Mobile Health Monitoring System via Bluetooth Technology

نظـام المراقبـة الصحـية باسـتخدام جهـاز الهاتـف النقـال عبـر تقـنيـة البلـوتـوث

Prepared By:

Mohammed Abu khadra

Supervised By:

Prof Dr. Muzhir Shaban Al-Ani

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Letter of Conduct

I, the undersigned "**Mohammed AbuKhadra** " authorize hereby Amman Arab University to provide copies of this thesis to libraries, institutions and any other parties upon their request .

Name: **Mohammed Fuad Abukhadra**

Signature: 

Date: 30/11/ 2011

Resolution of the Examining Committee

This dissertation titled "**Mobile Health Monitoring System via Bluetooth Technology**" Has been defended and approved on 30 / 11 / 2011.

Examining Committee	Title	Signature
1. Dr. Rashid Al-Zubaidy	Assoc. Prof.	
2. Dr. Mohammad Nassar	Assi. Prof	
3. Dr. Akram Othman	.....	
4. Dr. Muzhir Shaban	Prof.	

Letter of Conduct

Thesis title:
"Mobile Health Monitoring System via Bluetooth Technology"

I, **Mohammed Fuad AbuKhadra**, herby acknowledge my full responsibility conducting of the above mentioned thesis under the supervision of **Prof Dr. Muzhir Shaban Al-Ani**, submitted to **Amman Arab university** in partial fulfillment of requirement for Master degree in Computer Sciences, and if any of suspected research misconduct, including fabrication, falsification or plagiarism, and other irresponsible research practices that undermine the trustworthiness of my research, such as carelessness, improperly listing authors, failing to report conflicting data, or the use of misleading analytical methods.

Best Regards,

Name: Mohammed AbuKhadra

 **Signature:**

Date: 5/12/2011

DEDICATION

To My Mother, my family for their love and support and to Dr Muzhir Shaban, Dr Alla Al- Hameme for their Encouragement, and to every one support me during my study.

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My greatest debt also goes to the computer department staff and my friend at the university.

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List of Abbreviation

ACL	Access Control List
AMS	Application Management Software
APIs	Application Programming Interfaces
BANS	body area network
BCC	Bluetooth Control Center
BNEP	Bluetooth Network Encapsulation Protocol
Bpm	Beats per minute
CBS	Cell Broadcast Service
CDC	Connected Device Configuration
CDMA	Code division multiple access
CLDC	Connected Limited Device Configuration
ECG	Electrocardiography
EDR	Enhanced Data Rate
EMG	Electromyography
FTP	File Transfer Protocol
GAP	Generic Access Profile
GOEP	Generic Object Exchange Profile
GPRS	General packet radio service
GSM	Global System for Mobile Communications
HCI	Host Controller Interface
HFP	Hands-Free Profile
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure
IDE	Integrated development environments
IEEE	Institute of Electrical and Electronics Engineers
IrDA	Infrared Data Association
J2EE	Java 2 Platform, Enterprise Edition
J2ME	java2MicroEdition
J2SE	Java 2 Platform, Standard Edition
JNI	Java Native Interface
JVM	Java Virtual Machine
L2CAP	Logical Link Control and Adaptation Protocol

MAC	Media Access Control
Mbps	Megabit per second
MIDP	Mobile Information Device Profile
mW	Milli watt
OBEX	Object Exchange Protocol
OEM	Original Equipment Manufacturer
OS	Operating system
OSI	Open Systems Interconnection
OTA	Over-the-air programming,
PDA	personal digital assistant
RF	Radio Frequency
RFCOMM	Radio frequency communication
RFCOMM	Serial Cable Emulation Protocol
SDAP	Service Discovery Application Profile
SDDB	Server's Service Discovery Database
SMS	Short Message Service
SPP	Serial Port Profile
SSL	Secure Sockets Layer
TCKs	Technology Compatibility Kits
TCP	Transmission Control Protocol
TCS	Control Protocol Specification
TDD	Time Division Duplex
UDP	User Data Preservation
USB	Universal Serial Bus
UUID	universally unique identifier
Voip	Voice over Internet Protocol
WLAN	wireless local area network
WMA	Wireless Messaging API
WTLS	Wireless Transport Layer Security
Bpm	Beat per minute
HR	Heart Rate

نظـام المـراقبـة الصحيـة باستـخدام جهـاز الهـاتف النقـال عبـر تقنيـة البلـوتـوث

Arabic summary

المـلخـــص

مع تطور التكنولوجيا الحاســوبية التي تـدعم كـافة التطبيقات الالكترونية والطبية ،والتي تعتمد على اسـتخدام الآلات والأجهزة الالكترونية والطبية المختلفة في التطبيقات الحاسوبية وفي كافة المجالات، نتيجة الحـاجـة لآليـة ربط سريعة وبســيطة للقيام بعملية ربط مباشر بين المرضى والأطباء بأقل كلفة ومن أي مكان باستخدام أجهزتهم الخلوية.

من خلال هذه الأطروحة نقدم دراســة تحتوي شرحا وتفصــيلا عن اســتخدام جهاز الهاتف الخلوي في التطبيقـات الطبيـة و تتضــمن هـذه الدراســة القيام بصــنع دائرة الكترونية تقوم بقياس معدل نبض المستخدم ودرجة حرارته، من ثم إرسال هذه البيانات بعد تحويلها من صيغة تماثلية إلى رقمية عبر تقنية البلوتوث باستخدام جهاز بلوتوث يرتبط مباشرة في هذه الدائرة.

تمـت برمجـة النظـام عن طريق لغـة الجـافـا لأجهزة المحمول، وهو عبارة عن نظام تفاعلي يقوم بالبداية بالسـماح للأشـخاص المصرح لهم بالدخول إلى البرنامج عن طريق طلب اسـم المستخدم وكلمة سر خاصة بهم، ويقوم بالربط مع جهاز البلوتوث في الدائرة المصــنعة لجلب البيانات، عند اســتقبال البيانات يقوم بعرضـها بشـكل تفصيلي، ويقوم بتحديثها بشكل تلقائي بالإضافة لذلك عند وجود أي تغير كبير أو مهم في بيانات المريض يقوم البرنامج تلقائيا بإرســال رســالة إلى الطبيب أو الأشــخاص العاملين في الوحدة الطبية لاتخاذ الإجراء اللازم وهو ما يوفر نظام ربط كامل بين المرضى والأطباء من خلال اسـتخدام شـبكة الهاتف المحمول لتوفير الوقت والجهد والمال للمرضى وأبقاهم على اتصــال مباشر مع أطباءهم في أي وقت ومن أي مكان.

Mobile Health Monitoring System via Bluetooth Technology

Abstract

With the development of computer technology that supports all electronic and medical application, which relay on the use of machinery and electronic devices and various medical applications in computing and in all areas, there was a need for a mechanism to link a quick and simple direct link between patients and doctors with the least cost from anywhere using their handsets.

This thesis provides detailed explanation for the use of a cellular phone in medical applications; electronic circuit was developed and implemented in this thesis, this circuit measures the human heart rate and temperature, it was connected with analogue to digital converter that send the data via Bluetooth technology using Bluetooth device attached directly to the circuit.

The system has been programmed using j2me programming language for mobile devices. This system is an interactive system created to allow authorized users to enter the program by requesting a user name and password of their own, the program allows the connection with the Bluetooth adapter in the circuit to retrieve data. When receiving data the mobile display it in details, and also it can update the data automatically, so if there is any significant change for patient data then the software automatically sends a message to the doctor or to the working staff in the medical unit, this message contains information about patient status to take the necessary action, thus provide full linking system between patients and doctors through the use of the mobile phone network to save time, effort and money for patients to keep them in direct contact with their doctors at anytime from anywhere.

Chapter1 Introduction

1.1 Introduction

As mobile devices have become an important part of our life, it can integrate people's health care directly to medical staff. It enables the delivery of accurate medical information anytime and anywhere by the using of mobile devices. The potential for pervasive computing is evident in almost every aspect of our life including the hospital – emergency and critical situation industry, education or the hostile battle field.

Bluetooth is wireless and automatic. You don't have to keep track of cables, connectors, and connections, and you don't need to do anything special to initiate communications. Devices find each other automatically and start conversing without user input, except where authentication is required, Bluetooth handles both data and voice. Its ability to handle both kinds of transmissions simultaneously makes possible such innovations as a mobile hands-free headset for voice with applications that print to fax, and that synchronize the address books on your PDA, your laptop, and your cell phone.

Ranganath Kothamasu [1], defined system health monitoring is a set of activities performed on a system to maintain it in operable condition. Monitoring may be limited to the observation of current system states, with maintenance and repair actions prompted by these observations.

Martin Chaplin [2], define a biosensor as an analytical device which converts a biological response into an electrical signal.

He listed the generations of biosensors as:

- First generation biosensors where the normal product of the reaction diffuses to the transducer and causes the electrical response.
- Second generation biosensors which involve specific 'mediators' between the reaction and the transducer in order to generate improved response.
- Third generation biosensors where the reaction itself causes the response and no product or mediator diffusion is directly involved.

Because of rising cost for health care service, there is no justice between biomedical services and their costs, wireless transmission of real time bio signals is becoming more and more in use, the transmission over one of the available wireless network technology based on GSM, GPRS, as client server network.

GSM (Global System for Mobile communication) is a digital mobile telephony system. GSM uses a variation of time division multiple access

(TDMA) and is the most widely used of the three digital wireless telephony technologies (TDMA, GSM, and CDMA).

GSM digitizes and compresses data, then sends it down a channel with two other streams of user data, each in its own time slot. It operates at either the 900 MHz or 1800 MHz frequency band.

Mobile telemedicine system is becoming very important especially in the care of patients who is isolated or has to travel along way to reach a reference hospital.

Home health care is fastest –growing segment of the medical device industry. on increasing num of patient with chronic medical condition

and rising health cost are the main forces behind the trend of immersing the consumer home market with (smarter) and (friendlier) medical device .

The use of body area network (BANS) is to investigate and then its bio signal monitored and transmitted to remote health care center over GPRS or using SMS.

Cardiology monitoring can help in diagnosis and identification of syncope and other paroxysmal arrhythmias, long term patient; activity monitoring can help elderly people.

The research community has been active in pursuit of technologies for a Wireless ECG" where patients are no longer required to be attached to a large stationary device while their ECG signals are monitored.

A major motivator behind this trend is the reduced healthcare costs of remote monitoring, where patients can reside in their homes rather than occupy a hospital bed. Many systems have been proposed to accomplish this feat, with varying goals and approaches.

Depending on this huge concern which is people life and people heath status. Our need to make modification to use mobile device as health checker to examine patient health, store medical data of the patient and connect with his medical care unit like doctors, hospitals …etc.

Continuous personal monitoring of chronic patients can reduce hospitalization and improve patients' quality of life; the analysis of the ECG has been widely used for diagnosing much cardiac disease.

1.2 Literature Review

The Remote Health Monitoring System (RHMS) is the IT backbone that supports Health Frontier's entire portfolio of solutions. It captures data transmitted by the patient through USB, Bluetooth, or trans-telephonically. The RHMS then stores the information in a database, which can be accessed by the patient's doctor through a web-based interface [3].

W.Kannel, T.Gordon, W.Castelli, J.Margolis [4], describe the value of the electrocardiogram is established in determining high and low blood potassium and low blood calcium values in various conditions. W.Muchow [5], used java in a wide variety of computing platforms from embedded devices and mobile phones on the low end, to enterprise servers and supercomputers on the high end. Java is used in mobile phones, Web servers and enterprise applications, and while less common on desktop computers; Java applets are often used to provide improved and secure functionalities while browsing the Web.

There are many published works related to mobile computing technologies for improving the using of wireless health sensor to perform medical care along long time evaluation. I list them as three segments each one of the segment is proposed for the same type:

First segment wireless sensor attached to patient body collects health data, sends it to module using Wi-Fi technology, and sends it via Bluetooth technology to mobile device; this investigation is implemented as follows:

- Tsui, Chi Murch [6] proposed an invention that includes mobile device similar to today's cellular telephone acting as center for collecting health and life style data to provide the data to heath care professional also invitation include sensor embedded in user body the sensor operate the data using wireless technology.

- Rifat Shahriyar, Faizul Bari[7] proposed Wearable Wireless Body/Personal Area Network for collecting data from patients, mining the data, intelligently predicts patient's health status and provides feedback to patients through their mobile devices. Also it collects patient's physiological data through the bio-sensors. The data is aggregated in the sensor network and a summary of the collected data is transmitted to a patient's personal computer or cell phone/PDA. These devices forward data to the medical server for analysis. After the data is analyzed, the medical server provides feedback to the patient's personal computer or cell phone/PDA. The patients can take necessary actions depending on the feedback.
- CHRIS OTTO [8] described a general wireless body area network architecture and how it can be integrated into a broader telemetrically system. The writers Designed a prototype Wireless Body Area Network that consists of a personal server, implemented on a personal digital assistant (PDA) or personal computer (PC), and physiological sensors, implemented using off-the shelf sensor platforms and custom-built sensor boards. The WBAN includes several motion sensors that monitor the user’s overall activity and an ECG sensor for monitoring heart activity.

- Val Jones [9] proposed patient biological signals measured by means of body sensor which communicate wirelessly with hand held device by investigating the application of body area network technology with a number of clinical settings in order to offer remote health monitoring and treatment service using the mobile device as alarming and monitoring unit .
- Lin Zhong, Mike Sinclair, Ray Bittner [10] platform consists of one mobile phone, multiple sensor node and cache watch. The sensor node is powered using rechargeable battery size of coin .the platform make the solution to reduce power usage for the sensor node and also for the mobile device as the phone in standby mode consumes about 20 mw when Bluetooth is disabled, and consumes 21 mw when Bluetooth is enabled in pending mode with default parameters from windows mobile , when transferring data at 115 kps the phone consumes about 440 but when SIM card removed it consumes about 4 mw . By introducing an internet capable phone as the network center and manager and lever-aging its resources and implements Bluetooth parameter tuning to reduce Bluetooth energy consumption in peripherals to make connection between sensor nodes and mobile.

