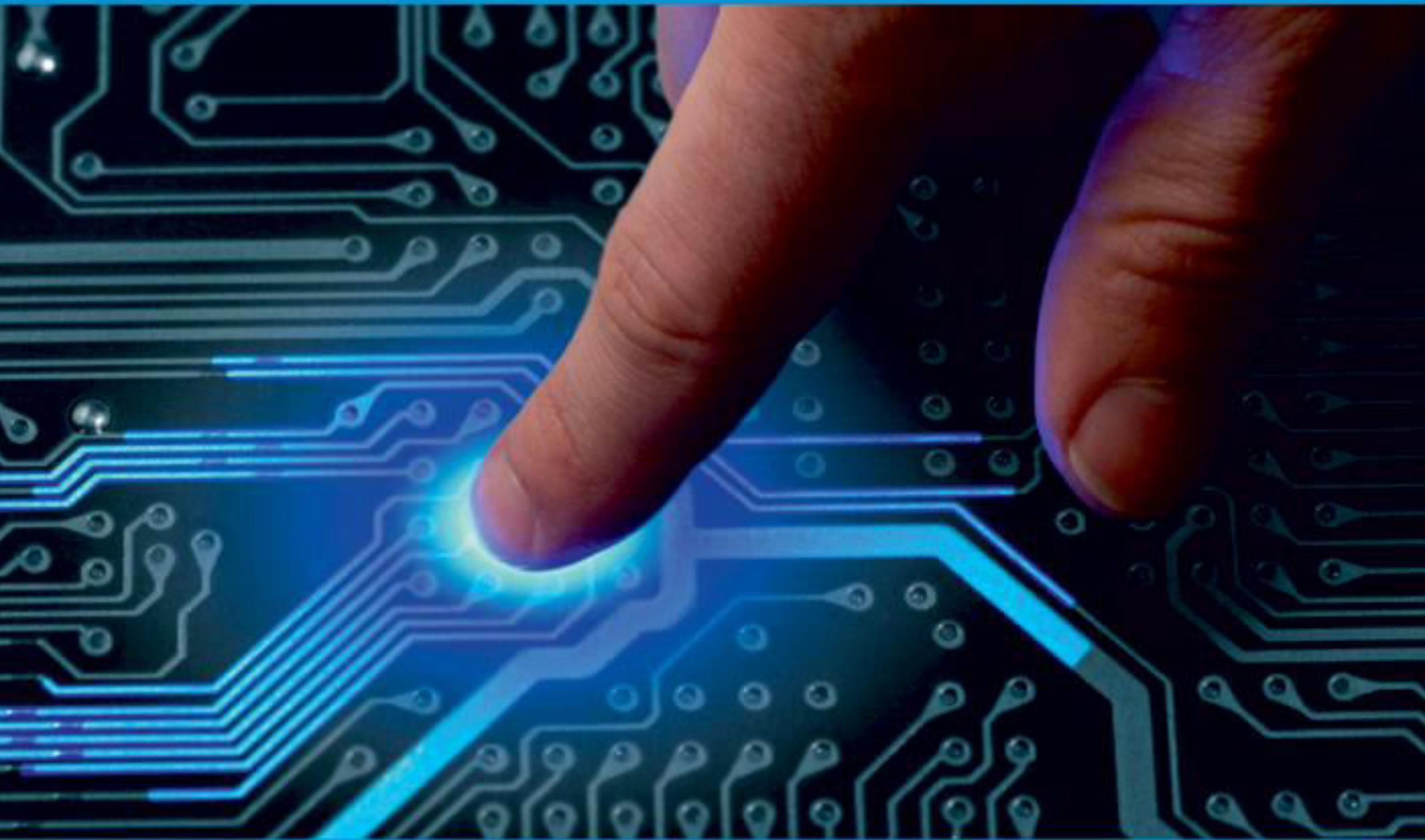
IJIRCCE

e-ISSN: 2320-9801 | p-ISSN: 2320-9798



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN COMPUTER & COMMUNICATION ENGINEERING

Volume 12, Issue 8, August 2024

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 8.625

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.625| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

A Distributed and Scalable System for Remote Patient Monitoring using Cloud Based Architecture

