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IoHT Based Tele-Healthcare Support System for Feasibility and Performance Analysis

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Abstract: - With the rapid development in Internet of Things (IoT) it come up with the subbranch Internet of Healthcare Things or the Internet of Medical Things. With the help of portable healthcare sensors and the wearable devices now, ambulance can be converted into critical diagnostics unit on the wheels. Monitoring the home care patient is not the just part of IoT application where doctor can remotely monitor the patient situation by the means of sensors. It requires a complete system may called as telemedicine where multiple components will play similar priority role to monitor the patient status using sensors, let the doctor connect the patient, data analytics calculate the progression, AI engine will detect the emergency and act upon. The proposed system is to design and developing centralized tele-healthcare support system and systematic analytics sharing with multiple level of user with privacy protection. This will allow different authorities to take advantages from patient generated records.

Keywords: IoHT, IoT, RTHMS

I. INTRODUCTION

The term "Internet of Things (IoT)" has recently gained popularity in the field of communication technology, emerging as the next frontier in technological advancement. Today, a wide range of objects, from household appliances and lighting systems to vending machines and automobiles, are equipped with the capability to connect to the internet and communicate with other devices. IoT encompasses devices and objects that can interact with the internet through the use of physical sensors, microcontrollers, and network connectivity, enabling them to collect and exchange data in real-time. Each device is assigned a unique identifier (UID), facilitating seamless communication through machine-to-machine (M2M) interaction. This massive amount of data collected from devices worldwide is stored in the cloud, leading to more efficient and intelligent systems.

In recent times, IoT has made significant strides in the healthcare sector, revolutionizing healthcare systems. The integration of medical devices with networks and patient monitoring has become a burgeoning industry. The Internet of Medical Things (IoMT) is a subset of IoT specifically dedicated to medical devices with internet connectivity. Unlike IoT, which encompasses all web-enabled devices, IoMT focuses solely on medical devices. IoT in healthcare involves the incorporation of sensors, microcontrollers, and other technologies to analyze and transmit sensor data to the cloud and ultimately to healthcare providers, such as doctors.

The integration of IoT features into medical devices has greatly improved the quality and efficiency of patient care, particularly for elderly and physically disabled individuals. Healthcare IoT systems can store and manage vast amounts of patient data in a digitized format, allowing patients to access their data at any time. Portable health monitoring devices have been developed, enabling patients to wear them for continuous monitoring. These devices are connected to patients, allowing healthcare providers to monitor their condition remotely. With IoT-enabled patient monitoring accessible over the internet, healthcare providers can detect changes in a patient's health status in real-time, enabling timely interventions and improved patient outcomes.

Yue et.al (2020) [1] article describes the development of a hardware-software complex for monitoring the health status of a vehicle driver, which uses portable devices to control the physiological parameters of a person and transfers data to a mobile terminal or uploads it to a cloud server for data analysis.

For Nduka et.al (2019) [2] Remote Health Monitoring (RHM) system sense certain human vital signs such as, temperature, respiration and heartbeat (pulse) which is connected in real time environment. They built RHM system on Arduino UNO board which houses other microcontrollers and sensor paired with IOT Gecko, physicians can

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view patient's vital sign reading in real-time irrespective of their geographical location. When these body vital signs fall below or above normal parameters, the system triggers an alarm, giving physicians the opportunity to carry out timely individualized intervention on patients in crisis.

Chao et.al (2017) [3] proposed a pervasive monitoring system that can send patients' physical signs to remote medical applications in real time. The system mainly composed of two parts: the data acquisition part and the data transmission part. The monitoring scheme includes monitoring parameters and frequency for each parameter in data acquisition part, and designed it based on interviews to medical experts. Multiple physical signs were found like blood pressure, ECG, SpO2, heart rate, pulse rate, blood fat and blood glucose as well as an environmental indicator (patients' location) was designed to be sampled at different rates continuously. Four data transmission modes were presented taking patients' risk, medical analysis needs, demands for communication and computing resources into consideration. A sample prototype was implemented to present an overview of the system.

In their studies Yadav et.al (2018) [4] familiarizes the status of IoT growth In India, reviews the Risk factor, security issues and challenges in India.

Lakkis (2017) [5] focus on two essential categories the emergency and the operational services. They tried to highlight new ideas of handling these services using IoT.

