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A Survey: Remote Patient Health Care Monitoring and Alert Generation System

Rani Utekar [1], Jayant Umale [2]

P.G. Student, Department of Computer Engineering, PCCOE Nigdi, Pune, Maharashtra, India[1]

Professor, Department of Computer Engineering, Dean Academics, PCCOE Nigdi, Pune, Maharashtra, India [2]

ABSTRACT: In last few years health care monitoring area have drawn more attention of researchers towards invent new methodologies for health care. A healthcare has become a big issue due to lack of availability of expert doctors and preventive treatments. Due to this issue there is a need to shift from need based health care to preventive health monitoring services. This paper presents several implementations of health care monitoring system used for remote patient monitoring and providing alerts in emergency case. These systems consists of health monitoring with measuring vital parameter of patients, monitoring daily activities, providing recommendation system, give alerts messages and storing data on clouds. This paper describes various techniques are used for developing health care monitoring systems with pros, cons and improvement for those systems. In today's world, mobile phones are not only use for communication purpose but also for health care purpose. This paper presents how these IoT based systems overcome drawbacks of existing system. These systems proved importance of health monitoring in heal care domain.

KEYWORDS: Smart healthcare, Real time remote monitoring, Wireless sensors, Cloud, Internet of things (IoT), India's IoT Based healthcare startup.

I. INTRODUCTION

Continued increased of population worldwide is causing challenging to existing framework of health care systems. Due to changing lifestyle of people like work habit, eating habit they don't get time for their health care. In the competitive environment more health related issues are faced by people. Due to advancements in biomedical field senior population is gradually increased. Out of total senior population more number of older people are preferring to living in their home for health care rather than hospitalized. Current scenario of living is single family lifestyle. Elder people are living independent in their home. So there is a need to continuously monitor health of their parents remotely from any place. Since, the real time health monitoring is necessary for today's world.

Current health care systems provide health services to patient only after diagnosis of disease [1]. Remote health monitoring is important but current systems provide only fixed monitoring system within hospital premises. ICU Patient's need all time monitoring of expert doctors. It is not possible because one expert doctor can handle more than one patient at a time. The devices used in existing system is huge in size. The cost for maintenance of those devices is very high. The devices are connected with wired communication within hospital which is tedious for long distance communication [1]. The remote health care monitoring systems overcomes all drawbacks of existing system. Below figure shows the general idea about architecture of remote health care monitoring and alert generation system.

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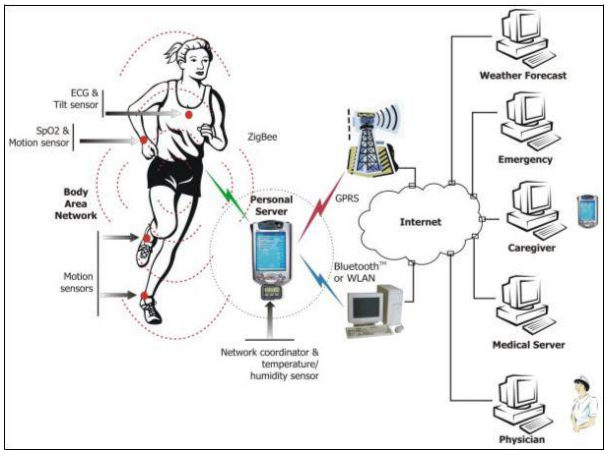

Fig. 1 Basic architecture of health care monitoring system

Figure 1. describes health care monitoring system consists of various wearable sensor devices are attached to human body and non-wearable sensor devices are kept in environment for taking context information. The wireless technologies like ZigBee, Bluetooth, Wi-Fi, GSM and also wired technologies like local area network (LAN), wide area network (WAN) etc. are used for communication. Depending upon application need communication technology is choose for transferring those sensor collected information to next server for further processing. Finally, processed data send over internet to the medical server or to the clouds. In any emergency situation alert messages will send to caretakers, physician. The preventive measure is taken with the help of such system. The wireless technology remove limitations of existing systems like fixed monitoring and communication over limited distance.

There is tremendous new developments in digital technology and wireless communication area. With those new developments computers, laptops and smart phones have become the most popular and fundamental tool of daily life. In health monitoring, physiological parameters are captured with wireless sensor network including wearable sensors, implantable sensors, and smart bands. In case of disease like Alzheimer there is continues need to monitor patient activities. The daily activities of those patients can monitor with sensors like gyroscope and accelerometer. Also fall detection can achieve with video camera by capturing video of daily activities of person. In hospitals, electronic health system is used for getting information about patient's health.

