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IOT Enabled Smart Heart Activity Monitoring Application

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Abstract*: *Internet of Things (IoT) has drastically changed the functionality of many sectors like health, education, transportation, home, city, etc. Health care underwent a crucial change through IoT, but the major concern is the functionality of the medical devices and their security. Heart disease has become a common problem now days due to smoking and aging. IoT based health care systems are already available but their usage is still a challenge due to their complex structure and deployment of sensors in the patient body. In this paper we propose a novel heart activity monitoring system called SHAM (Smart Heart Activity Monitoring) it monitors the heart activity through a smart watch app. This smart watch monitors the heart activity of the patient if there any irregular activity it notifies the patient and if very critical activity is identified it automatically sends SOS call to the ambulance with GPS coordinates of the patient. The main aim of the proposed system is to make the heartbeat monitoring device simple thereby providing comfort to the patient in its usage and reducing the risk of death.

Keywords* : *Biomedical Engineering, Internet of Things (IoT), Security, SOS, Smart Watch.

I. INTRODUCTION

Health is the main aspect for every human being in this world. So healthcare is the most important part in one's life. In the present modern world the number and type of diseases are increasing faster than the technology and the demand for medical resources is extremely high. One of the major diseases leading to the death of many patients is heart disease. As per the 2017 statistics of American Heart Association for every 40seconds a patient dies due to heart disease. So heart care is a major issue in health sector even today[1].IoT has potentially reduced the pressure of resources on health sector by delivering smart health care system away from the hospital. IoT is already in use for different health monitoring systems, for measuring the blood-glucose levels in diabetic patients [2], for detecting heart attacks using ECG sensor [3], for measuring respiratory-rate to predict heart attacks [4], for body temperature measuring [5], for measuring blood-oxygen saturation [6], etc. IoT has transformed the medical devices starting from small wearable activity tracker to implant devices. This transformation has totally changed the functionality of devices; sensors and embedded software are now integral part of these devices [7]. IoT plays a vital role in health care applications, from managing diseases to preventing diseases. Clinical care for hospitalized patients whose physiological status need to be monitored, remote monitoring of patients health by the physicians and home health hub [8-9].

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II. RELATED WORK

Even though IoT has made health care more sophisticated there are few issues in using IoT with healthcare. The major issue is security. Every patient expects confidentiality of his data; he does not want a third person to know his health related data. Even today security is the major issue in using IoT in health care. The following are the few security issues identified in IoT health care.[10-13]

A. Data Privacy

Like WSNs, data privacy is considered to be most important issue in BSN. It is required to protect the data from disclosure. BSN should not leak patient's vital information to external or neighboring networks. In IoT-based healthcare application, the sensor nodes collect and forwards sensitive data to a coordinator. An adversary can eavesdrop on the communication, and can overhear critical information. This eavesdropping may cause severe damage to the patient since the adversary can use the acquired data for many illegal purposes.

B. Data Integrity

Keeping data confidential does not protect it from external modifications. An adversary can always alter the data by adding some fragments or by manipulating the data within a packet. This altered data can be forwarded to the coordinator. Lack of integrity mechanism is sometimes very dangerous especially in case of life-critical (when emergency data is altered). Data loss can also occur due to the bad communication environment.

C. *Data Freshness*

The adversary may sometimes capture data in transit and replay them later using old key in older to confuse the coordinator. Data freshness implies that data is fresh and no one can replay the old message.

D. *Authentication*

It is one of the most important requirements in any IoT based healthcare system using BSN, which can efficiently deal with the impersonating attacks. In BSN based healthcare system, all the sensor nodes send their data to a coordinator. Then the coordinator sends periodic updates of the patient to a server. In this context, it is highly imperative to ensure both the identity of the coordinator and the server. Authentication helps to confirm their identity to each other.

Body Sensor Network is used to sense the different health parameters related to the patient. For measuring temperature a different sensor, for measuring BP a different sensor and for measuring ECG a different sensor are used. The Local Processing Unit (LPU) receives the data from the sensors and its transferred to the local physician, emergency unit, family members via the internet. The major issue with the BSN-Care System is data security [14-15].

III. PROPOSED SYSTEM

In this paper we propose a secure and smart heart activity monitoring system called SHAM. It provides a smart way of monitoring the heart activity of the patient through a Smart Watch app. SHAM provides a secure way of transferring the information from the patient to the doctor. The proposed system involves three phases namely registration phase, monitoring phase, and notification phase.

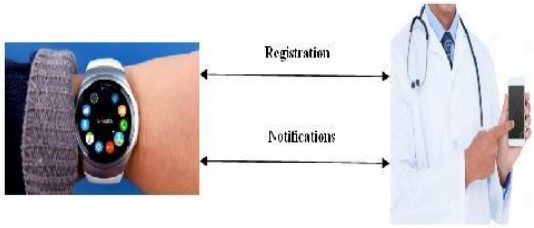

Figure 1 Registration Phase of SHAM

In the registration phase the doctor's mobile and smart watch is registered with each other. When the doctor identifies that a particular patient needs a continuous monitoring of his heart activity, a smart watch with a smart app is given to the patient. The smart watch is equipped with a unique bar code and the doctor can use his mobile to scan this code through SHAM app on his mobile. Once the scanning is over the patient details are added to the doctor's mobile device. Through this app the doctor can continuously monitor the heart activity of the patient even when the patient is in a remote location. During this registration process a unique secret key is generated which is feed into the smart watch and this key is also saved in the doctors mobile. This secret key is used for encryption and decryption process.

