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IOT BASED MULTIPATIENT HEALTH MONITORING SYSTEM

Neealm Maurya,sonal ullewar,Jayshri Wadibhsme,Asmita Wasnik,Abhishek Kumar
Electronics Engineering, Kdk College Of Engineering, Nagpur, India

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ABSTRACT

This paper illustrates the design and implementation of an health monitoring networked system. Statistics reveal that every minute a human is losing his/her life across the globe . More close in India, everyday many lives are affected by heart attacks and more importantly because the patients did not get timely and proper help. Care of critically ill patients, requires spontaneous & accurate decisions so that life-protecting & lifesavings therapy can be properly applied. The architecture for this system is based on smart devices and wireless sensor networks for real time analysis of various parameters of patients. This paper is based on monitoring of remote patients, after he is discharged from the hospital. Internet of Things (IoT) is the emerging paradigm, which contains huge amount of smart object and smart devices connected to the internet for communicating with each other. IoT devices are used in many fields which make the users day to day life more comfortable. These smart devices are used to collect body temperature, heart rate, ECG, and EEG. etc., which are used to evaluate the health condition of the patient. Communicating the collected information to the doctor, making accurate decision on the data collected. we have designed and developed a low cost, reliable, energy efficient remote patient monitoring system. It is able to send parameters of patient in real time. The medical history of each patient including medications and medical reports are stored on cloud for easy access and processing for logistics and prognosis of future complications. Use of smartphones to relay data over internet reduces the total cost of the system. We have also considered the privacy and security aspects of the system keeping the provision for selective authority for patients and their relatives to access the cloud storage as wellas the possible threats to the system.

Keywords: *multiple health parameters; patient monitoring system; real-time monitoring; sensors; wireless sensor network; smart device.*

I. INTRODUCTION

Wireless technology is ruling worldwide and has invaded the medical area with wide range of scope and capabilities.To monitor continuous medicare conditions of patient using existing wireless technologies were quite convoluted. To overcome this , we are proposing a change in wireless sensor technology by designing a biomedical monitoring device comprised of different sensors to acquire the information regarding human body temperature, heart rate which is sent to a personal votality measurement system and further transmit this information on IOT server which is user accessible over the internet. The applications of IoT can be grouped into domain like (i). Transport and logistics, (ii). Health care (iii). Smart Environment (iv). Personal and SocialThe roles of IoT in all these domains are remarkably high. In Transport and logistics vehicle identification, vehicle to vehicle communication, traffic communication etc. are the major advancements in the field of IoT. Nowadays Government focuses on creating smart cities to use all the emerging technologies and developing the nation to compete internationally. Each and every person is surrounded by smart devices, which is used to connect to the 3G/4G network, social networks and other intelligent technologies. The strength of IoT is its high impact on every person s day today life such as entertainment, work, communication and so on.

Section II describes the problem. Section III discusses the related work. Section IV explains the proposed system architecture. Section V presents a decision making algorithm for monitoring and detecting conditions of patients in hospitals. Section VI focuses on the implementation and results. Section VII describes the experimental setup. Section VIII describes theoretical calculations. Section IX and X contains the conclusion and future work respectively.

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II. PROBLEM STATEMENT

There are some shortcoming present in existing system. Currently there are number of health monitoring systems available for ICU patients which can be used only when the patient is on bed. This system is wired everywhere. The patient is monitored in ICU and the data transferred to the PC is wired. Such systems become difficult where the distance between system and PC is more. Regular monitoring of patient is not possible once he/she is discharged from the hospitals. To overcome these limitations of systems we proposed a new system. This system is able to transmit the parameters of patient continuously and over long distance wirelessly. Due to which we would be able to attend the patient immediately. Therefore by developing a system that can constantly measure the important parameters of patient's body.From which can alert the closed ones and the doctor on any time when the patient's condition gets bad, this can really provide quick service and be beneficial in saving a lot of lives. These systems cannot be used at individual level. The other problem with these systems is that it not capable of transmitting data continuously also range limitations of different wireless technologies used in the systems.