II. RELATED WORK

Various researches and work have been done in health care systems. The author Ittipong Khemapech developed UbiNurss system for real time health monitoring and warning system especially for nursing support [4]. In [4] mio and withings platform are used with raspberry pi. In [2] authors used heart bit sensor and body temperature sensor to measures patient health condition. Arduino Uno microcontroller was used for capturing health parameters. The Thingspeak new open source cloud used for storing health parameters and accelerometer sensor for tracking body position [2]. The smart phone based health monitoring system was developed for cardiac patients [1]. The GPS used for track location of patient [1]. Also health care monitoring is achieved with smart phones and smart bands. A real-time online activity and mobility monitoring (ROAMM) framework developed with smartwatch application for data collection, a server for data storage and retrieval as well as online monitoring by samsung Gear S smartwatch [6].

III. HEALTH CARE APPLICATIONS

A. *Health Monitoring Service:*

The patient/user to be monitored at any time, in any location with this application. It reduces the time between the occurrence of an emergency and the arrival. In a hospital health care monitoring system it is necessary to constantly

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monitor physiological parameters. For example a pregnant woman parameters such as blood pressure (BP) and heart rate of the woman and heart rate and movements of fetal to control their health condition.

B. *Intelligent Emergency Management System:*
This system detects abnormal conditions of patient with wireless body sensor network. Alerts will generate with different ways. The buzzer is on at patient side. The SMS/Emails or calls to caretakers or doctors. This system manages ambulance in high risk emergency case.

C. *Heath Care Data Access:*
Cloud computing has increased value in distributed computing environment. The use of cloud environments for storage and data processing needs on the rise in health care system. On the other hand, mobile devices have been seen as one of the most essential and adorable tool for data access. Collecting and analyzing patients' information using the existing processes requires more effort. Generally these processes are prone to error and time consuming, and provide delay in information storage and accessibility. The health care data access through cloud solves problem of existing system.

IV. DIFFERENT IMPLEMENTATIONS OF HEALTH CARE SYSTEMS

A. *UbiNurSS Real-Time Health Monitoring And Warning System [4]:*
The UbiNurSS stands for ubiquitous nursing support system. This system has been developed especially for nursing support. According to author, elderly population of Thailand gradually increased each year. Also, Thailand faced health related issues caused by heart disease, diabetics, cancer and hypertension. Current medical system only focus treatment rather than prevention. The government provides several policies like establishment of care center for disabled and elderly people. Those policies established with affordable fees but available number of beds and spaces is limited. Better facilities provided by private nursing home while it acquired high fees. Now a day's several wearable devices with inbuilt sensors at low cost are easily available in market. These wearable devices developed for preliminary monitoring health status of user. The vital sign of user measures with those devices. Such devices have been specially developed for healthcare instead of diagnosis purpose. The author describes UbiNurSS system was support two functionalities. Firstly, it provide real-time monitoring with low cost wearable devices which were easily available in market. Secondly, system generates warning if parameters crossed threshold value.

1. UbiNurSS System Development:
The author explained proper development of system. UbiNurSS system consists of two main sub-systems. First sub-system included Raspberry Pi which was situated at user/patient room. Second sub-system consist web application used by nurses at nursing station. The author was used Mio and Withings platforms for measuring pulse rate and blood pressure respectively of patient. The Mio platform was attached to patient's wrist watch. The Withings platform was attached to patient's arm. After measuring parameters platform delivered those parameters to the Raspberry Pi system. The architecture of UbiNurSS system is shown below **[4]**.

