# An Information System of Human Body Composition Based on Android Client

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***Abstract:*** *This paper proposes an information system of human body composition based on Android client. The system consists of the Android client, the measurement unit, the Database Server, the FTP Server, the Web Server and portable storage devices. It is able to collect, restore, synchronize, and batch import and export user profile information and human body composition information. The merits of the system are that the development cycle is shortened, the cost and energy consumption of equipment are reduced, and the portability and mobility are enhanced. The system has also optimized the communication of human body composition measurement. As a result, the client and the measurement unit are robust and capable of addressing the fault and solving deficiencies in the communication process. With a more reliable system, accurate transmission of data can be guaranteed.*

***Keywords:*** *Human body composition, Information system, Android client, Communication optimization.*

## Introduction

Human body, composed of total body water, body fat and muscle, is an important determinant of health and performance [11]. Currently, there are several ways to measure human body composition, such as 2H dilution, Skinfold method, Underwater weighting method, Total body K, Air replacement method, Ultrasonic method, Bioelectrical impedance analysis, Dual-energy X-ray absorptiometry (DXA), Nuclear magnetic resonance imaging, to name just a few.

Measurement and recording of changes in bioelectrical impedance *in vivo* has become a widely used method with various clinical applications [2]. Bioelectrical impedance analysis (BIA) is an indirect way of human body composition measurement. When the weak alternating current is introduced into the body, it will move along with the fluid that has small resistance and good conductivity. As the adipose tissue does not contain much water but is poor in conductivity, it has lower charge capacity than non-adipose tissue does.

BIA measures the difference of the current flowing through the adipose tissue and the non-adipose tissue to complete the computing of human body composition. Many experimental results have suggested that there lies a statistical relationship between impedance and human body composition. They are the sources of the BIA [12]. Usually, the user's height, age, sex, body weight and other information as well as the resistance value of all segments are crucial to calculate the human body composition. BIA is a non-invasive and practical method to assess human body composition [13]. Its accuracy has long been proven by many studies [1, 9, 10, 14].

Android is a Linux-based open source operating system designed for mobile devices [5, 16]. It is gaining momentum in the market, evidenced by a larger market share and exponential growth [7, 8, 15]. Smart mobile devices based on Android are low in cost and energy consumption, but high in performance and mobility. They also provide good man-machine interaction experiences. It is the ease of use, ease of learning, openness and strong industry support that make Android a popular development platform.

The human body composition measurement instrument produced by developers is short of the information system. It fails to manage the user profile information or the user's human body composition information. There is no way to batch import the user profile information, realize off-site backup or export and share diversified human body composition information through the network. Rather, the information is only stored locally.

In addition, as there is only one chance of data communication between the client and the measurement unit in the common process of human body composition measurement, fault to catch the deficiency and the instability should be addressed.

Therefore, this paper proposes an information system of human body composition based on Android client to solve these problems mentioned above.

## System design and realization

### *System framework*

The information system of human body composition proposed in this paper is consisted of the Android client, the Database Server, the FTP Server, the Web Server, portable storage devices and the measurement unit, as is shown in Fig. 1.