III. RELATED WORK

A two-tier clinical warning system, for hospitalized patients, was described in [1], which incorporates preventing clinical deterioration in patients, through early detection and intervention. Their system consists of an Early Warning System (EWS) which identifies at-risk patients from existing real-time Electronic Medical Record (EMR) data, using machine learning algorithms. A key challenge that they noted had not been overcome for such applications was to be able reliably deliver sensor data from mobile patients. This system focuses on a solution for this problem. Whereas the proposed system is capable of overcoming this limitation. a novel wireless sensor network structure to monitor patients, with chronic diseases in their own homes, through a remote monitoring system of physiological signals assessment is discussed in [2]. They present a new design which eliminates the need for a PC to send patients' data to a hospital. Mobile patient monitoring systems, which integrates current personal digital assistant (PDA) technology where used in [3] and [4]. [4] used PDA in CONJUNCTION with wireless local areanetwork (WLAN) and discussed the possibility of using Blutooth technology, in the future. However disadvantages of Bletooth are that is in capable of multiple hopping and its range is limited. [5] looks at currently used wireless techniques in hospitals. The technologies of wireless sensors and data transmission, and their ability to meet the needs of patient monitoring in the operating room and the intensive care unit, are reviewed.

IV. PROPOSED SYSTEM

The proposed system, as shown in 'Fig.1', monitors the parameters of multiple patients such as their blood pressure, Temperature, EEG and ECG. These are processed and are compared with the threshold limits and are wirelessly transmitted to the patient monitoring system held at doctor's room. The data is also networked to the monitoring system in nurse room. Each patient is identified using their Unique ID and thus doctors will get a detailed report of each individual patient's current status and state. In case of doctor's absence since the monitored data being stored at the nurse system, the monitored values along with their status can be send to the doctor's mobile phones [6] or make use of internet facility. Thus our system helps in the simultaneous monitoring of the multiple parameters in multiple patients

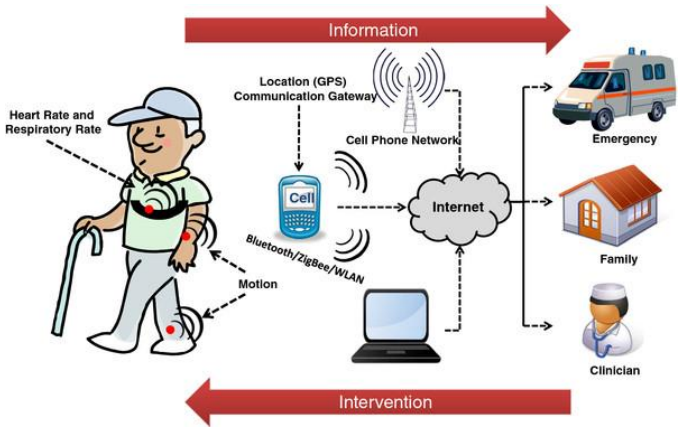

Fig 1. Basic architecture of patient monitoring system

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The various components of proposed system consists of

- Sensors attached to the body of patient.
- Signal conditioning section.
- Patient monitoring system.
- Doctors/nurse mobile phone.

The various sensors used are blood pressure sensor, temperature sensor, In this paper, we concentrate on the blood pressure monitoring of multiple patients.

V. FUNCTIONAL COMPONENT OF THE ARCHITECTURE

In this section we have discussed about the functionality of the system with emphasis on the operation of sensors, the types of parameters monitored, process of accumulation and dissemination of data. We have also taken into consideration the various services that are offered through this monitoring system in this section.

A. Sensors and Processing Units

The monitoring system is based on primarily two kinds of sensors. These sensors are medical sensors which are attached with the patient to measure vital parameters and the environmental sensors embedded in and around the various part of the parts of the room where the patient is present. These values considered together present the real time situation of the patient at all times.

1. Medical Sensors

These sensors are used to analyze the health of the patient by measuring various bodily parameters. The sensors in the environment as well as on the patient should be small in size and as unobtrusive to the patient as possible for acquiring natural values of the parameters. The sensors include heart rate monitor, oximeter, blood pressure sensor, ECG module, and thermometer.

These sensors produce raw values of data which are wirelessly relayed to a central transceiver unit worn by the patient. This transceiver unit processes the raw data and converts it into meaningful metadata [9]. Raw sensor data contains only values of the parameters measured hence has little value.

Sensor Metadata when added to these values, viz. type of parameter being monitored, feature of interest, timestamp and unit of measurement makes these values meaningful.

2. Environmental Sensors

These sensors monitor the surrounding of the patient and ensure that the patient is in healthy living conditions.