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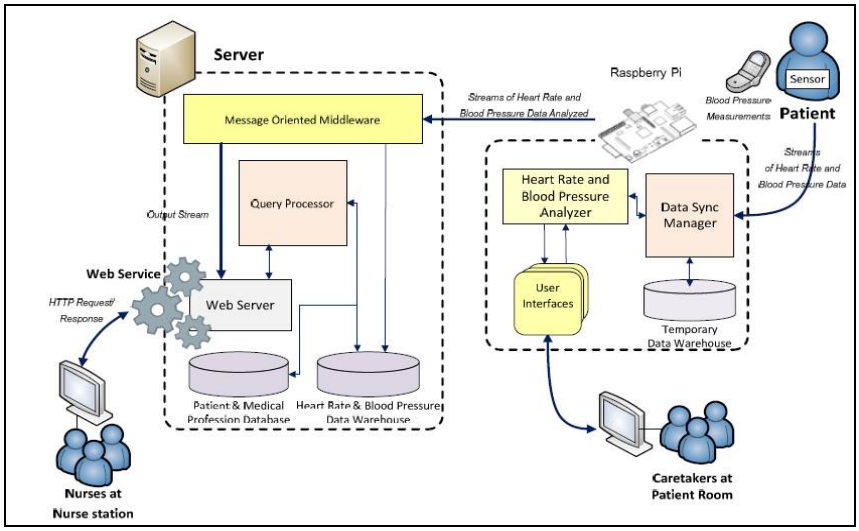

Fig 2: Architecture of UbiNurSS system [4]

The architecture figure describes heart rate and blood pressure data transferred to data analyzer with Rasberry Pi system. The data synchronization manager responsible for made comparison between read data and provided ranges. The analyzer component used for provide color-based warnings on user display to the nurse or caretakers at patient's room. The author used three colors for increasing and decreasing heart rate warning- 'Green', 'red', 'yellow' colors for 'Normal', 'Danger' and 'Warned' conditions respectively. Simultaneously reading data transferred to storage on web server of web application which written in PHP language. The open source messaging server Message Oriented Middleware (MOM) provides a real-time message exchange among nodes. The author used two databases at web application side. First database stored heart rate and blood pressure of patient. Second database stored details about patient and medical professional. The HTTP request and response from and to users' machine conducting through web services developed by web application.

The author conducted communication range tests between the Rasberry pi and the Mio device. In indoor environment tests conducted for four scenarios like 0-degree direction (No barrier), 45-degree direction (Concrete columns), 90-degree direction (No barrier) and 180-degree direction (Glass door). The author concluded that UbiNurSS was applicable in a normal room within communication range up to 5.40 m to 13.50 m with without barrier [4].

2. *Advantages and disadvantages of UbiNurSS system:*

According to author, this system is affordable to all people because the devices used for developing system having low cost. Also the system is open source system because it was written in Python and PHP open source platform. Since system could freely distributed and enhanced by other parties. The system could afford at low cost because it used wireless communication rather than communication cables. These all are advantages of UbiNurSS system. The author concluded that system having some disadvantages like limited communication range. Second con of system is unreliability of Rasberry Pi system because sometimes it stopped working after six hours of running that required restarting processes.

3. *Improvements in System:*

According to us, unreliability problem can be removed by using Rasberry Pi 3 system. The communication range problem will be solved by using devices which provides more distance range for communication.

B. *Non-Intrusive Tracking of Patients With Dementia Using Wireless Sensor Network [7]:*

Next implementation is tracking activities of patients who faced problem of Alzheimer's disease. Wireless sensor network (WSN) rely on wireless connectivity. WSN transfers sensor data wirelessly. Dementia is major health problem faced by elder people. There are various symptoms of dementia like loss of memory, sudden mood changes, problems

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with communication and reasoning. The two most common dementia are Alzheimer's disease and vascular dementia. Due to this symptoms dementia patients required constant supervision or monitoring. Keep in mind this problem authors have been developed non-intrusive tracking with WSN. The authors used wireless sensor network (WSN) because devices attached to body are hardly accepted by dementia patients. The system used for monitoring of person and generates alerts if person leaves the place without supervision.

1. *System Architecture [7]:*

The system was developed with inexpensive binary sensors. The processing overhead could reduce and allowed faster system response by using binary sensors. The passive infrared sensor and magnetometers provided a very good performance concluded after testing various sensors. The infrared light emanating from object measured by passive infrared (PIR) sensor. PIR sensors are cheap sensors. Also the presence of heat from an object or body nearby detected by PIR sensors. When the temperature changes occur at that time PIR sensors detected the movement of people. The change of direction of magnetic field detected by magnetometers sensors. The node using PIR sensor was placed on wall. The node equipped with magnetometers placed on door of room. The data collected by nodes sent to sink. The alerts sent to mobile when person leaves a room without supervision.

