**A CLOUD-BASED SMART IOT PLATFORM FOR PERSONALIZED HEALTHCARE DATA GATHERING AND MONITORING SYSTEM**

**1Sai Srinivas Vellela**

Asst. Professor,

Dept. of CSE-Data Science,

Chalapathi Institute of Technology,

Guntur, AP, India

sais1916@gmail.com

**2Vuyyuru Lakshma Reddy**

Asst. Professor, Dept. of CSE,

KoneruLakshmaiah Education Foundation,

Vaddeswaram, AP, India

lakshmareddy@kluniversity.in

**3Roja D**

Asst. Professor,

Dept. of CSE-Data Science,

Chalapathi Institute of Technology,

Guntur, AP, India.

bvreddymtech@gmail.com

**4G RamachandraRao**

Asst. Professor, Dept. of CSE,

Chalapathi Institute of Technology,

Guntur, AP, India

grrsoft30@gmail.com

**5Khader Basha Sk**

Asst. Professor,

Dept. of CSE-Data Science,

Chalapathi Institute of Technology,

Guntur, AP, India

khaderbasha576@gmail.com

**6K Kiran Kumar**

Professor, Dept. of CSE,

Chalapathi Institute of Technology,

Guntur, AP, India

kommineni.kiran11@gmail.com

**ABSTRACT: Several technological and informational technologies are currently developing quickly and profoundly altering our contemporary way of life. The Internet of Things (IoT) has become one of the most well-known and frequently discussed technologies out of all those now in use. Researchers, doctors, and patients are facing a wide range of new opportunities and difficulties as a result of the development of numerous new technologies. Yet, it is becoming increasingly challenging to manage and process the massive amounts of data they produce on local systems. Cloud computing's scalability offers a practical solution to this issue. The goal of this study is to present a cloud-based, intelligent IoT platform for a customized healthcare data gathering and monitoring system. This platform intends to advance healthcare services and improve remote patient monitoring. The system may collect data from various sources, combine it with a flexible semantic web, store it in the cloud for future analysis, and show it in an intuitive manner. It is crucial to prioritize privacy issues while developing a healthcare monitoring system that manages Electronic Medical Records (EMRs). The recommended remedy effectively protects privacy while utilizing standard IoT characteristics.**

**KEYWORDS: healthcare, IoT: Cloud computing, remote health monitoring, Smart IoT platform.**

**I. INTRODUCTION**

Many online services are now available thanks to the rapid development of modern networking and digital processing technology. These services use the Internet of Things (IoT) as a conduit to connect people, objects, and processes. This guarantees the usefulness and comfort of IoT in daily social interactions. [1].

Researchers have switched from centralized to decentralized contexts as a result of the emergence of these technology-based internet services. As a result, the

fields of smart homes, smart wearables, smart cities, smart mobility, and healthcare are growing rapidly [2].Because smart devices produce enormous volumes of data, the current internet technologies have transformed into data technologies to support their development.The Internet of Things (IoT) is a multidisciplinary approach that involves networking and connecting many of the objects in our surroundings to the Internet.Increasing effectiveness and providing new services are the goals.

These products, which require a distinct and clear identification, may encompass a variety of gadgets utilized in numerous fields [3]. IoT enables these objects/devices to connect intelligently, allowing them to detect, communicate, and exchange information whenever they want, with anyone and anything, ideally using any network or path.

Wireless Body Area Networks (WBANs) are expected to revolutionize the healthcare, real-time body monitoring industries, essential for providing remote and in-hospital health monitoring [4]. However, WBAN technology alone is insufficient to help healthcare stakeholders reach their ultimate objective. To increase the effectiveness of the health monitoring system, cutting-edge technologies like the Internet of Things (IoT) and cloud computing are required [5]. A typical WBAN is made up of several sensors that are implanted inside or on the patient's body, as well as IoT sensors that pick up on contextual or ambient data.

