Review on Development of Patient Monitoring System

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***Abstract*— In medicine, monitoring is the observation of a disease, condition or one or several medical parameters over time. Repeated or continuous observations or measurements of the patient, his or her physiological function, and the function of life support equipment, for the purpose of guiding management decisions, including when to make therapeutic interventions, and assessment of those interventions. A patient monitor may not only alert caregivers to potentially life-threatening events; many provide physiologic input data used to control directly connected life-support devices. For smart living, interactive applications are increasingly important especially on interaction of people and the environment. Smart Mobile Phones are the most accessible form of technology globally and offer a highly convenient system for self monitoring coupled with instantaneous feedback, and thus potentially engaging the patient in the monitoring Telemedicine systems have become an important supporting for the medical staffs. As the development of the mobile phones, it is possible to apply the mobile phones to be a part of telemedicine systems. Wireless technologies are bringing about dramatic improvements in the quality of patient care by allowing unprecedented mobility while providing medical staff with easy and real-time access to patient data. In the paper, we had reviewed about the different communication based patient monitoring system. Currently there are different communication systems available such as GSM, Bluetooth, zigbee, web service, intranet, etc.**

***Index Terms*— Patient Monitoring System (PMS), communication system, GSM, Bluetooth, web service, zigbee**

I. INTRODUCTION

The objective of patient monitoring is to have a quantitative assessment of the important physiological variables of the patients during critical periods of their biological functions. For diagnostic and research purposes, it is necessary to know their actual value or trend to change. Patient monitoring systems are used for measuring continuously or at regular intervals, automatically, the values of the patient's important physiological parameters. There are several categories of patients who may need continuous monitoring or intensive care. Critically ill patients recovering from surgery, heart attack or serious illness, are often placed in special units, generally known as intensive care units, where their vital signs can be watched constantly by the use of electronic instruments. The long term objective of patient monitoring is generally to decrease mortality and morbidity by:

1. organizing and display information in a form meaningful for improved patient care,
2. correlating multiple parameters for clear demonstration of clinical problems,
3. processing the data to set alarms on the development of abnormal conditions,
4. providing information, based on automated data, regarding therapy and
5. Ensuring better care with fewer staff members.

During surgical operation, the patient is deprived of several natural reaction mechanisms which normally restore abnormalities in his physical condition or alert other people. Indications or alarms that cannot be given by the patient himself can be presented by patient monitoring equipment. Besides this, in special cases, it is not uncommon for surgical procedures to last for several hours. During these lengthy operative procedures, it is difficult for the anesthesiologist and the surgeon to maintain intimate contact with patient's vital signs and at the same time attend to anesthesia, surgery, fluid therapy and many other details that are required under such circumstances. Also, when a patient is connected to a life support apparatus, e.g. heart lung machine or ventilator, correct functioning of these has to be monitored as well. A patient monitoring system thus better informs the surgeon and anesthesiologist of the patient's condition. With patient monitoring systems, the risk that surgery involves has been considerably reduced since it is possible to detect the complications before they prove dangerous as suitable remedial measures can be taken well in time [8]. Patient Monitoring System is a process where a surgeon can continuously monitor more than one patient, for more than one parameter at a time in a remote place. The technical brilliance and development in different fields has led to a drastic change in our lives, one among them is embedded systems and telecommunications. Telecommunications has the potential to provide a solution to medical services to improve quality and access to health care regardless of geography. The advances in information and communication technologies enable technically, the continuous monitoring of health related parameters with wireless sensors, wherever the user happens to be. They provide valuable real time information enabling the physicians to monitor and analyze a patient's current and previous state of health. Now days there are several efforts towards the development of systems that carry out remote monitoring of patients. Although many wireless standards can be used, there are

important considerations such as range, throughput, security, ease of implementation and cost. The patient monitoring involves handling of sensitive data. These data should be transmitted securely without any intrusion [1].

To know the physical states of in-patient, the physical parameters need to be monitored real-time. The traditional medical test instrument is large size and connected by wire often, and the patient is required to be quiet during test. In most of hospital, the medical instruments need to be read by doctor or nurse, and the physical parameters are tested and recorded one or two times each day, the real-time monitoring is expensive for most of patients, and can be only acquirable for ICU by nurse [3].

