# Design and Implementation of Human Body Composition Information Management System Based on Android

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***Abstract*—Human body composition (e.g., total body water, body fat, muscle) determines health to a large extent. The advent of Android has had a significant impact on the way people manage information. Taking advantage of this emerging technology to realize effective management of human body composition information can offer some help and reference for medical and health care. In this paper, we propose an Android-based human body composition information management system. Five major subsystems of our system were first designed and presented. The underlying data process flow was also given in detail. We then discussed a number of key technologies used to realize the system, including user interfaces, data communication, data synchronization and file upload. The proposed system features excellent user experience, low energy consumption, good mobility and portability, etc. Compared with systems running on desktop PCs, laptops or on traditional embedded systems, our proposed system combines their advantages, overcomes some of their major drawbacks and has better usability.**

***Index Terms*—Android, Information Management System (IMS), Human Body Composition.**

## I. Introduction

With the arrival of the information age, people are increasingly concerned about the information acquisition, storage, transmission, analysis, sharing and management. Smart mobile devices such as smart phones and tablets are often used to make phone calls, send text messages, browse the web and play movies. In particular, they are utilized to systematically manage information. Many excellent software systems have been developed to run on smart mobile devices, and have brought about great convenience to people's lives.

Android is a Linux-based open source operating system designed for mobile Devices [1][2]. It is becoming increasingly popular, enjoying a large market share and exponential growth factor [3][4]. Smart mobile devices based on Android tend to have high-performance processors and large-capacity main memory. They are also equipped with 3G, Wi-Fi [5], GPS, Bluetooth, portable storage such as SD card, accelerometer and gyroscope, etc. Their low cost [6], high performance and mobility, good man-machine interaction experiences and ease of use together with Android's ease of learning, profound industry support and openness [2] persuade us to choose Android as the development platform.

Human body composition including total body water, body fat, muscle, is an important determinant of health and performance [7]. For example, the relationship between cardiovascular diseases and obesity is mainly based on percentage body fat [8-10].

Currently, most human body composition information management systems are running on desktop PCs, laptops or on traditional embedded systems. However, both of the systems have their respective disadvantages which will be discussed in detail later. To overcome some of their major drawbacks, we propose an Android-based human body composition information management system. Exploiting Android to achieve effective management of human body composition information can also provide some help and reference for medical and health care. To our knowledge, relevant research work has not yet been reported.

The remainder of this paper is organized as follows. Section II describes the system design, analyzes five main subsystems of the system, and shows the system flow. A number of key technologies used to implement the system are given in detail in Section III. Section IV is devoted to discussing the advantages and shortcomings of different human body composition systems. Section V closes with conclusions and future work.

## II. System Design

We use Android devices to acquire and manage users' body composition data, and then store them in the database server. Measurement result reports generated by the system can be transferred to the FTP server. The web server provides the function of viewing information. Hospitals, research institutes and universities can use the data stored in the database server for analysis, data mining, prediction and other scientific researches. Fig. 1

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shows the framework of the Android-based human body composition information management system.

### *A. Design of the System Structure*

The system can be divided into five subsystems: user management, weight data processing, body composition data processing, body composition management and system management, as shown in Fig. 2.

1. User management subsystem

The user management subsystem is responsible for the management of user information, including name, age, gender, identification number and height. The user information is stored in the SQLite database and synchronized to the database server via WIFI or network cable.

2. Weight data processing subsystem

This subsystem receives weight data by communicating with the measurement module used to measure body weight and body composition, and displays the weight dynamically on an Android touch screen in real time so as to bring a good user experience. The received weight data will be recorded and passed to the body composition measurement interface.

3. Body composition data processing subsystem

The main role of this subsystem is to process the body composition data by communicating with the measurement module. First of all, this subsystem sends instruction to the measurement module. This instruction contains user information such as height, weight, age and gender that is significant in calculating human body composition. After that, the measurement module would analyze the instruction, extract useful information and calculate human body composition. Subsequently, the subsystem receives the body composition data returned from the measurement module.

4. Body composition management subsystem

After users complete the measurement, the body composition data is stored in the SQLite database. The system generates reports automatically according to the measurement result. If the network is not available at this time, users can choose another time for data synchronization and report upload. Alternatively, they can export the report and data to USB flash drives.