Second segment implements the connection of wireless sensor to PDA, Smart Phone direct which gets the health data from the user and sends it wireless to smart phone or special type of machines that process the data and view it to the user as figures or as numeric data.

- Felix Xiaozhu, Ahmad Rahmati, and Lin Zhong [11] Provides a framework for developing wireless body sensor application on smart phone, performing the programming for the body sensor and how to make functions for receiving data for the developer of the smart phone programmer and how to get the data from the sensor using sensor programming called sanselt, dandelion allows developers to easy write data processing code to be executed on sensor.

- Bernstein, Daniel [12] Implements a health monitoring device compression housing, the analyst sensor monitor an analyst level, and data transfer module coupled to housing and in signal communication with the analyst sensor. The health monitor transfers the data to the analyst sensor store the data to the monitor analyst level

- Chen, Ga-lane [13] Obtain the usage of mobile phone by improving mobile phone functionality of health care using special sensor physiological function director connecting direct with mobile to process body health information.

Third segment:

This Segment Concerns making modification for the wireless sensor to send the data intelligence (the important data) using Wi-Fi to laptop, pc or handheld devices (mobile and phones) to be processed and modified.

- Benny Lo, Guang-Zhong Yang [14] Describe the aim of the body sensor network which's to provide continuous monitoring of the patient under their natural physiological state by that life threatening abnormalities can be dedicated and predicted. In order to provide continuous monitoring ,micro powered miniaturized and low cost wireless biosensor are required. This paper also determines that wireless sensor network hardware platforms can be modified for body sensor network application and only few platform can actually be used for body sensor network in practice due to the extensive bandwidth and computational requirements and size constraints for body sensor network. Also it provides type of sensor such as ECG(Electrocardiogram)sensor very few sensors can be set up in a network due to high band width and high sampling rate required for ECG sensor 200 MHz .

- M. Jamil, M, F. M. Zain,V. Krishnamurthy[15] proposed a wireless intelligent sensor and actuator network has developed as vibration based structure monitoring network that allows extraction of mode shape from output only vibration data from structure, the mode shape information can further be used in model method of damage detection .

1.3 Statement of the problem

Patients usually have to visit their doctor for medical checkup or medical feedback. This traditional way of checking health monitor consumes both patient's time and money. If we provide patients (users) with a simple, easier and more personalized way to get their medical feedback and they get connected directly to their doctors using low cost technology using their mobile phones GSM via SMS technology, we will achieve a great phenomenon in our generation. Many diseases need heart rate and temperature monitor for long time after medical treatment like: Angina pectoris, stroke, heart attack, diabetes high or low blood pressure, hardening of the arteries, enlargement of the arteries, after serious surgery or a coma. Some of these diseases need full and continues heart rate monitor because it depends on the heart.

The implementation of using mobile device as a medical care unit in order to manage and to control the mechanism of health care check up for sick people will help them to spot problems (diseases) and keep patients heart rate on control even he is out of hospital or far from medical staff by sending alarms to medical department using SMS for patients heart status.

The Proposed Medical circuit connected with mobile devices as health monitoring unit, check patient health status and retrieve the medical information of them like temperature, heartbeat, using mobile screen and connects him directly to medical staff using GSM.

1.4 Aims of the thesis

This thesis gives an implementation for mobile Bluetooth health monitoring system, specified as follows:

Interface mobile device with medical sensors via Bluetooth technology for checking people (patient) health status and provide medical feed back to medical care unit any time from any where.

Mobile device applications can be used to detect health status of patients and view the result with easy implementation for the end user.

Continues health mentioning for patients who need real and important care through their sickness, by keeping direct connection between them and medical staff using their mobile phones GSM via SMS technology by sending SMS alarm directly Via GSM ,that will save patients cost, time and effort by providing medical care system for along time .

Flexible system that can be used by the normal user without need for medical staff assistant, smarter system runs and takes action directly.

1.5 Structure of the Thesis

Through this thesis, Chapter 1 provides introduction for the thesis with the literature review and the aim of the thesis. Chapter 2 provides description for the heart and ECG system, describes Bluetooth technology and full view for Java and J2ME. Chapter 3 describes system design and implementation of the system.

Chapter 4 provides the results and analysis for the implemented system. Chapter 5 provides the conclusion and recommendation for future work.

Chapter 2 Theoretical Approach

2.1 ECG Electrocardiogram

The analysis of the ECG has been widely used for diagnosing much cardiac disease Beat detection is necessary to determine the heart rate and several arrhythmias Cardiology monitoring can help in diagnosis and identification of syncope and other paroxysmal arrhythmias, long term patient activity monitoring can help patients save their money, efforts during their thereby from many type disease, like Angina pectoris, stroke, heart attack, diabetes high or low blood pressure, hardening of the arteries, enlargement of the arteries, After Serious surgery, a coma.

While Physiological monitoring system measures [16]:

1. Heart rate.
2. Two lead electrocardiogram (ECG).
3. Respiration rate and effort.
4. Skin temperature (multiple locations).
5. Core body temperature (ingestible capsule).
6. Body orientation.
7. Blood oxygen saturation.
8. Impact and fall detection

The intrinsic cardiac pacemaker system is responsible for generating these electrical signals which serve to command and coordinate contraction of the four chambers at the heart at the appropriate intervals [atria (upper chambers) first, then the

ventricles (lower chambers) a fraction of a second later], and their analysis reveals a wealth of information about cardiac regulation, as well insights into pathological conditions. Each heartbeat produces a similar pattern in the ECG signal [17].

Electrocardiography Definition is a commonly used, noninvasive procedure for recording electrical changes in the heart. The record, which is called an electrocardiogram (ECG or EKG), shows the series of waves that relate to the electrical impulses which occur during each beat of the heart [18].

An electrocardiogram is a measurement of the electrical activity of the heart (cardiac) muscle as obtained from the surface of the skin. As the heart performs its function of pumping blood through the circulatory system, a result of the action potentials responsible for the mechanical events within the heart is a certain sequence of electrical events [19].

2.1.1 ECG Electrocardiogram Characteristics

The ECG records the electrical activity that results when the heart muscle cells in the atria and ventricles contract. Atrial contractions (both right and left) show up as the P wave. Ventricular contractions (both right and left) show as a series of 3 waves, Q-R-S, known as the QRS complex [20].

The third and last common wave in an ECG is the T wave. This reflects the electrical activity produced when the ventricles are recharging for the next contraction (depolarizing). Interestingly, the letters P, Q, R, S, and T are not abbreviations for any actual words

but were chosen many years ago for their position in the middle of the alphabet. The electrical activity results in P, QRS, and T waves that have a myriad of sizes and shapes [20].

2.1.2 The QRS Complex

The QRS complex represents ventricular depolarization. The main elements are Q, R, and S waves. The Q wave is the first negative deflection after the P wave. The R wave is the first positive deflection after the P. The S wave is the first negative deflection after the R wave. During the ventricular activation, the right pericardial leads will record negative ventricular QRS complexes. On the other hand the complexes recorded by medial primordial leads will be equiphasic [21].

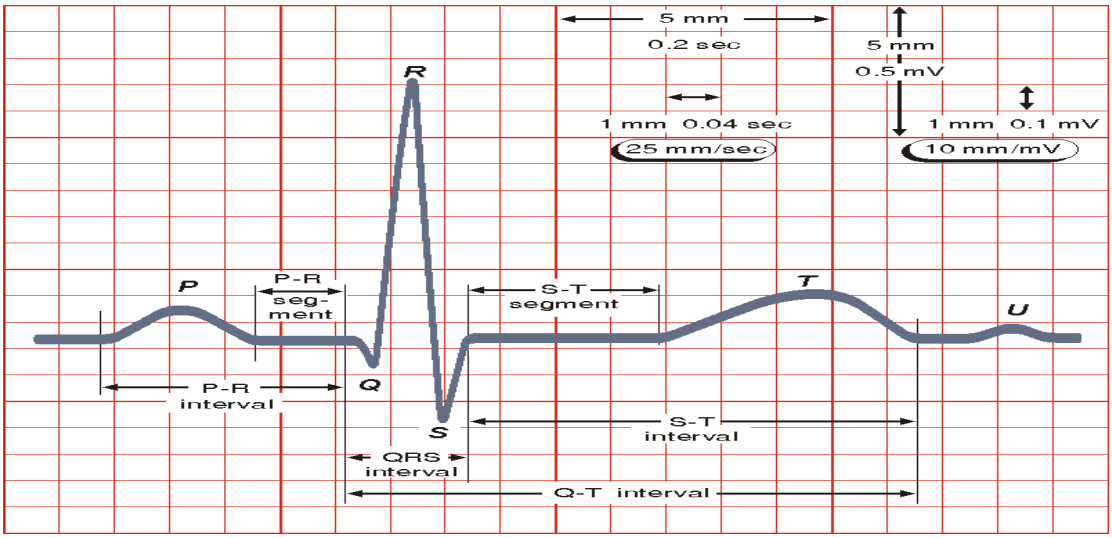

Figure 2.1: The normal electrocardiogram with QRS complex [22].

Based on the rhythm of the recorded ECG and the patterns of the segments and intervals in ECG waveform, abnormalities can be detected and a diagnose can be given, heart rate value will be taken in consideration in implementation for different age of patients.

In children, cardiac output is determined primarily by heart rate as opposed to stroke volume. With age, the heart rate decreases as the ventricles mature and stroke volume plays a larger role in cardiac output. Age and activity-appropriate heart rates thus must be recognized. Average resting heart rate varies with age; newborns can range from 90–160 beats per minute (bpm) and adolescents from 50–120 bpm. The average heart rate peaks about the second month of life and thereafter gradually decreases until adolescence, Heart rates grossly outside the normal range for age should be scrutinized closely for dysrhythmias [23].

Table 2.1: Pediatric ECG: normal values by age [23]

Age	HR (bpm)	QRS axis (degrees)	PR interval (sec)	QRS interval (sec)	R in V1 (mm)	S in V1 (mm)	R in V6 (mm)	S in V6 (mm)
1st wk	90–160	60–180	0.08–0.15	0.03–0.08	5–26	0–23	0–12	0–10
1–3 wk	100–180	45–160	0.08–0.15	0.03–0.08	3–21	0–16	2–16	0–10
1–2 mo	120–180	30–135	0.08–0.15	0.03–0.08	3–18	0–15	5–21	0–10
3–5 mo	105–185	0–135	0.08–0.15	0.03–0.08	3–20	0–15	6–22	0–10
6–11 mo	110–170	0–135	0.07–0.16	0.03–0.08	2–20	0.5–20	6–23	0–7
1–2 yr	90–165	0–110	0.08–0.16	0.03–0.08	2–18	0.5–21	6–23	0–7
3–4 yr	70–140	0–110	0.09–0.17	0.04–0.08	1–18	0.5–21	4–24	0–5
5–7 yr	65–140	0–110	0.09–0.17	0.04–0.08	0.5–14	0.5–24	4–26	0–4
8–11 yr	60–130	−15–110	0.09–0.17	0.04–0.09	0–14	0.5–25	4–25	0–4
12–15 yr	65–130	−15–110	0.09–0.18	0.04–0.09	0–14	0.5–21	4–25	0–4
>16 yr	50–120	−15–110	0.12–0.20	0.05–0.10	0–14	0.5–23	4–21	0–4

Raw of ECG signal acquired contaminated with several noise and artifacts, Noise of ECG raw signals can be classified as:

1. Power line interference
2. Respiration, known as baseline wondering
3. Noise from other electronic devices
4. Electrode pop or contact noises
5. Electromyography (EMG) noise

2.2.1 Bluetooth background

Bluetooth is a wireless communication protocol which is used for short distances and in low power consumption devices. Bluetooth can be used to communicate with other Bluetooth capable devices. In Bluetooth the one who initiates the connection is the master, and the ones who receive the connection are the slaves.

Andrea Zanella, describe Bluetooth technology is very low power consumption that permits its integration in portable, battery driven

electronic devices, such as mobile phone, mouse, PDA and so on. As a matter of fact, Bluetooth standard defines four operational modes, namely Active, Hold, Sniff, and Parked [24].

Bluetooth is an open specification for a low-cost, low-power, short-range radio technology for ad hoc wireless communication of voice and data anywhere in the world. An open specification means that the specification is available publicly. Short-range radio technology means devices can communicate over the air using the waves of radio at a distance of 10 meters (m). When the transmission power is higher than the range increases to approximately 100 m because communication is within a short range, the radios are low power and are suited for portable devices, battery-operated devices. Bluetooth wireless technology supports voice and data, allowing devices to communicate either type of content, Bluetooth wireless technology works anywhere in the world because it operates at 2.4 GH [25].
Power management in Bluetooth has Two main states defined for Bluetooth devices [26]:
1) Standby. No data are exchanged. Only the clock is running.
2) Connection. In this state each device is connected with the master of the Piconet, Four sub-states are possible:

- Active mode the device is active in the Piconet.
- Sniff mode this is a low power-consuming state as the listening activity is working during the sniff slots only.
- Hold mode. The ACL traffic of a device is stopped for a certain period.
- Park mode. The device is no longer a member of the piconet, but it remains synchronized with the master of the piconet. This is the lowest power-consuming state.