II. PROPOSED APPROACH

The ongoing COVID-19 pandemic has served as a significant wake-up call, highlighting the importance of embracing technology preemptively to mitigate its adverse effects. With many patients facing a lack of support from healthcare providers and doctors themselves grappling with resource constraints, the need for innovative solutions has never been more apparent. This is particularly true for individuals in remote areas, where access to instant diagnosis and medical assistance is crucial. Rural communities, perennially underserved in terms of healthcare, have struggled due to a scarcity of medical professionals willing to work in such environments. However, recent advancements in IoT technology offer a ray of hope, paving the way for the development of smart healthcare systems that can enhance overall patient care. Addressing the challenges of an aging population and the associated healthcare complexities, the concept of remote patient monitoring has gained traction. This approach, aimed at monitoring patients in real-time, especially the elderly, disabled individuals, and those with chronic conditions, holds immense promise. Traditional healthcare systems, often unwieldy and complex, pose difficulties for elderly and disabled patients. Thus, there is a pressing need for user-friendly Remote Telehealth Monitoring (RTHM) systems that can minimize the need for frequent hospital visits, especially during emergencies. Moreover, with the imperative to manage healthcare costs while simultaneously enhancing service quality, real-time remote monitoring emerges as a pivotal strategy. By enabling early intervention through the identification of condition relapses, such systems ensure continuous healthcare delivery, thereby addressing the evolving needs of patients effectively.

The proposed system aims to develop a tele-healthcare support system within an IoT environment capable of monitoring patients' basic health indicators and their surrounding environmental conditions in real-time. This tele-healthcare solution holds particular significance for elderly and disabled patients who may not always be aware of their true health status, especially in rural areas where access to healthcare professionals is limited. By leveraging tele-healthcare technology, diseases can be detected and treated promptly, even from remote locations, improving patient outcomes. Moreover, this system offers a low-cost and easily accessible method for monitoring human health, alleviating the need for frequent hospital visits and reducing medical expenses for patients. Additionally, doctors can remotely prescribe necessary medications based on continuous monitoring of patients' health data through a dedicated application. Ultimately, tele-healthcare serves as a vital bridge connecting patients with healthcare providers, enhancing accessibility to medical care and improving overall health outcomes.

Looking at the broader landscape of the Internet of Health Things (IoHT) or Internet of Medical Things (IoMT), it's evident that only a few companies and organizations have been focusing on developing limited solutions for remote patient monitoring. Despite advancements, patients and doctors still often need to physically meet for consultations and diagnoses, particularly in critical situations where the presence of a doctor is essential. This necessity highlights the challenges faced in providing remote healthcare. In remote and rural areas, patients often rely on mobile hospitals to access tele-healthcare support, bridging the gap in healthcare services. Additionally, elderly and disabled individuals require continuous monitoring of their health, as their physiological parameters can fluctuate frequently. Real-time data collection becomes imperative in such cases to ensure timely interventions and care. Moreover, it's essential for these systems to be low-cost and easily affordable for patients to encourage widespread adoption and accessibility. Therefore, developing affordable solutions that enable real-time remote monitoring remains a key focus in the field of healthcare technology.

The proposed system will be a multiple layered architecture with different functionality utilization through different type of users. Figure 1.0 illustrates the multiple layers involved in the system. Where every layer has its own research and development. The system must be medical grade to be ready to deploy and easy functioning for different users. This system is designed keeping primarily four type of users 1). Patients 2). Doctors or hospitals 3). Device manufacturer and 4). Medical associations.

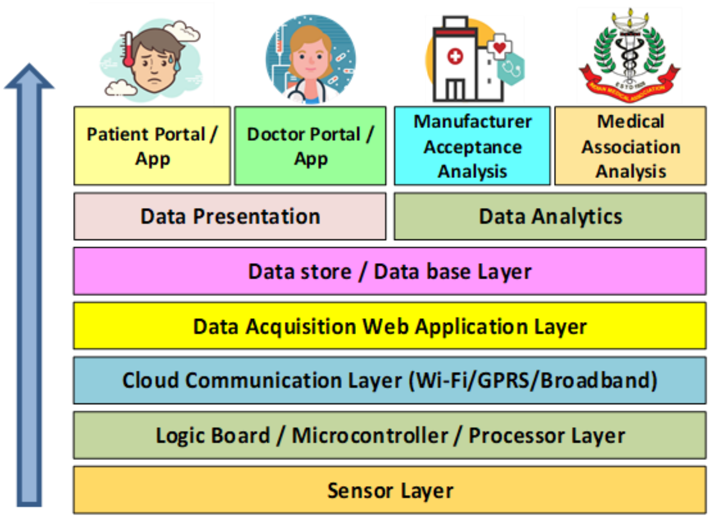

Figure 1. System layer architecture

Development and deployment of the system is defined as different phases as mentioned below.

