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Integration Framework Solution for Healthcare Monitoring

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Integration Framework Solution for Healthcare Monitoring

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Abstract. Huge volumes of data have flowed in recent years of healthcare research to follow a few factors of a person and inform the guardian in the event of a patient's emergency. This necessitates the creation of a single platform where consumers may monitor data in real time. This study discusses an interoperable health monitoring system. The module provides the essential chance for patients to obtain all-day service, which may be documented by the doctor and can be notified in the event of an emergency. When a patient requires regular check-ups or long-term home care, this platform comes in handy. It may be accomplished utilizing market sensors and includes monitoring devices that allow patients to be monitored without having to visit a doctor. Because it eliminates the need for data transcription and copying by humans. Because it reduces the need for human data transcription and copying, interoperability helps make patient data more secure. When computer systems are set up for optimum interoperability, with databases and other applications communicating and exchanging information, employees will be more productive. XMPP is an integrating platform for IoT available in open source for uploading instant messaging using generic XML data processing. The XMPP protocols are free and there are several implementations in the form of clients, servers, server components, and code libraries. The work is demonstrated using the XMPP interoperable IoT communication protocol for the health monitoring system..

1. INTRODUCTION

Every day, the IoT network of gadgets expands. The majority of these technologies are now being utilized to efficiently advance healthcare. In this paper, we discuss many scenarios in which a healthcare monitoring system might be beneficial to both doctors and patients. During traffic accidents, where the patient may be watched in the hospital, a healthcare monitoring system comes in handy. Patients who need to be observed for an extended length of time might save money by using a healthcare monitoring system. Patients in remote places without access to a hospital benefit from the module. In particular, for COVID-19 patients, high blood pressure patients, hypertension patients, diabetic patients, and so on, the number of doctors in rural areas is not the same as in metropolitan areas. Medical equipment is not readily available in rural areas, save in government medical facilities. In comparison to government medical institutes, these clinics have a larger percentage of patients. The majority of the equipment has likewise been decommissioned. As a result, in the case of an emergency, this hardware component will send a report to the doctors or medical professionals right away. The remaining work will be done by doctors based on their health reports.

The construction of an IoT-based health monitoring system is described in this study. The study's key contribution is the creation of an IoT-based real-time health monitoring system. The data of the patients were collected in real-time utilizing a variety of sensors. Furthermore, a smartphone application has been developed. It was tested once the entire system had been built. This study included three separate real-life human test volunteers. In India, healthcare services are few, especially in rural areas. People must travel a long distance for medical tests and treatment. This procedure can help people who cannot afford to have their pulse rate, oxygen saturation, or body temperature checked regularly. This technology is not only cost-effective but also user-friendly. Individuals of all ages will benefit from this technology, notably the elderly and those in intensive care units (ICUs). It will monitor the patient's heart rate, oxygen saturation, and body temperature and communicate the information to a web server and mobile apps. Then, in the future, we may build a website, similar to a mobile app, where individuals can log in and examine the output by looking at the date and time. In addition, if a crisis develops, the medical attendant or a member of the patient's family assesses the patient's condition. The goal is to create a system that has great precision at a reasonable cost, so that everyone may use it and manage the costs. The following system will be quite useful in the current COVID-19 pandemic crisis.

2. RELATED WORK

E-medical record systems are critical to the transformation of digital health because they allow patients to establish, maintain, and track their Personal Health Records (PHR) through the internet. Our proposed strategy, in particular, uses the RSA stage to change every authority to limit the search capacity of various purchasing-supported client rights. To improve scalability, we often use multi-authority attribute-based secret writing, which allows the authorization process to be executed just once across several authorities' rules. They provide a realistic and successful approved translated hunt strategy for multi-authority medical databases, as well as advanced security assistance.[1]. A new HL-7 interoperability standard for electronic health records is the Fast Healthcare Interoperability Resources (FHIR) standard. FHIR-based mortality reporting highlights the viability of creating SMART-on-FHIR operations that allow medical providers to record deaths in a timely and accurate manner across several Indian state agencies. Every year, over 56 million people die in the world, with 6.4 million of those fatalities occurring in India. To document disease or events that lead to death in a timely, accurate, and comprehensive manner. To help in the spread of infectious illnesses such as the flu, as well as to gather vital information such as life expectancy, mortality patterns, and so on [2].

The area of health information technology has advanced in the implementation of health record definition standards as a result of the usage of electronic health records (EHR). The purpose of an electronic health record (EHR) is to standardize health data without having to choose or define which standard to use. The personal health record is another technique to gather patients' health data electronically and uniformly (PHR) [3]. Medic is a platform for Medical Data Interoperability based on healthcare bias collaboration. With its delving and rephrasing agents, by using translation resources at the network edge, Medic outperforms a cloud-based IOMT. They developed a new IOMT frame in this study that brings data interoperability closer to the network edge, where medical data originates. Enrolment, registration, surveys, reprocessing, and publication are all services provided by the medic Framework. Healthcare services are also undergoing digital transformations as a result of the introduction of smart clothing in this paradigm. As an illustration in Figure 1, the automated infusion system and real-time monitoring of dialysis therapy in ambulances and smart hospitals [4].