II. System Description

2.1. Java-enabled 3G mobile phones

The rapid development of information and telecommunication technology has brought great revolutions in our everyday lives. The impact to medical field is being felt with many new applications using these technologies. Telemedicine is essentially the use of both information technology and telecommunications to provide health services or support health service provision over a distance. Telemedicine systems can be divided into two fields: one is that the mobile devices are used by patients to measure the medical data of them. For example, the European EPIMEDICS project has developed a Personal ECG Monitor having the capabilities of recording ECG at anywhere and anytime. The other field is that the mobile devices are used by medical staffs as an assistant for their daily work. By using a 3G mobile phone, the doctor can monitor the real-time biosignals of patients in ICU/CCU through the screen of the mobile phone while making a voice call. The software developed on the mobile phone can realize three main monitoring functions, including real-time waveform and data monitoring, list trend data monitoring and the patient information checking. The doctor can select which he wants to check using the keyboard of the mobile phone [4].

2.2. Zigbee

Wireless sensor network is made up of a large quantity of wireless sensors based on Zigbee technology. The Zigbee technology provides a resolution for transmitting sensors' data by wireless communication. Zigbee technology can transmit data with a rate of 250kbps, and then it is enough for the physical parameters of patient. The communication distance of Zigbee node can be over 200 meters, and can be spread by add route node, and then Zigbee technology is suited to short distance wireless sensors network. Zigbee technology owns many virtues, such as low power consumption, low cost, small size, free frequency, etc. With wireless sensors network, the patient can just take smart wireless sensors, and the real-time physical data of the patient can be acquired and monitored. The real-time monitoring system for patient can monitor and record the physical parameters, and then provide an auxiliary means for doctor to diagnose patient. On the other hand, with the intelligent diagnosis function, the system is helpful to find the patient be worse, and notify the doctor to help the patient [3].

2.3. GSM

The Implemented system provides mobility to the doctor to a certain extent. Measurements of vital signs and behavioral patterns can be translated into accurate predictors of health risk, even at an early stage, and can be combined with alarm triggering systems in order to initiate the appropriate actions for the physician. In case of emergency and critical situations we have to alert the doctor immediately. For this we are using a GSM based network for doctor to patient Communication in the hospital and even to communicate and indicate the status of the patient through SMS. The uniqueness of the developed system is that, in addition to real time monitoring and conveying of data, control action is provided wherein, the doctor can even take preliminary action remotely because of the feedback system provided. This way of communication is actually done with the GSM network and a feedback motor connected to the saline. In this way just by knowing the patient's biomedical parameters, the doctor can remotely control the flow of medicine [1].

2.4. Bluetooth

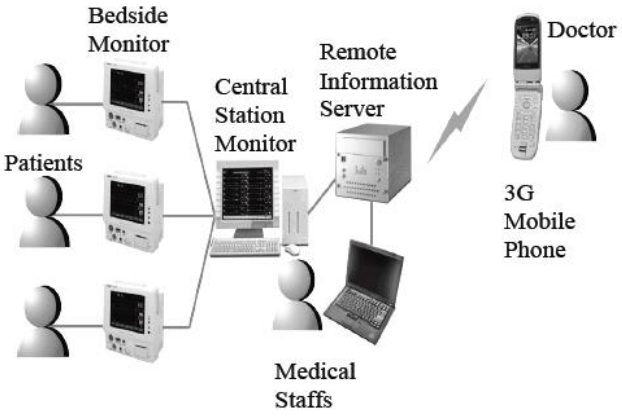
Bluetooth is a proprietary open wireless technology standard for exchanging data over short distances from fixed and mobile devices. It can connect several devices, overcoming problems of synchronization. With the characteristic of full-duplex communication of Bluetooth devices, the body sensor network system can be designed successfully. Android mobile phone can not only receive the data collected by our hardware device but also can transmit these data to remote server in time. This method not only simplifies and speeds up the process of information acquisition, processing and analysis, but also declines costs of equipment; therefore, researchers have become more interested in wireless health care. They report on a preliminary study of human body monitoring equipment including three main functions such as brainwave capture, ECG acquisition and human temperature detection, furthermore detail the usage of the key sensors [2].

III. Literature Review

3.1. Java-enabled 3G mobile phone based PMS

This system was developed in year 2007. The overview of the proposed System is shown in Fig.1. The system is mainly composed of three parts: patients monitoring system, Remote Information Server built in hospital and a Java-enabled 3G mobile phone. They are connected by the Internet and 3G mobile networks. The patients monitoring system is composed of Bedside Monitor, Central Station Monitor and PC used by Medical staffs in hospital. Conventionally, several patients' information can be collected by the Bedside Monitors and stored in the Central Station Monitor. In the proposed system, the patients' information in the Central Station Monitor, including numeric signal data, text data and real-time waveform data can be extracted by the Remote Information Server and changed into the recognizable pattern for Java jiglet application on the mobile phone, by using a PHP web application. The 3G mobile phone used should carry multitasking function, such as using a Java based application during a voice

call. Via the Internet and 3G mobile networks, the Java jiglet application on the mobile phone receives the data and displays the visual information on the screen of the mobile phone to the doctor [4].