Phase 1: Design and development of portable ICU system with sensors like temperature, ECG, heartbeat, and oxygen. This system will be having Wi-Fi or GPRS link to connect to internet and send the sensor in formation to web service. This system will be portable enough to carry anywhere and work on low power supply.

Phase 2: Development of web service to receive the information for the sensor hardware. This will receive the sensor input information and validate the information for valid source. Once the information gets validated it will store the information to the database for further analysis and the presentations.

Phase 3: Developing the web-based data representation application to plot the patient information in required graphical format. This platform will have option to feed patient information like demographic, symptoms, disease, or environmental. This will have tool to perform graphical analysis and show data in running comparison chart format for better understanding and visualization.

Phase 4: Developing the BI engine to generate the data manipulation and indexing functions to retrieve the information in minimum time. Here system will be enhanced to perform different analysis regarding location, disease, patient, parameters.

Phase 5: Testing the complete system in real-world environment and get the system performance along with the feasibility. Once system receive multiple records it calculates the live devices performance and test the acceptability. This will allow user to monitor the system live performance and detect any bugs of errors in the system.

Proposed system is primarily focused on finding the regional to health parameter level analysis. This will ensure accurate availability of information about the telehealth care system utilization and also the patient statistics.

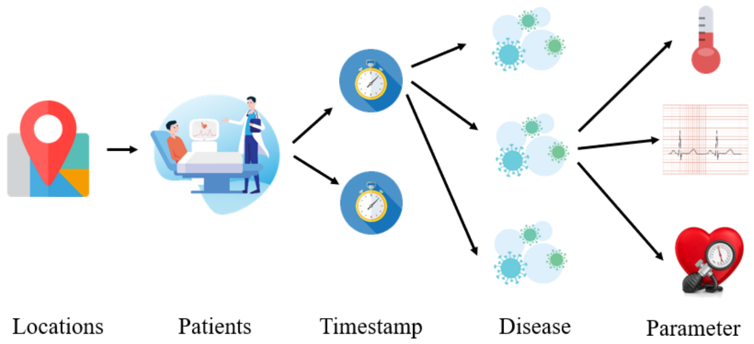

Figure. 2. Depth of telehealth care information tree

Fig. 2 illustrates the possible level of health information availability from individual patient from specific location to multiple patients and disease parameters. Telehealth care ensures the accurate data management to be utilized by multiple authorities.

III. IMPLEMENTATION

Fig 3 illustrates the proposed system workflow where hardware layer responsible for capturing the patient health statistics through body wearable sensor modules like temperature, Blood Pressure, ECG, and Oxygen level. These statistics then transferred to cloud server through physical medium like Wi-Fi or the GPRS module over HTTP web request. Not like traditional remote health monitoring system, proposed system also uploads hardware performance matrix information to manufacturer cloud server for better understanding and the acceptability of the proposed remote health monitoring system. This way also manufacturing company will ensure the utilization and the demand of the system. Upon uploading the data to central cloud server patient information will be bifurcated in different form of data and user base like patient health statistics for treating doctors and patient., dieses related data at regional level for government authorities, and hardware performance level data for manufacturing companies.