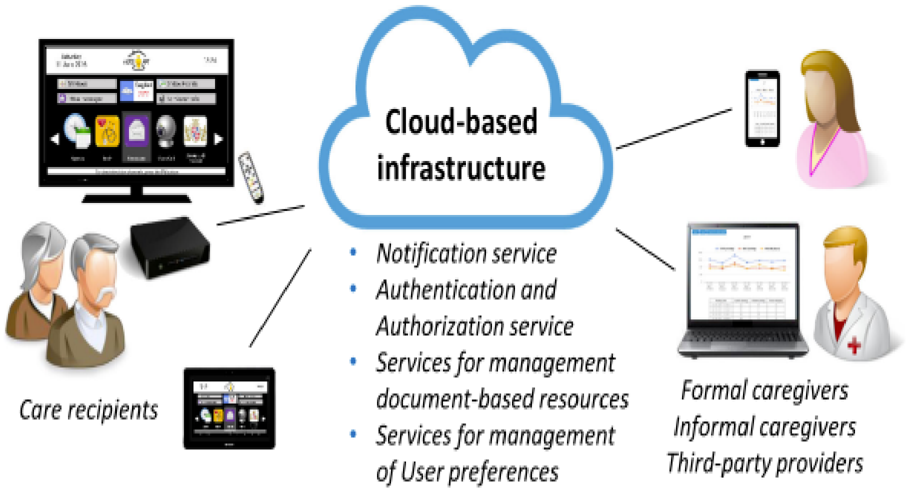

Figure 1: MultiCare telecare framework [4]

3. METHODOLOGY

3.1 Interoperability

Interoperability is defined as the ability of information and communication technology systems and software processes to communicate, alter data directly, effectively, and continuously, as well as to use that data. The capacity to properly comprehend data across[5] systems or organizational boundaries is known as data interoperability. Figure 2 illustrates the most important points. It's expected in this script that the individuals on the left have knowledge that the people on the right want, and that data from one system may be accessed by the other. As a result, interoperability will only be realized if both the entering system and the druggies comprehend the meaning of the data they accept and are qualified to utilize it.

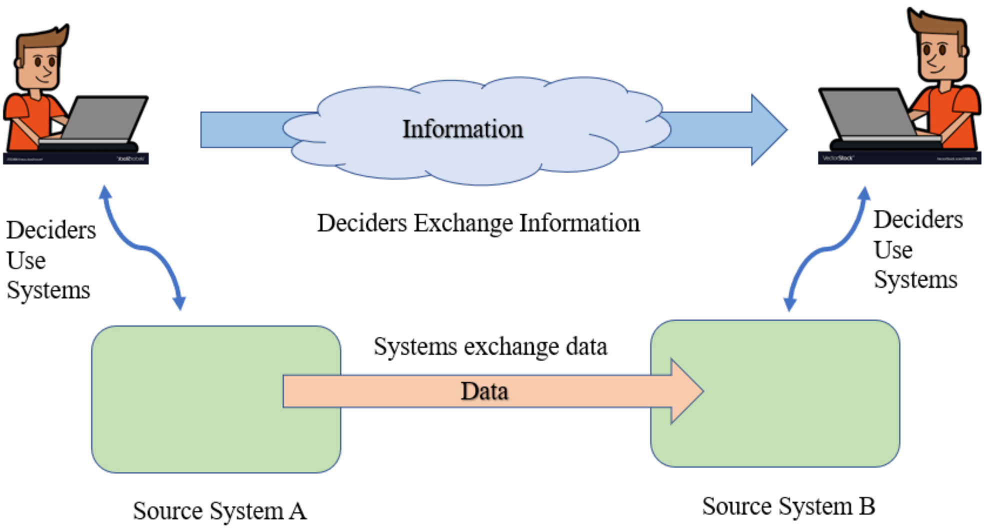

Figure 2: Concept of Interoperability

As ICTs become a vital component of healthcare, the healthcare sector is undergoing an abecedarian transition in its approach to providing care. Despite the growing expense of healthcare, constant inefficiencies, and healthcare quality failures, healthcare providers and cases continue to face challenges. The importance of interoperability in exchanging data across telehealth operations, decreasing healthcare costs, and enhancing treatment quality is self-evident. As a result, this part evaluates and critically examines the benefits of comprehensive interoperability in healthcare.

3.1.1 Easy access to patient records

Patients often receive care from a variety of providers (such as hospitals, labs, pharmacies, universities, and public health organizations) depending on their proximity to them and the distance they travel to bed. Furthermore, every year, unnecessary fatalities and injuries occur as a result of inadequate communication among healthcare interpreters. To oversee the safe and successful delivery of healthcare services, healthcare interpreters [6]require access to thorough and full records of their cases across many systems. This will improve healthcare procedures by providing case-specific information to care professionals, allowing them to consult on a case more efficiently. Interoperability, as a result, ensures a seamless healthcare continuum. The capacity to access health-related information held in various systems, independent of the geographic location of healthcare or the case, is a significant feature of healthcare interoperability shown in Figure 3.

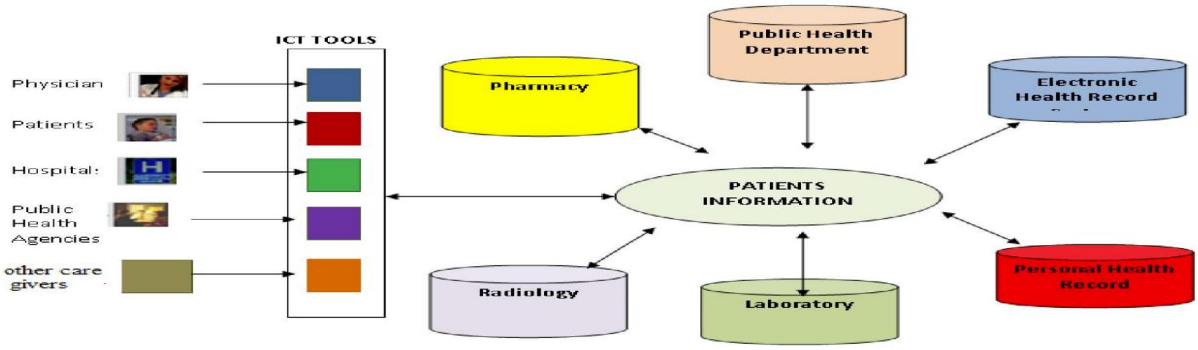

Figure 3: Easy access to patient information

3.1.2 Reduced healthcare cost

Dealing with increased fees is one of the most difficult aspects of healthcare. In the United States, for example, healthcare expenses are predicted to be 14.9 percent of GDP, or $1,6 trillion [7] in 2002 and $1.9 trillion in 2005. Similarly, the United States of America's healthcare budget is expected to reach $3.6 trillion by 2014. Interoperability across healthcare IT systems will save the government up to $77.8 billion each year. As a result, effective data sharing, information sharing, and knowledge sharing among diverse stakeholders in the healthcare network are critical to lowering healthcare costs.