2.2.2 Bluetooth versions

Bluetooth versions 1.1 and 1.2 specify transmission speeds of up to 1 megabit per second (Mbps) and achieve throughput of approximately 720 kilobits per second (kbps), Bluetooth versions 2.0 + Enhanced Data Rate (EDR) and 2.1 + EDR specify data rates up to 3 Mbps and throughput of approximately 2.1 Mbps. The range of Bluetooth devices is characterized by three classes that define power management; Table 2.2 summarizes these classes, Bluetooth devices which specify the antenna's output power. Class 1 devices broadcast using 1 mill watt to 100 mill watt of power; Class 2 devices broadcast using 0.25 mill watt to 2.5 mill watt of power; and Class 3 devices broadcast using up to 1 mill watt of power. Class 1 devices must be able to change their power output in increments of 2 dB to 8 dB; power control is optional for Class 2 and Class 3 devices. These power classes have signal ranges of approximately 100m, 10m, and 1m, respectively [27].

Table 2.2 Bluetooth Device Classes of Power Management [27]

Type	Power	Power Level	Designed Operating Range	Sample Devices
Class 1	High	100 mW (20 dBm)	Up to 91 meters (300 feet)	AC-powered devices (USB dongles, access points)
Class 2	Medium	2.5 mW (4 dBm)	Up to 9 meters (30 feet)	Battery-powered devices (mobile devices, Bluetooth adapters, smart card readers)
Class 3	Low	1 mW (0 dBm)	Up to 1 meter (3 feet)	Battery-powered devices (Bluetooth adapters)

There are many short-range wireless standards, but the three main ones are Infrared from the Infrared Data Association (IrDA), Bluetooth wireless technology, and wireless local area network (WLAN), Table 2.3 provides a comparison of these three technologies [28].

Table 2.3 Comparison of Wireless Communication

Feature and function	IrDA	Wireless LAN	Bluetooth communication
Connection type	Infrared, narrow beam, line of sight	Spread spectrum, spherical	Spread spectrum, spherical
Spectrum	Optical 850–900 nm	RF 2.4 GHz (5 GHz for 802.11a/n)	RF 2.4 GHz
Transmission power	40–500 mW/Sr	100 mW	10–100 mW
Maximum data rate	9600 bps–16 Mbps (very rare)	11 Mbps (54 Mbps for 802.11a, 802.11g)	3 Mbps
Range	1 m	100 m	10–100 m
Supported devices	2	Connects through an access point	8 (active), 200 (passive)
Voice channels	No	No	Yes
Addressing	32-bit physical ID	48-bit MAC	48-bit MAC

Technologies [28]

2.2.3 Bluetooth protocol

Incorporates a service-oriented architecture and employs a familiar client/server communication scheme used in other protocols such as HTTP and FTP: Servers wait patiently until a client initiates a request. Current Bluetooth devices on the market are capable of communicating at 3 Mbps and can support wireless audio in stereo. Figure 2.2, below is a diagram showing the layers for Bluetooth protocol [29].

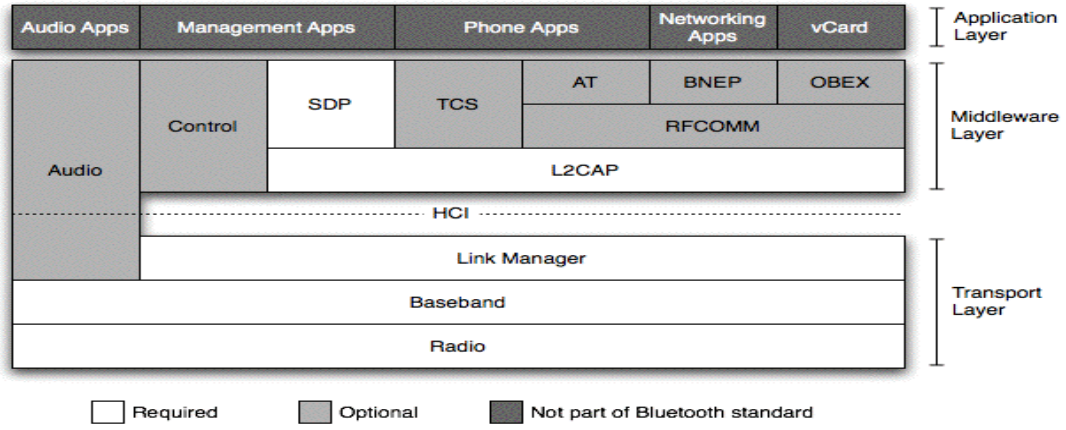

Figure 2.2: Bluetooth protocol stack [30]

Transport layer, The Bluetooth transport layer is roughly equivalent to the traditional OSI and MAC layers. All Bluetooth devices are required to implement this layer in hardware. The transport layer is composed from the radio, base band, and link manager layers, which are described below. [30]

Radio Layer, The radio layer dictates the frequency, power, and modulation used by Bluetooth antennas. Bluetooth occupies 79 channels of 1 MHz each in the 2.4 GHz spectrum, from 2.402 GHz to 2.480 GHz. Devices use only one of these channels at a time, hopping between them as described below. There are also guard bands reserved at either end of the spectrum, at 2.400 GHz–2.402 GHz and at 2.480 GHz–2.484 GHz. In the initial revisions of Bluetooth, all devices used binary phase shift keying (BPSK) modulation; this offers a maximum data rate of 1 Mbps, or about 723 kbps when all packets overhead is taken into account [30].

Base band and Link Layers, at the base band layer, Bluetooth devices form into piconets and/or scatternets. Piconets consist of one master device that communicates directly with up to 7 active slave devices. Piconets can also have up to 250 parked (i.e., inactive) slave nodes at any given time. Multiple piconets can also be combined into a single multi-hop scatternet [30].

Middleware Layer, The components in the middleware layer communicate with the transport layer using the standardized Host Controller Interface (HCI). Some of these components include [30]:

- Logical Link Control and Adaptation Protocol (L2CAP) provide TCP- and UDP-like features to ACL links.
- Radio Frequency Communication (RFCOMM) emulates IrDA infrared links on top of L2CAP.
- Telephony Control Protocol Specification (TCS): controls phone operations.
- AT: controls phone operations using the legacy Hayes ("AT") command set.
- Bluetooth Network Encapsulation Protocol (BNEP): encapsulates Ethernet packets in Bluetooth packets.
- Object Exchange Protocol (OBEX): supports IrDA's object synchronization features.

2.2.4 Bluetooth Piconet

The physical links are created on the basis of masters/slaves (function of the type point to multiple point), a master can control up to seven slaves in his zone. These form a small network called Piconet. The master is simply the first apparatus connected and is

the one that sets the clock, the frequency jumping sequence and the access code for the link. All the Bluetooth modules of the same Piconet use the same frequency jumping sequence and are synchronized with the master's clock [31].

Whatever happens, the machine's role (master or slave) is invisible to the user. Also, one apparatus can participate in several piconets, being the slave in one and master in another. The interlacing of several piconets forms what is called a Scatternet. Thanks to the frequency jumping, 10 independent piconet (or up to 80 apparatus) can transmit at maximum output. Above that, the network becomes saturated [31].

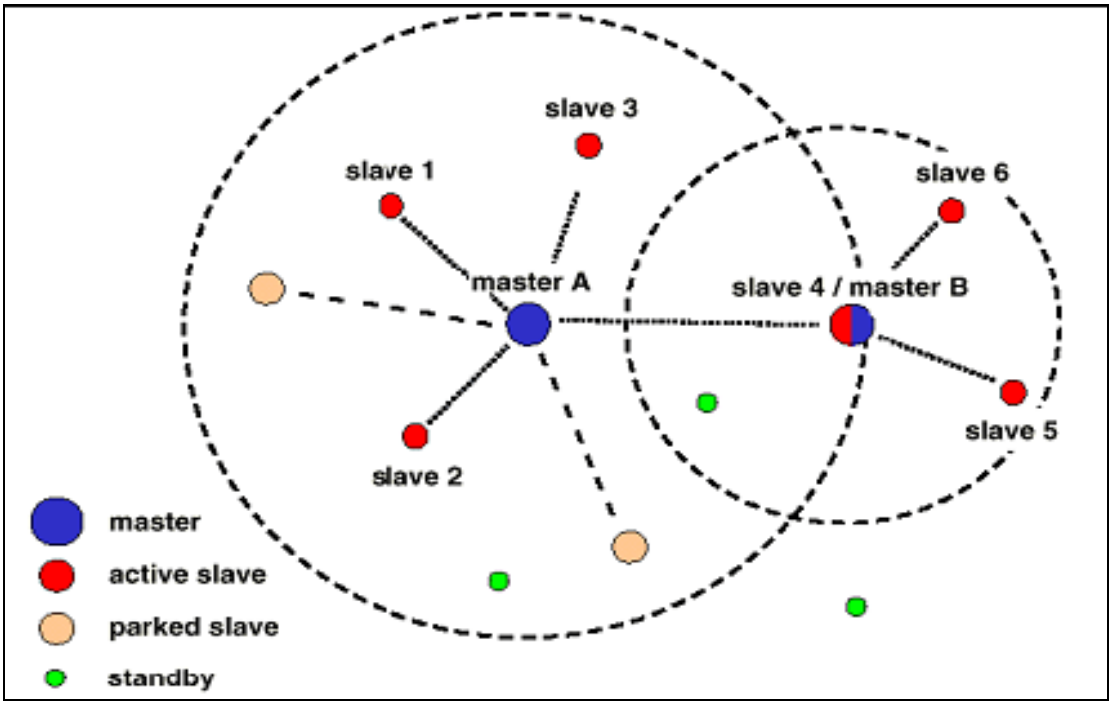

Figure 2.3: Bluetooth piconet [31]

The transmission diagram of the centre of one Piconet is based on the principle of time division duplex (TDD). At first it is the master who sends a packet at a frequency f(k), the slave to whom this packet is addressed (and only this one) has the right to reply to it in

the time interval following the arrival of the master packet. The reply from the slave is then given on the frequency channel f (k+1). On reception of a master packet, a synchronization word on the top of it enables the slave to re-synchronizes his clock [31].

A Bluetooth system is constructed to provide a point-to-point connection or point-to-multipoint connection, in point-to-point connection the physical channel is shared between two devices, and in a multipoint connection several devices share the same channel. Two or more devices sharing a physical channel form a Piconet, where one device act as master and the others as slave. A Scatternet is multiple piconet that share the same devices. If a device is connected to multiple piconet it can only be master in one of these [32].

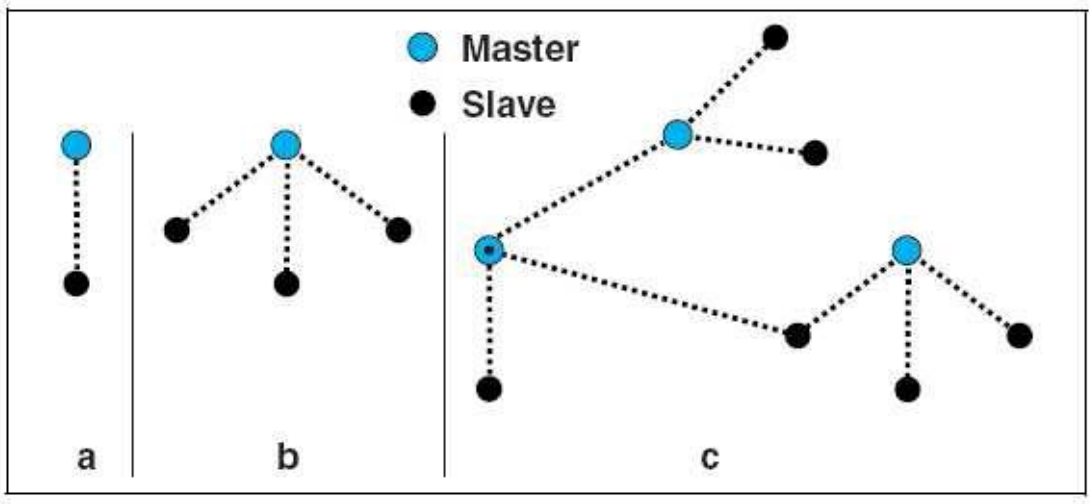

Figure 2.4 Piconet typology, a) Single piconet, b) Multipoint piconet, c) Scatternet [32]

2.3.1 Java Edition and Platform

Developers build applications to suit a particular set of users. Naturally, users of one application will have different needs from

users of another. An application may be built to serve one user at a time, many users at once or even users who might be in a different place any given time. The Java platform realizes the differing challenges facing developers and offers the choice of different Java technologies depending on the user's needs.

A platform is the hardware or software environment in which a program runs. We've already mentioned some of the most popular platforms like Microsoft Windows, Linux, Solaris OS, and Mac OS. Most platforms can be described as a combination of the operating system and underlying hardware. The Java platform differs from most other platforms in that it's a software-only platform that runs on top of other hardware-based platforms [33].

- **Java 2 Platform, Enterprise Edition (J2EE ™)** for enterprises needing to serve their customers, suppliers, and employees with scalable server solutions [34].
- **Java 2 Platform, Standard Edition (J2SE ™)** for the familiar and well established desktop computer market [34].
- **Java 2 Platform, Micro Edition (J2ME ™)** for the combined need of [34]:
    - Consumer and embedded device manufacturers who build a diversity of information devices.
    - Service providers who wish to deliver content to their customers over those devices.
    - Content creators who want to make compelling content for small, resource constrained devices.

Figure 2.5 illustrates the Java 2 Platform editions and their target markets,

Starting from the high-end platforms on the left and moving towards low-end platforms on the right. Basically, five target markets or broad device categories are identified. Servers and enterprise computers are supported by J2EE, and desktop and personal computers by J2SE. J2ME is divided broadly into two categories that focus on “high-end” and “low-end” consumer devices. J2ME is discussed in more detail later in this chapter. Finally, the Java Card™ standard focuses on the smart card market [34].