In the monitoring phase the smart watch records the pulse readings, BP of the patient and these details are stored for further analysis. Based on the condition of the patient the reading settings are configured by the doctor, if the patient needs critical monitoring the readings are collected in hourly basis otherwise once in four hour or once in eight hours based on the condition of the patient. In case if there is a change in health condition of the patient the doctor can change the configuration settings from remote through his mobile. The readings recorded are transferred in a secure mechanism and stored in a cloud as shown in Fig-2

Figure 2 Data Transmission in SHAM

The data is transmitted in a secure manner by using a simple symmetric encryption algorithm. The algorithm is made simple so that it does not lay any delay in the transmission of the data. Since when the patient is in very critical state more than security the timely delivery of the message is very important. In this paper we propose a simple and secure algorithm for providing the confidentiality and privacy to the patient data, the maximum value that can be represented in pulse and BP is a three digit number. So a maximum of 10bits are sufficient to represent these values in binary. The algorithm takes a 0 bit binary number as input and converts it into cipher text. The algorithm involves four basic operations XOR operation, Adding, 1's Compliment and Consecutive shift.

Algorithm 1: SHAM Encryption (P[n], K)

Result: Cipher text of patient BP

1. XOR(P[n],K)
2. Add 1 to MSB of Plain text. If there is a carry it's forwarded to the next bit.
3. Perform 1's compliment on the resultant of step-2.
4. Perform LCF (Left Consecutive Shift)

Algorithm 2: SHAM Decryption(C[n], K)

Result: Plain text of patient BP

1. XOR(C[n],K)
2. Add 1 to MSB of cipher text. If there is a carry it's forwarded to the next bit.
3. Perform 1's compliment on the resultant of step-2.
4. Perform RCF (Right Consecutive Shift)

In encryption process LCF is done which means consecutive shift operation is done on the bits starting from the left most bit. In decryption RCF is done which also means the same operation but the operation starts from right most bit. In the notification phase, when a critical heart activity is identified a notification is given to the patient by changing the display screen of the smart watch to orange color. When a very critical activity is identified than a SOS call with the location coordinates of the patient is sent to the ambulance and an alert message is sent to the doctor as shown in Figure-3:

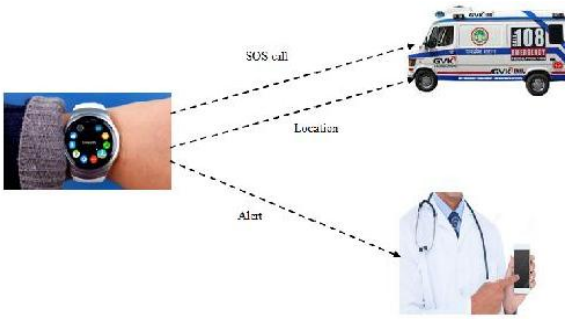

Figure 3 Notification Phase of SHAM

The doctor's mobile has an app though which he monitors the heart activity of the patient. An alert message with red color is displayed on the doctors mobile when the heart activity is very critical. In case if there is any mal-functioning of the device (smart watch) then also a notification is sent to the doctors mobile. The mobile app installed in doctors mobile has the five options. One is register new patient in which the doctor can add new patient details to the app by scanning the bar code on the smart watch after which a secret key is generated.

The next option is live monitor where the doctor can view the live recording of the patient and if required the doctor can call the patient give advice for his betterment.

The next option is offline monitor where the doctor can view the past readings of the patient the reading will be provided in the format shown in table-1. As show in the table the details of every patient is stored by using unique patient-Id and name. Along with this heart activity analysis of the patient will be provided to the doctor based on the configured settings, if the setting are configure for hourly monitoring the graph analysis is provided with the hourly reading for the day as shown in Figure-4.

Figure 4 Mobile interface of SHAM App

The next option is configure initially when the doctor gives the device to the patients the configuration settings are defined by the doctor. The configuration setting here mainly deal with the recording settings, once the doctor identifies that there is a change in the patient health condition he can change the setting remotely through this option.

Table-1 Format of Patient heart activity readings

Patient- ID	Patient - Name	Date	Time	HB	BP
0879	xxx	12.30 p.m.	12-12-2012	80Hg	13.5

The last option is notification where the doctor receives alert notifications when the patient heart activity is very critical, the notification message will contain the patient id, name and readings of pulse and BP. The notification message will be displayed in red color and when the mobile receives such a message it makes a peculiar beep sound. In case if the doctor is busy with some other emergency case he can forward the same notification to other doctor or a junior doctor.

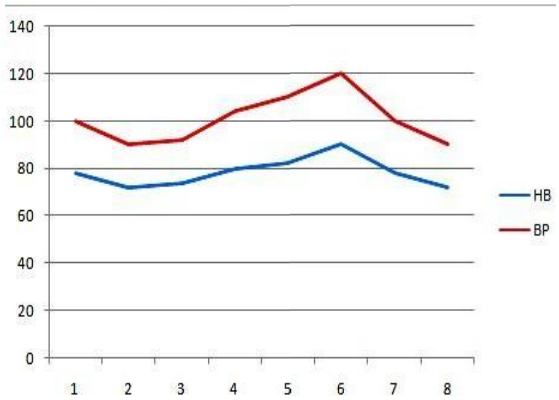

Figure 5 Graphical representation of Heart activity

IV. CONCLUSION

In this paper we presented a smart and secure heart activity monitoring system that helps the doctors to monitor the heart activity of the patients even when they are away from the hospital. The main advantage of SHAM is its does not create a sense of uneasiness in patients with the deployment of sensors; since the sensor is equipped with the watch the patient does not have the feeling of a foreign object in his body. The second main advantage of the proposed approach is it automatically sends a SOS call to the ambulance with exact location of the patient and an alert message to the doctor when the patient heart activity is very critical; this reduces the life risk of the patient. The third advantage of SHAM is the doctor has the entire heart activity log in his mobile device by using which he can understand the behavior of patient's body to his treatment which will lead to better treatment of the patient.

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