3.1.3 Reduction of medical errors

Moving the center of care across multiple locations and providers is common in healthcare delivery. As a result, case records are dispersed across several croaker's services, laboratories, and hospitals. The technique is usually error-prone due to a lack of interoperability among health systems. An outpatient investigation found that the fear of reporting this event was responsible[8] for 18 of the medical mistakes that impacted pharmaceutical side effects. Medical mistakes are the sixth biggest cause of mortality in hospitals, hence they are a major source of worry in the healthcare profession. Furthermore, it has been stated that at least as many as tens of thousands of Americans die in sanatoriums each year as a consequence of medical blunders, resulting in significant loss of life. Furthermore, each year, more than one million people are wounded as a result of faulty healthcare processes and system breakdowns. One strategy to reduce medical mistakes is to provide full interoperability in healthcare by ensuring that health-related data is organized in a way that allows remote IT systems to comprehend both the structure and content of the altered information.

4. PROPOSED SYSTEM & ARCHITECTURE

The proposed system for the work used is shown in Figure 4. The system [9] uses an ESP-32 processor to process all the functionalities. it is used with Heart rate, pulse oximeter sensor, temperature sensor, and ECEG Sensor to monitor various vital parameters for the patient. The Wi-Fi module connects this system remotely using mobile-based devices. The LCD is used to view the results of the system. The HTML is the server used to connect the processor with mobile devices

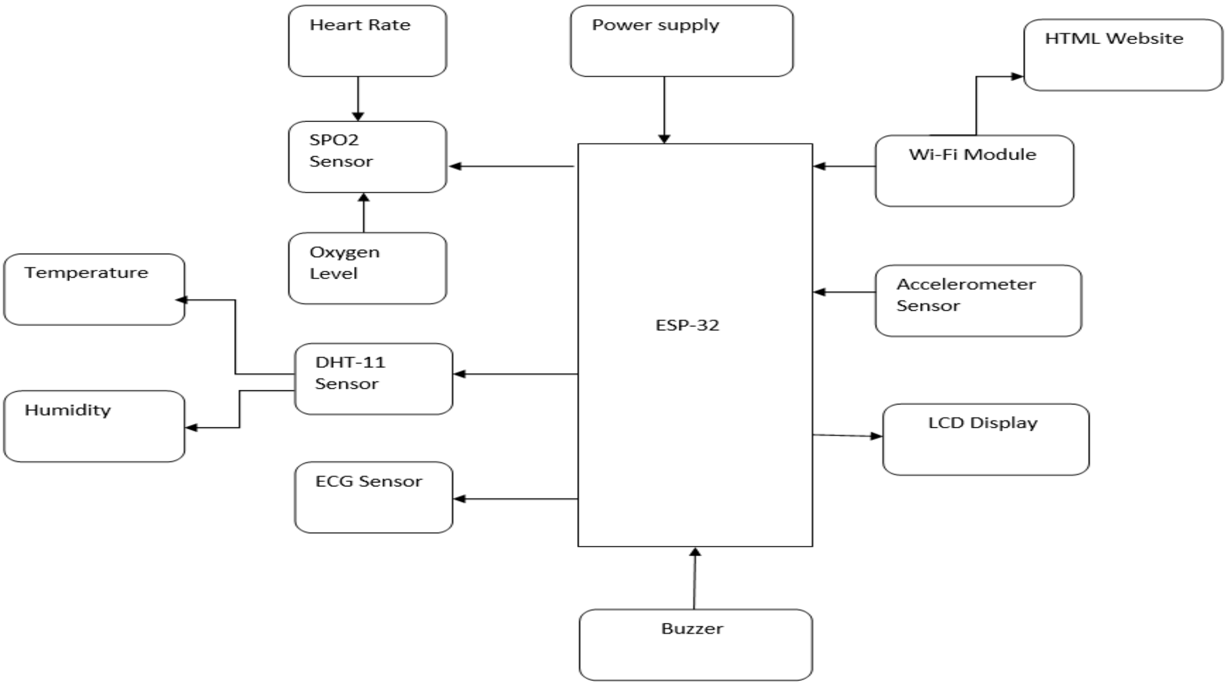

Figure 4: General view of healthcare monitoring architecture

- The prototype used for the architecture is shown in Figure 5.
- A native Visual Studio Application that works on both windows as well as a smartphone that displays the patient's data with an emergency notification alert.
- The caretaker in charge gets an emergency notification in case any fluctuations are found in the patient's body.
- The discovery board has an LCD that displays a log of the patient's records kept in the microcontroller. The display is a touchscreen that allows us to travel through the patient's medical history.
- The data is pushed to the cloud, where it may be retrieved by the PC app and saved in a local database for display on the app. For the convenience of doctors, the app also allows them to update or delete a patient's history.