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ABSTRACT: Remote Patient Monitoring (RPM) is the system that revolutionizes the health care system in monitoring patients continuously outside the clinical environment. Present, in this paper, a distributed and scalable RPM system based on cloud architecture, which integrates IoT devices, real-time data processing, and secure cloud storage to monitor critical health parameters such as heart rate (HR), blood pressure (BP), and oxygen saturation (SpO2). A medical center server makes data analysis in hospitals and doctors quite easy, which means they are able to intervene at the right time. The paper proposes a framework with three phases: identification process using DM, the development of a hospital selection model using integrated VIKOR and Analytic Hierarchy Process (AHP) methods, and the validation of the proposed framework, pointing out its possible use in telemedicine applications.

KEYWORDS: Cloud Computing, IOT, RPM, Hospital Management, Medical centre server, Healthcare Services

I. INTRODUCTION

In the Chronic conditions such as hypertension, diabetes, and cardiovascular diseases affected over two-thirds of deaths globally. Increase prevalence and shortage in-patient capacity place the need for care at home; however, most caregivers have greatly improved the quality of life of the patient. Ehealth systems, including telemonitoring of patients with RPM, EHRs, and telemedicine, alleviate these challenges by providing clock monitoring, diagnosis, and treatment. These systems reduce healthcare costs, allow patients to maintain daily activities, and empower them with knowledge about their conditions. In hospitals, PM systems prioritize critical care, improving patient management and overall healthcare efficiency. (Rashidy, 2021, p. 607) [1]

IoT and remote patient monitoring in healthcare: (Lakshmi, 2021, p. 170296) [2]
Reliability: By monitoring patients remotely, the healthcare system works faster and requires less doctor visits.
Seasonable: Weather monitoring systems help caregivers start medical treatment sooner during emergency situations.
Efficacy: Medical devices that detect early signs work better and connected through IoT technology.
Security and Safety: Better monitoring systems and protected network connections maintain both patient protection and safety of their personal health data.
Impact on Healthcare: IoT technology helps healthcare work better by tracking medical conditions with lower expenses.

1.1 Overview

The state-of-the-art architecture shown in Fig 1 and cloud computing technology for the restricted capabilities of IoT devices. Today's IoT technology uses multiple processing levels with edge computing at the device and fog computing for the network edge to store and process data in cloud services. Edge computing processes data in source to decrease latency and use bandwidth less. Researching IoT network security for remote health monitoring is done across multiple domains such as attack detection, security evaluation, performance-aware data protection creation, private data addition and device-level security modeling. It introduces a new ISRP metric that integrates different security performance measures to help choose models best suited for network security needs. (Ashok, 2023, pp. 2621–2651) [3]

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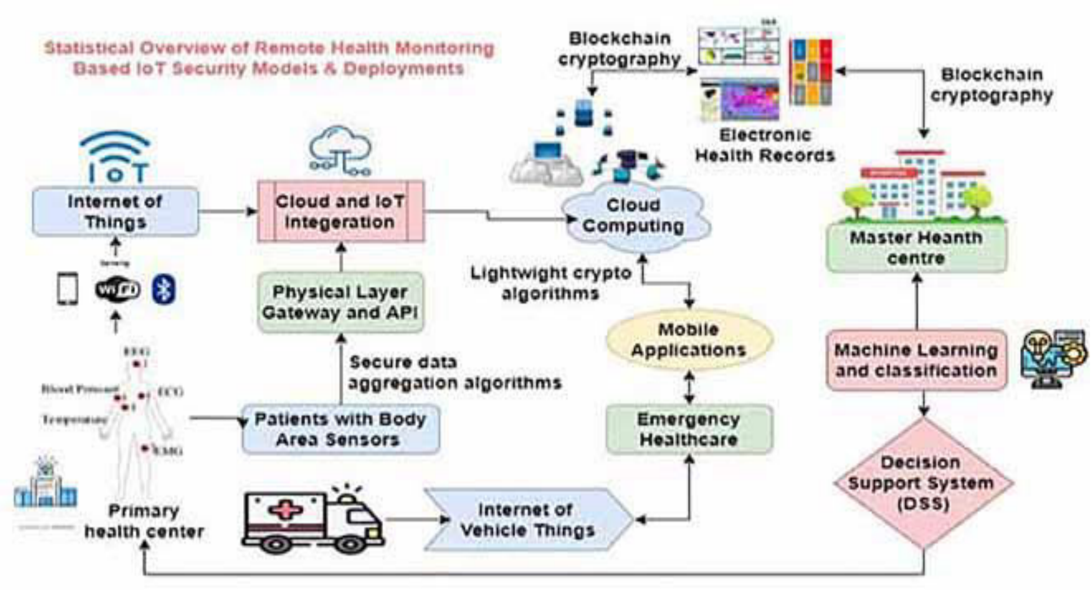

