Monitoring Health Care System using Internet of Things - An Immaculate Pairing

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***Abstract*—- IoT in health care is aimed at empowering people to live healthier life by wearing connected devices. Health care industry has perpetually been on the forefront in the adoption and utilization of information and communication technologies (ICT) for the efficient health care administration. Recent developments in wireless sensors, communication and information network technologies have created a new era of the Internet of things (IoT)[1]. Connected health care is very important application of the Internet of Things. The concept of connected health care system and smart medical devices bears enormous potential not just for companies, but also for the well-being of people in general. Hospitalized patients whose physiological status requires close attention can be constantly monitored using IoT-driven monitoring. This type of solution employs sensors to collect comprehensive physiological information and uses gateways and the cloud to analyze and store the information and then send the analyzed data wirelessly for further analysis and review. It replaces the process of having a health professional come by at regular intervals to check the patient's vital signs, instead providing a continuous automated flow of information. The main aim of this work is to give a comprehensive overview of this area of research and sensors used in health monitoring device, how the wearable health monitoring devices works, capture the data and generate report based on different parameters.**

Keywords- Monitoring device, Connected health care, Wearable, Automated information

I. INTRODUCTION

The health care scheme is focus on the measurement and monitoring various biological parameters of patient's body like heart rate, oxygen saturation level in blood and temperature using a web server and android application[2] where doctor can continuously monitor the patient's condition on his smart phone using an Android application, the patient history will be stored on the web server and doctor can access the information whenever needed from anywhere and need not physically present.

In this way, it simultaneously improves the quality of care through constant attention and lowers the cost of care by eliminating the need for a caregiver to actively engage in data collection and analysis.

For our case study we are considering Apple-I watch series 2 with an OS 3.2.0.We have specified all the specifications and sensors used to monitor the health parameters that is heart rate, calories burn, distance covered etc., how to extract the data from device and make the graph to visualize it. Explanation of all the parameters used in CSV is also very important aspects in this scenario we have also taken care of this part.

II. LITERATURE REVIEW & RELATED WORK

After considering different research paper, it has been noticed that, It is very hard to find the abnormalities in the heart beat count of a patient. The average count of 25 years old ranges from 140 to 170 beats/minute, whereas in 60 years old people, it ranges from 115 to 140 beats /minute. Patients are not satisfied with the treatment which doctors normally use for finding the heartbeat count. So there should be a device to track the internal changes in the human body.

Hossaina et. al [3] explained in her research that all The promising potential of the emerging Internet of Things (IoT) technologies for interconnected medical devices and sensors has played an important role in the next-generation health care industry for quality patient care. With the increasing number of elderly and disabled people, there is an urgent need for a real-time health monitoring infrastructure for analyzing patients' health care data to avoid preventable deaths.

Wearables [4] are being used to monitor patient and gather data for clinical research trials and academic research studies. In addition, fitness/wellness wearables are being used as clinical tools. This complements a trend toward counting physical activity as a vital sign category.

Research shows that the rapid proliferation of wearable devices and smart phone, the Internet of Things enabled technology is evolving health care from conventional hub based system to more personalized health care system (PHS). PHS will enable faster and safer preventive care, lower overall cost, improved patient-centered practice and enhanced sustainability. IoT enabled PHS will be realized by providing highly customized access to rich medical information and efficient clinical decision making to each individual by storing the data and using it later. However, empowering the utility of IoT enabled technology in PHS is still significantly challenging in the area considering shortage of cost-effective and accurate smart medical sensors, used in IoT system.

Suhas [7] in his paper discuss that the physiological parameters such as temperature pulse rate and ECG are obtained, processed using ARM7 LPC 2138 processor and displayed by using graphical user interface. If any of the

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vital parameter goes out of normal range then an alert SMS will be sent to doctor's mobile.