These sensors can be embedded in particular rooms for private health

- care or in Intensive Care Units in health care centers and hospitals. Following describe this category of sensors.
- Gas detection sensors are used to maintain proper oxygen level.
- Temperature sensors are used to report room temperature. This can be used in a feedback mechanism to control the temperature of the room.
- The bed is equipped with a set of piezoelectric sensor to detect whether the person is in the bed. The room can also be embedded with such piezoelectric sensors to detect motion. These sensors can also be programmed with a microcontroller to detect a fall or collapse of the patient.

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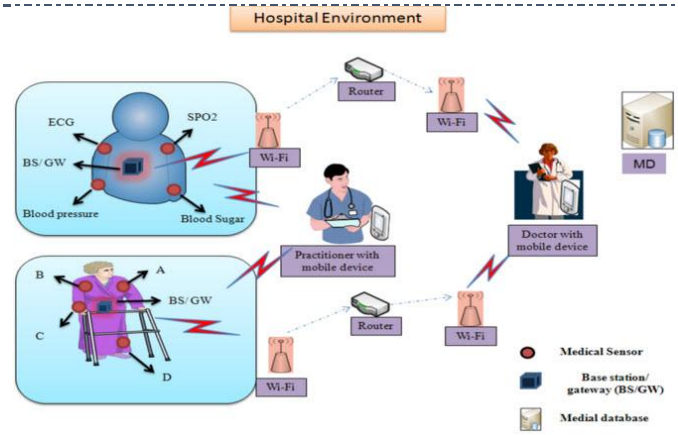

Fig.2 Hospital environment

B. Services for the monitoring system

The data acquired from the sensors are stored in a central database on the cloud. This data is processed in two ways, viz.

- on-board processing and on device processing [10].
- On-board processing can be carried out on the central base station preferably a smart device. This allows immediate detection anomalies and care could be taken before the patient reaches healthcare institutes.
- On-server processing uses the real time metadata received from the sensors to process them with respect to data stored in the cloud itself. This type of processing requires better resources in the form of memory, throughput and processing time and hence is more suitable for on server processing than On-device processing. Based on the processing and storage of data our system offers a set of services as follows.

1. Hospital Services

Each patient is monitored using the vital parameters from the sensors embedded on the patient as well as in the surroundings. The values are further monitored by attendees present in the health care centre premises. For any anomalies in the values both visual alarm and audible alarm are deployed. The caregivers monitor these alarms for each of the patients and attend the patient with required medication to address the situation. These services are also available to patients opting for private monitoring at their residences. In this case, a caregiver is present on the premises however the monitoring is done remotely at a hospital. If an alarm is triggered it alerts both the staff present in the hospital and the
caregiver on premises as well.

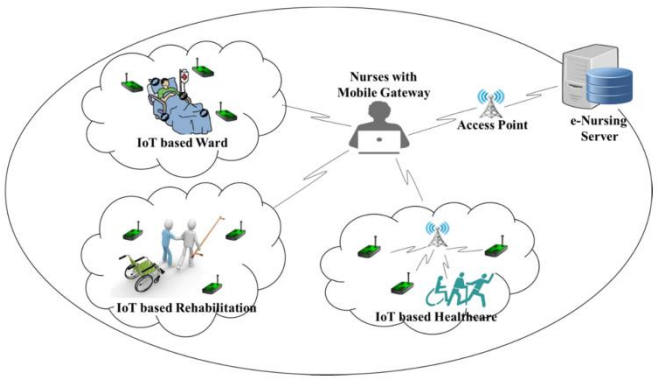

Fig.3. Services for monitoring system

2. Cloud Storage Services

In this set of services we offer a unique set of services in the form of cloud storage. The cloud storage is used to store medical histories of the patients with a particular database pertaining to each patient. These records can be

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used to correlate the current data received from the sensors for diagnosis. This pattern recognition process plays a pivotal role in the services mentioned subsequently. Cloud Storage can be used to securely store (i) medical reports, (ii) medical prescriptions along with particular medicines for which the patient has showed best recovery patterns and (iii) medicines to which the patient is allergic. The preferable method of storage for these prescriptions would be in the form of XML files rather than plain text. This would allow easier parsing of data and would hence facilitate the processing on the cloud.