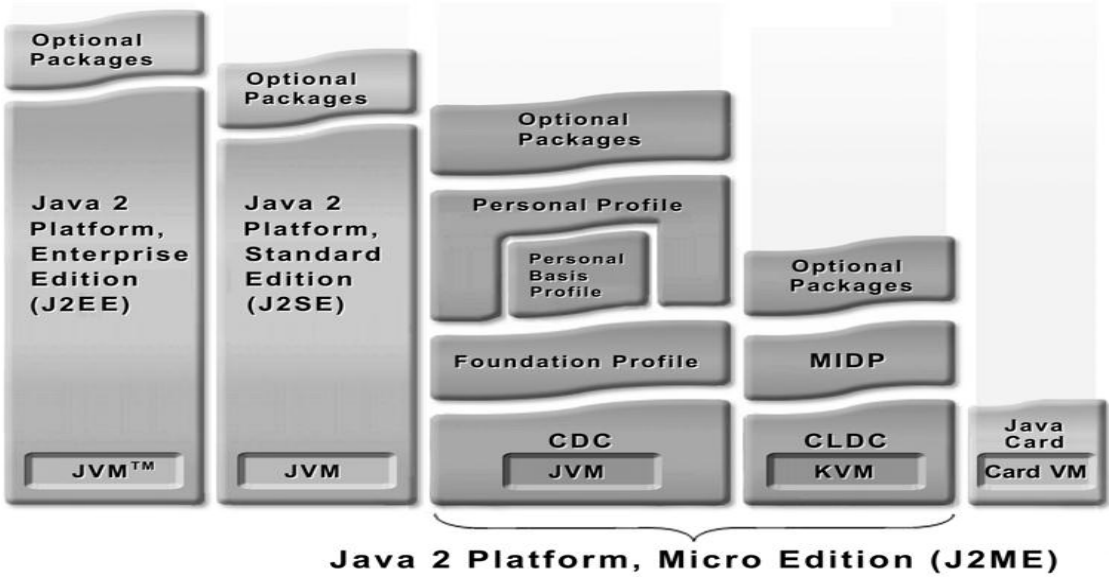

Figure 2.5: Java 2 Platform editions [34]

2.3.2 J2ME Configurations

A configuration is a specification that defines the software environment for a range of devices defined by a set of characteristics that the specification relies on, usually such things as [35]:

• The types and amount of memory available.

• The processor type and speed.

• The type of network connection available to the device.

The creators of J2ME have defined only two configurations to avoid a fragmented landscape of incompatible platforms. The two configurations namely are:

- **Connected Limited Device Configuration (CLDC)**: CLDC is aimed at the low end of the consumer electronics range. A typical CLDC platform is a cell phone or PDA with around 512 KB of available memory. For this reason, CLDC is closely associated with wireless Java, which is concerned with allowing cell phone users to purchase and download small Java applications known as MIDlets to their handsets. A large and growing number of cell phone vendors have signed agreements with Sun Microsystems that will allow them to begin using this technology, so the number of handsets with the capability to be programmed in Java will probably grow rapidly in the next few years [35].
- **Connected Device Configuration (CDC)**: CDC addresses the needs of devices that lie between those addressed by CLDC and the full desktop systems running J2SE. These devices have more memory (typically 2 MB or more) and more capable processors, and they can, therefore, support a much more complete Java software environment. CDC might be found on high-end PDAs and in smart phones, Web telephones, residential gateways, and set-top boxes [35].

2.3.3 J2ME Profiles

J2ME configurations have one or more associated profiles, some of which may themselves rely on other profiles, these processes are described in the following list:

Mobile Information Device Profile (MIDP): This profile adds networking, user interface components, and local storage to CLDC. This profile is primarily aimed at the limited display and storage facilities of mobile phones, and it therefore provides a relatively simple user interface and basic networking based on HTTP 1.1. MIDP is the best known of the J2ME profiles because it is the basis for Wireless Java and is currently the only profile available for Palm OS based handhelds [35].

PDA Profile (PDAP):

The PDAP is similar to MIDP, but it is aimed at PDAs that have better screens and more memory than cell phones. The PDA profile, which is not complete at the time of writing, will offer a more sophisticated user interface library and a Java-based API for accessing useful features of the host operating system. When this profile becomes available, it is likely to take over from MIDP as the J2ME platform for small handheld computers such as those from Palm and Handspring [35].

The J2ME platform consists of a set of layers that support a basic runtime environment with core Java libraries and virtual Machine (VM), a set of system-level application programming interfaces(APIs) in configuration, and a set of application-level APIs in a profile [36].

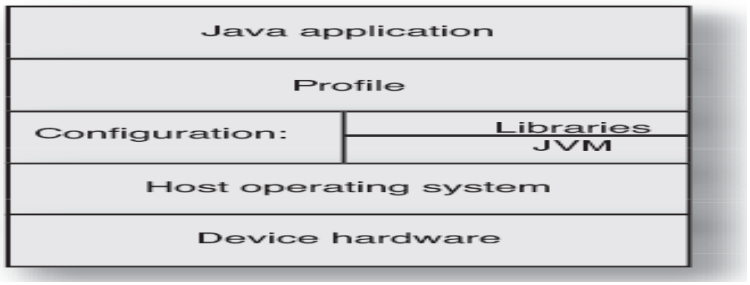

Figure 2.6 : J2ME Layers [36]

CLDC Characteristics as follows [36]:

- 160 to 512 KB total memory available for the Java platform
- 16-bit or 32-bit processor
- low power consumption, often battery powered
- Intermittent network connectivity (often wireless) with potentially limited bandwidth.

2.3.4 Mobile Information Device Profile (MIDP)

The Mobile Information Device Profile (MIDP) is a key element of the (J2ME) when combined with (CLDC); MIDP provides a standard Java runtime environment for today's most popular mobile information devices, such as cell phones and mainstream (PDAs). CLDC and MIDP provide the core application functionality required by mobile applications, in the form of a standardized Java runtime environment and a rich set of Java APIs. Developers using MIDP can write applications once, then deploy them quickly to a wide variety of mobile information devices. MIDP has been widely adopted as the platform of choice for mobile applications. It is deployed globally on millions of phones and PDAs, and is supported by leading integrated development environments (IDEs). Companies around the world have already taken advantage of MIDP to write a broad range of consumer and enterprise mobile applications [37].

MIDP Versions are:

- **MIDP 2.0** (JSR 118) is a revised version of the MIDP 1.0 specification. New features include an enhanced user interface, multimedia and game functionality, more extensive connectivity, over-the-air provisioning (OTA), and end-to-end

- security. MIDP 2.0 is backward-compatible with MIDP 1.0, and continues to target mobile information devices like mobile phones and PDAs. More detailed information on these features can be found in what's New in MIDP 2.0 [37].
- **MIDP 1.0** (JSR 37) is the original specification, which provides core application functionality required by mobile applications, including basic user interface and network security [37].

All MIDP implementations have and support the usage of the following high-level components [38]:

- Alert (used for showing dialog boxes and warnings).
- Choice Group (used for showing group of checkboxes or radio buttons).
- Date Field (used for selecting dates and times).
- Form (used for displaying the subclasses of Item).
- Gauge (used to showing the progress of an operation or process, but it can also be used to represent the percent of a whole).
- Image Item (used for showing images in high-level UI applications).
- List (used for showing lists and combo boxes).
- String Item (used for showing simple text strings).
- Text Box (used for entering text).
- Text Field (an alternate method used for entering text).

The MIDP 2.0 specification added a bridge between the high-level and low-level APIs: the CustomItem class. MIDP 2.0 also enhanced the capabilities of the low-level APIs by creating the MIDP Game API, javax.microediton.lcdui.game,

The Game API includes the Game Canvas class, which is a child of Canvas. In the MIDP 3.0 specification, there have been several additions to the high-level APIs including: [38]

- Animated Image (which allows the creation and rendering of animated images)
- File Selector (a mechanism for browsing directories and selecting files on the file system)
- Tabbed Pane (a mechanism for creating and displaying a tabbed pane)

Table 2.4: MIDP Packages [39]

User Interface Package	
javax.microedition.lcdui	The UI API provides a set of features for implementation of user interfaces for MIDP applications.
javax.microedition.lcdui.game	The Game API package provides a series of classes that enable the development of rich gaming content for wireless devices.
Persistence Package	
javax.microedition.rms	The Mobile Information Device Profile provides a mechanism for MIDlets to persistently store data and later retrieve it.
Networking Package	
javax.microedition.io	Classes for the Generic Connection framework.
Audio Package	
javax.microedition.media	The MIDP 2.0 Media API is a directly compatible building block of the Mobile Media API (JSR-135) specification.

javax.microedition.media.control	This package defines the specific Control types that can be used with a Player.
Public Key Package	
javax.microedition.pki	Certificates are used to authenticate information for secure Connections
Core Packages	
java.io	Provides classes for input and output through data streams.
java.lang	Provides classes that are fundamental to the Java programming language.
java.util	Contains the collection classes, and the date and time facilities

2.3.5 MIDlet

The MIDlet package defines MIDP applications and the interactions between the application and the environment in which the application runs, the use of MIDlet in our system application to provide the GUI and Service for all classes in the application as i will specify in chapter 3, An application of the MIDP is a MIDlet.

The elements of a MIDlet suite are: [40]

- Runtime execution environment
- MIDlet suite packaging
- Application descriptor
- Application lifecycle

A MIDlet is a set of classes designed to be run and controlled by the application management software via this interface. The states allow the application management software to manage the activities of multiple MIDlets within a runtime environment. It can select which MIDlets are active at a given time by starting and pausing them individually. The application management software maintains the state of the MIDlet and invokes methods on the MIDlet to notify the MIDlet of change states [40].

The MIDlet Lifecycle

Mobile devices, whether emulators or real, interact with a MIDlet using their own software, which is called Application Management Software (AMS). The AMS is responsible for initializing, starting, pausing, resuming, and destroying a MIDlet. (Besides these services, AMS may be responsible for installing and removing a MIDlet, as well.) To facilitate this management, a MIDlet can be in

one of three states which are controlled via the MIDlet class methods, which every MIDlet extends and overrides. These states are active, paused and destroyed [41].

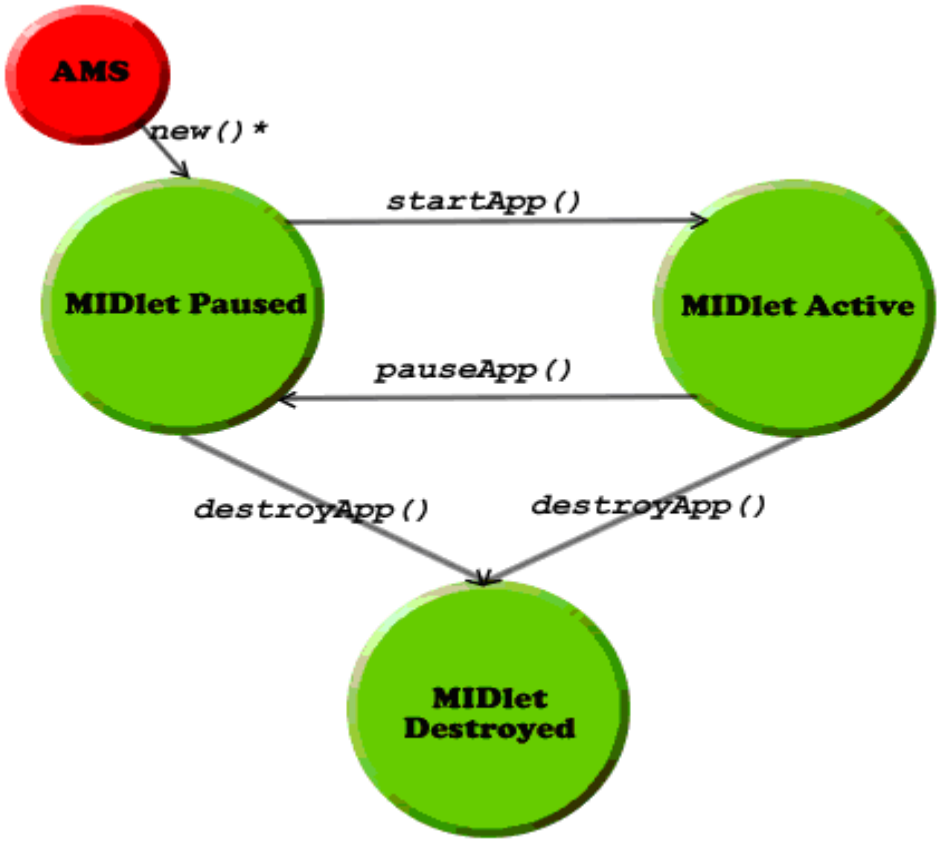

Figure 2.7: possible states of a MIDlet Method [42].

In a paused state, the MIDlet is waiting for a chance to get into the active state. Theoretically, in this state, it should not be holding or using any of the device resources and should be passive in nature. Once the MIDlet is created, this is the state to be in before becoming active. Also, entering the paused state is necessary when the device requires it to consume fewer resources, because these resources may be required for handling other device functions, like handling an incoming call.

This is when the device invokes the pauseApp () method through the AMS. If the MIDlet should inform the AMS that it has paused, it should invoke the notifyPaused () method, which tells the AMS that the MIDlet has indeed paused [42].