III. IOT HEALTH CARE NETWORK AND COMPONENTS

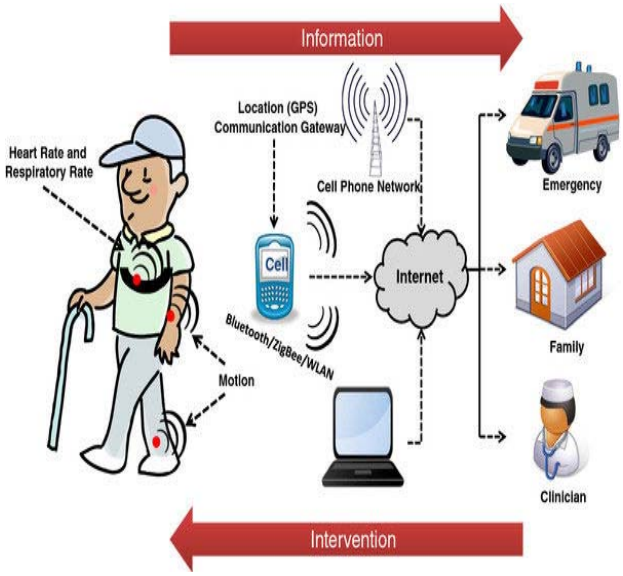

Figure 1. Health monitoring system using wearable sensors

In fig-1[4] it has been shown that Health related information is gathered via bodyworn wireless sensors and transmitted by gateway such as a mobile phone. This information can be used to implement interventions as needed.

As shown in Fig-2 The IoThNet topology, architecture, and platform used in health care network. The IoThNet topology[5] refers to the arrangement of different elements of an IoT health care network and indicates representative scenarios of seamless health care environments.

Using this topology heterogeneous computing grid collects enormous amounts of vital signs and sensor data such as blood pressure (BP), body temperature, electrocardiograms (ECG), and oxygen saturation and forms a typical IoThNet topology. It transforms the heterogeneous computing and storage capability of static and mobile electronic devices such as laptops, smartphones, and medical terminals into hybrid computing grids.

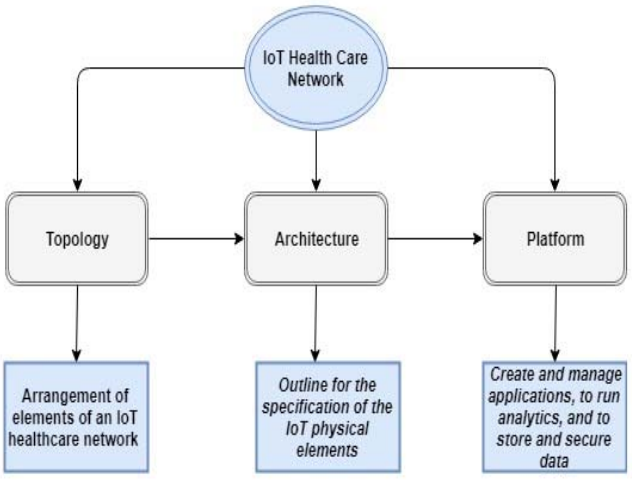

Figure 2. IoT Health Care Network

The IoThNet architecture refers to an outline for the specification of the IoThNet's physical elements, their functional organization, and its working principles and techniques.

The IoThNet platform refers to both the network platform model and the computing platform.

A. Sensors used in IOT devices

The IoT have many applications in the health care sector, with the possibility of using the cell phone with RFID-sensor capabilities as a platform for monitoring of medical parameters. The combination of sensors, RFID, NFC (near field communication), Bluetooth, ZigBee, 6LoWPAN, ISA100, WiFi will allow significantly improved measurement and monitoring methods of vital functions (temperature, blood pressure, heart rate, cholesterol levels, blood glucose etc.) Implantable wireless identifiable devices used to store health records which are useful to save a patient's life in emergency situations especially for people with diabetes, cancer, coronary heart disease, stroke, chronic obstructive pulmonary disease.

IV .SPECIFICATION OF DEVICE USED IN OUR CASE STUDY

Chip

- ✓ Dual-core processor
- ✓ Built-in GPS Features
- ✓ Wi-Fi (802.11b/g/n 2.4GHz)
- ✓ Bluetooth 4.0
- ✓ Heart rate sensor(pulse sensor)
- ✓ Optical sensor
- ✓ Accelerometer
- ✓ Gyroscope
- ✓ Ambient light sensor