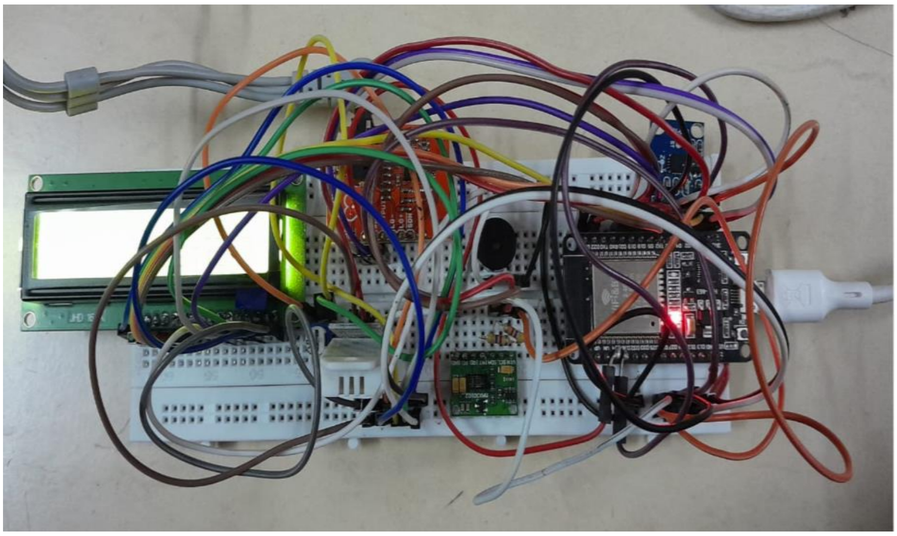

Figure 5: Prototype developed for interoperable health monitoring system

If the patient’s pulse is low is life-threatening and requires the doctor’s attention immediately. In that kind of scenario, the health monitoring system will need a common interface for that we are furnishing an interoperability solution. We used ESP-32 as [10] the control board. To utilize ESP-32 as a server, we'll install XAMP. The oximeter will be attached to the pulse detection sensor, which will detect the pulses. Wi-Fi or a wired network can be used to connect to it. An LED display, with the help of detectors, will display the heart rate and breathing rate of the patient. We will set a threshold value, if the patient’s heart rate is below 60 for the next three iterations, an alarm beep will sound, and an SMS and an email notification will be sent to the patient’s family. In an LED display, there would be two lights red light and green light. Red light symbolizes the patient is critical and needs attention. Also, the green light symbolizes patient is healthy. The system is integrated with the following three modules

(a). Hardware integration to the controller
(b). XAMP server integration
(c). Server integration to hardware

The circuit diagram for interfacing MAX30102 and DHT-11 with ESP-32 is given below in Figure 6.

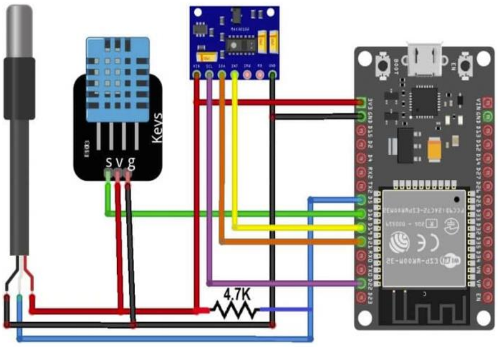

Figure 6: The system's schematic diagram of the ESP-32 controller connecting the sensors

All of the sensors can work at 3.3V VCC. As a result, double-check that their VCC is linked to a 3.3V power source. GND and GND should be linked. Connect the MAX30100's SDA and SCL pins to

GPIO21 and GPIO22, respectively, because it's an I2C sensor. Connect its INT pin to GPIO19 on the ESP32. The output pin of the DHT11 is connected to GPIO18 on the ESP32. Similarly, the output pin of the DS18B20 is connected to GPIO5 on the ESP32. A 4.7K pull-up resistor is located between the output pin and the VCC pin of the DS18B20.

If the patient is in a critical situation an SMS message will be sent to the family members to address the doctor immediately. The pulse sensor can be placed on a finger or earlobe, via a connection wire that can be connected to the ESP-32, to check the heart rate. To detect the presence of liquid, the pulse sensor employs a magnet and a reed switch. The reed switch is operated by a magnetic field and has its connections sealed in a glass tube containing inert gas. The pulse sensor's supply voltage is 3.3v -5v. the list of components required for the system used is shown in Table 1.

Table 1: The components required to develop the health monitoring system on the ESP board are as follows.

Sl.No	Components Name	Description	Quantity
1	ESP-32 Board	Esp-32 Development Board.	1
2	DHT-11 Sensor	DHT-11 Digital humidity temperature sensor.	1
3	Pulse Oximeter Sensor	MAX30102 Pulse Oximeter Sensor	1
4	SPO2 Sensor	AD8232 Heart Monitor	1
5	ECG Sensor	AD8232 ECG module	1
6	Accelerometer Sensor	HW-013 Accelerometer sensor	1
7	Buzzer	-	1
8	Connecting Wires	Male-to-Male Jumper Wires	15
9	Bread Board	Solderless Breadboard Mini	1
10	Resistor	4.7K	1

4.1 Major Hardware Components

In the suggested system, some kind of hardware components shown below in Figure 7 are employed and are used in development.

[a] ESP-32 Processor

The ESP32 SoC series is a Wi-Fi and dual-mode Bluetooth system on a chip that is both low-cost and low-power. At its heart is a dual-core or single-core Tensilica Xtensa LX6 microprocessor with a clock rate of up to 240 MHz. The ESP32 has antenna switches, RF baluns, power amplifiers, low-noise receive amplifiers, filters, and power management modules. To achieve ultra-low power consumption, ESP32 incorporates power-saving technologies such as fine-resolution clock gating, various power modes, and dynamic power scaling.

