, make health care more efficient, more practical.

## ACKNOWLEDGEMENTS

This work was supported by the National Natural Foundation of China, under Grant No. 61172167; the Natural Science Foundation of Heilongjiang Province of China under Grant No. F201311; the Foundation of Heilongjiang Educational Committee under Grant No. 12531119. The authors wish to acknowledge Heilongjiang province university students' innovative training program. The authors also would like to express their deep appreciation to all anonymous reviewers for their kind comments.

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