Abstract—Improving the quality of life for the elderly persons and giving them the proper care at the right time is the responsibility of the younger generation. Due to lack of awareness on proper elder care, unavoidable busy schedule etc. the elderly population is seem to be quite ignored. A simple, compact and user-friendly electronic gadget for continuous monitoring of elder health parameters is the need of the hour. Day by day the menace of weakening health and chances of skin related problems, bed sores etc are becoming critical in case of bed ridden patients. This paper analyses the old age diseases and the parameters to be monitored. Moreover, a detailed study is provided on the design of the gadget – placement of sensors, wired/wireless technology, Android applications etc. Based on the analysis a simple, comfortable, low cost gadget to monitor elder health and report any critical condition is proposed.

Keywords— Elder care, home-bound patient, Assistive technology.

I. INTRODUCTION

Providing quality and timely health care for the elderly has always been the area of concern for the younger generation. Employment, work stress and other family issues have always convoluted this problem. Though old age homes and elder care centers have emerged as a possible solution to this problem, they are rather business oriented and quiet expensive. Moreover elderly people does not prefer custodial care and want to be at home where they are not detached from their family, friends and society.

Analyzing the diseases of the elderly, we can see that many of the diseases that haunt them are chronic in nature. In many a case the detection and cure of these diseases require continuous monitoring of the physical parameters due to their special nature of occurrence. Another major issue affecting bed-ridden elderly is the case of bed sore and unintentional fall as in [1]. Though there are many products available in the market today for monitoring patients as in [2], we can see that many of them only measure individual parameters like heart rate, body temperature etc. In addition, many of them do not address the problem of tilt or fall.

II. PROBLEM DEFINITION

Projected increase in both the absolute and relative size of the elderly population in countries all over the world is a subject of growing concern. The proportion of elderly persons in the population of India rose from 7.5% in 2001 to 8.5% in 2010. The Indian aged population is currently the second largest in the world. As population ages, more demand is placed on caring for the elderly. The absolute number of the elderly (above 60 years old) population in India is projected to increase from 77 million in 2001 to 137 million by 2021.

Many of the elderly have various degrees of disabilities. They are often dependent on others for their activities of daily living. Some of them remain bedridden due to various causes. This means that a ‘Care Team’ (including family, friends, nurses and other professionals) will likely be working together. The healthcare provider would want a record of body temperature, pulse, and respiration. In case of bedridden elders we have to make sure that the position of the elder is changed periodically so as to reduce the possibility of bed sore. Clearly, in view of such a demographic trend, medical assistance to the rising number of dependent elderly is a major problem that many countries are facing now. In this scenario, a constant and reliable assistive technology, which can cater the needs of these homebound elders, is the need of the hour. Assistive technology devices are helpful products that improve a person’s ability to live and function independently. These types of assistive gadgets can also prove to be a boon to the caregivers, since their workload can be drastically reduced.

III. RELATED WORKS

Some of the elder care systems as mentioned in [2] monitor activities of the elders in their home. They embed a video system in the living environment of elders and continuously monitor their activities at home. However, this system doesn’t measure any of the vital parameters of the elderly patient. Measuring the vital parameters is inevitable if the elder person suffers from any sort of heart ailments, which are very common in individuals aged above 60[11]. In [1] mobile devices like Caalyx (Complete Ambient Assisted Living Experiment) which can measure vital signs like ECG, pulse, Blood pressure, Movement and Fall detection. However, the design we have proposed can monitor vital parameters and fall detection along with tilt monitoring for the bed-ridden patients to monitor any case of bed sore. Some devices as in [1] monitor only fall detection for the elderly patients based on the sensor readings from accelerometers and microphones attached to the body of the patients. The system proposed in [4] is applicable to patients.

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and elders for activity monitoring and fall detection and also sports athletes’ exercise measurement and pattern analysis.

IV. ELDER CARE GADGET DESIGN
A detailed analysis is highly required before implementing any continuous health-monitoring gadget for elders. In future, the rating of such a device in the market will be done considering many aspects. This paper discusses about the various aspects, which plays a very important role in the design of a continuous health-monitoring gadget.

A. Parameters To Be Monitored
The numbers of parameters a gadget monitor at a time matters a lot while designing it. All the measurements should be of non-invasive since the monitoring has to occur in 24*7 hours. After researching through various articles related to elder health, certain health parameters, when monitored continuously, can avoid critical situations. It includes blood pressure, body temperature, tilt of body, fall of body, oxygen content in blood and heart rate.