5. System management subsystem

The system management subsystem consists of system settings and data management. The system settings module consists of clothing weight settings (i.e., the clothing weight that should be subtracted automatically

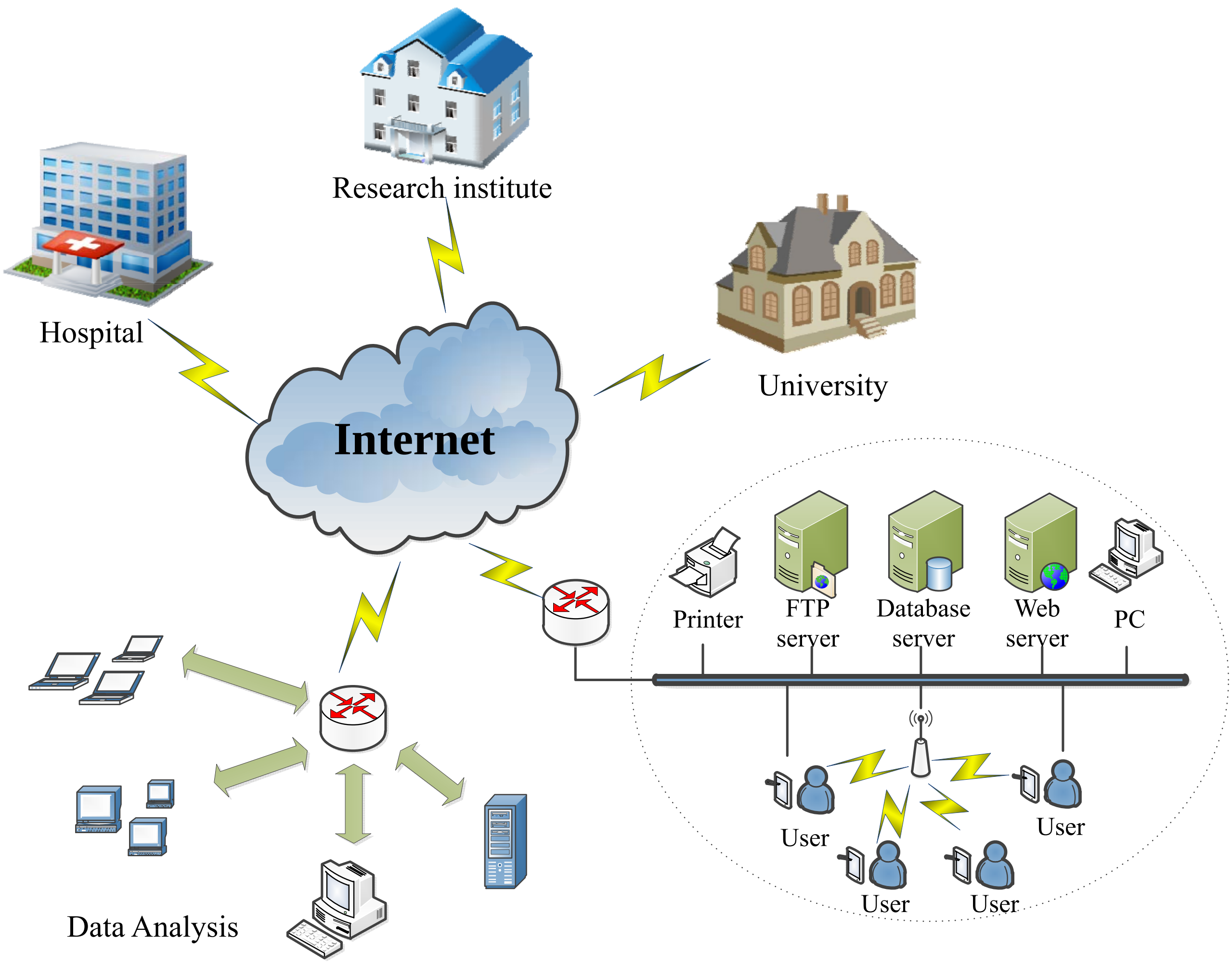


Figure 1. System framework

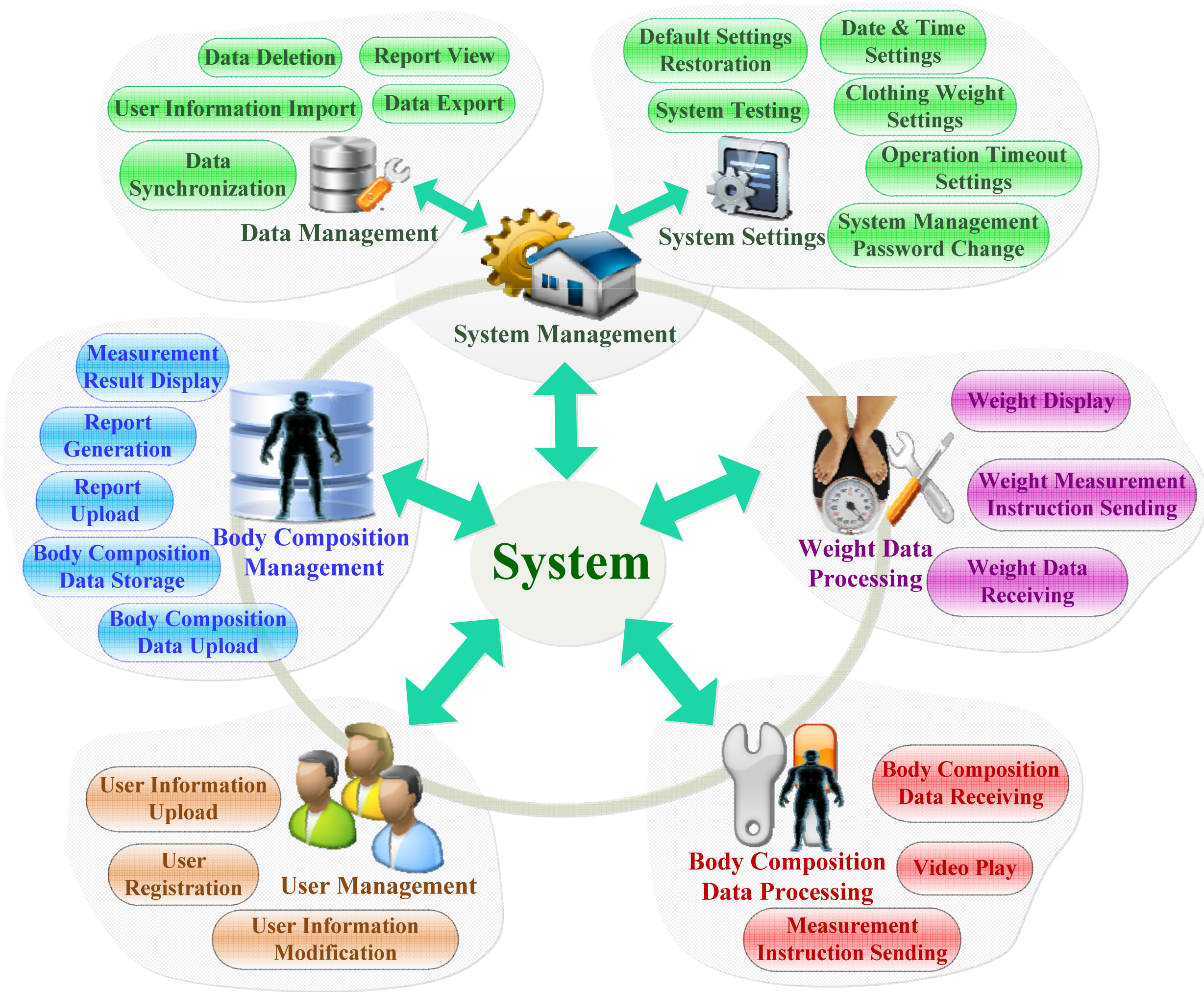


Figure 2. Structural topology of the system

from the body weight after the weight measurement in order to get a more accurate body weight), system testing, default settings restoration, etc. The data management module is made up of report view, user information import and data-related operations, such as data export, deletion and synchronization.

## B. System Flow

After system startup is over, users enter the login interface. In the login interface, new users could enter the registration interface and complete their registration information by filling in their names, ages, genders, heights, identification numbers, and so on. Registered users could enter the information modification interface after the verification of their identification numbers. If an abnormal weight/body composition is found in the weight/body composition measurement interface (this is often caused by the absence of subjects on the measurement platform), users would be asked whether to re-measure their weights/body composition or not. A negative choice could lead the system to go back to the login interface. After the measurement of body composition, users enter the measurement result display interface where they can view their measurement results. The system flow chart is shown in Fig. 3.

# III. System Implementation

The system is developed using the Eclipse Integrated Development Environment (Eclipse IDE). The requirements include Java Development Kit (JDK), Android Software Development Kit (Android SDK) and Android Development Tools (ADT). We choose a proprietary Android tablet to develop and demonstrate the system. The system configuration is shown in Table I.