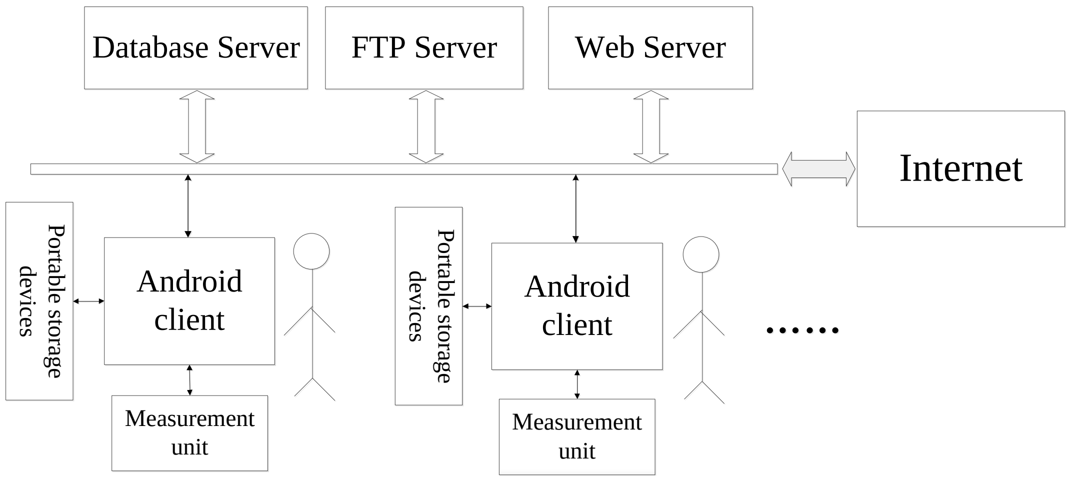


Fig. 1 System framework

### *System module*

The Android client has a user registration module, a weight measurement module, a human body composition measurement module, a synchronization module, a system setting module and a data management module; the measurement unit includes a main control unit, potential electrodes and a weight sensor, as is shown in Fig. 2.

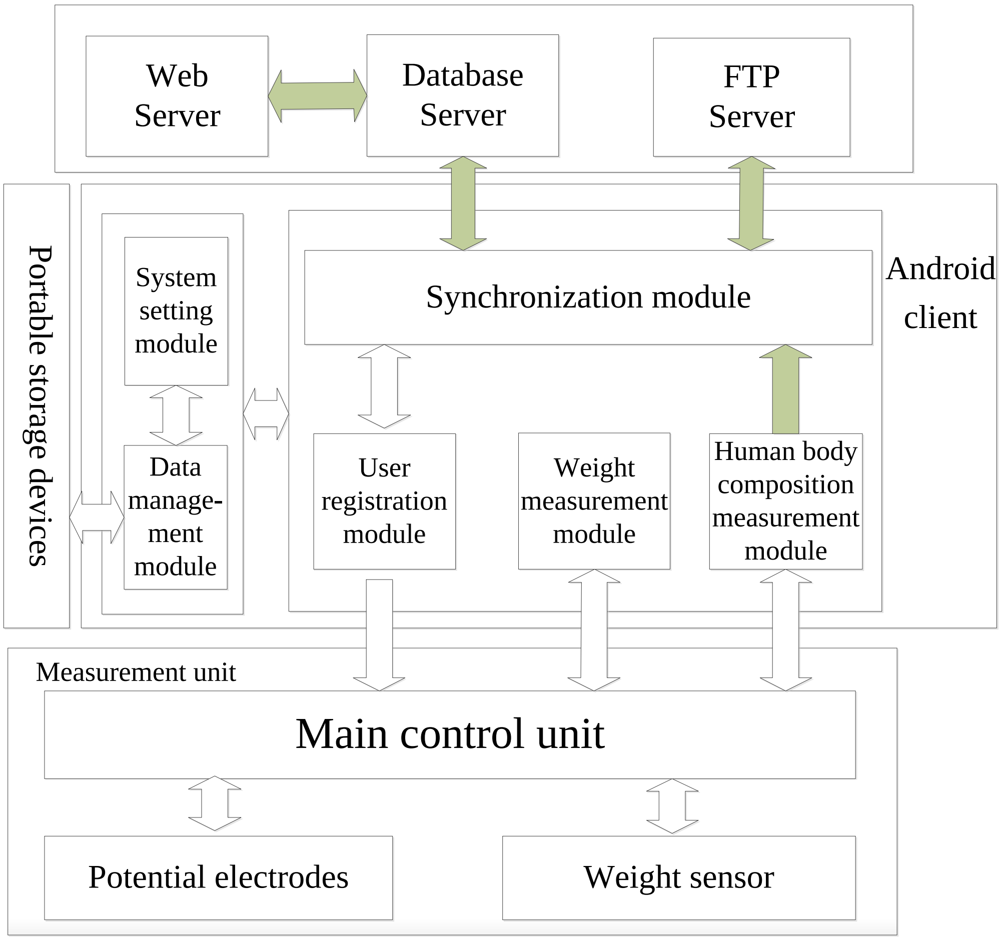


Fig. 2 System module

## *System realization*

The Android client can obtain the human body composition information from the measurement unit. It is running on a tablet PC with an Android operation system. The tablet PC also can be superseded by an Android cellphone. The user imports individual profile through the Android client and the information is stored at the local SQLite database by the user registration module. The synchronization module establishes a connection with the Database Server, and synchronizes the information to Database Server through data insertion.