2. *Non-Intrusive Tracking Functions [7]:*

If the door was opened because someone entered into room, or door opened for someone leave the room would be decided by the system. For this reason authors proposed an algorithm. The information fusion technique was used in proposed algorithm to combine values measured by PIR and magnetometers sensors to determine whether a person enters a room (*I)* or leaves a room *(O).* A sample recorded by a sensor node represents by St in this model, where t is the time when the event was detected. $S \in (M,P)$, where P is a sample recorder by PIR sensor and M by the magnetometer. Authors considered the behavior of an I event, that the event starts at $t = 1$. The sampling period T is 1 second, the event I can be represented as:

$$I = (M1, M2, \ldots, Mi, Pj, Mi+1, Pj+1, \ldots, Mk, Pk+1, \ldots, Pn-1, Pn)$$

Event was took placed in the interval (1, n). In the interval (1, k), the magnetometer detected activity whereas in the interval (j, n), the PIR sensor detects activity. The time elapsed between two consecutive samples during the interval (i, k), named t, satisfies the relationship $0 \leq t \leq T$. The following expression used to determine if an event I has taken place.

$$E_I = 1 - (|NS - \bar{A}_I|) / (\lambda \cdot \sigma_{SI})$$

Where, NS = Number of samples of the event I (person entering the room)

$\bar{A}_I$ = Mean of the number of samples I

σ_{SI} = Standard deviation of the number of samples I

λ = constant ($\lambda \geq 1.1$)

If $E \geq 0$, system concluded that an event occurred.

3. *Advantages of System:*

- Flexibility - This system uses wireless sensor network so it does not required previous infrastructure like wires.
- Cost - This system develop a simple solution using inexpensive binary sensors.
- Provide monitoring system to dementia patient non-intrusively.

4. *Disadvantages of System:*

- This system couldn't detect the patient fall.

5. *Need of improvement in system:*

The RFID device can be used with system to overcome the problem of fall detection of patient. This model can integrating with RFID devices attached to patient, and to detect patient falls.

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C. *A Cloud-Based Radiological Portal For The Patients [8]:*

We explored above two techniques for health monitoring which didn't use cloud for storage. This technique focuses on storing radiological data of the patients on cloud and securely accessing those data over internet at any time. Cloud computing provides three services IaaS, Paas and Saas [9]. The IaaS (Infrastructure as a Service) service provides virtual computer resources over the internet at any time and at any location [9]. The author used IaaS service of cloud computing. The use of cloud environments for storage and data processing is on the rise in health care systems. Now a days patients need to have ubiquitous access to their medical records, especially when they required mobility. The ubiquitous access to patient's data can be possible with cloud storage. In normal health care systems, the PACS (Picture Archiving and Communications System) stored medical image data which is released by medical imagine department of hospital. The medical data stored in PACS system is restrict to access within hospital network only. The physical support like reports or CD provides by hospital to patients. Such physical support can become deteriorated or lost. Really it is very hectic to carry all these medical data for patients such as pregnant women and handicap people. This fixed storing system do not provide mobility. This project was a part of the EU FP7 CocoCloud project [10]. There were four requirements for establishing portal are functional, privacy, security, data usage control and performance requirements. Only the authenticated user could access cloud's data with digital certificate under functional requirement.

1. *System Implementation:*

The authors describes the main system consists of three subsystems:

- Portal application subsystem (public cloud).
- Hospital subsystem (private and cloud gateway).
- Client subsystem (authorized clients).

The private cloud placed in hospital premises. The usual components of radiological department hold by the private cloud. The medical imagine data stored on Picture Archiving and Communication Systems (PACS). The PACS system stored data into DICOM objects. DICOM stands for digital imaging and communications in medicine. DICOM objects in form of reports and medical images of patients. The HTTP protocol defined by DICOM standard to interact with PACS that allows query for storage and retrieve of images, reports, and patients' related data [8]. The portal infrastructure and components outside radiological workflow supported by the public cloud. The private cloud and the public cloud communicated with help of gateway. The gateway provided access to the hospital private network from the Internet securely. For security purpose the SSL-VPN means secure socket layer virtual private network connection. The SSL-VPN connection used for connecting portal application directly to the Coco Cloud gateway. The client application requests handled by public cloud subsystem and derives them to the gateway. Then wrapping of DICOM objects within their authentication keys. After this process those DICOM objects converted into an encrypted object and finally sent them to those objects clients.