[b] Temperature Sensor (DHT-11)

The DHT11 is a simple, low-cost digital temperature and humidity sensor. A capacitive humidity sensor and a thermistor monitor the ambient air, and the data pin generates a digital signal. Although it is simple to use, data collecting requires careful planning. The sensor can detect temperatures ranging from 0°C to 50°C, as well as humidity levels ranging from 20% to 90%, with a precision of 1°C and 1%.

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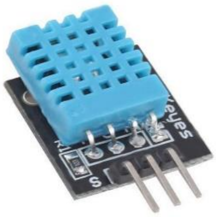
[a]


[b]


[c]

[d]


[e]


[f]

Figure 7: Components for the healthcare monitoring system's hardware. [a] ESP-32 [b] DHT-11 Temperature Sensor [c] MAX30102 Pulse Oximeter Sensor [d] AD8232 Heart monitor [e] ECG Sensor [f] HW-013 Accelerometer Sensor.

[c] Pulse Oximeter Sensor (MAX30102)

The MAX30102 is a pulse oximetry and heart rate monitor biosensor module. Low-noise circuitry with ambient light rejection, internal LEDs, photodetectors, optical components, and low-noise electronics are all included in the package. The MAX30102 is a complete system that simplifies the development of mobile and wearable devices. A single 1.8V supply and a separate 3.3V supply for the internal LEDs power the MAX30102. The communication is done over an I2C-compatible interface. The software can switch the module off with a 0% standby current while keeping the power rails on.

[d] Heart Rate Sensor (AD8232)

The AD8232 includes a quick restoration feature that compresses the settling tails of high-pass filters that would otherwise be too long. After an abrupt signal change that rails the amplifier, the AD8232 adapts to a higher filter cutoff on its own. This feature enables the AD8232 to recover quickly, providing precise readings as soon as the electrodes are linked to the patient. The AD8232 is a signal conditioning block that may be used to measure biopotentials in the heart and other organs. It was designed to gather, amplify, and filter small bio-potential signals in noisy situations, such as those created by mobility or remote electrode insertion.

[e] ECG Sensor

The electrocardiogram (ECG) is a graphical representation of the heart's electrical impulses that may be used to determine a person's heart rate and rhythm. It also serves as a signal for heart-related actions. An ECG may be used to determine whether your excessive blood pressure has caused damage to your heart or blood vessels. An ECG may be requested when you're first diagnosed with high blood pressure. ECG is measuring electrical changes generated by cardiac movement.

[f] Accelerometer Sensor (HW-013)

Analog Devices' HW-013 accelerometer sensor is a low-power triple-axis MEMS accelerometer with minimal noise. The module's main component is HW-013. The maximum detection range of the sensor is around 3 g. It may indicate both static and dynamic acceleration induced by motion, shock, or vibration in tilt-sensing applications. The sensor runs on a voltage range of 1.8V to 3.6VDC (ideally 3.3V) and consumes just 350A of electricity. Its internal 3.3V regulator, on the other hand, makes it excellent for use with 5V microcontrollers like the Arduino.

5. RESULTS & DISCUSSION

Data gathering, data monitoring, and alerting for the user to communicate are the three categories of health monitoring systems.

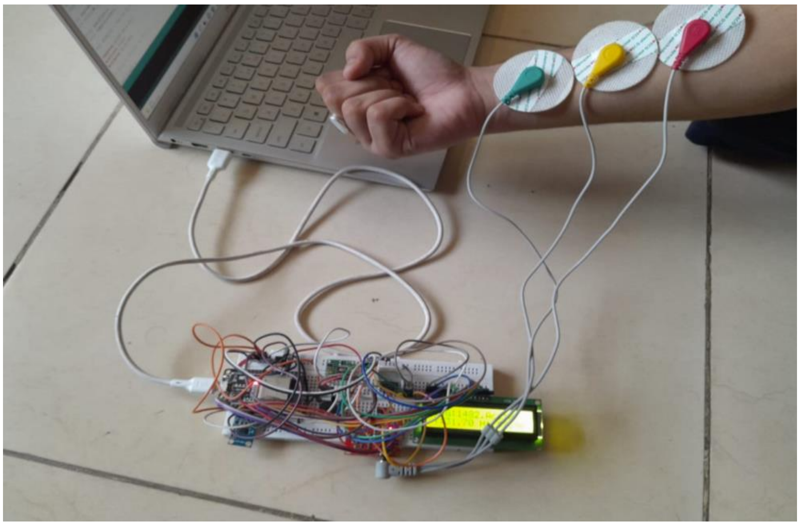


Figure 8: Diagram of the patient utilizing the IOT device and giving the test results instantly.

- Biometric Data Collection:
  Various sensors affixed to the patient's body, as illustrated in Figures 8 & 9, can be used to gather data. A microcontroller platform can capture the data, which can then be mapped into the patient's records. Multiple sensors can be mapped to the patient's database initially. The patient other vital parameters of humidity and body temperature are verified by connecting DHT 11 sensor as shown in Figure 9. The results are taken by touching the sensor on the patients

- Data processing:
  A patient's bodily parameters can be tracked and sent to the cloud regularly. You can take advantage of a sensor platform.

- User Interface:
  The user interface's objective is to identify the parameters of the patient's body and alert the caregiver in the event of an emergency. A mobile app or a PC program with a navigational display is frequently used.