The Database Server database is the one from Oracle's MySQL. Small in size, high speed, convenient and practical are all its merits, let alone low cost and open source. The synchronization module connects with the Database Server through MySQL Connector/J which is the official JDBC driver for MySQL [4]. When the connection between the synchronization module and the Database Server or the FTP Server is established, information such as server address, login name, password and other parameters for landing is obtained from the system setting module. Then data synchronization and file uploads are realized. The system setting module has set up some special parameters, including deduction of clothing weight, weight sensor regression equation parameters, process control parameters of human body composition measurement, FTP Server parameters, Database Server parameters, etc.

The Database Server receives and stores the user profile information. Meanwhile, the user registration module of the Android client sends the user profile information to the main control unit in the measurement unit. The main control chip is a STM32R8T6 MCU with 64 pins. It is simple with low cost and good quality. After the main control unit receives the user profile information, the data are stored in the register variables to calculate the human body composition information.

The weight sensor is a Transcell SBS-ESH cantilever sensor. The effective measurement range is 0-200kg with high accuracy and a good stability. The weight sensor has a corresponding equation: $y = Ax + B$, in which $x$ represents the AD signal value gained by the weight sensor while $y$ represents the actual weight. $A$ and $B$ represent the regression equation parameters whose value is given by the system setting module. When measuring the weight, the weight measurement module first issues an instruction to the main control unit, after which the main control unit instructs the weight sensor to measure the weight. Then the sensor sends the collected AD signal to main control unit, allowing the main control chip to process the AD signal value $x_1$ through steps of sampling, averaging and encapsulation and then issue the gained instruction to the weight measurement module. Next, the weight measurement module plugs AD signal $x_1$ into the equation and gains the actual weight $y_1 = Ax_1 + B$. However, since the present value includes the weight of the scale, the net weight of the scale: $y_0 = Ax_0 + B$ needs to be subtracted. Hence the initial weight value of the user is:

$$initial\_weight = y_1 - y_0 = Ax_1 + B - (Ax_0 + B) = A(x_1 - x_0) .$$

Deduction of clothing weight is set up in the system setting module. There are three modes: the first one is to subtract a fixed weight of clothing after each body measurement; the second one is to set up a clothing weight differentiated by four seasons and the system automatically does the subtraction according to the date; the third one is to set up a customized clothing weight by the user and the system automatically does the subtraction after weight measurement.

The weight measurement module subtracts the initial clothing weight and gets the actual weight of the user. It then sends the information to the main control unit. The main control unit stores the weight of the user in the register variable to calculate human body composition information.

The human body composition measurement module sends instructions to the main control unit which measures bioelectrical impedance values of limbs and the torso while the main control chip controls the electrodes. Then bioelectrical impedance values are stored in the register variables to calculate the human body composition information.

The main control unit extracts the information such as age, sex, weight, height and users' bioelectrical impedance value stored in the register variables. The human body composition is calculated according to the specific formula integrated in the main control chip. Then the main control unit sends the encapsulated human body composition information as instructions to the human body composition measurement module. The human body composition measurement module stores the user records in the SQLite database. The user records also include the measurement time and other important human body composition information.

The synchronization module uses Android Droidtext library to generate PDF reports and save them in the internal memory or SD card of the Android client. The auxiliary library for the

FTP Server is the Apache Commons Net library [3]. When uploading, the synchronization module first establishes a connection with the FTP Server through the FTPClient class. Then the PDF reports in the Android client internal memory or SD card are saved in the file folder under the FTP Server. The location of the folder can be set up in the system setting module.

Users can store the information that not registered in the Android client previously by order of field, and then add it to the Excel file line by line and write the user profile information in an Excel file. Users can store the file in a portable storage device or the folder for batch import under the root directory of the FTP Server. The location and the name of the folder can be set up in the system setting module.

If there is a necessity to add a certain number of users, it is clear that the most efficient way is to batch import. The user inserts portable storage devices such as U disk or mobile hard disk. Then the data management module mounts the devices to a specific system folder and find out the Excel file. Then it uses Jxl.jar which is produced by Java Excel API to parse the file contents.