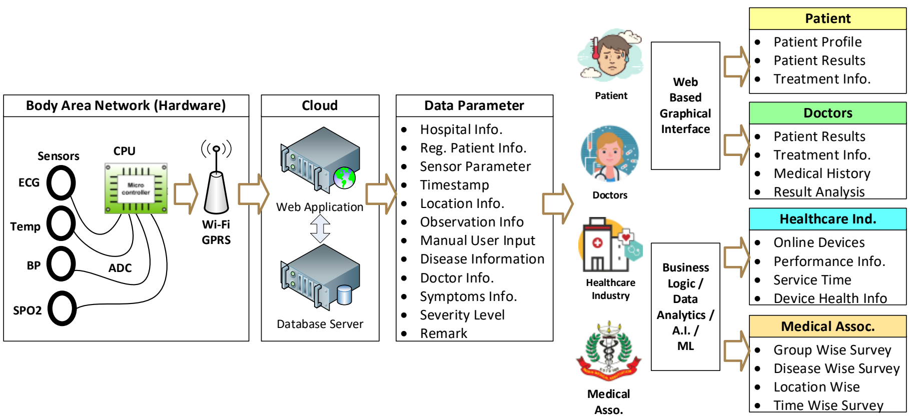

Figure. 3. Proposed system workflow

Proposed model presented in figure 4.0, which clearly shows the portable size and wire connected sensors modules. Central processing unit has display unit, USB wired and Bluetooth wireless communication unit, control unit, and Sensor unit. The system work in four different modes mainly A) Temperature reading, B) Heartbeat and Oxygen reading, C) Blood Pressure reading, and D) ECG reading. User can switch and work in any selected mode at a time and move to next mode on demand. There is no specific sequence of mode working, any mode can be exit and start at any point of time. LCD display to is used to show the current working mode and the sensor input reading of selected mode. Using left side switch user can jump between different modes of operations and using right side switch user can enter in to selected mode or exit the selected mode. Once user select and enter in any mode, system activate and start reading from specific selected sensor. If sensor is not connected to body properly system will show abnormal reading or displays system error message. Central unit can be connected to computer system combined with software to show reading on computer software using USB cable or user can pair hardware with android mobile phone over Bluetooth link and monitor the sensors reading on mobile application. Finally, computer software also provides an option to upload the data to central cloud web service for further data analysis and treatment advice from concern doctors. Every hardware will be an individual node with serial number identity and connected to concern service provide, doctors or the hospital server. A web-based application can then fetch and show the patient information with uploaded timestamp in graphical and reporting format view This gives doctors to monitor the statistics and suggest the further treatment or the medication. (*The scope of this research is more towards hardware designing and development so limited functionality is presented as a proof of concept in software model).*

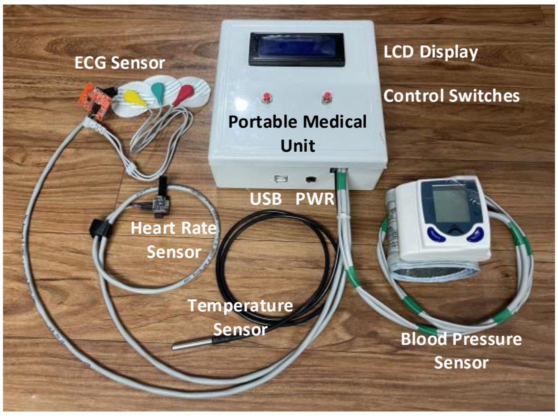

Figure 3.0: Portable hardware model

As presented in figure 4.0 patient is using the different sensor connected to body. All sensors are design and select to be very precise to connect to body without any electrical hazard or the side effects. Patient can connect all sensor at a time or on demand. Temperature sensor, Heartbeat sensor, and Blood pressure sensors can be reuse without any extra supplement multiple time and easy to use, but ECG sensor need to connect to body through single use gel-based electrodes. These electrodes are at low cost subject to purchase in bulk order. Cable size of every sensor are kept with feasible connection length with comfortable seating or sleeping posture. Product design and engineering aspect could make the product more acceptable in real world environment. We successfully tested the working with different modes randomly and on demand.

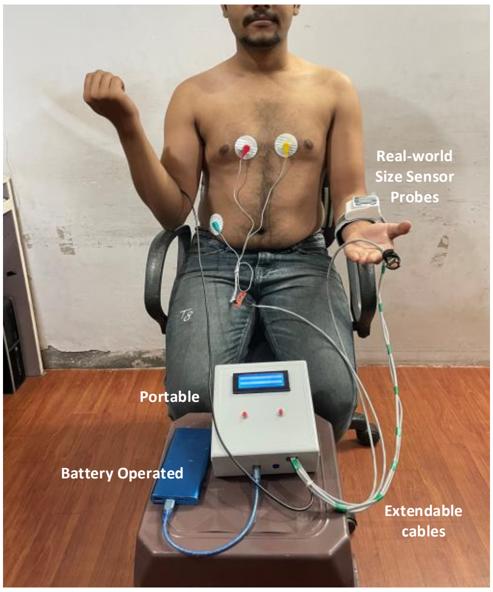

Figure 4.0: Patient live connected and using the proposed system

Computer software will fetch the data from hardware over serial communication using USB cable and display the incoming data in graphical format like labels and graphs. Temperature, Heartbeat, Blood pressure parameters are instant and latest reading is consideration, hence presented in label format and current reading only mode. In case of ECG, the incoming reading has standard flow and patterns hence ECG data is presented in graphical series format. In ECG reading it clearly presented the pattern of ECG signal is formed from incoming reading in a series. This software also allow patient or user to upload the data to central cloud server for further analysis. Software also allow user to select the communication port if connected to different USB port on computer. In future this port selection could be change to automatic hardware detection mode.