The system could be packaged into an application package (APK) file and installed on the tablet. The size of the system software is approximately 46 MB, and most of

TABLE I.
Configuration Of Testbed Android System.

| Component | Specifications |
|---|---|
| CPU | 1 GHz |
| RAM | 1 GB |
| SD card capacity | 16 GB |
| Screen resolution | 1024×768 pixels |
| Screen density | 160 dpi |
| Android version | 4.0.3 |

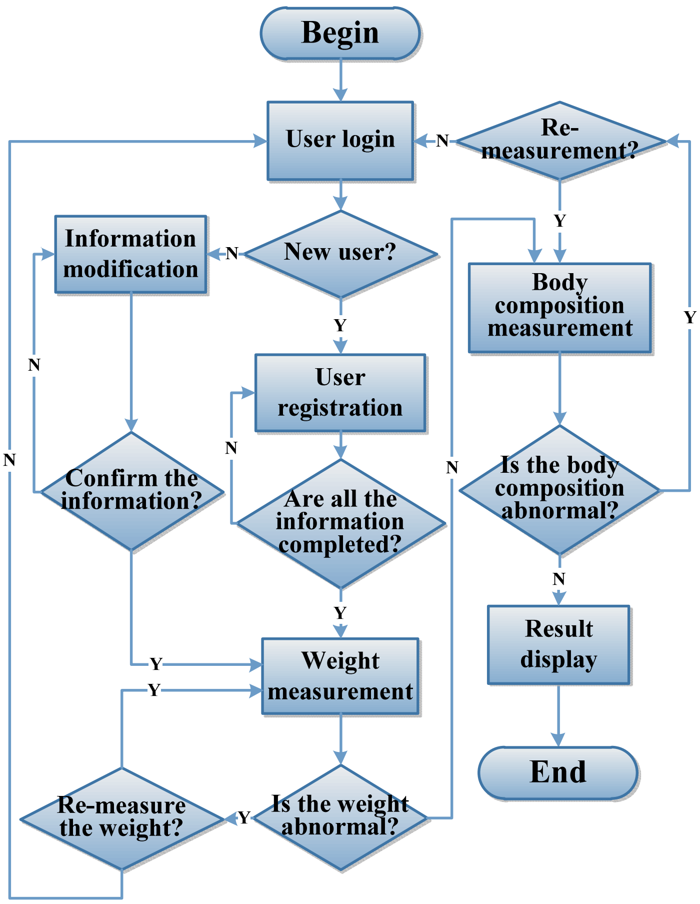


Figure 3. System flow chart

the space is occupied by videos, audios and pictures. Large files and resources such as videos are transferred automatically to specified locations in the SD card when the software first starts in order to reduce latency in resource loading in the future. The installed Android version is 4.0.3, whose code name is Ice Cream Sandwich with an API level of 15.

Through mini USB ports, the system establishes connections with the measurement module which measures body composition and integrates the control of the weight sensor. The measurement module calculates body composition using Bioelectrical Impendence Analysis (BIA) which is a practical and non-invasive method to assess human body composition [11]. The principle of BIA is to put variables (e.g., height, weight, age, gender, electrical impedance which is obtained through users' limbs, trunks and other body parts) into specific equations to calculate body composition. The system measurement components are shown in Fig. 4.

BIA equations are population-specific, and the accuracy of the BIA result is considerably dependent on the agreement of age, ethnicity, physical characteristics, etc., between subjects and the reference population data used to generate the BIA algorithm [12-15]. Therefore, we do not intend to discuss much about BIA and the measurement module. Instead, we concentrate fully on the processing and management of body composition information.

A number of key technologies in implementing the system are discussed below, including user interfaces, data communication, data synchronization, and file upload.

### A. *User Interfaces*

The user interface is what users can see and interact with. Its quality has a direct influence on the user experience. Basic Android UI elements used in the system include Button, TextView, Image, ViewFlipper which is used to implement sliding effects, Dialog which is used to give tips or choices to users, etc. Multimedia resources such as videos and audios are also important to bring a good user experience. We use the VideoView class to play videos and the SoundPool class to play audios. With the combination of these elements and the implementation of their corresponding events or methods, we have built all the visible user interfaces which are user-friendly and beautiful. Though they seem complex, the implementation principle is relatively simple. We show some user interface examples in Fig. 5 – Fig. 7.