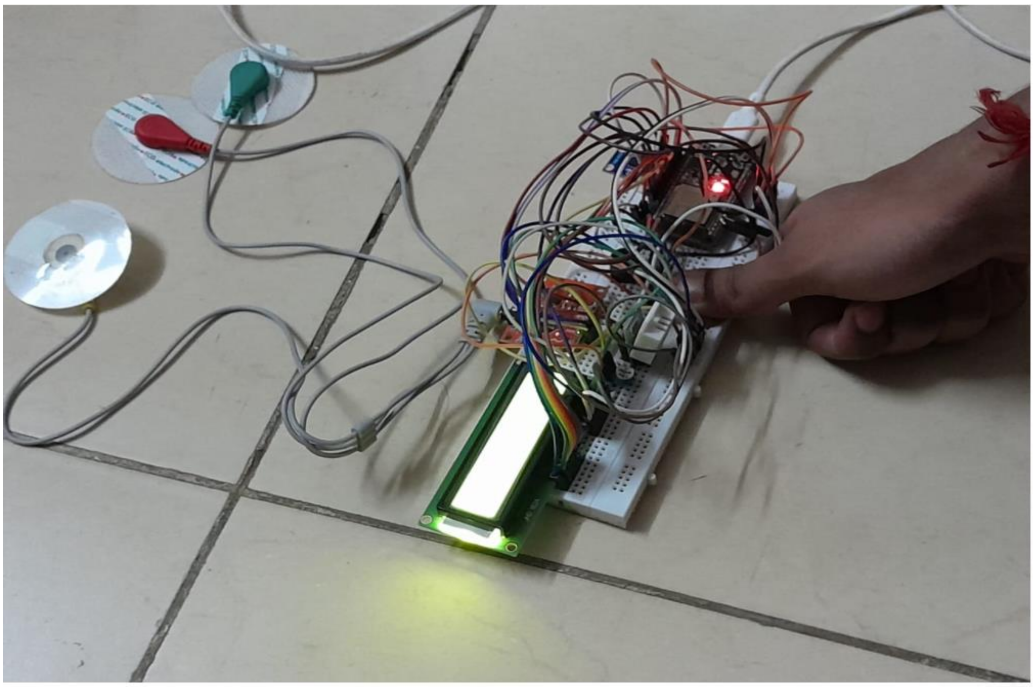


Figure 9: A patient inspecting his body temperature

The outcomes of the system, as well as the system's results, are shown in Figure 10, the following section. Pulse rate, room temperature, ECG, humidity, and an accelerometer are all connected to the ESP-32 as part of the whole system. The ESP device is connected to the system through a USB connection, which allows us to power it up.

Figure 10: LCD screening the values of ECG, accelerometer, Temperature in degrees Celsius, and Heart rate.

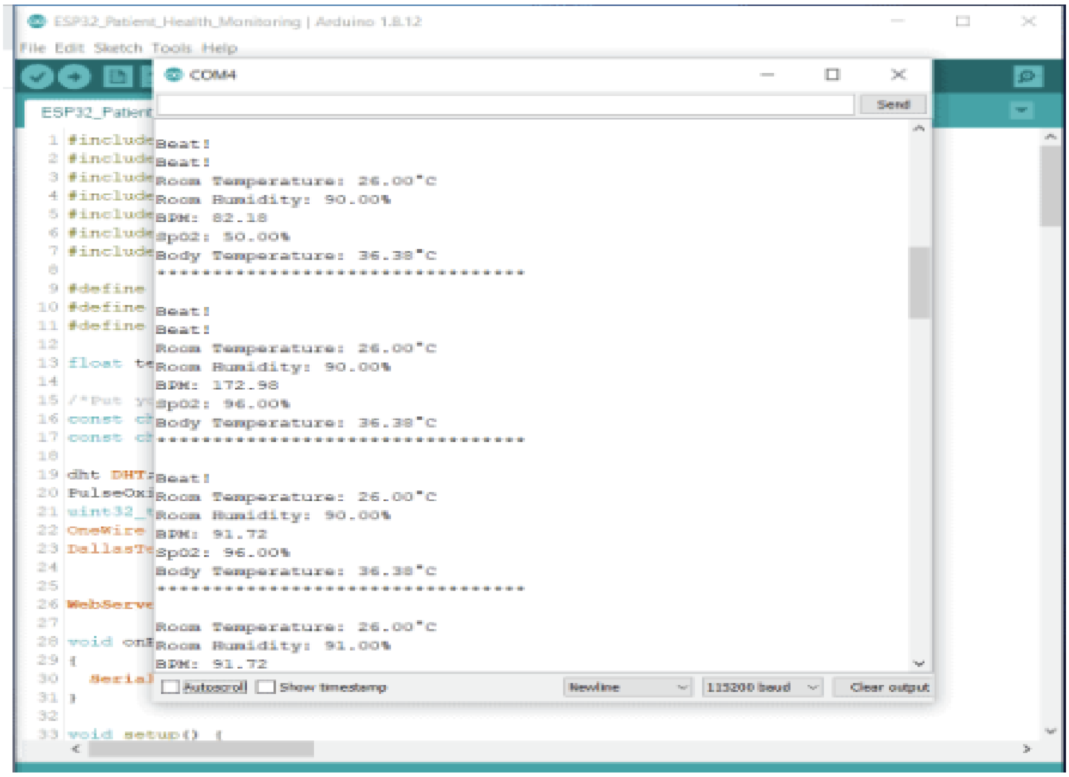


Figure 11: Diagram depicting the measurement on the Arduino IDE's serial monitor.

When we upload data to the Arduino, the system begins to operate, and the measurement data is presented in the serial monitor of the Arduino Integrated Development Environment (IDE) and the Liquid Crystal Display (LCD) display, as shown in figure 11, as well as on a mobile app through Wi-Fi. Figure 10 illustrates the full system, including body temperature and ECG measurements shown in the Arduino IDE's serial monitor and the mobile app. Figure 10 shows the results of the measurements of all the parameters in the serial monitor of the Arduino IDE. The MAX30102 and DHT-11 sensors provide the data value.