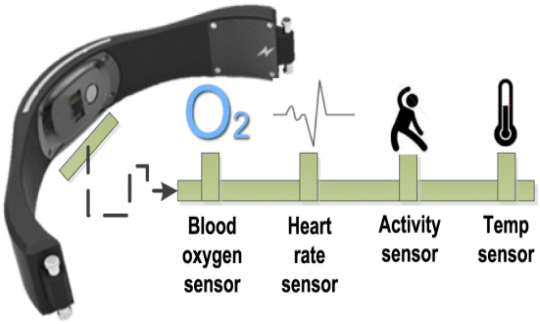

Figure 3. Sensors used in device

- **Heart rate sensor:** Heart Beat can be measured based on optical power variation as light is scattered or absorbed during its path through the blood as the heart beat changes. heart rate Heart rate is directly related to the soundness of the human cardiovascular system. We monitored one month data for case study.
- **Accelerometer:** An accelerometer is an electromechanical device that measures acceleration forces. These forces may be static, like the constant force of gravity pulling at our feet, or they could be dynamic caused by moving or vibrating the accelerometer.
- **Ambient light sensor:** Ambient light sensors are used as backlighting controls in any number of LCD display applications from consumer electronics to automotive, and by automatically adjusting display brightness, they conserve battery life, which is a key benefit in mobile device applications.
- **Optical sensor:** An optical sensor converts light rays into an electronic signal. The purpose of an optical sensor is to measure a physical quantity of light and, depending on the type of sensor, optical sensor translates it into a form that is readable by an integrated measuring device.

In Fig-4 we have shown the expanded view of Apple watch, the diagram shows the internal components used in the device all the components work in coordination. Various nonintrusive sensors have been developed for a diverse range of medical applications, particular for WSN-based healthcare services. Such sensors are prospective enough to deliver the same services through the IoT. On the other hand, wearable devices come with a set of desirable features appropriate for the IoT architecture. Therefore, the integration of sensors into wearable products is apparent. However, the heterogeneous nature of wearable products and medical sensors uncovers numerous challenges.

Figure 4. Expanded view of Apple watch

TABLE-1 Description table of internal components

COMPONENTS	DESCRIPTION
NFC Antenna	Near Field Communication antenna establish communication between two devices by bringing them close together.
Aluminium housing	Outer shell and it protects the sensors from external damage.
PCBB	A printed circuit board connector.
Taptic Engine	It provides tactile sensations in the form of vibrations to users of the Smart IoT device.
Digital Crown	Circular crown used for setting-up the device.

As we have specified earlier that we are doing our case study by using Apple Smart watch (3.2.0). Monitoring health care system using IOT is three step processes as following-

- Monitoring (By sensors)
- Extracting Health App Data
- Generating Health report

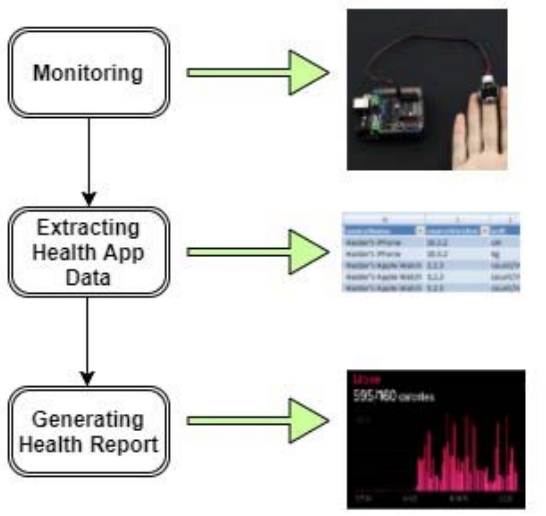

Figure 5. Flowchart of Health care monitoring system

A. *Monitoring*

The Smart IoT implemented Apple Watch is used to measure its wearer's pulse, calories burn, walking distance, blood pressure. The sensors include infrared and visible-light LEDS in addition to photo sensors, which all work together to detect signals, NFC antenna establish communication between two devices that is wearable and mobile phone. The monitored data then finally stored at IoT sever.

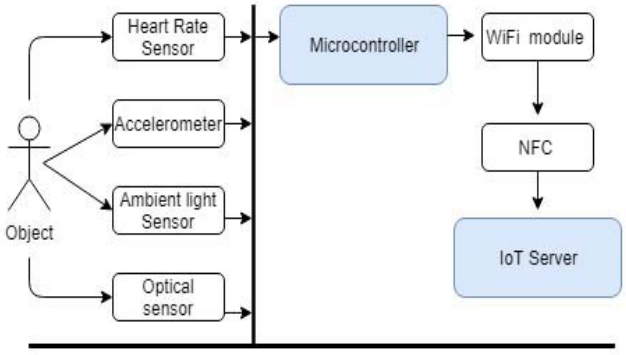

Figure 6. Block diagram of Health Monitoring System

A. *Extracting Health Data from IoS Health App*

Extracting data is not a single step process it involves several steps. We have shown the complete process stepwise

Step 1: Launch the health app on smartphone connected wearable device.