In the domain of medicine and healthcare, gadgets can include cutting-edge activity quantifiers, sleep levels, blood pressure, and heart rate monitors, as well as ones that are advanced and can monitor things on specialist implants like under-skin glucose monitors or wearable Dopplers [6]. The adoption of this new Cloud IoT paradigm presents numerous opportunities in the healthcare sector to improve healthcare outcomes while reducing costs. The scalability offered by cloud computing can help to solve the problem of storing and interpreting the enormous volumes of data generated by sensors andIoT devices. The available options, however, typically cater to certain usage cases.

Healthcare applications have significant interest from various researchers. These applications typically utilize radio-frequency-dependent networking and various functionalities. The actuators and nodes around the human body that are inter-connected to gather data. This data produced by the actuators and sensors is collected and used by medical consultants and physicians. Pharmaceutical and medical researchers require patient data for investigational purposes. Recent advancements in cloud technologies have improved the abilities of services of e-healthcare. Yet, collecting and keeping Electronic Medical Records (EMRs), which are sensitive health records from the cloud requires strict privacy considerations, particularly for patients' identities.

A data detection method, a data organization module, and a data transmission module has three primary parts of the remote health monitoring system. The module for data detection is one of the parts which uses a heart rate sensor to detect changes in physiological parameters [7]. This data is then transmitted to the data processing module's microcontroller where it is processed and prepared for transmission over the internet to a cloud server. The cloud server stores the data and can send it to various locations and systems. A smartphone-based system can also be designed for analyzing health data and monitoring a patient's physical condition. The Smart IoT platform described in this paper is cloud-based and aims to provide a comprehensive solution for the data monitoring, gathering, analysis, and activation of sensors and Internet of Things devices.

The article is set up as follows: We evaluate pertinent material and give our main conclusions in Part II. The proposed platform is then introduced in Section III, while Section IV describes the experimentation and evaluation of the platform prototype. This paper's conclusion includes a summary of our findings in Section V.

**II. LITERATURE SURVEY**

By providing emergency detection and notification with life-saving effects, wearable sensors and cellphones, according to Satija U., Ramkumar B., Manikandan M. S., et al. [8], have the potential to revolutionise health monitoring, especially in distant regions with restricted bandwidth. The authors stress that it can be difficult to teach medical staff to give priority to patients who physically arrive at emergency rooms, especially when those patients originate from various places.As a feasible solution, telemedicine can be used to remotely monitor patients' essential signs and prioritize patients' care before they are transported to hospitals.

Corno F., De Russis L., and Roffarello, et. al. [9] developed a healthcare system by using IoT technology for supporting caregivers in Assisted Living Facilities. The system is designed to alert caregivers in case of hazardous situations, such as falls or epileptic seizures which may occur to inhabitants with physical or cognitive disabilities.

A system named SAHHc (Smart Architecture for In-Home Healthcare), developed by Mano L. Y., Faic al B. S., Nakamura L. H., Gomes P. H., Libralon G. L., Meneguete R. I., Geraldo Filho P., Giancristofao G. T., Pessin G., Krishnamachari B. et al. [10], uses visuals and feelings to help healthcare in environments such as smart home, using an IoT infrastructure. The system integrates wearable sensors such as smartwatches and clothing items to collect physiological data and transmit it to the Decision Maker, which can take appropriate actions. The work, The "ECG Android App" is an Android platform developed by Mohammed J., Lung C.-H., Ocneanu A., Thakral A., Jones C., and Adler A., et al. [11] that uses the Internet of Things (IoT) and cloud computing in the healthcare industry. The app allows users to view their ElectroCardioGram (ECG) waves and logs the data in the background.

An IoT-based management platform for smart environments was proposed in the paper by Moreno, Santa, Zamora, and Skarmeta [12]. The authors acknowledged the spread of smart devices and sensors as well as the heterogeneity of the data they provide. Their platform was designed to overcome problems with interoperability in the collecting, processing, and management of IoT data. Despite the fact that their concepts are comparable to ours, although, they focused on comfort and energy efficiency in smart buildings rather than cloud-based solutions for data processing.