Once the code is uploaded to your respective board, you may view the program in action using the serial monitor when the code has been uploaded to your board. The Wi-Fi network will be activated by the Node MCU ESP32. It will show the ESP IP Address after it is connected. Use the ESP32 IP Address in the Web Browser.

The system's Wi-Fi may be switched on or off using the choices in the mobile app, as shown in Figure. For ECG, SpO2, and temperature measurement, a default symbol "--" meaning nil will appear on the screen before setting the Wi-Fi "On." When Wi-Fi is switched on, the figure illustrates a diagram of measurements on the mobile app. When we switch the Wi-Fi "on" in Figure, the data will be transferred into the IoT system we built via the Wi-Fi device. The acquired data will be accessible on the mobile application when it has been collected. Depending on the available data connection, it may take a few moments. On the mobile application, the measured heartbeat, Spo2, and temperature are shown in Figure 12.

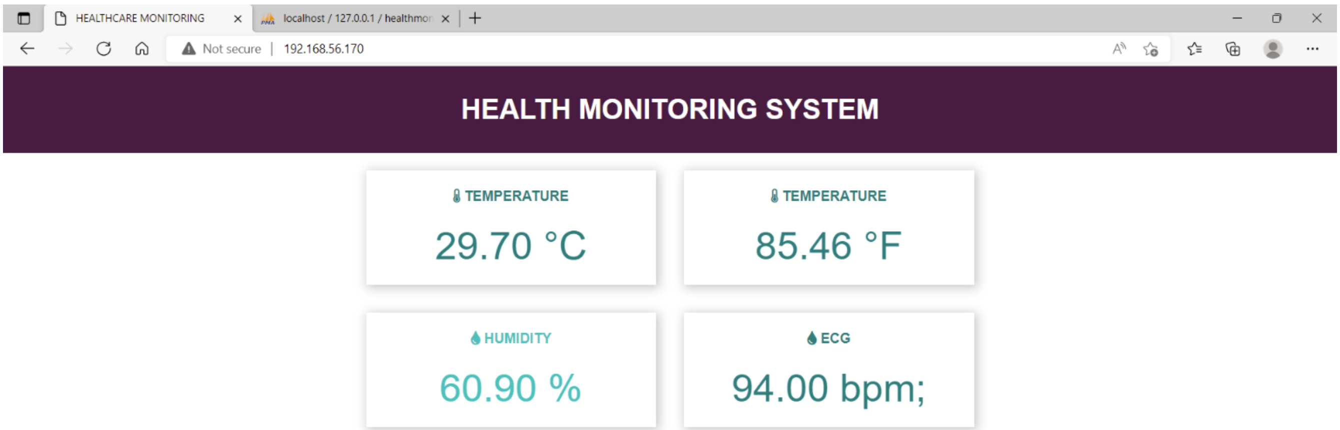


Figure 12: Temperature in degrees Celsius, Fahrenheit, Humidity, and ECG are all shown on this health monitoring system.

In the figure, we observed an individual measure of six different patients in real-time their temperature, ECG, accelerometer, and humidity. Their current data is gathered and shown on the mobile app, as illustrated in table2. The data indicate that patient 1 is in good health and poses no threat. As a result, they aren't required to seek medical help.

Table 2: The suggested system's body temperature test results for three separate persons.

Body Temperature	Actual Data[deg F]	Observed Data[deg]	Error[%]
Patient-1	97.4	97.9	0.52
Patient-2	98.5	97.6	0.72
Patient-3	98.2	98.9	0.51
Patient-4	96.8	97.4	0.63
Patient-5	97.6	97.2	0.52
Patient-6	98.3	97.4	0.82

Patient 2's report is depicted in Table 2. Patient 2's health data was determined using a technique identical to that of patient 1. Conceivably the report of patient 2 indicates that the body temperature is extremely high. The person may be suffering from a high temperature. As a result, this person may keep a close eye on his health and seek medical help in the days ahead. They can track their health in real time and receive medical help. The system would share notifications to the doctors with the data if their cardiac rate gets high or low during testing.

We looked at the health data for patient 3 in Figure to see if it followed the same pattern. "Patient 3" has a quicker heartbeat. Over the following four days, they'll be able to track their health data and diagnose themselves with medical assistance.

In the table, you'll find the test results as well as an analysis of all the patient data. Two human test participants were employed in the study to test the following system. The findings of the measurements were utilized in the development of our newly manufactured technology. Real-world scenarios were used to test and implement the system. The real-world test results acquired with the systems are listed in the following tables in the order that they were obtained. The findings of three people's body temperature readings are shown in Table 3. The temperature findings are pretty close for each measurement setting of a test subject. The data for each test, however, differs significantly due to the variances in human bodies.

Table 3: ECG test results of three different people of the proposed system.

ECG	Patient-1	Patient-2	Patient-3
Take-1	96	92	98
Take-2	96	92	98
Take-3	96	92	98