The overview of the system [4]

Remote Information Server is the focus of the system's data transferring process. As is shown in Fig.2, the server can be accessed both from the 3G mobile phone and PC used by medical staffs in hospital [4].

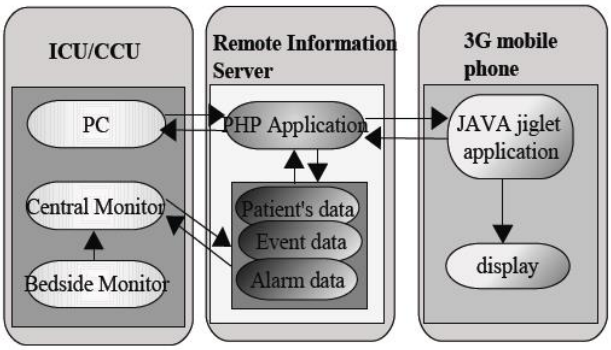


Fig. 2. The working process of the system [4]

The networks between the Remote Information Server and
The 3G mobile phone is shown in Fig.3.

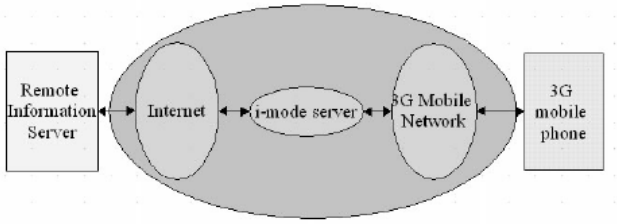


Fig. 3. The network structure between the remote information server and the 3G mobile phone [4]

The system developed over here has many advantages but the major drawback is the time delay which is of 20 sec which is very large delay for the doctor.

3.2. Ubiquitous Health Monitoring System (UHMS)

This system was developed in a year 2008. This system was first developed by Japan people. Currently six types of biological signal data (ECG, blood pressure, glucose, temperature, weight) are monitored and collected from the U-house. Fig.4 shows the overall architecture of UHMS. It consists of two main servers: the U-house server and the central repository server. We named the central repository server as BIRD (Biometric Integrated Repository Database). The main role of U-house server is to compress the biosignal data and upload it to the BIRD. The main roles of BIRD are to store the biosignal data and provide easy-to-use interface to access the data for the health practitioners and U-house tenants [5].

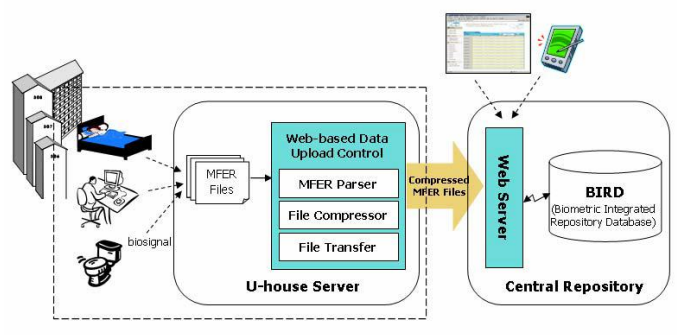


Fig. 4. The overall architecture of UHMS [5]

They have developed a web-based biosignal monitoring system which can be used for ubiquitous health environment. The launching of the ubiquitous computing in the health domain involves multiple level technical challenges. There are some unsolved technical issues which should not be minimized at the designing level. One of them is the effective management of the biosignal data. The second issue will be the automatic interpretation of the measured data. Among the recorded data, the ubiquitous health system should detect abnormal findings and give warning messages to the responsible personnel. In order to detect abnormal findings automatically, the basic normal patterns and abnormal patterns are predefined and implemented on the ubiquitous health monitoring system. This will be the hardest step in the ubiquitous health arena [5].

3.3. Zigbee based PMS

The system is mainly made up of two sub-systems: patient physical states data acquisition and communication system based on Zigbee technology, and hospital monitoring and control centre, it is showed in Fig.5. The main function of the system include: On the basis of keeping the patient movement intact, the main physical states and movement parameters of patient can be continuously monitored and recorded real-time with wireless multi-sensors' terminal , and then the doctor can analyze the trend of the patient with the physical parameters. The measured data can be sent to hospital monitoring and control centre with wireless communication system. The hospital monitoring centre receives the measured data from each patient and saves them to database, and then diagnoses the patient automatically with the intelligent diagnosis software to find emergency of the patient. The doctor can watch the parameter's change as graph or numeric on computer and analyze these data to get more information about the patient, thus the doctor can know the physical states or movement parameters of patient, and then it is helpful to get the correct diagnosis result of doctor [3].

