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Design and Development of e-Health Care Monitoring System

Kirti Raghav[1]; Jeet Paul[2]; Raji Pandurangan[3]
UG Student[1, 2], Assistant professor[3], Bharath University,Chennai, India[1,2, 3].
{Kirti.raghav1[1],jeet.paul29[2], spranavraj[3]}@gmail.com

Abstract—
In this paper, we illustrate the implementation of patient health management using e-health monitoring architecture. The design of this system is centered on Wireless Sensor Networks (WSN) and smart devices. The analysis of different parameters of patient is done using various sensors and smart devices. The whole architecture of the system is designed to implement a set of building blocks which can be utilized to set a strong network between the patients, doctors and care givers on the diagnosis grounds for the doctor and instantaneous condition of the patient. Care givers judge the condition of the patient by investigating through tele-monitoring of patient. Monitoring of the patient's surroundings as well as health is done by using medical and environmental sensors which measures the . The data from the sensors are relayed to the prior devices through the transmitter and then to the end user. In real time the doctor and the care givers can observe the patient without visiting him/her physically. The medical history and the complication such as reports and medications of the patient can be uploaded to web server which can be accessed at any point of time ease. This cloud data is further used to analyze the patient's health in better way. With this architecture doctors can get updates from private home patient to public health care center patients. By introducing tele-monitoring module reduces the cost of the whole system. We have also define the sets of add-on services which include Real Time Health Advice and Action (ReTiHA) and Parent monitoring.

I. INTRODUCTION

A wireless sensor network (WSN) (sometimes called a wireless sensor and actor network (WSAN)) are spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure,etc. and to cooperatively pass their data through the network to a main location. The more modern networks are bi-directional, also enabling control of sensor activity.

The development of wireless sensor networks was motivated by military applications such as battlefield surveillance.Today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on. Each such sensor network node has typically several parts: a radio transceiver with an inbuilt antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting. A sensor node might vary in size from that of a shoebox down to the size of a grain of dust, although functioning "motes" of genuine microscopic dimensions have yet to be created. In computer science and telecommunications, wireless sensor networks are an active research area with numerous workshops and conferences arranged each year, for example IPSN, SenSys and EWSN. Becoming mature enough to be used for improving the quality of life, wireless sensor network technologies are considered as one of the key research areas in computer science and healthcare application industries. The pervasive healthcare systems provide rich contextual information and alerting mechanisms against odd conditions with continuous monitoring. This minimizes the need for caregivers and helps the chronically ill and elderly to survive an independent life, besides provides quality care for the babies and little children whose both parents have to work. Although having significant benefits, the area has still major challenges which are investigated in this paper. We provide several state of the art examples together with the design considerations like unobtrusiveness, scalability, energy efficiency, security and also provide a comprehensive analysis of the benefits and challenges of these systems.

In this paper we have aimed to integrate the present health facilities with wireless sensing networks and smart devices. The patients' health is

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analyzed using a handy and mobile device which fetch and processes data from an arrangement of wearable sensors. This data is furthermore allied to the figures from the sensors implanted in the surrounding environment. The responsive trait in the time of emergencies is correlated with the accuracy of data they receive from high quality sensors. This in turn maintains the balance between the effectiveness, complexity and the reliability of the system.Our system is utilized by all age group in health motoring and specially for those who require regular monitoring and also accelerates the diagnosis of the subject by providing the immediate attention. We have projected this architecture so that it can be utilized in rural areas where the numbers of doctors are less than usual and doctor can monitor huge number of subjects with an ease.

II. MONITORING ARCHITECTURE

This architecture is divided into three layers which forms the backbone of the structural design. Based on the functionality of the components the architecture is categorized into three main layers. Figure 1 describes the major layers of the architecture.