2. *Advantages of Cloud Based Radiological Portal System:*

- Mobility - Cloud storage provide ubiquitous access of patient's data when patient needs mobility.
- Cost decrease – With cloud storage system hospital organization do not need to store and maintain data base server so cost of maintenance is less.
- Security - This system gives authorized access to each user with authenticated username/password and digital certificate.
- Availability - Full time data available on cloud access by user at any time ad at any place through internet.

3. *Disadvantages of Cloud Based Radiological Portal System:*

- Control of third party: In this cloud based system the control of data is in hand of third party cloud vendor.

4. *Improvements for System:*

- You can overcome the disadvantage of system by building your own organization's cloud which is handle by organization itself. In this scenario cost of system will be increases but data control is in hand of organization rather than third party.

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D. *Wireless Sensor Based Healthcare Monitoring System Using Cloud [5]:*

The third system cloud based radiological portal is only for storing medical imagine data to clouds and access those data. The last system is limited for storage only. The wireless sensor based healthcare monitoring system using cloud technique providing automated healthcare monitoring system and also cloud for storage. This paper proposed two methodologies. First method used wireless sensors like temperature sensor for measuring vital parameters of patient [5]. Also captured body movement of patient by using accelerometer wireless sensor. The second method recorded the patient's status and stored on the cloud. The authors introduced importance of internet of things (IoT) for healthcare application. The world uses IoT for interconnecting various objects which are outfitted with sensors. The wireless sensor network (WSN) use in daily life to remotely acquire and monitor the physiological parameters. WSN removes the mobility issue of wired network. This system based on internet of things.

1. *Methodology Used in System:*

The wireless communication is used for measuring pulse rate, body temperature and body movement in this system. The sensors attached to patient's body captured physiological parameters and then transmitted to pc computer. The cloud processes the sensor data and then stored patient's record. The cloud facilitated the real time monitoring of patient by the doctors. The healthcare professionals could monitored and accessed physical condition of patient from anywhere and at any time through internet.

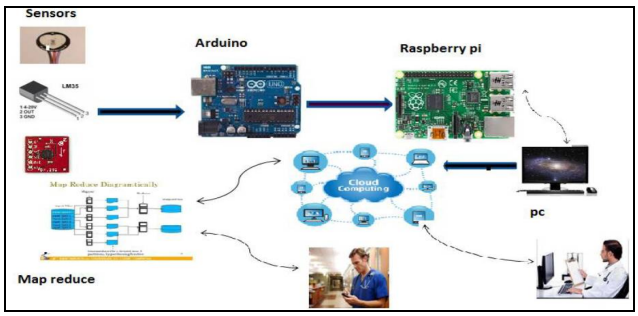

Fig 3: Healthcare Monitoring System Architecture [5]

2. *System Modules:*

This proposed system has three modules. First module for sensing parameters, second module for retrieving and stored data, and third module for displaying information.

Module 1: Sensing the patients physiological parameters

This module used for sense body temperature and pulse rate of patient. The authors used $LM35_Z$ for measuring body temperature and heart beat sensor sensing pulse rate. This system used open source Arduino microcontroller and Raspberry pi microprocessor. The $LM35_Z$ and heart bit sensor attached to Arduino microcontroller. The sensors data read by Arduino software and display on serial monitor of Arduino. The data captured by Arduino forwarded to the Raspberry pi. The Raspberry pi microprocessor processed that data. After processing data by microprocessor then processed data updated into database and stored on the cloud.

Module 2: Retrieve the data from the sensors and store in the cloud server

The system used open source WAMP server to display physiological parameters of patients. WAMP server provides open source Apache server, PHP scripting language and MySQL database. PHP and MySQL used for developing the health care application. Gobetwino is a kind of generic proxy for Arudino. The 'Gobetwino' required for sensing body temperature and pulse rate of the patients' and to display those results in server.

Module 3: Display the health information in mobile

The web server used for measuring and monitoring physiological signals like heart rate, body temperature of patient's. This system developed android application for receiving and displaying the health parameters on android

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mobile. At the same time data uploaded on android web server. The android application developed to display body temperature, pulse and body movement of patient. The history of patient stored on web server. The doctor could access patient's data from anywhere whenever needed without physical presence of patient.

3. *Advantages of System:*

- The main advantage of system is it provides two healthcare services. It provides real time monitoring of physiological parameters and stored that parameter on cloud for resolving mobility issue.
- This system enables personalization treatment and management.
- The cloud provides reliable storage.