The active state is where every MIDlet wants to be! This is when the MIDlet can do its functions, hold the device resources and generally, do what it is supposed to do. As said previously, a MIDlet is in an active state when the AMS calls the startApp () method on a paused MIDlet (actually, the MIDlet enters the active state just before this method is called by the AMS). A paused MIDlet can request to go into the active state by calling the method resumeRequest (), which informs the AMS that the MIDlet wishes to become active. The AMS may of course, choose to ignore this request or, alternatively, queue it if there are other MIDlets requesting the same [42].

The destroyed state is entered when a MIDlet's destroyApp (Boolean unconditional) method is called and returns successfully, either from an active or paused state. This method is called by the AMS when it feels that there is no need for the MIDlet to keep running and is the place the MIDlet may perform cleanup and other last minute activities, The MIDlet can enter this state itself, by calling the notifyDestroyed() method, which informs the AMS that the MIDlet has cleaned up its resources and is eligible for destruction. Of course, since in this case, the destroyApp (Boolean unconditional) method is not called by the AMS, any last-minute activities must be done before this method is invoked [42].

2.3.6 Java API for Bluetooth Wireless Technology

Bluetooth System Requirements

The requirements of the underlying Bluetooth system upon which this API will be built are [43]:

- The underlying system shall be “Qualified” in accordance with the Bluetooth Qualification Program for at least the Generic Access Profile, Service Discovery Application Profile and Serial Port Profile.

• The following layers are supported as defined in the Bluetooth specification version 1.1, and the implementation of this API has access to them [43].

• Service Discovery Protocol (SDP)

• RFCOMM (type 1 device support)

• Logical Link Control and Adaptation Protocol (L2CAP)

• An entity called the Bluetooth Control Center (BCC) is provided by the system. The BCC is a “control panel”-like application that allows a user or an Original Equipment Manufacturer (OEM) to define specific values for certain configuration parameters in a stack [43].

The Bluetooth specification covers many layers and profiles and it is not possible to include all of them in this API Rather than try to address all of them, this specification prioritizes API function based on size requirements and the breadth of usage of the API. This specification addresses the following areas [43]:

1. Data transmissions only (Bluetooth wireless technology supports both data and voice transmissions)
2. The following protocols:
   - L2CAP (connection-oriented only).
   - RFCOMM.
   - SDP.
   - OBject Exchange protocol (OBEX).
3. The following profiles:
   - Generic Access Profile (GAP).
   - Service Discovery Application Profile (SDAP).
   - Serial Port Profile (SPP).
   - Generic Object Exchange Profile (GOEP).

The API is intended to provide the following capabilities:

1. Register services.
2. Discover devices and services.
3. Establish RFCOMM, L2CAP and OBEX connections.
4. Conduct these activities in a secure fashion.

JABWT is the basic API that supports development of Bluetooth-enabled software on the Java platform. JABWT consists of two optional packages [44].

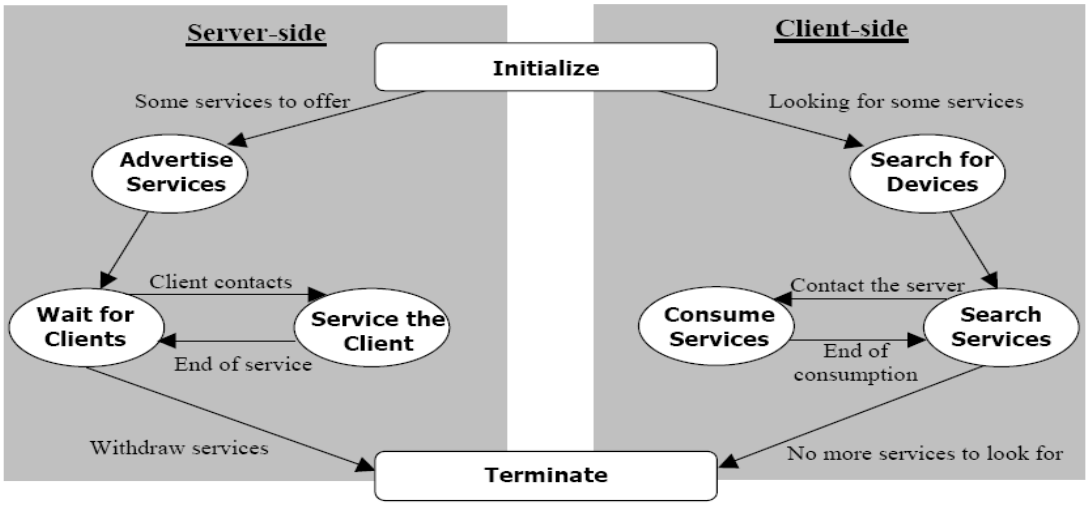

Figure 2.8 State diagrams for server-side and client-side activities [45]

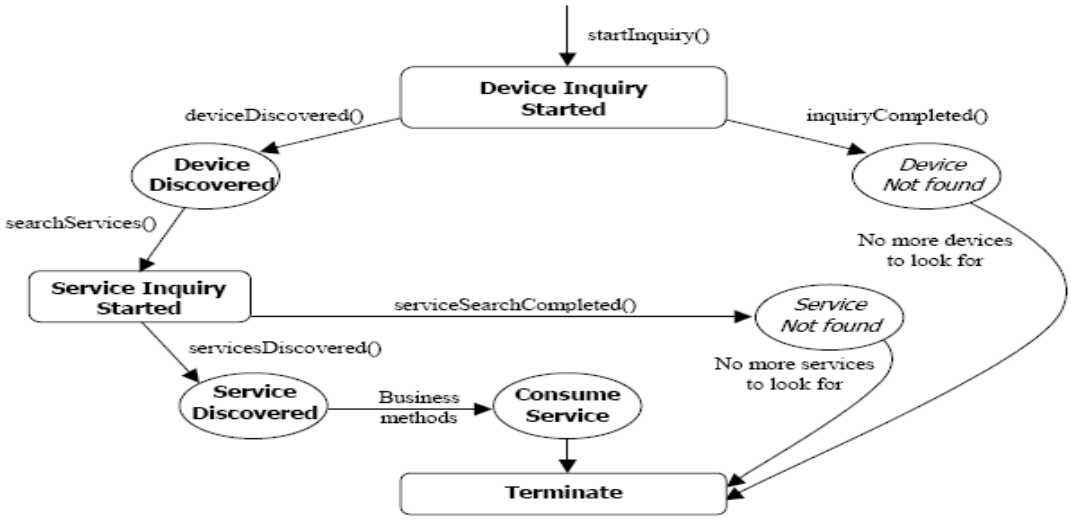

Figure 2.9 The change of state due to some of the important API [45]

There are a lot of classes and interfaces involved in developing a simple Bluetooth-enabled client-server application these class and description of them mentions in table 2.5.

Table 2.5 Classes in the javax.bluetooth Packages [46]

CLASS NAME	DESCRIPTION
DiscoveryListener	The DiscoveryListener interface allows an application to receive device discovery and service discovery events.
L2CAPConnection	The L2CAPConnection interface represents a connection-oriented L2CAP channel.

L2CAPConnectionNotifier	The L2CAPConnectionNotifier interface provides an L2CAP connection notifier.
ServiceRecord	The ServiceRecord interface describes characteristics of a Bluetooth service.
DataElement	The DataElement class defines the various data types that a Bluetooth service attribute value may have .
DeviceClass	The Device Class class represents the class of device (CoD) record as defined by the Bluetooth specification.
DiscoveryAgent	The DiscoveryAgent class provides methods to perform device and service discovery
LocalDevice	The Local Device class represents the local Bluetooth device
RemoteDevice	The RemoteDevice class represents a remote Bluetooth device
UUID	The UUID class defines universally unique identifiers
BluetoothConnectionException	This BluetoothConnectionException is thrown when a Bluetooth connection (L2CAP, RFCOMM, or OBEX) cannot be established successfully.
BluetoothStateException	The BluetoothStateException is thrown when a request is made to the Bluetooth system that the system cannot support in its present state.

SessionNotifier	The SessionNotifier interface defines a connection notifier for server-side OBEX connections.

Chapter 3 System Design Implementation

3.1 Background

Home health care is a fast–growing segment of the medical device industry, on increasing number of patients with chronic medical conditions and rising health cost are the main forces behind the trend of immersing the consumer home market with smarter medical device, continuous personal monitoring of chronic patients can reduce hospitalization and improve patients' quality of life.

The implemented system provides an effective concept that connects a mobile device with Bluetooth electronic circuit to maintain user temperature and heart rate that are detected using a low cost circuit.

Our Personal patients monitoring comply with some specific requirements to achieve system benefits by determining:

- Long term signal processing using Alternate Current (AC) without battery consumption for the circuit, and using long term electro code.
- Transmission capability using Bluetooth from circuit to user mobile phone also send user status using SMS to medical staff real time monitoring with speed response, connection to medical staff.

- Any type of mobile device that can install the Software on it as receiver for user health status.

3.2 Components of the Developed System

Mobile health monitoring system consists of three parts, each one of them describes how the system will work to get the health data process it and send it to medical department to take an action when necessary; after we finish the system we divide this parts as follows:

1- Human Medical Network (HMN)

This part consist of the implemented ECG and temperature Circuit, which detect the status of the patient using wire cables for the ECG circuit as we will specify later to measure user heart rate, using temperature sensor which is LM35 to detect the users temperature, connected with Bluetooth module using ADC (analog to digital converter) to convert the ECG and temperature signal from analog signal to digital signal to be send to mobile device via Bluetooth technology.

2 - Health Monitoring System (HMS)

This part provide the system software that has been programmed at mobile device using J2ME (Net Beans IDE open-source integrated development environment), which is suitable for most types of mobile devices that have been used by normal users. Mobile device receives the medical information from the HMN via Bluetooth technology, processes and views it using a mobile screen, these numeric data can be understood by the end user, the achievement is

to have connection between clinical system and the user any time from any where and that can be achieved by sending direct message to the responsible medical staff (doctor or nurse) if any up normal change from patient mobile using SMS without any confirmation or restrictions .

3- **Medical Care Unit (MCU) :**

Using medical staff mobile device for receiving data from patients to store patient data in their system in medical department database system any time, with speed response to save patient time before being in danger.

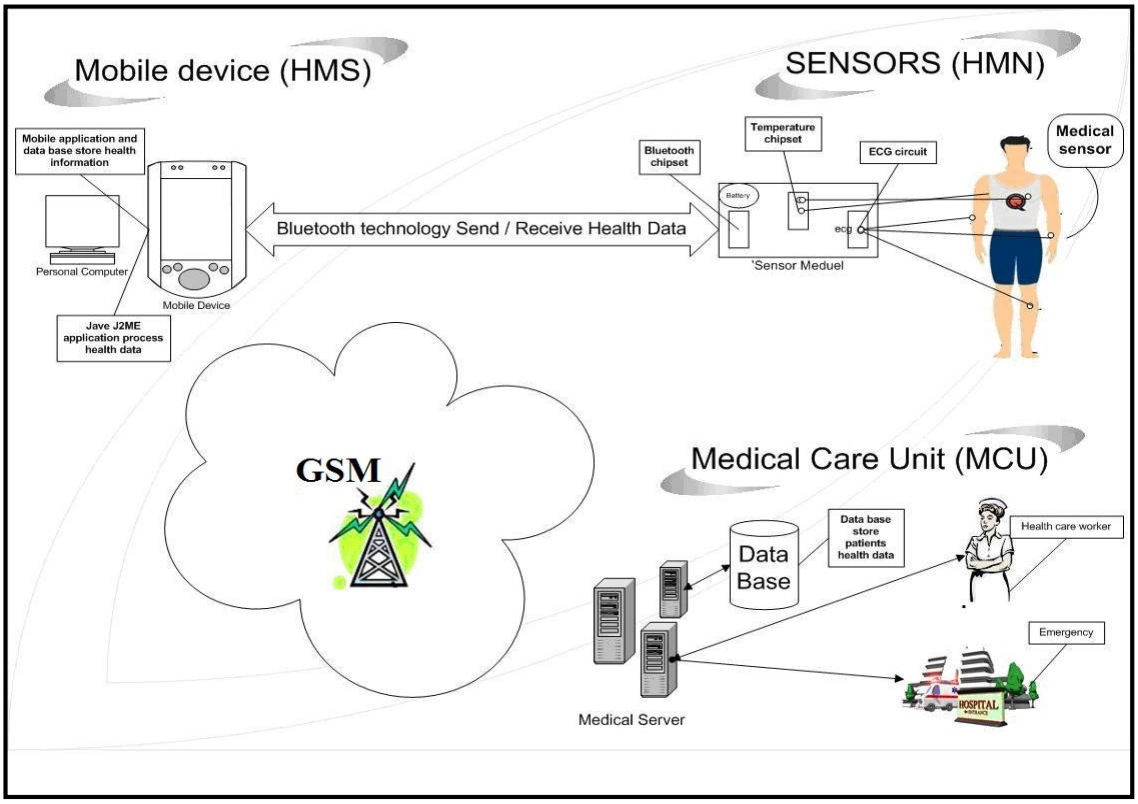

Figure 3.1: Bluetooth health monitoring system components

Figure 3.1 shows a brief description of the implemented system components, how they are being connected, that mobile device

implements (HMS), Medical ECG and temperature circuit implements (HMN) via Bluetooth technology, Mobile Device via SMS technology as (MCU) via GSM Network .

3.3 Developed System Hardware

System hardware contains ECG circuit and timer relay circuit, with ADC Circuit to convert ECG signal, all of them are connected directly to a microcontroller to control data and send it via Bluetooth using Bluetooth chipset attached to the circuit.

3.3.1 ECG Circuit

The developed circuit designed to detect the user heart rate and have been implemented and tested, also to detect the temperature value, we use a sensitive temperature sensor which is LM35 which can be used by placed it in some places in the human body like (armpit, mouth under tongue, anus) to detect the right temperature for the end user.