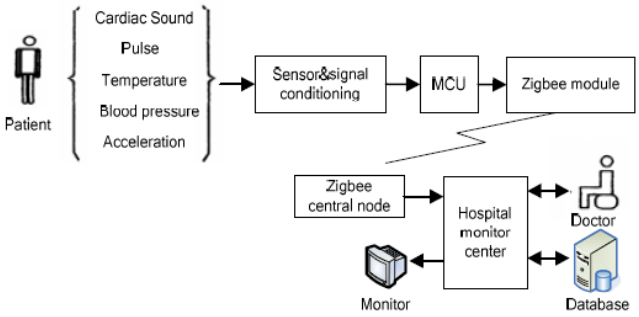


Fig. 5. The monitoring system for cardiac patient [3]

The Zigbee technology can be suited for short distance communication, and the transmission distance is limited only about 200 meters, and then it can be suitable for in-patient monitoring [3]. This is the main disadvantage of this system.

3.4. GSM based PMS

The system design consists of both hardware and software. Firstly as per the block diagram the hardware components required were assembled. The code is written in embedded C, and is burnt into the microcontroller using flash programmer [1].

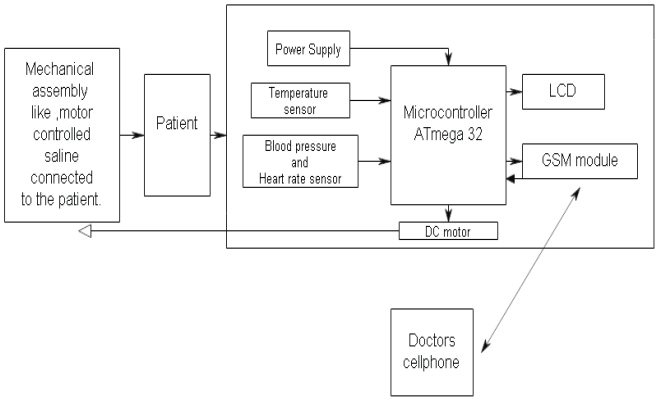


Fig. 6. Block diagram of GSM system [1]

The patient's all 3 biomedical parameter's viz blood pressure, heart rate and temperature are measured at a fixed time interval and stored in memory if they are within limits. Mean while the system will also continuously measure temperature using RTD and feed to ADC .It compares the measured temperature with the predefined value, and checks if the value is above or below a set range. If the temperature exceeds beyond the set value the module immediately starts measuring heart rate and blood pressure by a micro pump, valve, and pressure sensor and cuff assembly. The air will be pumped into the cuff using the motor and pump about 120 -160mmHg (average for human) .Then we will slowly release the pressure using the valve and measure, the pressure, at a point when we start getting the oscillations this is our systolic pressure ,the pressure value from the transducer at this point is our systolic pressure. Now we go on deflating the cuff, the point when the oscillation damp is our diastolic pressure. The pressure transducer will convert it into a range of 0-40mV which we will amplify using operational amplifier to 4v. The value of systolic and diastolic is measured using adc1 and adc2 respectively. The value is put in a buffer and sent to two physicians simultaneously; using our GSM module and wait for 3 minutes for anyone to response If any of the doctor does not respond in three minutes a buzzer will ring. If any of the doctors acknowledges the messages, he can send back a message asking for last history details. Thereafter he can diagnose those parameters and revert back a message to the GSM module. The GSM module message will be read by the microcontroller to generate a signal which will drive a dc motor connected to the saline unit, whose rotation will control the flow of medicine. GSM provides for longer distance communication. Fig.7 shows the flowchart of the implemented system [1].