Java Excel API is a mature, open source java API enabling developers to read, write, and modify Excel spreadsheets dynamically [6]. The data management module parses out the user profile information in the file. The user registration module batch imports the user profile information to the SQLite database, which is simultaneously backed up in the Database Server. When it is necessary to batch import from the network, the data management module can use the synchronization module to download the Excel file of the user profile information according to a specific folder name in the system setting module and parse it. Then use the user registration module to batch import.

The data management module can also be used to batch import user records to the portable storage device or the FTP Server for data analysis. The user inserts portable storage devices such as U disk or mobile hard disk. Then the data management module mounts the device to a specific folder in the system. It subsequently uses Jxl.jar to write in the temporary Excel file line by line. Once done, it closes the file and moves it to the folder under the portable storage device, marking the completion of the export. Besides, the data management module can upload the temporary Excel file to the folder under the root directory of the FTP Server by using the synchronization module. The location of the folder can be set up in the system setting module.

Users can be access to the Internet through PC, notebook, tablet PC or mobile phone at any time they want. A user first logs in the IP address issued by the Web Server. The user’s browser as a client sends queries to the Web Server. Then the Web Server uses the WebService technique to check out all user measurement records from the Database Server and returns the results to the client. The Web Server can also provide other data access interface for research institutes, hospitals or colleges, so that the human body composition information can be analyzed, studied and modeled.

## Communication optimization

As is shown in Fig. 3, the common communication process between the client and the measurement unit in the human body composition measurement is described as: ① the communication starts and the client sends the measurement instruction; ② the measurement unit takes the measurement and the client is waiting for the result; ③ the measurement unit finishes the measurement and returns the human body composition information, and the communication is done.

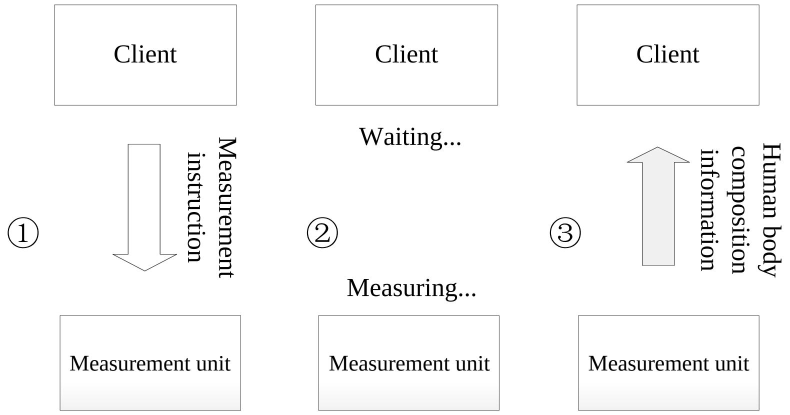


Fig. 3 Common communication process of human body composition measurement

As is shown in Fig. 4, there are seven communication instructions in three groups in the process of human body composition measurement in our proposed system. $S_1$ is the measurement instruction. $S_5$ is the instruction of inquiring whether the measurement is finished. $S_{10}$ is the human body composition information inquiring instruction. $S_3$ is the measurement response instruction. $S_{12}$ is the human body composition information instruction. $S_9$ is the completed measurement response instruction and $S_7$ the uncompleted measurement response instruction. There are three types of response instructions, namely, normal response, error response and no-response. When there is a mistake in the length of instruction, validation, byte sequence or the flag, etc., the error response will utter a sound.