Fig 1. Overview for RPM and IOT Security

1.2 Background

With the increasing adoption of remote patient monitoring (RPM) systems, healthcare has transformed itself into a real-time monitoring process for patients' health data. The AI-powered, distributed healthcare framework uses cloud-based systems to efficiently manage and analyze huge amounts of patient data. These systems are designed to keep track of process, and analyze data in real time while complementing various external data sources like a health monitoring wearable, or home security systems. The approach focuses on data security and resilience and addresses the main challenges around data breaches and system failures. Using AI algorithms, it can detect potential health problems before they arise, allowing for customized care. It makes the entire healthcare experience more positive and more patient-oriented. (Pamulaparthyvenkata, 2024, pp. 2034-2041) [4]

Challenges:

Data Privacy and Security: The system requires powerful encryption methods together with stringent access rules to prevent improper people from accessing the information or initiating breaches.

Real-time Accuracy: Real-time accuracy is a foundational requirement for delivering effective remote health monitoring services**.**

Interoperability: The seamless integration between diverse health monitoring systems and medical devices requires resolving their interoperability challeng**es.**

1.3 Objectives

- To implement cloud computing resources to implement an affordable solution to reduce the cost of healthcare delivery.
- To evaluate the monitoring in real-time patients for vital signs, such as heart rate, blood pressure, oxygen saturation and body temperature.
- To develop an early warning system for predicting potential health problems before they escalate to allow timely medical interventions that improve patient recovery rates.

1.4 Significance

Healthcare monitoring is particularly great importance because it addresses essential aspects of real patient care during the pandemic. The proposed model can measure the blood pressure, room temperature, body temperature, oxygen saturation and heart rate and track the patient's location using various sensors through transmit the data to mobile apps online and offline. The system sends doctors and caregivers an alert notification to identify when a

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patient's medical status becomes life threatening. Our system provides doctors and caregivers easy access to the patient's statistical health metrics. (Bhuiyan, 2022, pp. 91984-91997) [5]

II. LITERATURE REVIEW

IOT-Based Health Monitoring

Medical practitioners increasingly use Internet of Things (IoT) and healthcare systems to collect and interpret patient data. It measures these health parameters in real time for BPM, SpO2 and body temperature. The proposed system solves this issue by achieving 100% accuracy with decision time running at 16.3 seconds and improving overall productivity by 23% (Ebadinezhad, 2024, p. 1349) [6]. This work presents to track diabetes using remote decentralized application features. Current systems have serious limitations to handle decentralized data securely and precise predictions. It uses performance measure their results through accuracy, recall, F1-score, and AUC score. The IoT system improved performance for AdaBoost achieves 92.64% accuracy in diabetes classification. (Ratta, 2024, p. 100338) [7]

In patient monitoring system offers efficient healthcare delivery to patients. PMS enables real-time access to health and vital signs monitoring that including body temperature, heart rate, sleep tracking, falls and blood pressure (Mahmmod, 2024, pp. 132444-132479) [8]. Edge computing and latency detection for smart digital health technology and remote health monitoring systems. Their research focuses on developing edge computing techniques to control latency within IoT-enabled microservice systems. (Alasmary, 2024, p. 1346) [9]