Body Temperature
Body temperature is a basic parameter, which has to be monitored in any individual. Body temperature sensor fixed at a particular location of body measures the temperature and transmits the value to the main central circuitry using the same ZigBee technology.

The fall of the body
Another serious issue related to Elders is fall detection. Falls can be markers of poor health and declining function, and they are often associated with significant morbidity. More than 90 percentages of hip fractures occur as a result of falls, with most of these fractures occurring in persons over 70 years of age.

The tilt of the body
The most grave and gruesome problem faced by bedridden elders is the formation of bed-sores. They develop quickly, progress rapidly and are difficult to heal. Constant monitoring of bed ridden elders thus becomes very crucial issue in maintaining proper health condition. Thus it requires that the caretaker to monitor the elder at regular intervals. If the caretaker fails to keep track of the elder posture it could lead to a case of bed sore. Thus a system is necessary to keep track of the elder posture continuously and assist the caretaker in taking timely action in order to avoid the cases of bedsores.

Oxygen content in the blood
As people get older, the activity of heart reduces. The rate at which oxygenation and deoxygenation occurs decreases. This can create a concern regarding the oxygen content in the blood. So, It is always advised to monitor the oxygen level in the blood also. This is done using the technology called photoplethysmography (PPG) [5].

Blood Pressure
Blood pressure is a major concern for any human being. Maintaining the Normal value of Blood pressure is possible only through good diet and continuous exercises. Heart Failure is more common at the elderly. A poorly Pumping Heart may not have the ability to pump the blood through the arteries at the adequate level resulting in the Blood Pressure. As a result, Blood Pressure is a major health concern in elders compared to middle aged or young people[6].

Heart rate
A poorly pumping heart is major issue in elderly community. The overall activeness of heart reduces since all the nerves and arteries get weaker. More than 83% of the people who die of heart disease are older than 65 years. So, it is compulsory required to include the heart rate monitoring in gadget. The Electrocardiogram itself can achieve this. A three-lead system which can provide the basic PQRS waveform is sufficient in the continuous monitoring device. The electrodes fixed on the body are attached to the ZigBee End devices which in turn transmit the information to the ZigBee coordinator attached to the main central circuitry [7]. Blood glucose level and cholesterol are the other important health parameters which should be monitored in an aged person’s health.
B. Various Designs and Sensor Positioning

Positioning of Wearable elder health care gadgets can have the potential to make a lasting positive impact on wearer. The ability to remotely monitor the physiological signals like blood pressure, heart rate, oxygen content, temperature, and motion has been designed to be minimally invasive and intrusive. At the same time, the wearable networks require multiple sensors and electronic components to be mounted on the body. Oftentimes, elder patients will be forced to stay at hospitals and nursing homes while health monitoring. Such patients will be able to stay home safely and with improved quality of life with a proper wearable gadget. Placement of electronic components plays a vital role in the designing of wearable gadget. It requires careful consideration for physical interface of components, bulk and weight of board design, routing of wires (for wired networks) from each node around the body. Various user-friendly wearable designs are discussed in the following the parameters like blood pressure, heart rate, temperature, oxygen content, tilt, and fall detection etc. This can be categorized into two. They are Wired Design and Wireless Design.

Wired Design

Wrist watch design

Developing a wrist gadget where temperature is measured by placing sensor in strap of watch, heart rate and oxygen content are detected using photoplethysmography technique (PPG). Blood pressure can be measured through ECG and PPG techniques together based on Pulse transit time (PTT). The idea of design is shown in below. However, it’s a kind of complex involved in integrating the tilt and fall measurement into this prototype.

Conductive fabric design

Here direct-current power line carrier communication (DC-PLC) technology is applied to wearable monitoring system. DC-PLC is the technology in which a single shared DC bus is used to provide power supply to each power node and facilitate communication between multiple nodes in an electrical network. These sensor nodes are embedded into a garment at various desired locations. However, there are some demerits with this system. Routing of transmission medium is more complex. Bulky heavy metallic or optical cables that may not behave like a normal garment and it will make normal daily life difficult. Overall, the system may not be advantageous for long run continuous monitoring and risks becoming obsolete[8].

Wireless Design

Modern communication systems have widely extended the Wireless body area networks (WBANs) which provides a finest platform for remotely transmitting the physiological signals. In this study, various types of wearable sensors are discussed, their medical parameters like temperature, blood pressure, detection of oxygen content, pulse rate, respiration rate and non-medical parameters like tilt and fall detection.