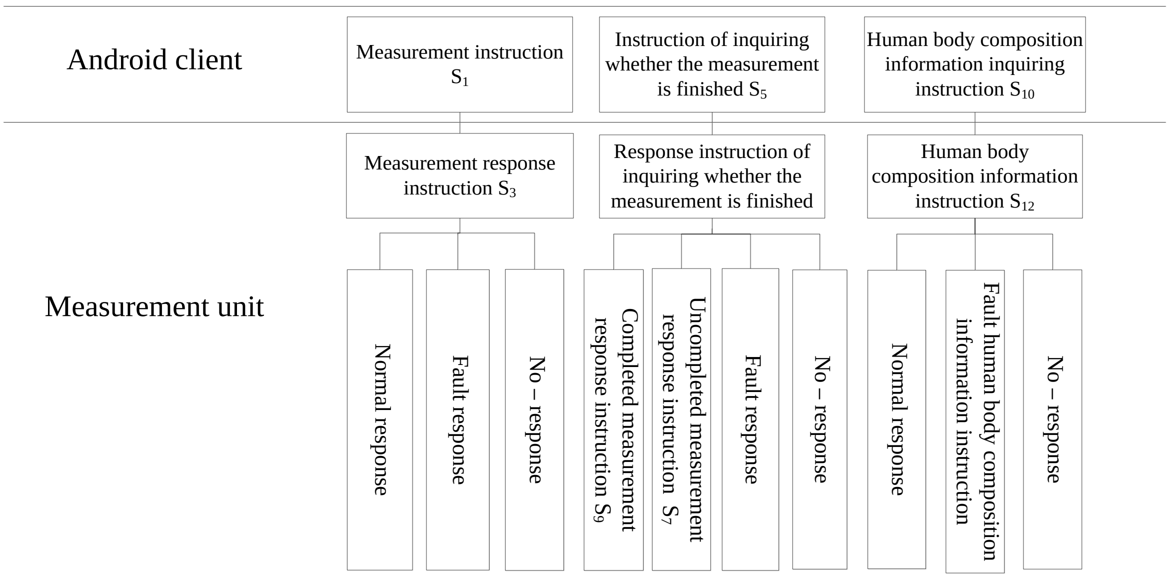


Fig. 4 Instruction for obtaining human body composition information from the measurement unit

To make the system reliable and able to handle deficiencies, the following parameters are added in the process of communication. Their values can be set up in the system setting module. The maximum number of fault $M$; the maximum number of no-response $N$; fault time interval $T_m$; no-response time interval $T_n$; inquiry interval $T_i$ and the maximum waiting time of measurement $T$.

As is shown in Fig. 5, the Android client follows steps below to obtain the human body composition information from the measurement unit:

Step 1: Initialize parameters of the Android client. The number of the Android client not receiving the first response instruction $S_2$ is $n_1 = 0$. The number of the Android client receiving the measurement fault instruction $S_4$ is $m_1 = 0$. The number of the Android client not receiving the second response instruction $S_6$ is $n_2 = 0$. The number of the Android client receiving the inquiry fault response instruction $S_8$ is $m_2 = 0$. The waiting time of the Android client receiving the uncompleted measurement response instruction $S_7$ is $T_i = 0$. The number of the Android client not receiving the third response instruction $S_{11}$ is $n_3 = 0$. The number of the Android client receiving the fault instruction of human body composition information $S_{13}$ is $m_3 = 0$.

Step 2: The Android client sends the measurement instruction $S_1$ to the measurement unit.

Step 3: The Android client makes a judgment on whether it has received the first response instruction $S_2$ from the measurement unit. If it doesn't, then $n_1 + 1$ is assigned to $n_1$ and implement Step 4. Otherwise implement Step 5.

Step 4: Judge whether the number $n_1$ of not receiving the first response instruction $S_2$ is ≥ the maximum number of no-response $N$. If it does, then report the error of the first no-response. Otherwise, wait the no-response time interval $T_\mathrm{n}$ and be back to implement Step 2.

Step 5: The Android client makes a judgment on whether the first response instruction $S_2$ is the measurement response instruction $S_3$. If it isn't, then it means $S_2$ is the measurement fault instruction $S_4$. $m_1 + 1$ is assigned to $m_1$ and implement Step 6. Otherwise implement Step 7.

Step 6: Judge whether the number $m_1$ of not receiving the first response instruction $S_4$ is ≥ the maximum number of fault $M$. If it does, then report the error of the first fault. Otherwise, wait the no-response time interval $T_m$ and be back to implement Step 2.

Step 7: The Android client sends $S_5$: the instruction of inquiring whether the measurement is done.

Step 8: The Android client makes a judgment on whether it has received the second response instruction $S_2$ from the measurement unit; If it doesn't, then $n_2 + 1$ is assigned to $n_2$ and implement Step 9. Otherwise implement Step 10.

Step 9: Judge whether the number $n_2$ of not receiving the second response instruction $S_6$ is ≥ the maximum number of no-response $N$. If it does, then report the error of the second no-response. Otherwise, wait the no-response time interval $T_n$ and be back to implement Step 7.

Step 10: Judge whether the second response instruction $S_6$ is the uncompleted measurement response instruction $S_7$. If it is, implement Step 11. Otherwise implement Step 13.