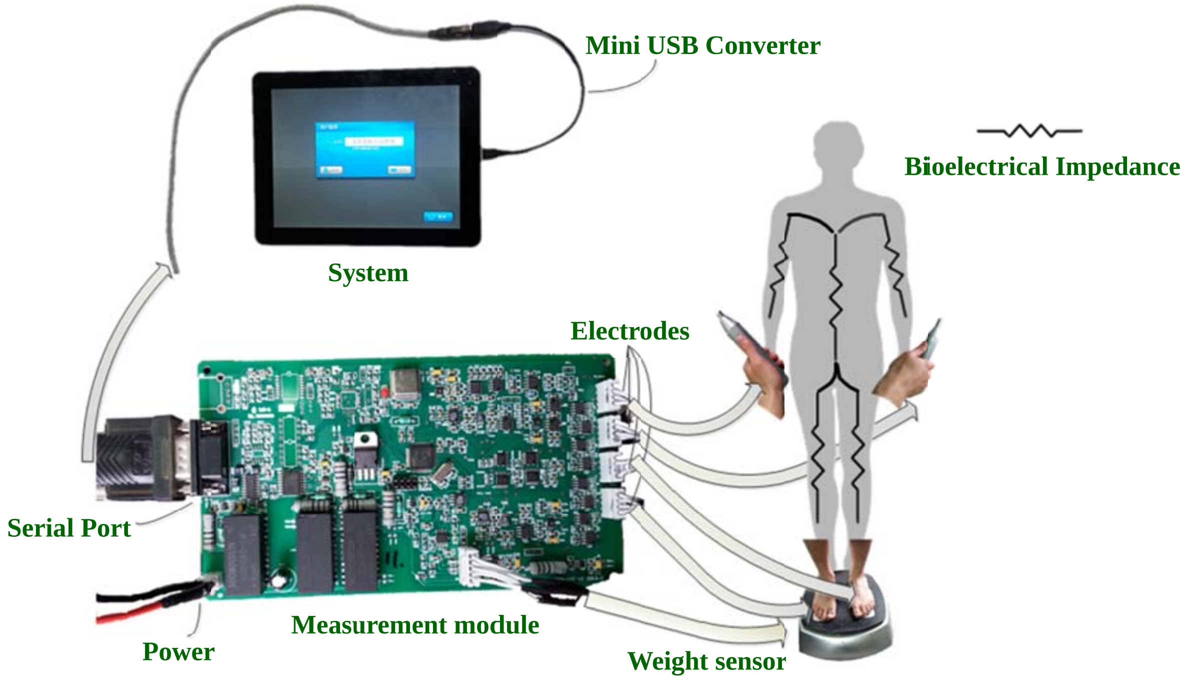


Figure 4. System measurement components

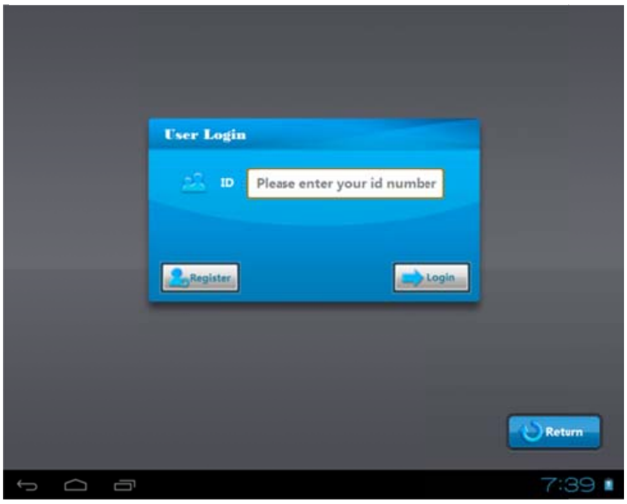


Figure 5. Login interface

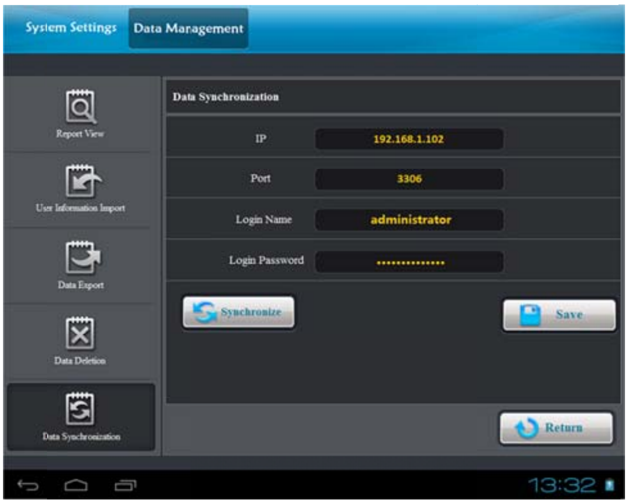


Figure 7. System management interface


Figure 6. Weight measurement interface

## *B. Data Communication*

The auxiliary tool we use to establish communication between the system and the body composition measurement module is the android-serialport-api library [16]. The system sends and receives data through serial ports. The received data in the form of binary byte will be converted into byte arrays. After receiving a specified number of bytes, the system will take these bytes as an instruction and response according to the instruction. We take the body weight measurement for example to illustrate this. Communication contents including S1, S2, S3, and S4 which contains 8 bytes each are shown in Table II.