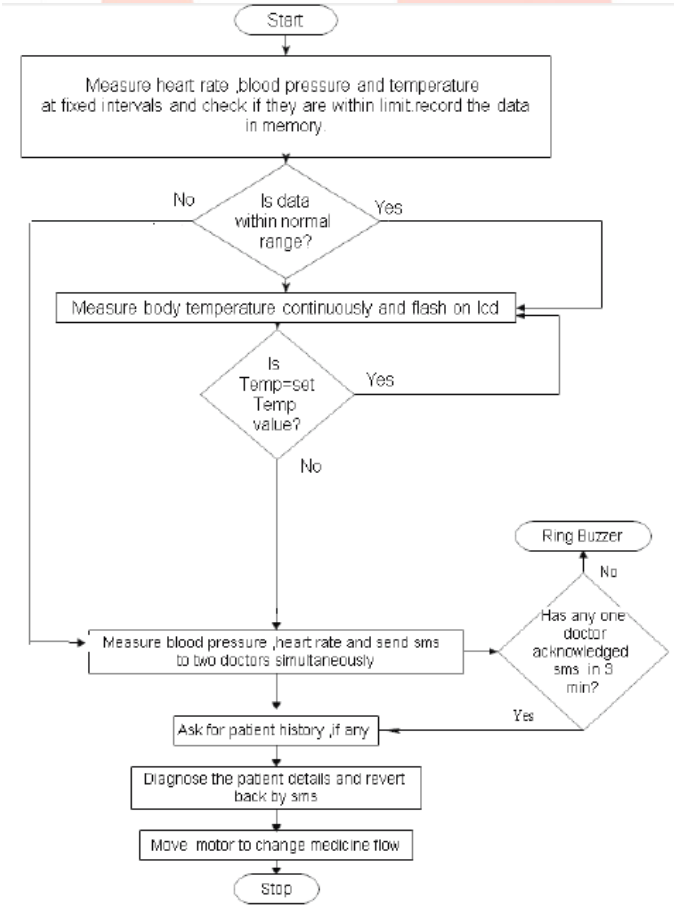


Fig. 7. Flowchart of implemented system [1]

The major drawback of this system is that the nurse or any medical staff has to manually feed the data to transfer to respective doctors. This can lead to time loss in chronic cases.

3.5. Bluetooth based PMS

The system is composed of software and hardware. The main functions of this system are detecting human's temperature, electrocardiogram, electro-encephalogram (EEG) by different hardware. These data which are gathered by hardware are sent to the Bluetooth receiving device of android smartphone over the Bluetooth transmission equipment which is fixed on our device. They are analyzed and then saved into SD card which is inserted in the android smartphone [2].

- Software includes: Application programs of android platform based on the java language can be implemented and tested by eclipse. These application programs were eventually packaged in an apk file which is installed on the android smartphone. The installed software can start the Bluetooth on your android smartphone to receive information from the hardware [2].
- Hardware includes: The single chip microcomputer system (SCMS), an infrared thermometer detecting human temperature module--ZTP-135SR, an electrocardiogram detection module--BMD101, an electro-encephalogram detection module--TGAM, a wireless Bluetooth devices, an android smartphone. Fig. 8 provides a flow chat to describe the body monitoring system design based on android smartphone [2].

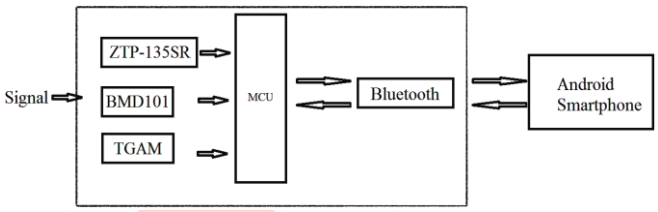


Fig. 8. Flow chart of the system [2]

The drawbacks of this system is the use of Bluetooth, which works in particular range only, if the device goes out of range then the system goes fail. This system is also not sensitive to the time so the result may reach doctor little late.

IV. CONCLUSION

SMS services and alarm system for emergency cases can be available using the Bluetooth or GSM based system and so that if doctor doesn't reply he/she will get an SMS alert on his/her mobile. But in above all system, communication is possible but doctor can't get the actual biosignal graphs. So that's the main disadvantage of the above all systems. Ubiquitous health monitoring system is totally based on web-based system, which has many advantages according to other system. But this system has two major drawbacks which are yet to be solved which are effective management of the biosignal data and automatic interpretation of the measured data. The table 4.1 shows the comparison of the all above system.

Sr. no.	Name of the system	Year in which the system was developed	Advantages
1.	Java-enabled 3G mobile phone based PMS	2007	• Voice call used to transfer the data • User interface is in java applet form
2.	Ubiquitous Health Monitoring System (UHMS)	2007	• Web-based system • Integral access to the data at any moment from any place
3.	Zigbee based PMS	2008	• Short distance communication up to 200 meters
4.	GSM based PMS	2012	• Long distance communication • SMS services • System is real time
5.	Bluetooth based PMS	2012	• Compact • Very short range communication • Stored Graph and parameters can be view by the doctor

Table 4.1: comparison of the all above system.

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