The circuit designed to detect the heart beat each one provide a voltage value from the heart bombs this voltage is difference from beat to beat.

To detect the heart voltage value using two leads electro codes.

Simple way to amplify the electrical difference between two points is to use an operational amplifier, The gain (multiplication factor) of an op-amp is controlled by varying the resistors attached to it, and an op-amp with a gain of 1000 will take one mill volt signal and amplify it to one volt.

The heart is not the only source of voltage on the skin; Radiation from a variety of things (computers, cell phones, lights, and especially the wiring in your walls) is absorbed by your skin and is measured with your ECG, in many cases masking your ECG through electrical noise.

After detecting ECG signal which an analog type that to be detected using mobile or PC must be converted to digital signal using ADC attached to the ECG circuit to be send via Bluetooth technology.

The components used in the circuit are :

- One piece of low voltage op-amp LM358N .
- One 100 kΩ resistor.
- One 1 kΩ resistor.
- One 0.1 uF capacitor.
- Two pennies Electrodes.
- Three small batteries 1.5 volt.

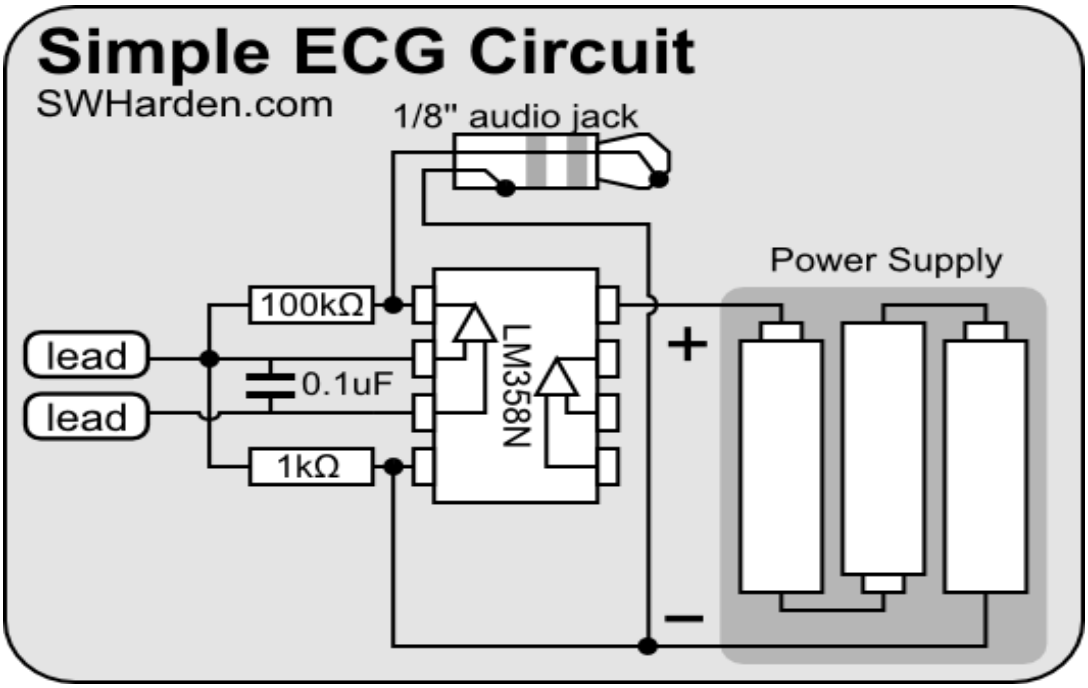

Figure 3.2 simple ECG circuits

3.3.2 Timer Relay Circuit

To implement the circuit we use a timing voltage circuit that take the input from power supply which is the three small battery about 5 volts, connecting to the output voltage for this circuit to the input power for ECG circuit, to make variance power for the circuit, I notes that the ECG signal circuit detects the signal for one time and then stop working till the power is refreshing that the circuit detect the

variance of the heart beat voltage for one time only as its simple ECG circuit, to solve this issue I use this time relay circuit to make refreshing power for the ECG circuit.

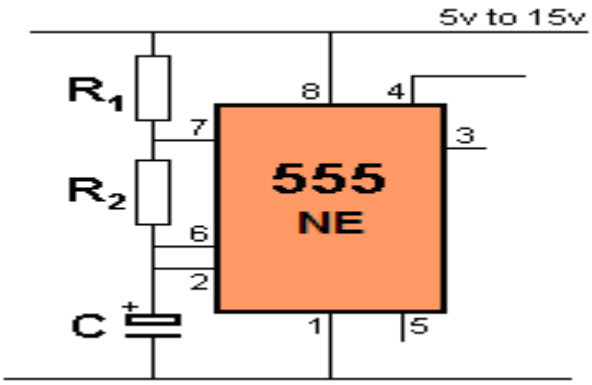

Figure 3.3 Time Relay Circuit

Time relay circuit components are:

1- NE555 timer IC .

2- R1 47 kΩ ohm resistance.

3- R2 47 kΩ ohm resistance.

4-10 uf Capacitor.

Table 3.1: NE555 time delay

NE 555 Delay Times (Sec)			
Capacitor	**R_1 = 100kΩ R_2 = 100kΩ**	**R_1 = 470kΩ R_2 = 470kΩ**	**R_1 = 1 MΩ R_2 = 1 MΩ**
10 µF	2.2 s	10 s	22 s
100 µF	22 s	100 s	220 s
470 µF	100 s	500 s	1000 s

The designed and tested NE555 time delay circuit made delay for about 0.8 – 0.9 sec voltage power for each approximately 5 volts power supply from the batteries.

3.3.3 Temperature Sensor

The temperature sensor (LM35DZ) can measure from 0°C to 100°C. However, the output is 0V at 2°C. Therefore, the voltage of minus is required in order to measure 0°C. Since the minus power supply is not used with this equipment, the measurable temperature is above 2°C. The output of a sensor goes up by 10mV for every 0°C. The output voltage in 32°C is 300mV. The output voltage of a sensor is amplified by an operational amplifier, and is inputted into the Analog/Digital converter.

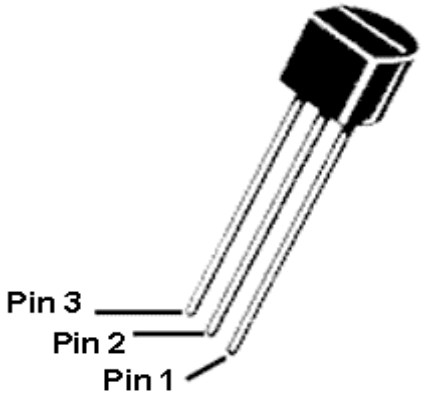

Figure 3.4 LM35DZ Temperature sensors

The LM35DZ connected and his pin specification as:

- The voltage on pin 1 is low (0V).
- The voltage on pin 2 is the output voltage.
- The voltage on pin 3 is high (the supply voltage).

3.3.4 Complete Circuit

The signal from ECG circuit and temperature sensors connected to ADC to convert the analog signal to digital. This signal programmed in microcontroller to be send via Bluetooth chipset as:

* temperature Value * heart rate Value # connected directly to the Bluetooth module to send it via Bluetooth technology to mobile device.

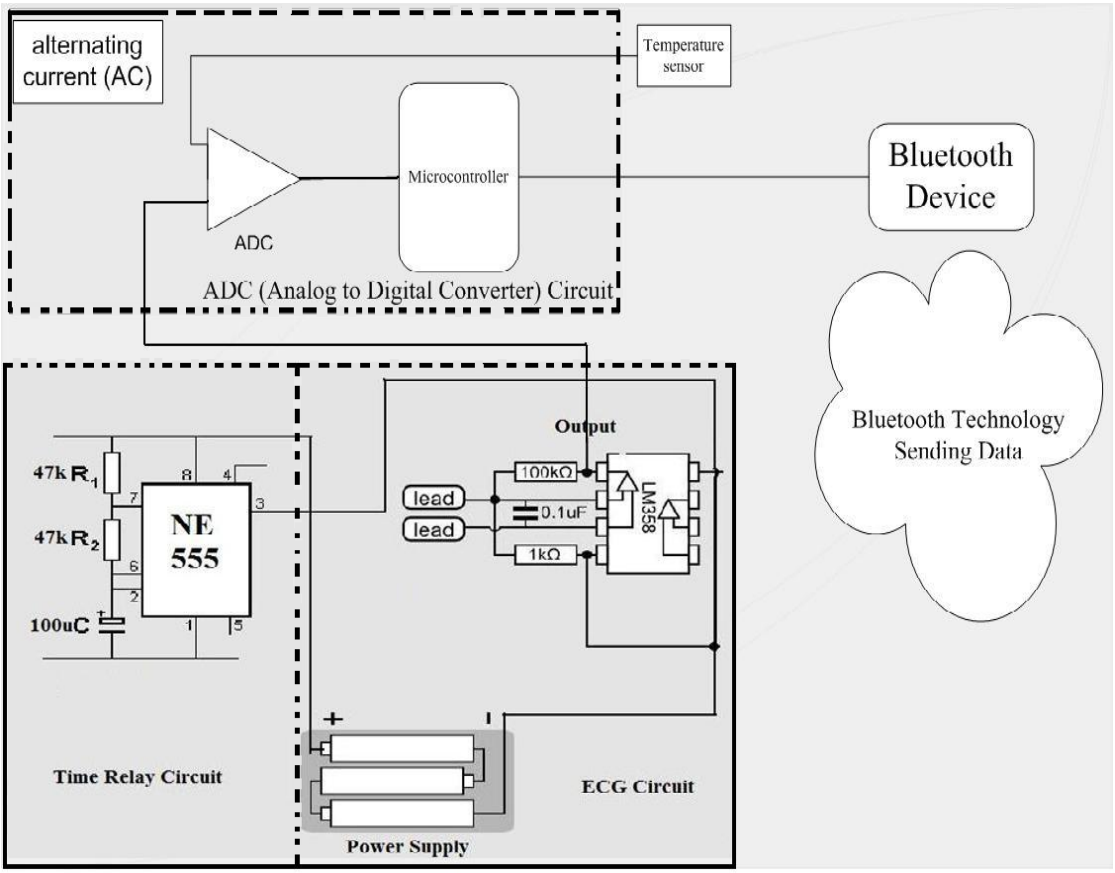

Figure 3.5: full ECG and temperature circuit

Figure 3.5 shows full view and specification for the implemented circuit as will as how the Bluetooth device connected directly to the circuit after the signal for the heart rate and temperature value processed and sent using the micro controller, the equipment for this circuit over all cost about 20 $, which can be considered as cheep device to detect heart rate and temperature with Bluetooth output by comparing with other Heart rate devices patients can save 50% than other heart rate equipments.

3.4 Implemented System Software

As described in the hardware platform the Bluetooth device sends user data via Bluetooth technology to the mobile device which receives it, via Bluetooth and makes processing for the received data to view it.

The software implementation using J2ME programming language developed by using Net Beans 7 application programming. Mobile health monitor software application implemented to receive the data from the Bluetooth module and view it to the end user.

Software Architecture:

The main application for the implemented system is a MIDlet performs the GUI for the user, and inherits an object that provide GUI service for all other classes, MIDlet is the main application control all components and classes in the system, main application view the logo for the system and some hint to help using application by the end user.

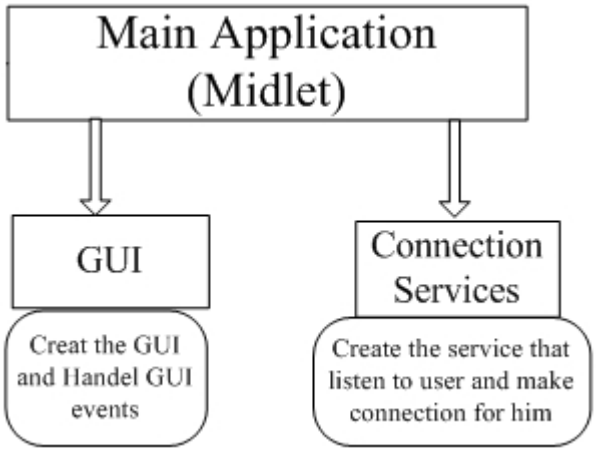

Figure 3.6: MIDlet provided

The main application provide the authentication process using two text field, requesting user name and password from the user that will

increase the level of security and keep the integrity for user data.

After performing the authentication for the user MIDlet using the start button to start Bluetooth Device discovery in Bluetooth Finder class by calling Bluetooth finder object in the MIDlet class and calling thread that performed Bluetooth finder class to start working, Bluetooth finder class MIDlet have the Command Listener class which perform the action caused by press any commend on the form screen of class.

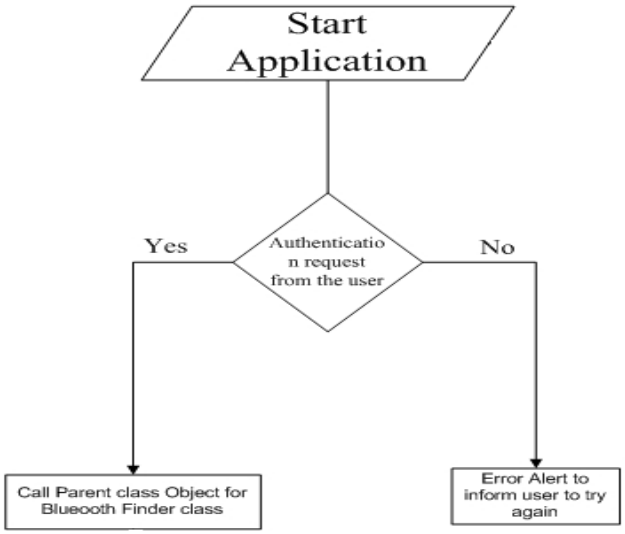

Figure 3.7: Authentication process

Bluetooth finder contains Discovery Listener class which provide Device discovered process and service discovered by import (javax.bluetooth.DiscoveryListener) Library.