The symbols x in Table II represent special flags used to verify the instruction type, check the validity of instruction senders, perform data verification, etc. The commonly occurring communication format is {b, c, d, x,

TABLE II.
COMMUNICATION CONTENTS USED IN WEIGHT MEASUREMENT

| Name | Format | Meaning |
|---|---|---|
| S1 | x x x a x x x x | Begin to measure weight |
| S2 | x x x b c d x x | Weight data can be extracted from it, weight = b*10+c+d/10 kilograms |
| S3 | x x x e x x x x | Weight measurement stops |
| S4 | x x x f x x x x | The response to S3 |

x, x, x, x}. However, this format is inherently flawed in that it results in the incapability of the system to judge whether the first byte is the weight data or the error byte. By contrast, our system can effectively minimize the required re-transmission time when errors occur. For example, if an error is detected in the first byte of S2, the system is able to rapidly response, discard the subsequent 7 bytes, perform data re-transmission, etc. Fig. 8 shows the communication process in weight measurement.

As we can see from Fig. 8, the system starts the weight measurement by the sending of instruction S1, and then the measurement module connecting to the weight sensor returns the weight data instruction S2 continuously. When the system receives the returned instruction, it will judge whether the instruction is S2. Weight data will be extracted from S2. After receiving a specified number of weight data, the system will send S3 and stop receiving weight data at the same time. That the measurement module returns S4 and stops sending weight data instruction marks the finish of the communication process of weight measurement. Detailed communication data processing flowchart is shown in Fig. 9.

### C. Data Synchronization

Data in the system can be synchronized to the database server, and afterwards, shared with other users, applications, systems, etc. The data synchronized to the database server are mainly user profiles and body composition information. The implementation principle is to open the connection to the database server first, and then execute the synchronization commands using database transactions. If the data synchronization is unsuccessful, the database will roll back to its original state.

### D. File Upload

Users can use FTP (File Transfer Protocol) to connect their own terminals to servers that run FTP, and then get information from them. The objectives of FTP are to transfer data reliably and efficiently, to shield a user from variations in file storage systems among hosts, to promote sharing of files, and so forth [17].

Users' measurement result reports generated in the system can be uploaded to the FTP server. We use the Apache Commons Net library [18] to implement the file upload. Key classes used are FTPClient, FTPReply in Apache Commons Net library, and FileInputStream in java.io package.

## IV. DISCUSSION

Currently, most common human body composition information management systems are running on desktop PCs, laptops or on traditional embedded systems. On one hand, desktop PCs and laptops are powerful. Owing to the rapid application development (RAD) of high level programming languages, their development costs are low. However, their device costs and energy consumption are generally very high, and the use of mouse and keyboard leads to an indirect man-machine interaction experience. Their bulkiness and heaviness also cause poor mobility and portability. On the other hand, traditional embedded systems have low device costs and energy consumption, but they are flawed in that the development costs are relatively high due to long development cycles and