Chronic Disease for Health Monitoring

Remote healthcare systems bring preventive care services to patients who need attention for their health risks or chronic conditions. When medical data gets corrupted it leads to harm patient health. The integration of Fog computing technologies boosted the remote patient monitoring system responsiveness by 40% (Cheikhrouhou, 2023, pp. 1-33) [10]. In the COVID-19 pandemic and monitor vital signs while using NEWS-2 scores for health problems. It still lacks to expand across different healthcare facilities and improve data security for remote monitoring applications (Paganelli, 2021, p. 100399) [11]. On the present study on PHD enables the development of large-scale disease research through data collection and supports health studies in COVID-19 detection. (Bahmani, 2021, p. 5757) [12]

Cloud-Based System for Health Monitoring

This research proposes cloud technology to improve livestock health is monitored. The platform utilizes IoT technology through low-bandwidth signals. The system improves worldwide livestock health monitoring and increases production output (Gordon, 2024, p. 100524) [13]. Cloud-based electronic health records (EHRs) allow remote monitoring of patients. There are challenges in protecting sensitive and personal information about patients from hackers. However, these traditional solutions could not attain the trade-off between the requirements of EHR security solutions and computing efficiency (Mahajan, 2023, pp. 2329–2342) [14]. This paper presents a digital twin framework based on cloud computing for structural health monitoring to achieve efficient real-time monitoring. It is demonstrated for damage detection achieved at higher accuracy of 92%. (Dang, 2022, pp. 3820-3830) [15]

III. REMOTE PATIENT MONITORING USING CLOUD BASED ARCHITECTURE

This section discusses the methodology for understanding the concept of Distributed and Scalable System for Remote Patient Monitoring using Cloud Based Architecture. The subsections are as follows:

3.1 Application of remote patient monitoring systems

Remote Patient Monitoring (RPM) transform healthcare delivery by allowing better and quicker patient treatment. The following subsections elaborate on various RPM applications:

3.1.1 Chronic Disease Management

RPM technology is essential for helping patients manage long-term health conditions including diabetes, high blood pressure and heart problems. RPM devices and IoT monitors track medical data including blood glucose values and heart rate along with blood pressure and body temperature measurements. Early action plans save medical resources and deliver better patient care.

© 2024 IJIRCCE | Volume 12, Issue 8, August 2024| DOI: 10.15680/IJIRCCE.2024.1208067

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.625| ESTD Year: 2013|

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3.1.2 Post-Operative and Rehabilitation Care

Patients need ongoing assessment during recovery and rehabilitation steps to prevent problems and promote healing. Healthcare tracking systems to detect heart rate conditions in ECG monitors and wound healing from smart bandages. In post-operative care, use smart bandages that include sensors that track for wound heals.

3.1.3 Elderly and Assisted Living Care

Wearable devices for monitoring purposes sense your vital signs (blood pressure, oxygen levels, heart rate, temperature) and send them automatically to healthcare providers. RPM systems help patients stay healthy by recognizing warning signs of medical problems at their earliest stages.

3.1.4 Infectious Disease Management

Remote Patient Monitoring demonstrated its importance during the COVID-19 outbreak, utilized healthcare teams care for patients with infectious diseases. In COVID-19 suspect wears a pulse oximeter it sends real-time data about their oxygen levels (spo2) to medical professionals for assessment.

3.1.5 Rural and Remote Healthcare

Healthcare facilities in rural regions because medical facilities and limited medical personnel. Health care through mobile apps (mHealth) connects with cloud services to help rural communities get proper health diagnosis and disease prevention.

3.2 Remote Patient Monitoring Based on Architecture

Modern healthcare depends on Remote Patient Monitoring systems to supervise patient's health performance while staying at remote locations. This architecture typically consists of three main layers: The Sensor Layer at Tier 1, the Gateway Layer at Tier 2, and the Medical Center Server at Tier 3 and shown in Fig 2.