Discovery process search devices in the area of Bluetooth and after selecting the device by the user thread start to search if the selected device have valid serial port or not, by Compare the UUID of the device with stored UUID in the software, thread retrieve the serial port URL view it on mobile user screen .

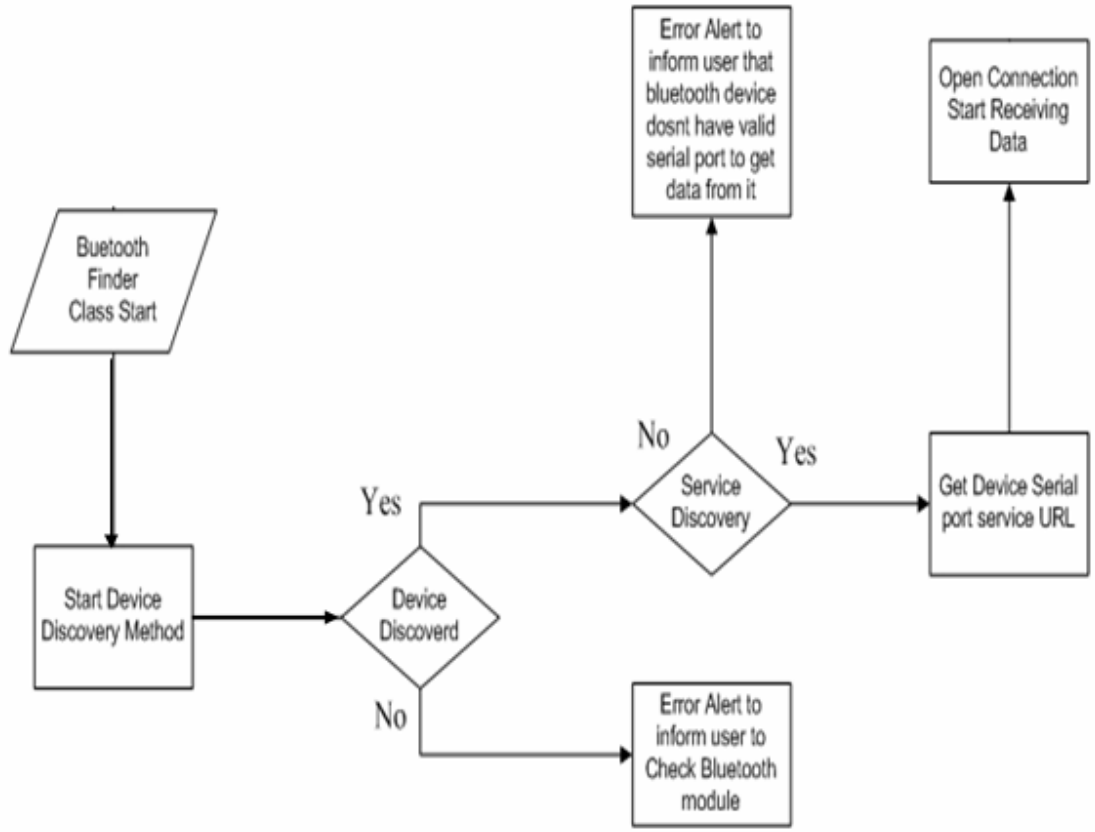

Figure 3.8: Bluetooth Finder class diagram

If the user clicks on the connect button then thread start, on the COM reader class which respond to view the data on the final data form and convert the receiving data from byte to integer value and then view it on the mobile screen .

All the received data before being viewed on the screen must be checked using if statement to determine patients status if its up normal or urgent directly sends SMS to medical staff worker number stored in the application software using class object call SMS connection class and opens SMS connection with stored text like (my heart beat is above normal please contact me as soon as possible) to take action and response as fast they can for the patient and we will explain it briefly in chapter 6.

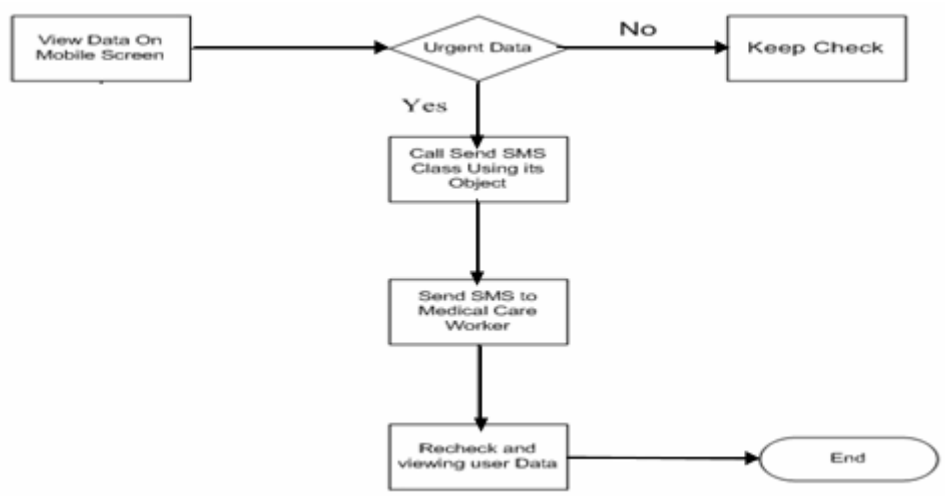

Figure 3.9: Check Data Diagram

Figure 3.10 shows the full diagram for the implemented system with brief description for each class in the application and how each screen work for any process during receiving data, process and view it in the patient mobile screen, sending SMS process from user mobile device to medical staff number, software provide speed for access, process and accuracy. viewing and sending data saves users money and provide real time monitoring.

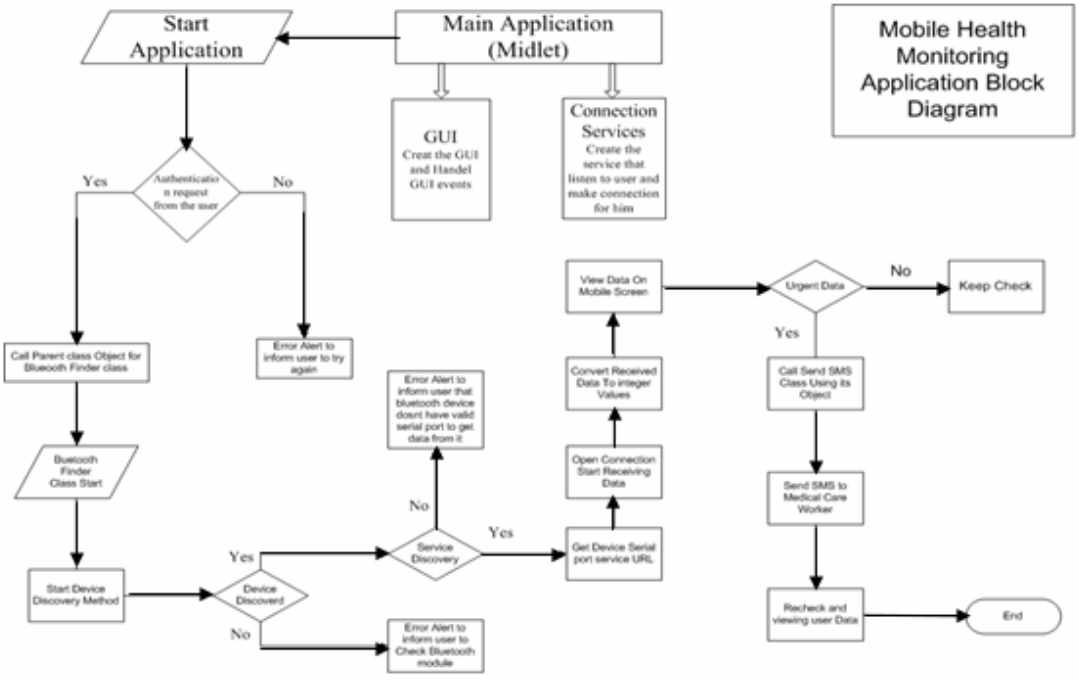

Figure 3.10: Mobile Health Monitoring System Block Diagram

Figure 3.11 shows the implemented system classes and procedures in each one of them, with service provided to the end user.

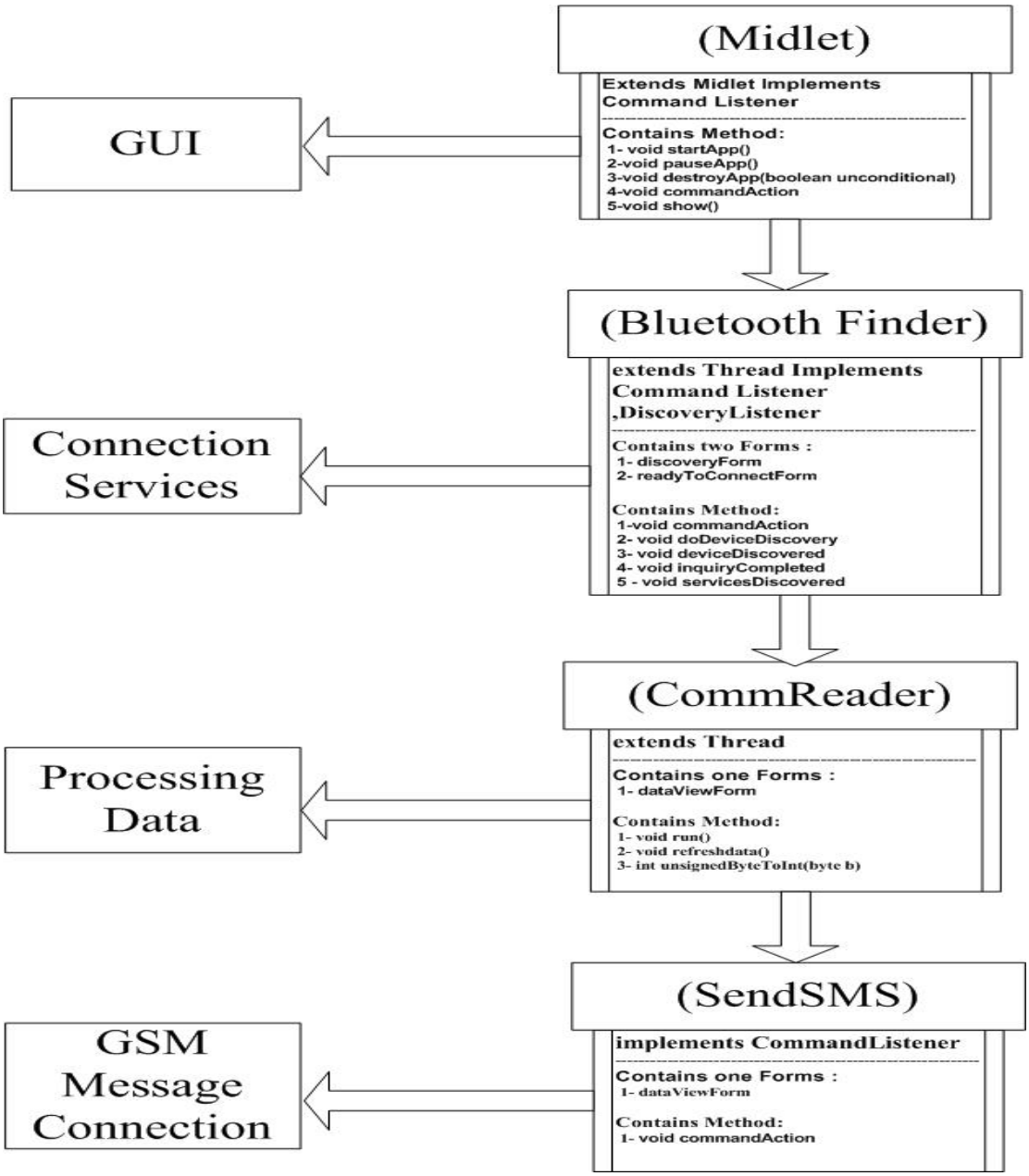

Figure 3.11: Implemented System Classes

Chapter 4 Result and Analysis

The implemented system programming has been developed using the Net Beans 7 Programming application that develop Java and Java 2 Micro Edition Programming Languages and the application have four parts that the end user of the application dealing with during the use of the application to determine and get his health Status in fact the temperature and the heart rate result.

4.1 Main Screen

Main screen in the software provides the authentication process for the user to enter user name and password for the application to access and implement it using the J2ME MIDlet with a form that contains MHMS Logo Picture and the Date and two Text Field first one to enter the users name and the second one to enter the password and after the user fills them, the application move the user to the next screen to start Bluetooth searching.

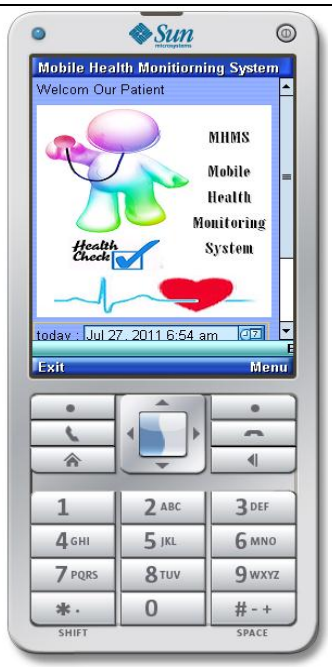

Figure 4.1: MMS Main Screen

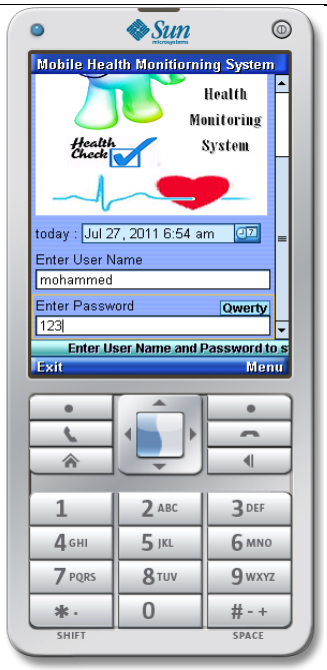

Figure 4.2 Authentication process apps

Figure 4.3: Authentication failed

As shown in figure 4.1 the Main Screen With the Designed Logo for the Application and on the same form will be user name and password text box, while in figure 4.2 user type user name and the password to start the application, while figure 4.3 shows the Error Alert Screen when the user enters wrong user name or password and then after two second back again to the main screen.