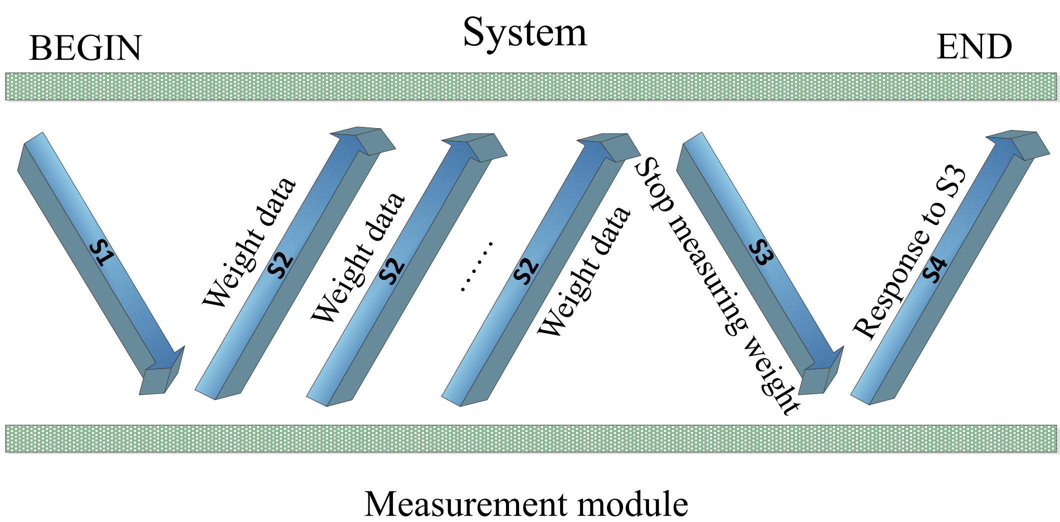


Figure 8. Communication process in weight measurement

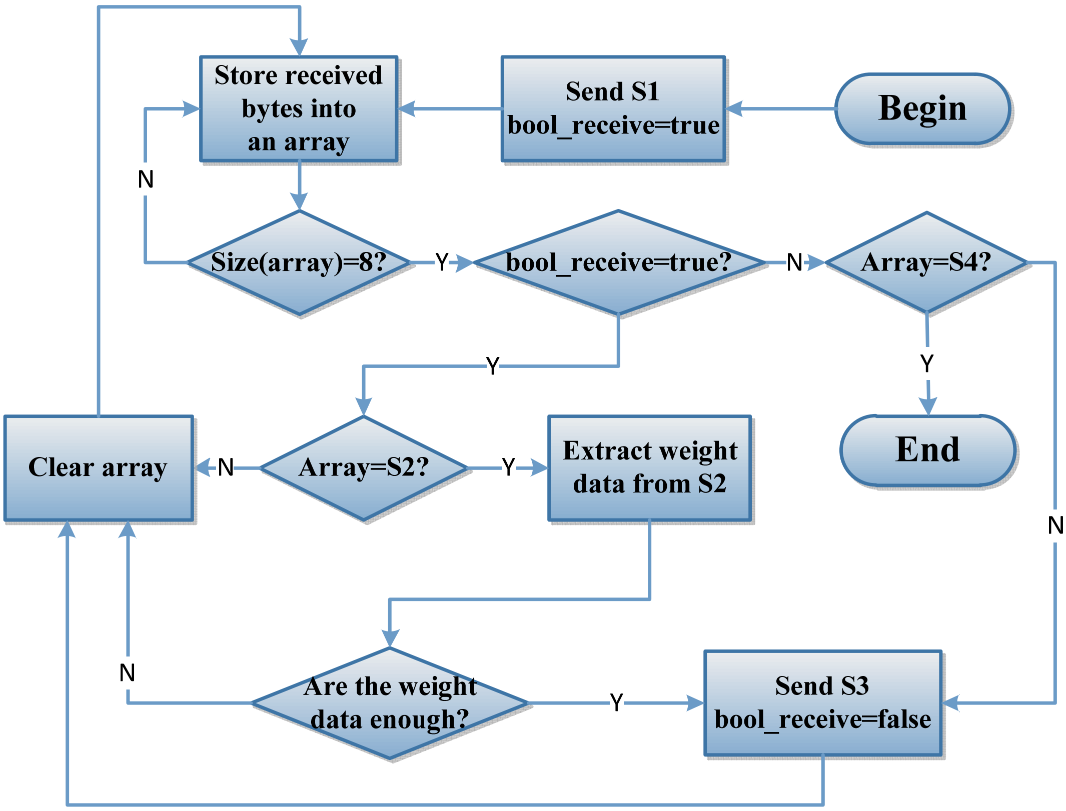


Figure 9. Communication data processing flowchart in weight measurement

difficulties in system development and maintenance, especially in graphics programming. Besides, the LCD used for display often offers unattractive user interfaces and could not bring a satisfactory user experience.

We compare our proposed system with two kinds of systems mentioned above in detail, as shown in Table III. Our proposed Android-based system has many features. Firstly, Android devices are popular. Instead of buying specific components, users can install the system APK file into any android devices they already own. Thus, costs are saved in both manufacture and purchasing sides. Secondly, Android's ease of learning, profound industry support and openness can greatly reduce development costs and shorten development cycles. Thirdly, Android's sensitive touchscreen and great graphic power can easily make a good user experience. Android devices have low energy consumption. Their small size and light weight also contribute to good mobility and portability.

## V. Conclusions And Future Work

In this paper, the human body composition information management system based on Android was presented with its design and implementation given in detail. Compared with systems running on desktop PCs, laptops or on traditional embedded systems, the proposed system combines their advantages, overcomes some of their major drawbacks and has better usability. We believe it can substantially enhance the effectiveness of information management process.

Future work will be dedicated to deploying our system to many research institutes, universities, gymnasiums and hospitals to collect data from people of different ethnicities, ages, physical characteristics, genders, heights, weights, medical histories, and so forth. These data will then be utilized for classification, statistics, data mining and modeling to find out inherent relationships between

TABLE III.
COMPARISON OF DIFFERENT HUMAN BODY COMPOSITION SYSTEMS

| System | Good user experience | Low device costs | Low development costs | Low energy consumption | Good mobility and portability |
|---|---|---|---|---|---|
| Desktop PCs/Laptops system | | | √ | | |
| Traditional embedded system | | √ | | √ | |
| Our proposed system | √ | √ | √ | √ | √ |

different parameters. Our system has functionalities of diagnosis and prevention. Therefore, epidemiological studies on obesity, edema and osteoporosis will be conducted later. Moreover, the system could be used to monitor changes in body composition to periodically detect the subject's physical condition or the patient's rehabilitation to evaluate the pros and cons of designed fitness interventions, medical prescriptions, etc.