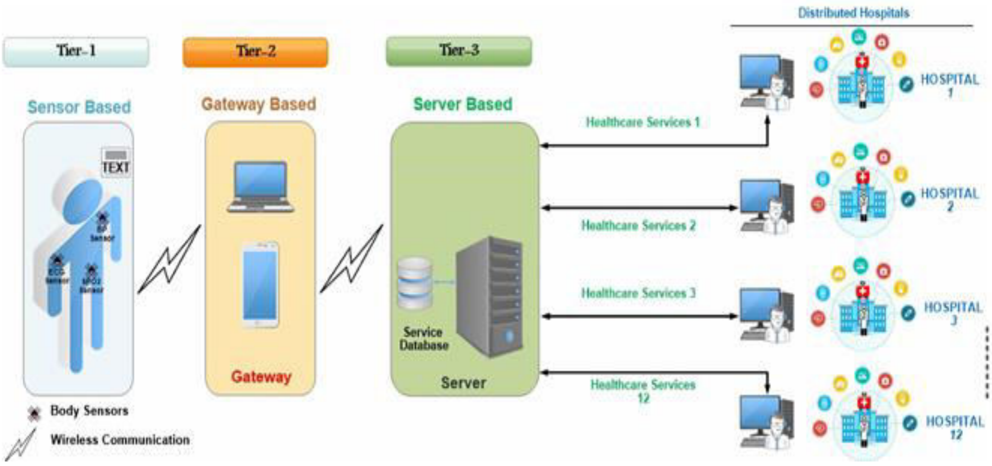

Fig 2. RHMS Architecture

1. Sensor Layer (Tier 1)

The foundation layer in RPM technology exists in the sensor layer. The system gathers essential health information through medical devices and sensors. These are wearable, implantable, and portable devices and are primarily used to measure critical data such as:

- **Electrocardiogram (ECG):** Utilizing heart electrical signals measuring through healthcare practitioners identify cardiovascular problems.
- **Blood Pressure (BP):** It demonstrates the blood pressure readings so that high or low problems of blood pressure can be identified.
- **Blood Oxygen Saturation (SpO_2):** Pulse oximeters detect blood oxygen levels to show body's breathing system works.

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• **Temperature, Motion, and Other Physiological Data:** Sensors are the basic health measures detect temperature changes, movement patterns, and blood sugar levels in the patient.

2. Gateway Layer (Tier 2)
The gateway layer connects medical sensor data between devices and the main medical center server. The gateway receives input from multiple sensors and pre-processes the data for complete analysis. Key features of this layer include:
• **Data Aggregation:** The system receives information from all patient sensors and verifies complete data transmission.
• **Real-Time Communication**: The gateway uses different wireless data transfer methods including Wi-Fi, Bluetooth or mobile signals to move information fast.
• **Pre-Processing:** To save bandwidth and lower server gateways prepare the data before they send it to their destinations.
• **User Interface:** The system combines the gateway with easy-to-use apps (m-health) that display health readings on user's portable screens.

3. Medical Center Server (Tier 3)
The medical center server required medical servers to store and process all patient data gathered through RPM. This centralized server performs several critical functions:
• **Real-Time Monitoring:** Healthcare providers receive accurate patient updates and respond faster.
• **Decision Support Systems (DSS):** Our medical team uses advanced analysis systems to examine healthcare data and find meaningful patterns to enhance patient care planning.
• **Integration with Healthcare Systems:** The system interfaces directly with both electronic health records to connect healthcare providers across multiple networks.
• **Telemedicine Support:** The server enables remote healthcare functions through its support for video consultations and diagnostic procedures which lead to treatment solutions.

3.2.1 Methodology
Phase 1: Identification
In the early stages of developing an RPM system for the identification phase sets out essential healthcare standards and selects hospitals for further development. This phase includes key subsections:

Healthcare Services Identification: This phase helps to determine which health metrics such as ECG, BP and SpO_2 need to be tracked while specifying monitoring needs to be live or for chronic disease management. A Decision Matrix (DM) evaluates services using weighted criteria: It plan ranks services using results from evaluating three aspects: feasibility(F), relevance (R) and impact(I).

$$P= w_F.F\ w_R.R\ w_I.I$$

Hospital Selection and Service Matching: Hospitals are evaluated using VIKOR-AHP to compare hospital services (H_i). Hospitals (H_i). receive their rankings through testing different criteria. (C_n)

$$S_i= W_1.\,C_1 + W_2.\,C_2 + \ldots.. + W_n.\,C_n$$

Phase 2: Development
The problem involves hospitals with different services need to be ranked using a system and add different amounts of weight to specific factors. AHP determines weights based on how much each criterion helps make decisions while VIKOR ranks hospitals based on their measured data. Using AHP-VIKOR algorithm helps healthcare professionals make better hospital selection choices.
Several AHP procedures determine the correct weights for multiple service evaluation criteria.
Step 1: Defining the problem's criteria in the model and initiate the AHP process.
Step 2: Determine pairwise matrix connections.
Step 3: To compare value of all features in evaluation is delivered to heart disease
Step 4: It normalized through dividing column-level elements by the total column value to form a ranked results matrix.