A cloud-based m-Health monitoring system dubbed Cloud-MHMS, which is intended for pervasive health monitoring, was proposed by XuBoyi, XuLida, CaiHongming, Jiang Lihong, et al. [13]. The system is made up of three basic modules: service composition, data analysis, and storage of data. The data analysis module uses domain knowledge to evaluate the health aspects of the monitored people. whereas, In data storage, monitoring data is kept in numerous tenant spaces. A technique for service composition is also created to dynamically distribute and assign public healthcare resources. The authors demonstrated the applicability of their framework in elderly homes and show the usability of the method.

Khyamling A. Parane, Naveenkumar C. Patil, Shivananda R. Poojara, Tejaskumar S. Kamble, et al. [14] introduce the Cloud based Intelligent Healthcare Monitoring System (CIHMS), which can offer the patient medical feedback or support through the cloud (if data is already available) or hospital. A cloud-based healthcare system consists of a computing device and a number of sensors placed on the body of the patient. To gather sufficient information about the patient's condition, the appropriate sensor(s) must be employed. Gubbi J., Buyya R., Marusic S., Palaniswami M., et al. [15], described that an IoT system should be composed of three primary parts: end users, middleware, and hardware. As sensors are hardware, they allow the cloud to act as middleware , provide computing and also storage services. The end user(s), who make up the third component, are those who will be interested in data gathered from the Hardware component and processed by the middleware.

**III. PERSONALIZED HEALTHCARE SMART IOT CLOUD-BASED PLATFORM**

The architecture of the cloud-based smart IoT platform for data gathering and monitoring system for personalized healthcare is shown in Fig. 1 below.

Users (Doctors/ Patients)

Mobile/Desktop multi-platform API

Personalized user interface

Multi functional services

Visualization

Control panel

Load balancer

Data Interoperability

Generic cloud interface

Gateway connection

IoT device

EHR, Medical DB

**Fig. 1: ARCHITECTURE OF CLOUD-BASED SMART IOT PLATFORM**

Efficient management is crucial for the input and querying of sensor data on a Cloud platform. Database technologies play a crucial role in this process. While existing

Solutions focus solely on IoT devices, the platform controls two categories of data sources: 1) Internet of Things (IoT) devices, such as pulse oxygen metres, ECGs, and blood pressure controllers used by patients for healthcare monitoring 2) Additional sources, including as electronic health records and databases related to health information system used by various healthcare providers. As a gateway, the Network layer enables the flow of data from numerous data sources to the following layer (Data processing layer). IoT devices and sensors use wireless communication protocols including Zigbee, Bluetooth, Wifi, and LTE (Long Term Evolution) to transmit data.

The general interface of the cloud platform acts as a bridge between applications, middleware, and sensor servers. Several time-series and alphanumeric data formats coming from sensors and IoT devices are supported. Moreover, it has a user-friendly interface. Raw data originating from various information sources, specifically data produced by sensors and devices, cannot sense and fail to provide any valuable information unless effectively processed. To enable interoperability among diverse Cloud environments, platform-neutral data interchange formats are utilized. The three core elements of the generic Cloud interface are security, data exchange standard, and communication mechanism, which are crucial for its core functionalities and necessitate further elaboration.

The Data Interoperability module's objective is to ensure that our platform's many data sources interact with one another in a seamless manner. It is made up of four major parts: the data collecting component, Data classification component, Semantic Annotation component, and Data integration component.

The platform's controller is a web based application powered by the Spring web framework and the Thymeleaf HTML (HyperTextMarkup Language) template engine. It permits the management of sensors, IoT devices, triggers, and actuators, as well as the load balancer configuration. Additionally, the control panel includes visualization capabilities, enabling the display of historical data readings and analyzed information.

The Application layer offers connectivity, enables users to access various features and services available on the platform. This layer comprises a Desktop/Mobile application that is compatible with different platforms and a web-based application. The user interface of these applications permits users to interact with the platform which is personalized, intuitive, unified, adaptive, and contextual. Apart from collecting and integrating patients' health information from various sources, the user can benefit from several other services by connecting to our platform.