Step 2: Navigate to the Health data tab. The following screen shown in Fig-7 will come-up be having information that is body measurement, health records, results and reproductive health. At the top right corner of the screen, tap on the Profile icon.

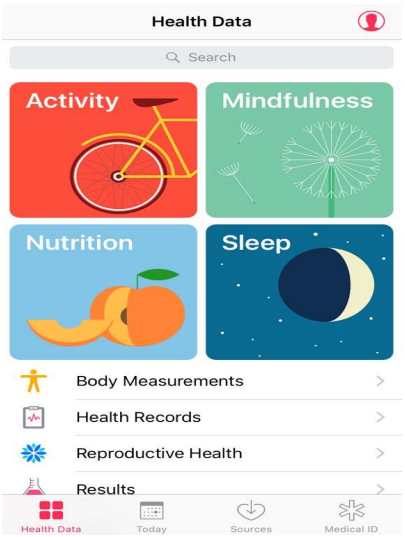

Figure 7. Exporting Health data from device

Step 3: After taping on the profile icon we will end up with a new screen as following shown in the Fig-8 at the bottom click on Export Health Data button. It will be asked to confirm to export health data.

Step 4: After clicking on Export Health data button, the app will automatically create a new email containing Health export in a Zip file. This zip file contains the data in XML format

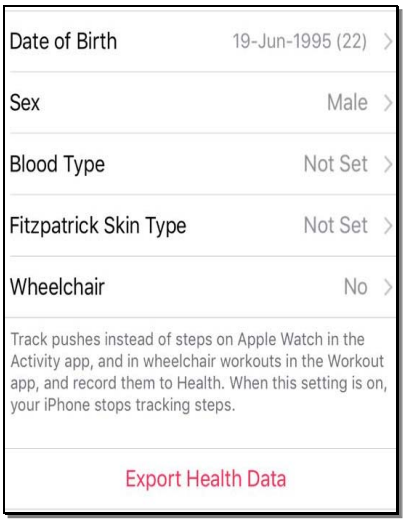

Figure 8. Profile window of user

C. *Parameters used in CSV file*

H	I	J	K	L	M	
sourceName	sourceVersion	unit	creationDate	startDate	endDate	value2
Haider's iPhone	10.3.2	cm	2017-07-31 00:32:43 +0530	2017-07-31 00:32:43 +0530	2017-07-31 00:32:43 +0530	161
Haider's iPhone	10.3.2	kg	2017-07-31 00:32:43 +0530	2017-07-31 00:32:43 +0530	2017-07-31 00:32:43 +0530	86
Haider's Apple Watch	3.2.3	count/min	2017-07-31 05:59:09 +0530	2017-07-31 00:34:25 +0530	2017-07-31 00:34:25 +0530	62
Haider's Apple Watch	3.2.3	count/min	2017-07-31 07:53:26 +0530	2017-07-31 07:50:03 +0530	2017-07-31 07:50:03 +0530	90
Haider's Apple Watch	3.2.3	count/min	2017-07-31 07:56:31 +0530	2017-07-31 07:52:06 +0530	2017-07-31 07:52:06 +0530	89
Haider's Apple Watch	3.2.3	count/min	2017-07-31 08:26:11 +0530	2017-07-31 08:15:36 +0530	2017-07-31 08:15:36 +0530	102

Figure 9. CSV file of exported data

- **/@locale:** The parameter /@locale hold the information of the country where data is stored. Its value will never change and it will repeat for every single row.
- **/ExportDate/@value:** This parameter shows the date and time when the data was exported. The value of this parameter also repeated for each row.
- **Me/@HKCharacteristicTypeIdentifierBiologicalSex:** This is the biological sex, as entered by user in the Health app. It will remain the same for all entries.
- **/Record/@unit:** The units that the data is recorded. Blank cells indicate data such as gender and blood type, that have no units. The unit 'count' used for steps walked, and km for distance walked.
- **/Record/@value:** This parameter has the individual values for the data collected.

D Generating health report using imported data

We have imported data after monitoring and exported from the device in XML format. We have converted this data into CSV file for our case study. The converted CSV file is used for data analysis using R. A graph for heart rate has been plotted and noticed the fluctuation in the graph.