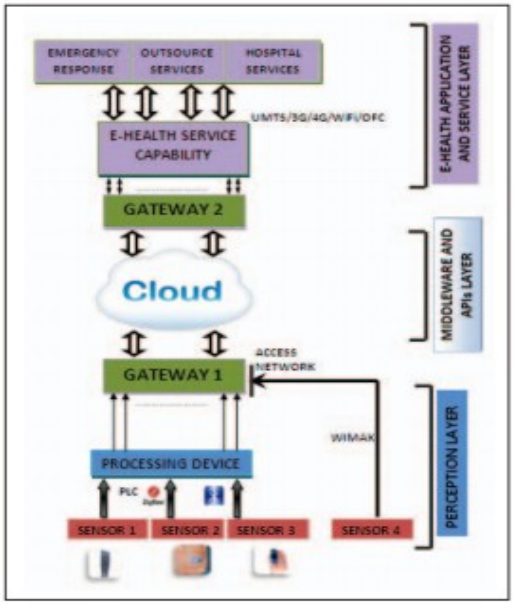

Fig. 1. Illustration of the e-Health Monitoring Architecture

A. *Perception layer*

The first layer consists of wearable sensors which are embedded with the surrounding of the patient as well as the environment to record the data during real time implementation. Sensors used can be further classified into two types, viz, environmental sensors and medical sensors. The medical sensors screens up the dynamic parameters of the patient whereas environmental sensors screens up the parameters of the environment rather surroundings i.e. room temperature oxygen level etc. The data recorded by the sensors are further send to processing unit which tags up the data with timestamp, unit etc. and thereby creating a metadata. With those distinctive id is attached to the each data, which helps to distinguish the data form. Then the data is ready to process to the next layer. It uses Sensor Markup Language (SenML). The sample representation of data in SenML is given as,

{"e":[{"n":"body","v":101.3,"u":"Far", "t": 1753.36084}]};

Where “100.2” denotes the temperature value, ”t” denotes the time elapsed, “u” denotes the unit in Fahrenheit and “n” denotes the data type like in this case is temperature of the patient. The communication between the sensors and the gateway is established via short range communication components like Local Area Network (LAN), ZigBee, Bluetooth, Wi-Fi or Power Line Cable (PLC).

B. *Middleware and APIs layer*

This layer consists of APIs (Application Programming Interfaces). The cloud storage used to store the medical history of the patients and gets updated with current records. This storage plays a major role in acknowledging response during emergencies. Whenever a patient is registered under a gateway API (Application Programming Interface) creates a separate profile for the patient. That would help to fetch the medical history of the patient. API (Application Programming Interfaces) supports profile formation, storing, enquiries concerning patient who is already a user and synchronization of old records with the new ones.

C. *Application and service layer*

In this layer the outsourcing of resulted monitored data is done. This process invokes from prescribing to suggesting the patient that what is need to be done. Depending on the pattern of data or past medical records of the patient, the e-health services offers an add-on in comparing the previous and present drifts.

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The emergency response system plays the role of informing the doctors and the caregivers in accordance with the level of emergency. The required action is taken dependent on the level of emergency. This architecture also allows study of all patients under monitoring centrally in the hospital or health care center which enables the doctors and caregivers to respond in emergency situations.

III. PURPOSEFUL COMPONENTS

In this section we have described the functions of major components of the system. It puts a greater emphasis on working of sensors, parameters that has to be monitored, process of collecting all the data, dimensions of data with reference to parameters.

1) Medical sensors

With these sensors we can analyze and measure the various bodily parameters. These sensors should be small in size and as inconspicuous to the subject so that it can acquire the real and perfect values. These sensors include heart rate monitor, oximeter, blood pressure sensor, ECG module and thermometer. These sensors produce perfect and instantaneous value which is further relayed by the transceiver to processing unit. In the mean while transceiver converts the raw data into metadata which helps the processing unit to understand the data accurately.

2) Environmental sensors

These sensors capture the raw data from the surroundings of the patient like room temperature, oxygen content in the air etc. which helps to analyze the living condition of the patient. These sensors are planted to particular rooms for private health care unit or Intensive Care Unit (ICU). Following describes the category of environmental sensors.

a) Gas detection sensors are used to maintain proper oxygen level.

b) Temperature sensors are used to report room temperature. This can be used in a feedback mechanism to control the temperature of the room.

c) 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.

3) Central Transceiver Unit and Central Base Station.

It is wearable module and can be devoted to the patient. It is designed so that to fetch the raw form of data from wearable sensors through multiple channels and multiple frequencies. Serial data transmission through one channel may cause delay in the data transmission or loss in data. Hence multiple channels are used in data transmission to prevent collision or interference at different frequencies with a certain data offset value. Further transceiver transmits the data for processing of metadata values to Central Base Station (CBS).CBS collects value from the sensors and then sends the data to layer 2 as stated in the architectural design. Hence Central Base Station acts as a gateway for the two layers in the architecture used as the gateway being carried at all times by the patient. The metadata of sensors sent from the base station to the cloud

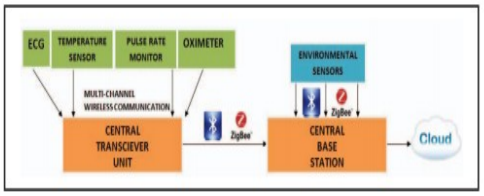

Fig. 2. Communications in Layer 1 of the Architecture

storage is in the form of eXtensible Markup Language (XML) which facilitates sharing of SenML data. The smart device can be also used for local processing of data to analyze the health condition of the patient. The communications in this system is depicted in Fig. 2.