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Phase 3: Validation

According to statistical methods, rank potential hospitals for selection follows specific guidelines. In hospital data provides numerical results represented as the mean value and standard deviation for each hospital. It can be defined as the average or mean (x) and can be computed as the summation of all observed outcomes from the sample divided by the total number as indicated by the following equation: $\bar{x}\text{-}\frac{1}{N}\sum_{i-1}^{n} x_i$

A measure that represents the amount of variation or dispersion in a set of data values can be defined by standard deviation as presented in the following equation:

$$s - \sqrt{\frac{1}{N-1}\sum_{i-1}^{n}(x_i\text{-}\bar{x})(x_i - \bar{x})^2}$$

The scope of this research is to rank hospitals individually for 500 patients. The final value of the validation process for ranking hospitals represented in Equation:

$$Fv = \frac{(Sum(x)*100)}{500}$$

where Sum(x) is the summation of valid process, fv is the final validation and 500 is the number of patients.

IV. DISCUSSIONS

This section will provide the analysis of the methodology and performance evaluation of the data mining and cloud base based techniques for improving the RPM process.

1. **Data Mining Techniques in RPM:** RPM uses data mining methods including classification, clustering, and regression to help patients' health data. Various classification tools like K-star, Random Forest and Support Vector Machines prove they can accurately identify health conditions. K-star shows 95% accuracy with 94.5% precise decision-making and 93.5% accurate diagnosis results on various medical datasets. (Akhbarifar, 2023, pp. 697-713) [16]
2. **Cloud-Based Architecture and Scalability:** RPM operates through three cloud-based components: Sensor Layer, Gateway Layer, and Medical Center Server. This system structure makes it possible to track patient health information in real time across healthcare organizations. The Gateway Layer decreases data volume transmission while the Medical Center Server connects health data smoothly with medical applications.
3. **Performance Evaluation and Cross-Validation:** Performing 10-fold cross-validation strengthens RPM systems by giving us better ways to test model performance. Our tests demonstrate that K-star produces better performance than RF and MLP networks which indicates that our system works well in practical healthcare scenarios. (Akhbarifar, 2023, pp. 697-713) [16]
4. **Real-Time Monitoring and Alerts:** RPM continuously monitors patient vital signs including heart rate and oxygen levels then sends data updates from the patient device to the central server every 30 seconds. The system sends immediate information to medical staff so they can respond quickly to protect patients. (Majeed, 2021, pp. 1640-1647) [17]
5. **Measurement Accuracy and Reliability:** RPM shows accurate and dependable performance in simulation outcomes with measurements of RMSE 1.44 and MAE 1.12 which remain consistent with clinical industry standards. The Bland-Altman plots match performance results with standard medical devices showing our product can work in medical situations. (Siam, 2021, p. 8016525) [18]

In data mining and cloud-based techniques collectively improve the RPM process. These advances pave the way for improved healthcare and better patient outcomes.

Pseudocode: Remote Health Monitoring

Algorithm: Distributed monitoring and prediction of health data
Input: Patient IoT data (vital signs, sensor readings), medical history.
Output: Early diagnosis and notifications for critical conditions.