Mainly two wireless models are proposed in this paper for continuously monitoring the health parameters of a patient. The sensing part, parameters measured and measured data processing are same in the two models. They differ only in the communication interface they use between patient and caretaker.

Arduino Bluetooth Mobile model (ABM model)

In ABM model, the information received from the sensors about the patient’s health condition is transferred to the Arduino board using ZigBee. The Bluetooth shield connected with the Arduino board sends these details to a Bluetooth enabled android mobile phone that is within the Bluetooth range of the device attached to patient’s body. These details are then compared with the preloaded values in the application developed in the mobile. The mobile application has the feature to make an automatic urgent call to a specific number incase if any parameters exceed the critical value. There is also an option to send the message to the caretaker or the concerned doctor about the patient’s condition periodically. This message includes various health parameters measured through various sensors. The system architecture of ABM model is given in fig.1

Methods of parameter measurement in ABM Model

Body Temperature Sensor

Normal body temperature does change significantly with aging. Temperature regulation, however, is more difficult. Older people are at greater risk for critical fall in body temperature. Fever is one of the important sign of illness in the elderly. DS1620-Temperature sensor is used to measure the body temperature of the subject [9]. The largest organ of the human body is the skin and it is most readily affected by temperature.

Photoplethysmography-Heart rate and blood oxygen content sensor

Heart rate is the number of heartbeats recorded per minute typically recorded as Beats per Minute (BPM). In the proposed system, photoplethysmography technique (PPG) is used for obtaining the heart rate. PPG is a simple and low cost optical technique that can be used to detect the blood volume changes in the micro vascular bed of tissues. In this technique, an IR led and a phototransistor is employed to detect the blood flow at fingertip or any other peripheral part of the body. Here when more light is transmitted through the tissues in case less blood flows through the blood vessels. This minute variation can be detected using the phototransistor and the voltage output can be amplified and filtered. Thus, we get the voltage variation corresponding to the blood flow through the tissues. The heart rate and oxygen content is related to blood flow and is taken into microcontroller where further manipulations take place to obtain values.

Wireless Electrocardiogram

A wireless three-lead ECG system is developed as a part of this continuous health monitoring gadget. It is turned wireless with the help of ZigBee Technology. Each electrode fixed on the chest is attached to a ZigBee node from where
the data is transmitted to the ZigBee coordinator of central control unit. The voltage difference from the electrodes, which appears to be in the mV range, is amplified with the help of instrumentation amplifier AD620. The signal from the electrodes is transmitted to the main Central control unit using ZigBee technology after all processing [10].

**Blood Pressure using Electrocardiogram and PPG**

Blood pressure (BP) is a major concern for any human being. It is measured using Pulse Transit time (PTT) method. PTT is the amount of time a particular volume of blood inside the artery takes to shift from one arterial site to another. Photoplethysmography and ECG are the two main technologies used for measuring Pulse Transit time. In this method, PTT is calculated by an ECG-PPG combination. The PQRS waveform obtained by the ECG is compared with the Photoplethysmography waveform which is obtained by the apparatus fixed at the fore-fingertip. The time interval between the R-peak of the ECG waveform and the peak of photoplethysmography waveform gives the pulse transit time. The blood pressure and pulse transit time are highly related. An increase in blood pressure makes an increase in blood velocity as a result of which blood takes very less time to move from one arterial location to another. A low blood pressure gives a high PTT value. An algorithm is developed to find the systolic and diastolic blood pressure from the PTT [6].

**Accelerometer-tilt and fall sensor**

Our system makes use of Accelerometer ADXL335 to monitor the tilt and the fall of the elder. The microcontroller continuously monitors the angle values produced by ADXL335 for a pre-defined time. If these values form the three outputs belong to a threshold range during the time interval, a critical situation arises and this is informed to three outputs belong to a threshold range during the time.

**Central Control Unit**

This is the most important module in this system which controls the entire gadget. It consists of arduino board, ZigBee module and Bluetooth module. The Bluetooth module makes the system compact, simple and wireless. The microcontroller is programmed to collect the analog data coming from the sensors using ZigBee technology and simultaneously converts them to its corresponding digital value. These digital equivalents of the vital parameters are then transferred to the Bluetooth module for its wireless transmission to the mobile phone. The arduino board used in the central control unit will be replaced by the ultra-low power microcontroller in the final product.