IV. SECURITY AND DISCLOSURE

In this section we have conferred about the various security concerns to e-health monitoring system. As the prescription is generated online by the doctors, we must go through severe security.

This is necessary in order to secure the privacy of the patient so that individual receives proper treatment and medication. While the health reports are send and receive between doctor and patient, no other person is authorized to access the data and record.

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Hence the end –to-end security is proposed in this architecture.

A. Confidentiality

The confidentiality of data is necessarysuch that the privacy of the patient is safeguarded. No other person is authorized to interfere while sending and receiving of data. In our architecture we have declared a provision in which only few trusted members are allowed to access the patient profile. These trusted and authorized member are allowed to access the through secret password or private key that is shared and approved by patient. The data can be treated using 8-bit or 16-bit microprocessor, after which RSA-256 is used to protect all data.

B. Authenticity

The identity of authorized user is done by validation, in order to confirm genuineness of the system. Digital signatures are used to ensure authorize person is accessing the data and this symbol of validation assures that the person is a legal one to review the stored medical records. The dedicated digital signature is utmost process of assuring the validation.

C. Integrity

The accuracy of data during the course of the process is ensured by integrity. So that no one is allowed to alter or tamper the data resulting to wrong diagnosis. The system has used Secure hash algorithm (SHA-I) to assure the integrity. The freshness of the data is checked through timestamp that is attached before transmission. If the timestamp is shows that the data is not fresh then it is needed to be discarded because the health of the patient may change within few seconds.

V. RELATED WORK

Health Care Systems have vastly improved over the recentpast with the introduction of devices compatible with digitalsignal processing; better image processing techniques,introduction of MEMS based sensors facilitating diagnosis ofvarious diseases. With the advent of better health care technologies research on monitoring systems have beenextensive in the past few years. Various publications on thisresearch area are based on different aspects of healthmonitoring including data collection from sensors, datadissemination methods and protocols, processing of sensordata as well as security and privacy of these systems. Theresearch can also be classified according to the nature of application whether in a private scenario, for elderly patients or for monitoring in a health care center. These proposed methods and their implementations have facilitated health care systems in multiple aspects in more ways than one. Existing literature has mentioned monitoring systems based on Wireless Sensor Networks with unobtrusive sensors embedded on the patient who does not restrict his activities and body movements. The architecture used is multi-tiered with ad-hoc self-managing sensors to reduce operational costs.A.Triantafyllidis et al mentions use of reconfigurable and decentralized sensors for monitoring which will henceforth
allow easy addition and deletion of sensors for new patients to the system. The authors of have proposed a whole architecture for collection and dissemination of medical sensor data based on SNMP and Code Blue Agents. Hairong Yan et al takes into consideration the localization of the patient using Received Signal Strength Indicator (RSSI) with respect to beacon nodes whose positions are fixed and predefined. The use of video to monitor the patient in addition to the existing architecture is mentioned in literature. The video is triggered when values of sensors breach a certain giventhreshold. Wan-Young Chung et al. puts forward the idea of using a mobile device in the communication layer toreceive data from the sensor networks when the threshold isreached. The mobile device is used to perform minorcomputations and relay the data to the management layer. AnAndroid device used to analyze ECG signals from a mobilemonitoring terminal is also mentioned in existing literature. MarÕa de los Angeles Cosio Leon, in her paper studiesthe privacy and security issues of privacy and security in aWSN based monitoring system. The paper considers theprivacy aspect of when recording from the microphone orcapturing video is to be considered inappropriate and when itis necessary by defining a filter for the same. This paper also considers active and passive attacks to the system along withkey management schemes to ensure safe end to endcommunications.

VI. CONCLUSION

Although a lot of study has been piloted on e-health monitoring systems, we have projected a set of novel

services based on the monitoring system. ReTiHA will necessitate enormous testing and study before implementation. Howeverit concretes a new way for remote health monitoring systems. We have also anticipated other novel services in the form of Emergency Response Services and the Parent Monitoring system. Transmission of sensor metadata is implemented by SenML ensures the organized. The privacy content of the history and medical data is also defined under this system. Hence our system ensures security of the highest order for the medicaldata on cloud storage. With advance research in this aspect, there can be advancement in our proposed system and can change the medical monitoring system.

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