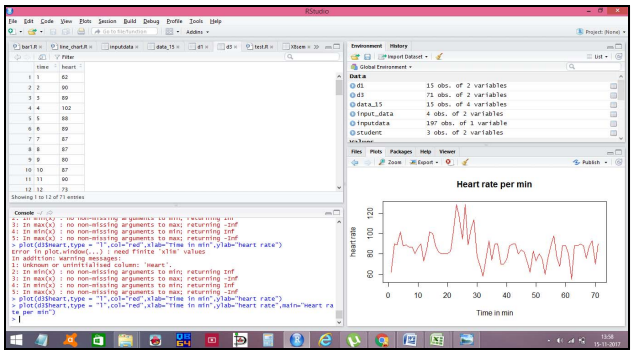

Figure 10. CSV file in R for creating a graph

We have created two graphs one is line graph heart bear per min and second graph is bar graph. It shows calories burned per day.

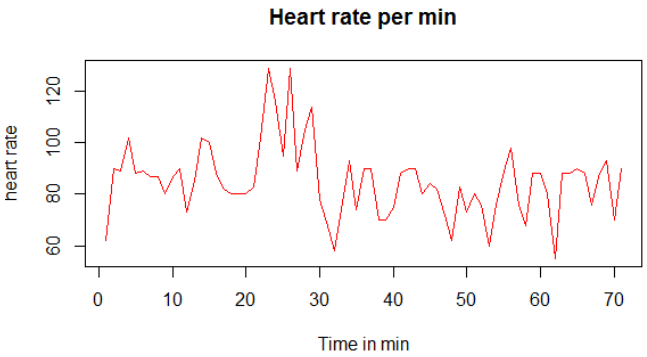

Figure 11. Heart rate per min

It has been identified that during working hours the heart rate increases and in down time there is less fluctuations. A normal resting heart rate for adults ranges from 60 to 100 beats a minute. Generally, a lower heart rate at rest implies more efficient heart function and better cardiovascular fitness.

The second graph is bar graph it is showing calories burnt per day. The graph lists the calories burned by doing dozens of activities listed by category (such as gym activities, training and sports activities, home repair etc.) for per day. Activities and exercises include walking (casual, race, and everything in between), swimming, jogging, yoga, and even watching TV and sleeping. The findings are that on rest days less amount of calories burnt in comparison to other working day.

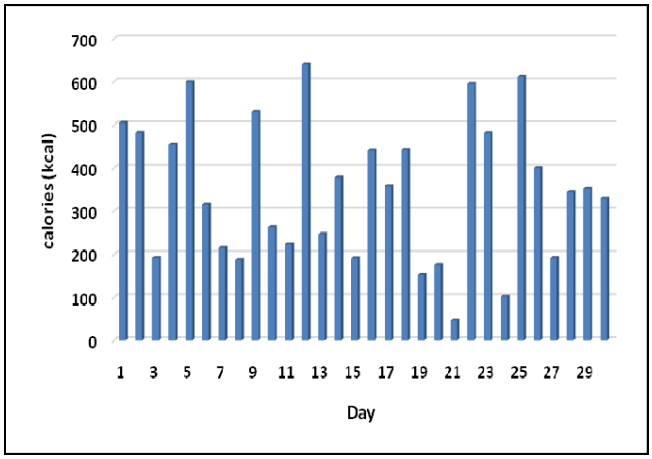

Figure 12. Calories burned per day

V. Conclusion

As we have discussed earlier connected health care is very important application of the Internet of Things. The concept

of connected health care system and smart medical devices bears enormous potential Connected health care devices monitored the data and provide it for an improved quality of care, leading to better clinical outcomes. The Internet of Things (IoT) is a concept reflecting a connected set of anyone, anything, anytime, anyplace, any service, and any network. The IoT is a megatrend in next-generation technologies. The system also help professional workers who are subject to considerable physical and psychological stress and/or environmental and professional health risks. Measurable benefits of connected medical devices include reduces clinic visits, including reduction in bed days of care and length of stay in hospitals. Using Internet of Things (IOT), patient conditions are obtained and stored for further analysis and consultation.

In our case study we have monitored heart rate and calories burnt per day of a person are. From this research it is expected to monitor the whole body of the patient from remote location and improve the technology to world widely for patient monitoring by providing personalized and optimized services, it will promote a better standard of living.

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