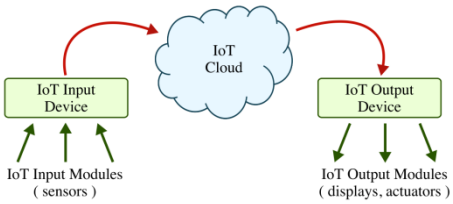

Fig.4. Cloud storage

3. Emergency Response Services

Unlike the response from caregivers mentioned in the Hospitality Services, there are cases in which immediate attention is required from the caregivers for situations which may prove to be life threatening. There may be cases in which the threat may be beyond the scope of the caregivers and require intervention from the doctors. Fig. 3 illustrates the block diagram for the emergency response module.

The values received in real time from the sensors are sent to the cloud for storage as well as processing. The database for each patient stores abnormal values for each parameter considered. On-server processing is used to compare all these values to the thresholds in real time. The breaches in threshold values acquired from the initial stage of processing are then sent to the Emergency Type Handler. The Emergency Type Handler then applies predefined logic to determine whether the breaches are inter-related and pose a greater threat combined. Based on the kind of threat the Emergency Type Handler assigns the threat to one of three levels.

- For Level III emergency, a message/alarm is sent with vital parameters and threshold breaches only to the caregivers.
- For a Level II emergency, a message/alarm is sent in a similar manner but to both the patient□s doctors and caregivers.
- For a Level I Emergency or emergency with the maximum threat, the system sends a call with a recorded message of the threat and breached parameters to both doctors and caregivers.

Based on these alerts the patient is immediately attended by the doctors or the caregivers in an attempt to bring the patient back to a normal state with required treatment and medications.

4. Real Time Health Advice and Action (ReTiHA)

This service is designed to operate when the Emergency Response System fails to arrive or the patient is unattended even though a level I emergency is disseminated. If the monitoring system in the On-Server processing determines further deterioration of the patient as a result of further breaches in thresholds, this service is triggered. In this service the On-Server program executes a pattern recognition program to determine whether such an emergency has been reported earlier in the records. If such a pattern is found matching the current pattern of parameters, the on-Server program checks with the prescribed history as to which medicine was applied to cure the patient in such a situation. If such a suitable medication is found, the On-server program suggests the medication to the patient through the central reporting system. The medication can then be applied by a relative present in the bedside or by the care giver. This is particularly useful and applicable to patients with a chronic disease requiring similar yet vital medications on emergency and for patients on private monitoring where emergency response might be delayed.

5. Parent Monitoring Services

With the ageing population worldwide and opportunities to work abroad, it is a common situation in which the parents stay away from their working off-springs. In cases of sudden health disorders and medical emergencies the off-springs are often deprived of the information regarding the emergency due to a delay in communication. To bridge this gap between working professionals and their parents we have designed this service.

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This is designed as a value-added service in which the off-springs receive continuous updates of the vital parameters of their parents and are updated on the emergencies through alerts similar to that of a caregiver. To implement this service we can send these updates through a smart phone application. This smart device application will be equipped with an API which can received updates from Layer 2 of the architecture. For e.g. the date and time for the next appointment with the doctor or change in prescribed medicines can be relayed through this application. The location of the parent can be also monitored by using a wearable GPS device or by localizing the parent using beacon nodes [11].

VI. SECURITY AND PRIVACY

In this section we have discussed about the various security threats to this e-health monitoring system. As the system is concerned with the condition of human health and prescriptions are made online by the doctor, we need to consider rigid security measures.

This is required in order to secure the patient□s health and to assure whether the patient is receiving proper medical guidance. If the patient□s profile is compromised or a prescription is uploaded by any unauthorized person other than the doctor, this can have a deleterious effect on the patient. Hence the following aspects of end-to-end security are to be considered to ensure that there are no loopholes in the security of the system.

VII. CONCLUSION

Even though a lot of research has been conducted on health monitoring systems, we have proposed a set of novel services based on the monitoring system. ReTiHA will require immense research and testing before implementation, however it paves a new path for remote health monitoring systems. We have also proposed other novel services in the form of Parent Monitoring system and the Emergency Response Services. The use of SenML in our system ensures organized transmission of sensor metadata. The medical data and history acquired for the patients are personal in nature. Hence our system ensures security of the highest order for the medical data on cloud storage. With further research in this aspect, our system can change the way we currently look at remote health monitoring services.

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