Future work will also be devoted to developing and expanding the system to embrace more useful functionalities and richer external interfaces to different measurement modules. Meanwhile, we would enhance compatibility between different android versions, and improve the reliability, efficiency and performance of the system by optimizing the code and algorithm. We would try to develop our software system in other mobile operating systems, such as Apple iOS [19] and Microsoft Windows Phone [20].

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## REFERENCES

[1] Android Developers, "Android, the world's most popular mobile platform", http://developer.android.com/about/index.html, last visited: December 2013.

[2] R. Yanggratoke, A. Azfar, M.J.P. Marval and S. Ahmed, "Delay tolerant network on Android phones: implementation Issues and performance measurements", *Journal of Communications*, vol. 6, no. 6, pp. 477-484, September 2011.

[3] T. Vidas, C. Zhang, N. Christin, "Toward a general collection methodology for Android devices", *Digital Investigation*, vol. 8, no. Suppl. 1, pp. S14-S24, August 2011 [11th Annual DFRWS Conference, New Orleans, LA, United States, pp. S14-S24, 2011].

[4] Engadget, "Android tops 81 percent of smartphone market share in Q3", http://www.engadget.com/2013/10/31/strategy-analy tics-q3-2013-phone-share, last visited: December 2013.

[5] J. E, J. Ma, "A research on seamless indoor and outdoor positioning", *Journal of Computers*, vol. 8, no. 12, pp. 3047-3057, December 2013.

[6] W. Budiharto, W.D. Putra, Y.P. Putra, "Design and analysis of fast driver's fatigue estimation and drowsiness detection system using Android", *Journal of Software*, vol. 8, no. 12, pp. 3055-3059, December 2013.

[7] W. Mueller, R.J. Maughan, "The need for a novel approach to measure body composition: is ultrasound an answer?", *British Journal of Sports Medicine*, vol. 47, no. 16, pp. 1001-1002, November 2013.

[8] B. Gutin et al, "Relation of percentage of body fat and maximal aerobic capacity to risk factors for atherosclerosis and diabetes in black and white seven- to eleven-year-old children", *Journal of Pediatrics*, vol. 125, no. 6, pp. 847–852, December 1994.

[9] P. Zimmet et al, "The metabolic syndrome in children and adolescents – an IDF consensus report", *Pediatric Diabetes*, vol. 8, no. 5, pp. 299–306, October 2007.

[10] H. Talma et al, "Bioelectrical impedance analysis to estimate body composition in children and adolescents: a systematic review and evidence appraisal of validity, responsiveness, reliability and measurement error", *Obesity Reviews*, vol. 14, no. 11, pp. 895-905, November 2013.

[11] K.J. Shafer, W.A. Siders, L.K. Johnson and H.C. Lukaski, "Validity of segmental multiple-frequency bioelectrical impedance analysis to estimate body composition of adults across a range of body mass indexes", *Nutrition*, vol. 25, no. 1, pp. 25-32, January 2009.

[12] M. Deurenberg-Yap, P. Deurenberg, "Is a re-evaluation of WHO body mass index cut-off values needed? The case of Asians in Singapore", *Nutrition Reviews*, vol. 61, no. 5, pp. S80–S87, May 2003.

[13] S.S. Sun et al, "Development of bioelectrical impedance analysis prediction equations for body composition with the use of a multicomponent model for use in epidemiologic surveys", *American Journal of Clinical Nutrition*, vol. 77, no. 2, pp. 331–340, February 2003.

[14] E.C. Rush, V. Chandu, L.D. Plank, "Prediction of fat-free mass by bioimpedance analysis in migrant Asian Indian men and women: a cross validation study", *International Journal of Obesity*, vol. 30, no. 7, pp. 1125-1131, July 2006.

[15] A. Bosy-Westphal et al, "Accuracy of bioelectrical impedance consumer devices for measurement of body composition in comparison to whole body magnetic resonance imaging and dual x-ray absorptiometry", *Obesity Facts*, vol. 1, no. 6, pp. 319-324, December 2008.

[16] http://code.google.com/p/android-serialport-api, last visited: December 2013.

[17] "File Transfer Protocol", RFC 0959, http://tools.ietf.org/html/rfc959, last visited: December 2013.

[18] Apache Commons, "Apache Commons Net", http://commons.apache.org/proper/commons-net, last visited: December 2013.

[19] Apple Developer, "Develop Apps for iOS", https://developer.apple.com/technologies/ios, last visited: December 2013.

[20] Windows Phone Developer Center, "Develop everything you need to build great apps", http://developer.windowsphone.com/en-us/develop, last visited: December 2013.

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