4.2 Bluetooth Search Screen

In the search screen service discovery method start running and get the Bluetooth devices in the area of the mobile device and prompt the user for the devices in range and if they provide a valid serial connection to start the connection, figure 4.4 shows Bluetooth Search Screen if Bluetooth Enabled, application start search

Bluetooth Mobile Health Monitoring Device that attached in the ECG and temperature circuit, which send user health data via Bluetooth technology in the range for Bluetooth area.

Figure 4.4: Bluetooth Search Screen

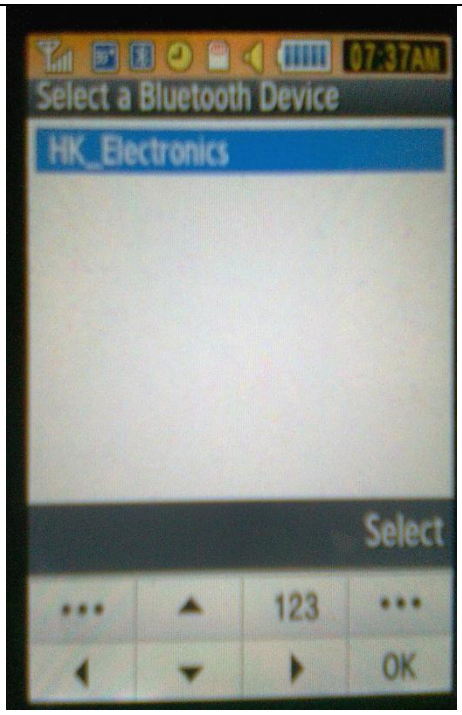

Figure 4.5: Bluetooth Device Discovery Screen

Figure 4.5 shows Bluetooth mobile health monitoring Screen, after discover Bluetooth module attached to the ECG circuit and retrieve its address and name.

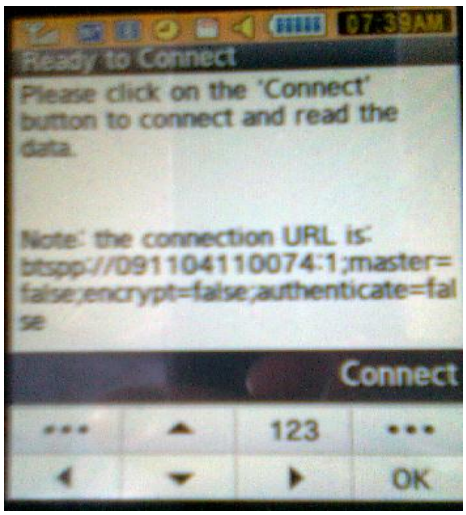

Figure 4.6: Bluetooth device details

Figure 4.6 shows Bluetooth device URL that used to open serial Bluetooth Connection and start receiving data from the Bluetooth circuit.

4.3 User Data Screen

After reading the data from the Bluetooth module, mobile Bluetooth open connection with module and start show the receiving data into the Text Field one for heart beat and the other for temperature.

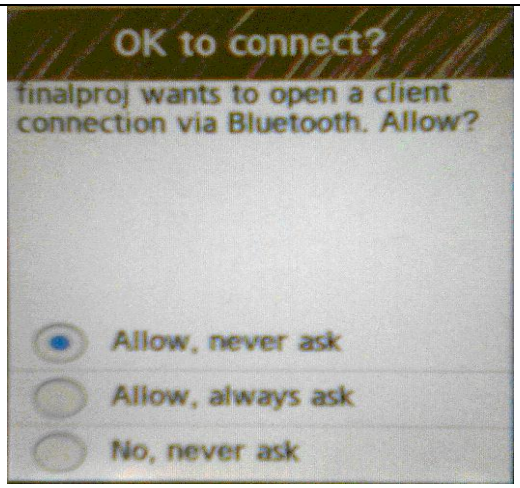

Figure 4.7: open connection verification

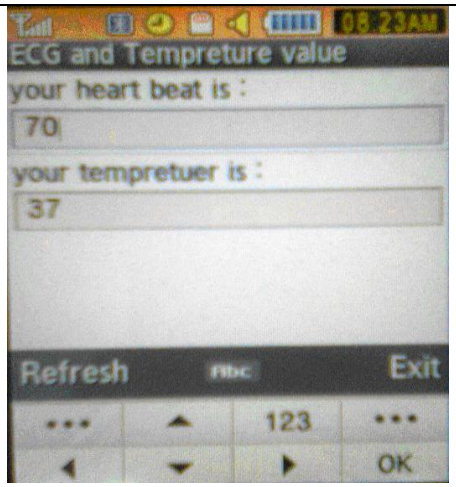

Figure 4.8: User Heart Beat and Temperature Data

Figure 4.7 mobile devices verify the Bluetooth serial connection to open and start receives the stream of data from Bluetooth, Figure 4.8 shows the heart rate and temperature values for the user, and updated direct when the heart rate change in the first text field shows heart rate value, and in the second Text field it show the temperature value for the end user, refresh button help the end user to retrieve the data again without wait for the next value of the heart rate or temperature to be viewed .

4.4 Sending SMS Screen

Starts when the user has up normal change in his health status value like very high or low heart rate or temperature.

Improved our application by provide connection between patient and medical staff, without user's control, application sends SMS

direct using patient mobile device using his mobile network GSM via Bluetooth technology to medical staff about patient up normal heart rate or temperature status.

Other benefits that heart rate stored value can be changed from user to other, the detection range for sending SMS also can be changed easily.

The implemented system provides full assistance and real time monitoring for long time while patient at home or any place.

Connects patients with their responsible medical staff via SMS technology, that doctors need simple and easy technology connecting them with their patient without big effort or time.

Patients connected with their doctors using sheep and available technology using their own mobile device via GSM by sending SMS.

Figure 4.9 shows an interactive system by taking action directly when user heart rate value is high, application send user status directly to the receiver about user heart status to take action and contact patient immediately, this text stored in the application data base and can be change from user to other also send the heart rate or temperature value directly to doctor that provides full information about patient status help doctor for his action, medical staff number stored also in the application and can be changed from patient to other and for very urgent situation we can send SMS direct to emergency or hospital to save patient life.

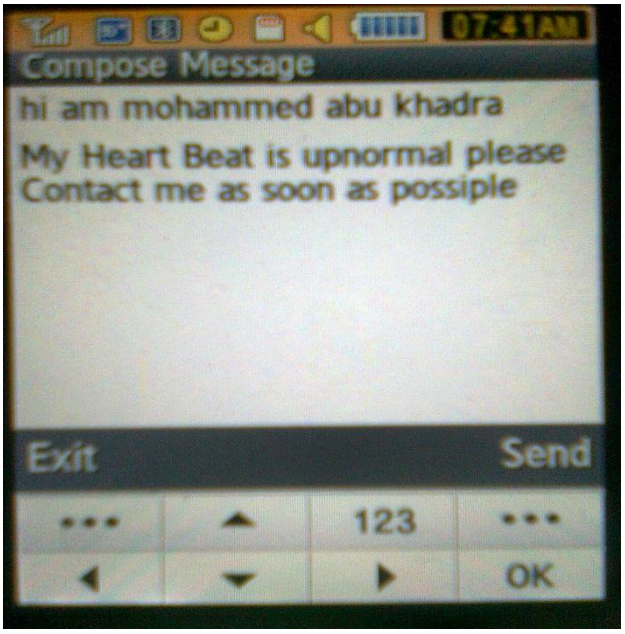

Figure 4.9: HR MSG Sending by application

Figure 4.10 is the confirmation screen for sending MSG using GSM directly which verifies that it will cost the user, application also provide doctor number stored in the application which MSG will sends to him and to make sure that MSG will be viewed and monitored we stored more than one phone number for medical staff in the application so patient status will be send to all number stored in the software to provide farther assistance.

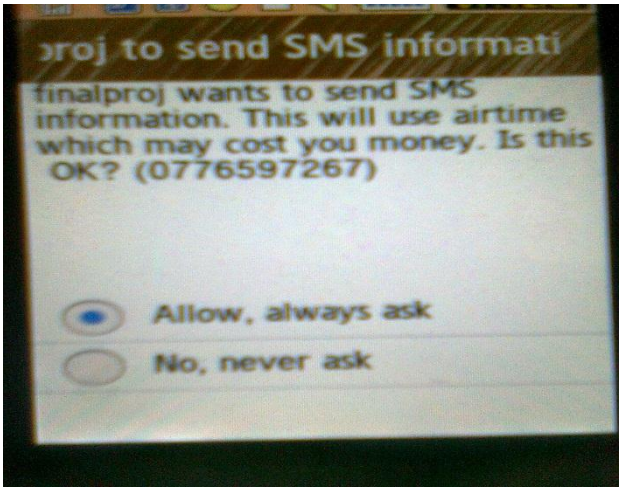

Figure 4.10: Sending MSG Confirmation Screen

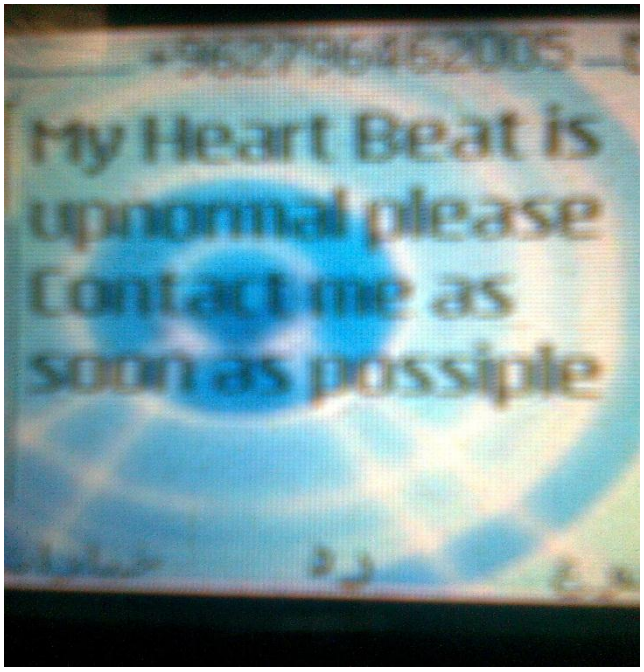

Figure 4.11: Received MSG in the Receiver Screen

Figure 4.11 shows receiver mobile device screen, which is the MSG that has been sent from user mobile device as SMS via GSM, the receiver mobile screen contains sender mobile number and patients status screen MSG which contains that the heart beat is not good and ask him to contact him as fast he can.

After making tests for a number of patients on the mercury temperature for measuring patients temperature, and on holter machine for checking heart rate, and comparing it with the result from our implemented system we have an excellent result as shown in table 4.1.

Table 4.1 : Heart rate and temperature value compare

Name	Age year	Mercury temperature Celsius C`	System Temperature Celsius C`	holter machine (HR) Bpm	System (HR) Bpm
Jameel Mare	45	37.8	38	66	68
Rame Alfaiz	50	37.6	38	74	72
Hussam Alsaigh	42	37.4	37	80	78
Ahmad Dabash	35	38	38	84	82
Mohammed Dabobash	38	37.6	38	90	88
Ibraheem Alsbakhe	40	37.6	38	74	72
Tamer Alabsi	29	37.9	38	68	70

Chapter 5 Conclusions and Future Work

5.1 Conclusion

The implemented system has many benefits for checking patients health status listed as follows:

- Developing j2me mobile application runs on traditional mobile phones views heart rate and temperature value for user and automatically updated, Modify mobile application device to be more useful for human's life for a long time.
- Connect medical care unit (doctors, hospitals …….etc) directly with patients by using smart medical network using SMS technology any time from any where even patient at home.
- Many ECG and heart rate monitoring hand held devices been viewed in literature review are costly for patients without real time and direct connection between patients and their doctors, our platform saving cost that all circuit costs about 20 $ without battery consumption by using direct current and their own mobile devices using GSM via Bluetooth technology.
- Providing Accuracy and data integrity: our system provides an effective application by implementing tests on our circuits from the end users mobiles and we get impressive results.
- Usability: can be used easily; the users have to follow a few simple steps, and for important and urgent situation application take action directly.
- Affordability: affordable system with a maximum cost of each piece less than 20 dollars that included ECG circuit, the temperature circuit and Bluetooth module.

- Connectivity: direct and speed connection between patient and medical care staff any time, any where using their mobile device using GSM via SMS technology, sends all patient data and keep them in connection make comfort for patients while they are at home and have full monitoring using their Mobile device, that will save money, make comfort for medical staff and decrease pressure on them.

5.2 Future Work:

The main recommendation for future work is:

- Develop a Web-based application that can store and update patient data and enable accessing these data any time, any where for diagnostic and evaluation.
- Develop application to view ECG signal via Mobile Device and send it as Multimedia Message (MMS) via GSM to doctor or medical staff workers.

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