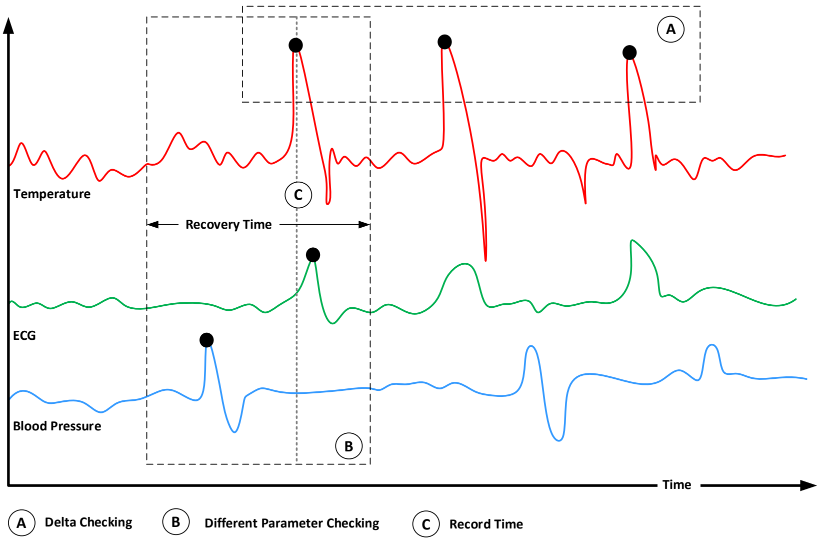

Figure. 4. Comparison of patient data at multiple level

Remote health monitoring system also allow user to compare the patient multiple timestamp statistics in different modes. A). delta checking mode where multiple timestamp data of single parameter will be used to monitor the progress of recovery, B). Multiple health parameters are compared for specific timestamp, and C). Multiple health parameter for comparison for defined or recovery time in multiple intervals. These comparison method will help doctors to accurately understand and study the impact of treatment and progression of recovery.

IV. CONCLUSION

An IoHT-based telehealth care support system can be utilized for feasibility and performance analysis through various methodologies and approaches. Here are some key steps:

Feasibility Assessment: Conduct a thorough analysis of the technical feasibility of implementing the IoHT-based telehealth care system. This involves evaluating factors such as hardware and software requirements, network infrastructure, data security protocols, and compatibility with existing healthcare systems. Assess the economic feasibility by estimating the cost of deploying and maintaining the system, including hardware, software licensing fees, staffing, and training expenses. Compare these costs with the potential benefits and savings generated by the system, such as reduced hospital admissions, improved patient outcomes, and increased efficiency.

Performance Evaluation: Define key performance indicators (KPIs) to measure the effectiveness and efficiency of the telehealth care system. These may include metrics such as system uptime, data transmission speed, response time for patient queries, and accuracy of health data monitoring. Conduct simulated testing or pilot studies to evaluate the performance of the system under different scenarios and conditions. This could involve simulating high patient loads, network congestion, or device failures to assess the system's resilience and scalability. Utilize data analytics techniques to analyze the collected performance data and identify any bottlenecks, inefficiencies, or areas for improvement. This may involve using tools such as predictive modelling, machine learning algorithms, or data visualization techniques to gain insights into system performance.

User Experience Assessment: Gather feedback from patients, healthcare providers, and other stakeholders about their experience with the telehealth care system. This could be done through surveys, interviews, or usability testing sessions to identify user satisfaction, usability issues, and areas for enhancement. Evaluate the accessibility and usability of the system for different user groups, including elderly patients, individuals with disabilities, and healthcare professionals with varying levels of technical expertise. Incorporate user feedback into iterative design and development cycles to continuously improve the usability and user experience of the telehealth care system.

Regulatory Compliance: Ensure that the IoHT-based telehealth care system complies with relevant regulations and standards governing healthcare data privacy, security, and interoperability. This may involve conducting audits, risk assessments, and compliance checks to verify adherence to regulations such as HIPAA (Health Insurance Portability and Accountability Act) and GDPR (General Data Protection Regulation). Engage with regulatory authorities, industry associations, and legal experts to stay updated on evolving regulatory requirements and best practices for telehealth care systems and incorporate these into system design and operations.

By following these steps, stakeholders can effectively assess the feasibility and performance of an IoHT-based telehealth care support system, ensuring its successful implementation and adoption in healthcare settings.

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