The system facilitates communication between patients and healthcare providers about their health status, treatment efficacy, side effects, etc. Physicians can also interact with patients, view their real-time health information, and communicate with their family in emergencies or when the patient is unable to communicate, in the case of children, unconscious people, or those who have communication difficulties.

**IV. RESULT ANALYSIS**

Cloud-based Smart IoT platform was created and developed based on the needs of patients, healthcare professionals, and healthcare providers. Throughput, Cloud Request View Ratio (CRVR), Security and Privacy are parameters used for the performance analysis of described Cloud-based Smart IoT platform.

Throughput is a measure of the amount of EHR data that can be transmitted and received within a specific time frame. It is the average rate at which messages are successfully delivered to their intended destination which is measured in bits per second (bps) or data packets per second. System throughput is calculated by taking an average, providing an accurate representation of overall system performance. A low throughput may indicate a packet loss issue, and is often a mean for network and system administrators.

The Cloud Request View Ratio (CRVR) has been evaluated for Rivest-Shamir-Adleman (RSA)  andDSA (Digital Signature Algorithm) algorithms, and it was found that other algorithms have a view of all unnecessary requests, resulting in a lower CRVR for this model. This study highlights the importance of utilizing cloud consensus, as this model handles the accessibility view of EMR and achieves a lower CRVR which is beneficial for privacy concerns.

The comparative analysis of described model of the Cloud-based Smart IoT platform and normal IoT platform in terms of throughput and CRVR is represented below in Table 1. Figure 2 and Figure 3 are the graphical representation of the comparative analysis.

**Table 1: COMPARATIVE PERFORMANCE ANALYSIS**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Number of EHR** | **Cloud-based Smart IoT platform** | | **Normal IoT platform** | |
| **Throughput** | **CRVR** | **Throughput** | **CRVR** |
| 100 | 45 | 62 | 21 | 89 |
| 200 | 48 | 68 | 29 | 84 |
| 300 | 52 | 67 | 34 | 90 |
| 400 | 57 | 70 | 40 | 95 |
| 500 | 65 | 72 | 42 | 93 |

**Fig. 2: COMPARATIVE ANALYSIS OF THROUGHPUT**

Security and Privacy are two main parameters of designed Cloud-based Smart IoT platform for personalized healthcare Data Gathering and Monitoring System. Results of the Comparative analysis that both Security and Privacy parameters are high compared to the Normal IoT platform which is represented in below Fig. 4.

**Fig. 3: COMPARATIVE ANALYSIS OF ‘CRVR’**

**Fig. 4: COMPARATIVE ANALYSIS IN TERMS OF SECURITY AND PRIVACY**

From results it is clear that high throughput, high security, high privacy and low CRVR parameters are achieved by described model which expresses the better performance of Cloud-based Smart IoT platform for personalized healthcare Data Gathering and Monitoring System.

**V. CONCLUSION**

This paper describes a Smart IoT platform that utilizes Cloud technology for personalized healthcare data gathering and monitoring. The adoption of IoT technology in healthcare has the potential to offer various advantages, including disease diagnosis and prevention, remote monitoring of vital signs, improved decision-making, and an enhanced quality of life for patients, with reduced costs. The primary sources for collecting the data are IoT devices and EHR data.

The Cloud interface, which serves as a mediator, connects the Cloud platform to the middleware, applications, and sensor servers. The platform's features are accessible by users through individualized GUIs that are intuitive, unified, adaptive, and contextual. Throughput, Cloud Request View Ratio (CRVR), Security and Privacy are parameters used for the performance analysis. From the results, it is clear that high throughput, high security, high privacy and low CRVR parameters are achieved by described model which expresses the better performance of a Cloud-based IoT platform for individualized healthcare data gathering and tracking system. Patients can interact with healthcare professionals using this system about their health state, the efficiency of their medication and any side effects.

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