Step 11: The Android client waits for the inquiry time interval $T_i$, and $T_i + T_i$ is assigned to $T_i$.

Step 12: Judge whether the inquiry time interval $T_i$ is ≥ the maximum waiting time $T$ of measurement. If it is, report the error of overtime. Otherwise, implement Step 7.

Step 13: Judge whether the second response instruction $S_6$ is the inquiry fault response instruction $S_8$. If it is, $m_2 + 1$ is assigned to $m_2$, and implement Step 14. Otherwise implement Step 15.

Step 14: Judge whether the number $m_2$ of inquiry fault response instruction $S_8$ is ≥ the maximum number of fault $M$. If it does, then report the error of the second fault. Otherwise, wait the no-response time interval $T_m$ and be back to implement Step 7.

Step 15: Judge whether the second response instruction $S_6$ is the completed measurement response instruction $S_9$.

Step 16: The Android client sends the instruction $S_{10}$ of human body composition information to the measurement unit.

Step 17: The Android client judges whether it has received the third response instruction $S_{11}$ from the measurement unit. If it doesn't, $n_3 + 1$ is assigned to $n_2$, and implement Step 18. Otherwise implement Step 19.

Step 18: Judge whether the number $n_3$ of not receiving the third response instruction $S_{11}$ is ≥ the maximum number of no-response $N$. If it does, then report the error of the third no-response. Otherwise, wait the no-response time interval $T_n$ and back to implement Step 16.

Step 19: Judge whether the third response instruction $S_{11}$ is the $S_{12}$: human body composition information instruction. If it is not, it means the third response instruction $S_{11}$ is the fault instruction $S_{13}$ of the human body composition information. $m_3 + 1$ is assigned to $m_3$ and implement Step 20. Otherwise the Android client successfully obtains the human body composition information from the measurement unit.

Step 20: Judge whether the number $m_3$ of the fault instruction $S_{13}$ of the human body composition information is ≥ the maximum number of fault $M$. If it is, then report the error of the third fault. Otherwise, wait for the fault time interval $T_m$ and back to Step 16.

## Discussion

Currently, most commonly occurring human body composition systems are running on traditional embedded systems or PCs. On one hand, systems running on traditional embedded systems have low device costs and energy consumption. Owing to long development cycles and difficulties in system development and maintenance, especially in graphics programming, their development costs are relatively high. Moreover, they often could not offer attractive user interfaces and do poor in man-machine interaction. On the other hand, PCs are powerful. Systems running on them have low development costs due to the RAD (rapid application development) of high level programming languages. However, their major drawbacks are that they have poor mobility and portability because of the heaviness and bulkiness of their devices. The use of mouse and keyboard leads to an indirect man-machine interaction experience and could not bring a satisfactory user experience. Furthermore, their energy consumption and device costs are generally very high.