4. *Disadvantage of System:*

- This system used to monitor body movement but it can't provide fall detection mechanism.

5. *Improvements in System:*

- The system can use various machine learning techniques like classification algorithms are used for detecting fall detection.

E. *India's Healthcare Startups Working For IoT In India:*

We have studied three healthcare startups working for IoT in India. These are follows:

1. *Forus Health [11]:*

The forus health is located in Bangalore. The 3nethra Camera is compact & portable fundus camera. It is used for capturing digital images of posterior (retina) and anterior (cornea) segments of the eye by forus health. The camera is use for identifying common eye problems such as diabetic retinopathy, glaucoma etc. The device is integrated to a cloud based telemedicine platform which enables remote diagnosis [11].

Fig 4: The 3nethra camera [11]

2. *Spectral Insights [12]:*

The Spectral Insights aims to bring innovative & affordable imaging systems. The spectral insights is located in Bangalore. It built an affordable automated microscope that makes digital images which are available to pathologists on a computer screen, either locally or over the Cloud. The Spectral Insights developed Digital Pathology Imaging System. This system is a fully automated digital microscopy system for Pathology Labs & hospitals *[12]*.

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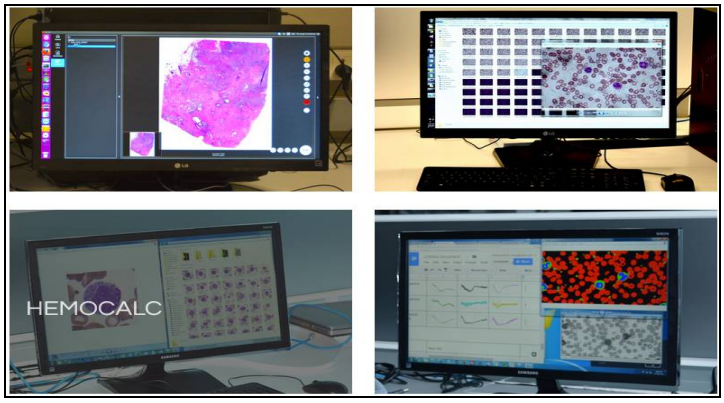

Fig 4: Digital Pathology Imaging System [12]

3. *Cardiac Design Labs [13]:*

The Cardiac Design Labs is also located in Bangalore. This lab developed MIRCaM system. MIRCaM is a wearable device called Mobile Intelligent Remote Cardiac Monitor. MIRCaM is capable of providing real time advanced cardiac diagnosis & monitoring even in remote areas. This system is enabling real-time and remote early detection of heart problem. This system reduced cost of treatment.

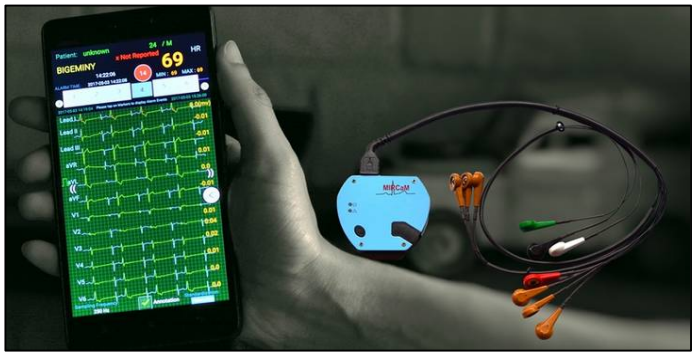

Fig 5: Mobile Intelligent Remote Cardiac Monitor (MIRCaM) [13]

V. CONCLUSION

Based on advancements in digital technology like wireless sensor network, cloud computing etc., this paper surveys different implementations of real time health care monitoring and alert generation system. Some of health care systems are discussed with system architecture, advantages, disadvantages and improvements need for system. Today's word is digitized world and people want to monitor their health daily. The preventive medical treatment achieved with the help of health care systems which we discussed in this paper. According to various patients, diseases and personal demands may differ in providing health care services under different settings. As really it is a big challenge to build a health care system with new technology. The main aim of study is to explore various health care systems to support health and social care is fulfilled. We have given some improvements in systems so that you have get better health services from same system. We concluded that you can make better health care system with integrating all these technologies we have studied in this work. Building the new system with integrating all these new technologies is again big challenge for health care.

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