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Begin
Step 1: Initialize and collect real-time medical data from patients
Step 2: Data Acquistion
- In real-time input from IoT-based devices such as heart rate, blood pressure, respiratory rate, oxygen saturation
- Historic patient data available from cloud-based storage
Step 3: Data Preprocessing
- Normalization and cleaning data for anomalies due to missing values.
Step 4: Disease Prediction
-Input preprocessed data into distributed classification models
-Classify the patient's health status into categories
-Normal, Hypercholesterolemia (HCLS), Hypertension (HTN), Heart Disease (HD), Blood Pressure (BP), and Oxygen Saturation (SpO2).
Step 5: Alert Generation
- If critical condition is detected
-Notify healthcare providers and emergency services in real time.
- Patient’s medical reports to validate
Step 6: Patient Feedback
-Diagnosing results to patients through secure application or emails.
-Patient data should also be constantly scanned for updates and monitor their health track in real time.
End

4.1 Implications
• **Improved Healthcare Delivery:** In medical teams track patients in real time and take data-based decisions.
• **Personalized Treatment Plans:** Patient data to recommend customized treatments for long-term conditions plus sudden health problems. (Boloban, 2024, pp. 23-29) [20]
• **Cost-Effective Care:** It save costs for lowering patient face-to-face contact and using automatic tools. (Haque, 2024, pp. 48-65) [19]
• **Telemedicine Innovation:** In medical care reach by patients with doctors through video calls and perform diagnostic results.

4.2 Benefits
• **Real-Time Monitoring:** It helps medical teams reach patients.
• **High Accuracy:** Special algorithms help doctors make more accurate medical diagnoses.
• **Interoperability:** Connects EHR systems to maintain patient medical records.
• **Scalability:** The system easily adjusts to serve patients better in upcoming healthcare changes.

4.3 Applications
• **Chronic Disease Management:** The device monitors ECG rates along with measuring SpO_2 levels and blood pressure.
• **Telemedicine Services:** The system brings medical help for community through online consultations.
• **Emergency Alerts:** It delivers alerts for essential medical alterations.
• **Healthcare Analytics:** In clinical outcomes perform predictive modeling.

V. CONCLUSION AND FUTURE WORK

The proposed distributed and scalable Remote Patient Monitoring (RPM) system effectively leverages IoT devices and cloud-based architecture for real-time monitoring of vital parameters such as SpO2 and heart rate. With integrated advanced analytics and machine learning, the system ensures early detection of abnormalities, enables timely medical interventions and improves patient outcomes. The secure design protects sensitive medical data while improving healthcare delivery, reducing hospital readmissions and reducing costs. In future enhancement for the integration of AI-driven predictive analytics with edge computing to further reduce response times and improve system efficiency. In addition, the scope of clinical trials and the use of personalized healthcare models could help enhance diagnostic

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accuracy and provide an overall and flexible approach to remote patient care in any healthcare scenario.