**Android Application Module**

This application will be responsible for the communication between the Control unit and the mobile in ABM model. The application uses Bluetooth facility of the mobile for communication. The user is provided with various customizable options like critical heart rate, oxygen content, temperature value and timing arrangement for turning the elder in order to avoid skin related problems etc. This will also display the current status of the elder giving the current physical parameter values. The Android application module will provide options for setting critical values for health parameters. The monitored data is stored into the mobile phone database system and whenever the user requests to display the details, the Data Display option will display the whole parameter data along with graphical representation of value variations till that point of time. For reliable security needs, this area will provide the system, a password based access to all of its management and database access.

**Arduino General Packet Radio Service model (AGPRS model)**

A different way of communication interface between Central control unit and caretaker is proposed in AGPRS model. Here, the Bluetooth device and mobile phone is replaced by a GPRS/GSM modem. The modem is connected to Arduino UNO board. As in the ABM model, health parameters are received by the central control unit using the ZigBee technology and monitored. If any values are found critical, Arduino UNO immediately informs the GSM Modem to make an urgent call to the pre-stored caretaker’s phone number. This is done with the help of AT commands which are sent serially to the modem from arduino. In case of any emergency, patients can report their current health parameters to the caretaker on pressing a push button which is integrated with the central circuitry. An android mobile or application is not required for this model. A small database of monitored values is maintained by storing them in the SIM card itself. This avoids the memory card interface with the arduino which in turn helps to make the system more compact. The modem and arduino should be synchronized by setting a common baud rate. With the help of this modem, the user is able to send and read SMS, can make audio calls, attend the incoming calls, or connect to internet via GPRS using simple AT commands. All the AT commands are sent to the GSM modem from Arduino serially [12].

**C. Communication Interface between Sensors and Central Circuity**

The design of the circuit is such that different sensors will be placed at different parts of the body and each sensor need to be connected to the central control unit. If connected by wires the entire circuit would be ill-fitting and uncomfortable for the patient to use. So the use of wireless sensor network is preferred. Bluetooth and ZigBee are the two main wireless technology standards which are used for short distance data transmission. ZigBee power consumption is very less compared to the Bluetooth. This will help to increase the battery life of the system which is a major criterion for a continuous monitoring gadget. From the Table 1, it is very evident that ZigBee is more suitable in the communication interface between sensors and central circuity.
TABLE I.

<table>
<thead>
<tr>
<th>Features</th>
<th>ZigBee</th>
<th>Bluetooth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data rate</td>
<td>20,40 and 250 Kbits/sec</td>
<td>1 Mbits/sec</td>
</tr>
<tr>
<td>Range</td>
<td>10-100 meters</td>
<td>10 meters</td>
</tr>
<tr>
<td>Operating frequency</td>
<td>868 MHz(Europe), 900-928 MHz(NA), 2.4 GHz( worldly)</td>
<td>2.4 GHz</td>
</tr>
<tr>
<td>Complexity</td>
<td>low</td>
<td>high</td>
</tr>
<tr>
<td>Power consumption</td>
<td>low very</td>
<td>medium</td>
</tr>
<tr>
<td>Security</td>
<td>128 AES plus application</td>
<td>64 and 128 bit encryption</td>
</tr>
<tr>
<td>Other information</td>
<td>Devices can join an existing network in under 30 ms</td>
<td>Device connection requires up to 10 sec</td>
</tr>
</tbody>
</table>

V. POWER REQUIREMENTS

The design of the gadget should be in such a way that the overall power consumption is very less. The low data transmission rate in ZigBee which is appropriate for continuous health monitoring help to reduce the power consumption to a large extent. Power consumption by the ZigBee nodes are extremely less compared to the Bluetooth chips. AGPRS model has an added advantage over AGM model since Bluetooth is not associated in its whole design. Other resources like solar energy and heat energy has to be considered for recharging the battery. The possibility of the conversion of body heat energy into electrical energy using thermo electric generators is also taken into account.

VI. CONCLUSION

The proposed design will be able to effectively measure six health parameters of an elderly person and if needed alert the caretaker which can help to prevent unexpected fatal medical conditions. The system uses ZigBee standard communication protocol for data transfer between the sensors and the arduino. After a comparative study between AGM model and AGPRS model, we decided to proceed the implementation with the AGPRS model which would eliminate the need for a smart phone and a Bluetooth interface. Altogether the paper proposes a wireless sensor network using ZigBee and a central arduino chip interfaced with a GPRS modem which would really prove helpful to the elderly patients when encountering severe health situations when not under supervision.

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