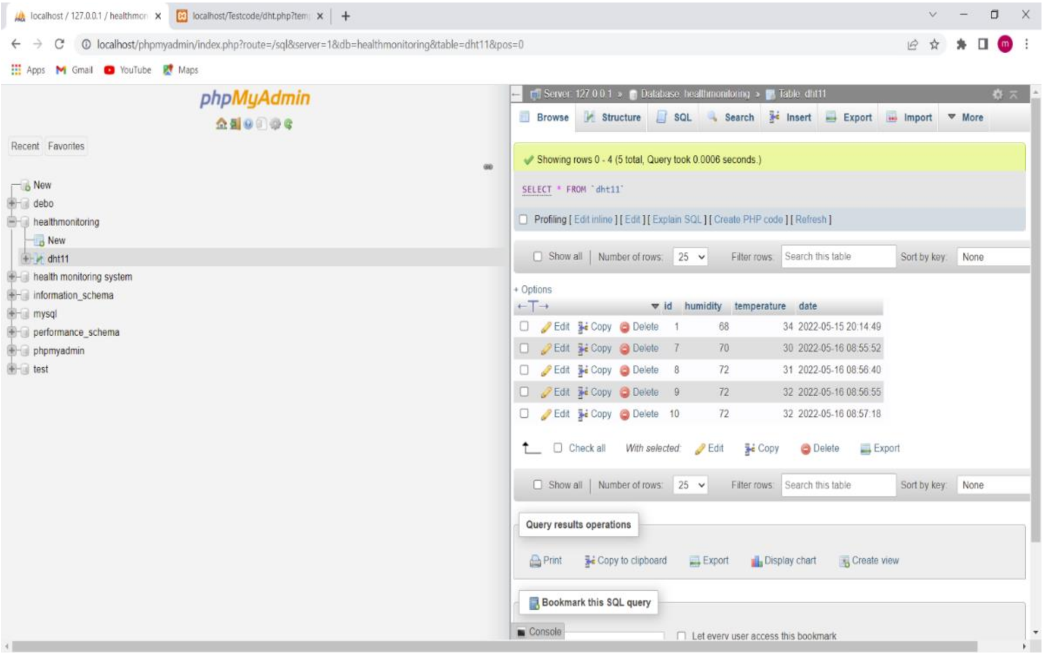


Figure 13: Health Monitoring System displaying temperature, and humidity through the XMPP server

XMPP is a widely used cross-platform web server that helps programmers to develop and test their applications on a native web server. It's an open-source web results package for a range of servers and command-line executables, as well as Apache, MariaDB, PHP, and Perl server modules, that comes with the Apache distribution.

XMPP allows the host or origin server to test their websites and visitors on PCs and laptops before publishing to the back-end server, as seen in Figure 13. It's a server-based platform for testing and verifying Apache, Perl, MySQL databases, and PHP-based systems. Perl is a web programming language, PHP is a backend scripting language, and MariaDB is a MySQL database server.

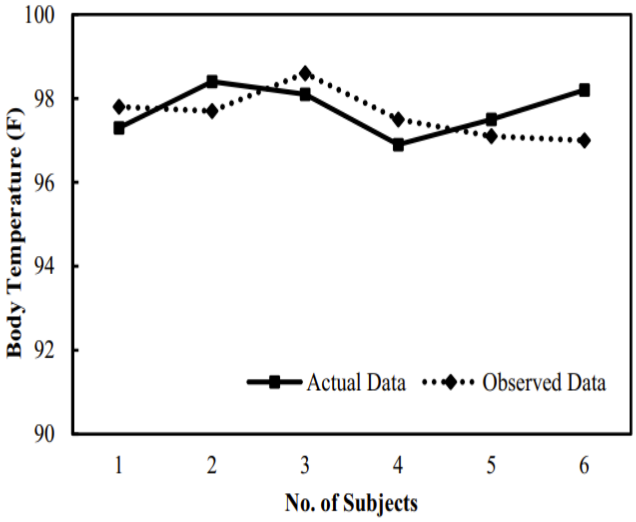


Figure 14: Test result of actual and calculated data for body temperature

To evaluate the proposed model developed the error accuracy metric is used to check its validity. The error percentage is calculated between two data namely, actual data of the patient and measured data from the system. the actual data for a different set of patients are taken without connecting to the system, and by using the integrated system same set of patients' measured data is noted. The error difference is calculated by using the formula shown in equation (1). This accuracy tells how much the measured data is nearer to the observed data. The same thing is plotted as a line chart graph and is shown in Figure 14.

$$\boldsymbol{Error}\ (\%) = \frac{\boldsymbol{Actual\ Data - Measured\ Data}}{\boldsymbol{Measured\ Data}} \rightarrow \mathbf{(1)}$$

As the measured data closely matches the actual data, the integrated system can efficiently help in monitoring different vital parameters simultaneously and helps monitor the parameters remotely.

Merits

(a) Self-monitor and exchange critical physiological indicators to have a better understanding and control over their current health state.

(b) Patients benefit from healthcare monitoring because it improves the quality and durability of care.

(c) Real-time access to medical records, as well as their portability, may be ensured, and patients can receive high-quality medical care at any time.

6. CONCLUSION

The design and deployment of an Internet-of-Things-based health monitoring system are presented in this study. This Internet of Things (IoT)-based device allows users to identify their health indicators, which may help with long-term health management. If the necessity arises, the sufferers may eventually seek medical help. They might effortlessly communicate their health parameter data with the doctor using a single application. The main purpose of healthcare interoperability is to provide a smooth flow of health-related data between caregivers and patients for clinical decision-making. The viability of employing the health monitoring system is demonstrated in this study. This platform may be used to integrate sophisticated analytics to improve the telemonitoring system's delicacy even further. The prototype can also be extended to include additional open and personal health rules. The system will transmit data regarding a patient's body temperature, heartbeat, and blood SpO2 levels to an app using

Bluetooth. This information is also supplied to the patient's LCD, which allows them to check their current health state right away. Elderly patients, asthmatics, COPD patients, patients with chronic diseases, COVID-19 patients, and diabetic patients will be able to maintain their health over the time with the help of the system we built.

7. FUTURE WORK

The system may be updated and altered in the future in a variety of ways. The ESP-32 microcontroller in the system may be swapped out for a Raspberry Pi and used in several ways. The system's sensors may be updated when additional sensors are added, allowing us to track a wide range of health measures. For system security, new algorithms may be integrated with the entire system. For consumer safety and dependability, the healthcare industry's future depends more on health monitoring systems.

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