REFERENCES

[1] E-Rashidy, N., El-Sappagh, S., Islam, S. M. R., M. El-Bakry, H., & Abdelrazek, S. (2021). Mobile Health in Remote Patient Monitoring for Chronic Diseases: Principles, Trends, and Challenges. Diagnostics, 11(4), 607. https://doi.org/10.3390/
diagnostics11040607
[2] Lakshmi, G., Ghonge, M., & Obaid, A. (2021). Cloud based IoT Smart Healthcare System for Remote Patient Monitoring. EAI Endorsed Transactions on Pervasive Health and Technology, 170296. https://doi.org/10.4108/eai.15-7-2021.170296
[3] Ashok, K., & Gopikrishnan, S. (2023). Statistical Analysis of Remote Health Monitoring Based IoT Security Models & Deployments from a Pragmatic Perspective. IEEE Access, 11, 2621–2651. https://doi.org/10.1109/access.2023.3234632
[4] Pamulaparthyvenkata, Saigurudatta & Murugesan, Prakash & Gottipalli, Dinesh & Preethi, P. (2024). AI-Enabled Distributed Healthcare Framework for Secure and Resilient Remote Patient Monitoring. 2034-2041. 10.1109/ICOSEC61587.2024.10722492.
[5] M. N. Bhuiyan (2022)"Design and Implementation of a Feasible Model for the IoT Based Ubiquitous Healthcare Monitoring System for Rural and Urban Areas," in IEEE Access, vol. 10, pp. 91984-91997 doi: 10.1109/ACCESS.2022.3202551.
[6] Ebadinezhad, S.; Mobolade, T.E. (2024) A Novel Cloud-Based IoT Framework for Secure Health Monitoring. Sustainability 16, 1349. https://doi.org/10.3390/su16031349
[7] Ratta, Pranav & Abdullah, & Sharma, Sparsh. (2024). A Blockchain-Machine Learning Ecosystem for IoT-Based Remote Health Monitoring of Diabetic Patients. Healthcare Analytics. 5. 100338. 10.1016/j.health.2024.100338.
[8] B. M. Mahmmod et al., (2024). "Patient Monitoring System Based on Internet of Things: A Review and Related Challenges with Open Research Issues," in IEEE Access, vol. 12, pp. 132444-132479, doi: 10.1109/ACCESS.2024.3455900.
[9] Alasmary, H. (2024) ScalableDigitalHealth (SDH): An IoT-Based Scalable Framework for Remote Patient Monitoring. Sensors, 24, 1346. https://doi.org/10.3390/s24041346
[10] Cheikhrouhou, Omar & Mershad, Khaleel & Jamil, Faisal & Mahmud, Md & Koubaa, Anis & Rahimi Moosavi, Sanaz. (2023). A Lightweight Blockchain and Fog-enabled Secure Remote Patient Monitoring System. 10.48550/arXiv.2301.03551.
[11] Paganelli, A. I., Velmovitsky, P. E., Miranda, P., Branco, A., Alencar, P., Cowan, D., Endler, M., & Morita, P. P. (2021). A conceptual IoT-based early-warning architecture for remote monitoring of COVID-19 patients in wards and at home. Internet of Things, 100399. https://doi.org/10.1016/j.iot.2021.100399
[12] Bahmani, A., Alavi, A., Buergel, T. et al. (2021). A scalable, secure, and interoperable platform for deep data-driven health management. Nat Commun 12, 5757 https://doi.org/10.1038/s41467-021-26040-1
[13] Gordon, Miriam & Bhaskaran, Harini & Neethirajan, Suresh. (2024). Development of a Cloud-Based IoT System for Livestock Health Monitoring Using AWS and Python. Smart Agricultural Technology. 9. 10.1016/j.atech.2024.100524.
[14] Mahajan, H.B., Rashid, A.S., Junnarkar, A.A. et al. (2023). RETRACTED ARTICLE: Integration of Healthcare 4.0 and blockchain into secure cloud-based electronic health records systems. Appl Nanosci 13, 2329–2342. https://doi.org/10.1007/s13204-021-02164-0
[15] H. V. Dang, M. Tatipamula and H. X. Nguyen (2022). "Cloud-Based Digital Twinning for Structural Health Monitoring Using Deep Learning," in IEEE Transactions on Industrial Informatics, vol. 18, no. 6, pp. 3820-3830, doi: 10.1109/TII.2021.3115119.
[16] Akhbarifar, S., Javadi, H.H.S., Rahmani, A.M. (2023). RETRACTED ARTICLE: A secure remote health monitoring model for early disease diagnosis in cloud-based IoT environment. Pers Ubiquit Comput **27**, 697–713 https://doi.org/10.1007/s00779-020-01475-3
[17] J. H. Majeed and Q. Aish (2021) "A remote patient monitoring based on WBAN implementation with internet of thing and cloud server," Bulletin of Electrical Engineering and Informatics, vol. 10, no. 3, pp. 1640–1647, doi: 10.11591/eei. v10i3.1813.
[18] Siam. (2021) "Secure health monitoring communication systems based on IoT and cloud computing for medical emergency applications," Computational Intelligence and Neuroscience, vol no. 1, doi: 10.1155/2021/8016525.

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[19] K. N. Haque, J. Islam, I. Ahmad, and E. Harjula (2024) "Decentralized Pub/Sub Architecture for Real-Time Remote Patient Monitoring: A Feasibility Study," in Communications in computer and information science, pp. 48–65. doi: 10.1007/978-3-031-59080-1_4.

[20] O. Boloban, I. Pysmennyi, R. Kyslyi, and B. Kyriusha (2024) "Development of a patient health monitoring system based on a service-oriented architecture using artificial intelligence," Technology Audit and Production Reserves, vol. 3, no. 2(77), pp. 23–29, doi: 10.15587/2706-5448.2024.306622.

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