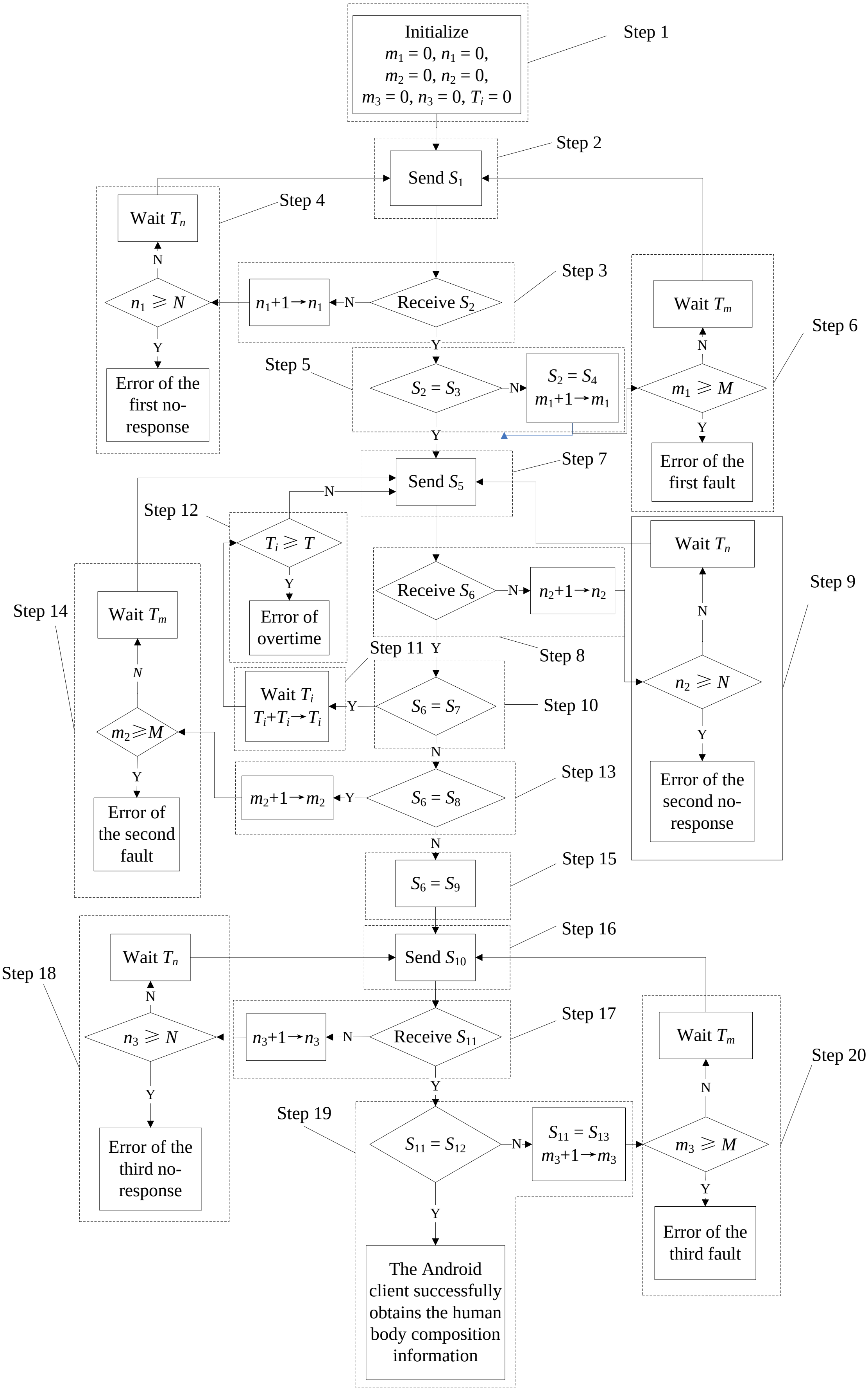


Fig. 5 Steps that the Android client follows to obtain the human body composition information from the measurement unit

Our proposed system has the merits of low device costs, low development costs, low energy consumption, good user experience and mobility. Compared with systems running on traditional embedded systems or PCs, our proposed system combines their advantages, makes up for their major weaknesses and has better usability.

As is shown in Fig. 3, there is only one chance of data communication between the client and the measurement unit in the common communication process of human body composition measurement. Therefore, the communication process cannot be supervised. Nor the fault can be captured or handled.

Compared with the common communication process, whenever the Android client of our proposed system sends a communication instruction, it will always receive a response instruction from the measurement unit so that the measurement unit is under supervision. Instruction waiting and retransmission control under different circumstances are added. The number of retransmissions can be set up through the system setting module. Our proposed system is introduced with exception handling mechanisms that can category, capture, handle and report different communication errors. Each process is under effective control. Thus, the communication of the system is very reliable.

## Conclusion

This paper proposes an Android-based information system of human body composition. It is much advanced than the previous ones running on PCs or traditional embedded systems which do poor in man-machine interaction and have high cost and poor mobility, etc. Our proposed system combines their advantages, makes up for their major weaknesses. The measurement unit is able to control the weight sensor and potential electrodes. It can quickly and accurately measure the weight and human body composition information through BIA, thus providing users with important and comprehensive health information. In addition, this new system also makes it possible to popularize the home-style human body composition measurement devices. It can manage user profile information in an all-round way and back up the information into the Database Server. Time is largely saved when batch importing the information from the FTP Server or portable storage devices. Besides, the system can also store the human body composition information in local areas and the Database Server, and export it to the FTP Server or portable storage devices for data analysis. Users are able to look through the information through the Web Server. More importantly, the system has optimized the communication process of human body composition measurement. As a result, the client and the measurement unit are robust and capable of addressing the fault and solving deficiencies in the communication process. With a more reliable system, accurate transmission of data can be guaranteed.

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