International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 12 Issue: 03 | Mar 2025 www.irjet.net p-ISSN: 2395-0072

Development of a Cloud-Based Platform for Real-Time Management of Healthcare Services

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Abstract - In the busy world, Optimal resource management, attendance monitoring, and rapid response to emergencies are primary challenges in the healthcare system, especially in dispersed health centers. Traditional methods lack centralized coordination, and therefore, inefficiency takes place in resource use and the provision of services. A cloud-based system is proposed to integrate Primary Healthcare Centers (PHCs) and Sub-Centers with the Deputy Director of Health Services (DDHS). The system offers real-time tracking of healthcare services, doctor availability and notification of doctor absenteeism as well as communication among Sub-Centres and higher-order nodes. The system sends automatic notifications regarding doctor unavailability and allows Sub-Centers and PHCs to place requests of resources such as vaccines, medicines, and injections. Sub-Centers can elevate requisitions, if necessary, to other PHCs or the DDHS, who oversee the allocation of resources and emergency response. The unified communication of intra-PHCs and inter-PHCs in the platform will enable enhanced resource coordination and sharing of resources. Cloud technology is scalable, facilitates seamless information sharing, and enables security of healthcare accessibility, hence enhancing the world healthcare management system.

Key Words: **Healthcare Management, Cloud-Based Platform, Primary Healthcare Centers (PHCs), Sub-Centres, Resource Allocation.**

1. INTRODUCTION

Efficient healthcare management is crucial for ensuring equitable access to medical services, optimizing resource allocation, and improving public health outcomes. However, healthcare systems, particularly those operating across dispersed regions, often face challenges in real-time monitoring, attendance tracking, and resource shortages. Traditional healthcare management approaches lack centralized coordination, leading to inefficiencies in service delivery, delayed responses, and ineffective resource utilization. Additionally, conventional systems often raise security concerns due to vulnerabilities in data storage and access management, making them susceptible to breaches and unauthorized modifications.

To address these challenges, this project introduces a cloud-based, centralized platform that connects Primary Healthcare Centers (PHCs), Upgraded PHCs, Sub-Centres, and the Deputy Director of Health Services (DDHS). The system enables real-time tracking of doctor availability, medicine stock levels, and emergency healthcare services, enhancing operational efficiency. It integrates intra-PHC and inter-PHC communication to streamline coordination, allowing Sub-Centres and PHCs to request essential resources such as vaccines, medicines, and first-aid supplies. Unlike traditional models that rely on manual oversight, this platform automates doctor availability alerts while allowing healthcare facilities to proactively raise requests for resource shortages, ensuring timely action.

To enhance data security, the proposed system incorporates cloud integration, ensuring secure access control and encrypted data storage. This approach mitigates the risks associated with traditional healthcare management systems, protecting sensitive patient and operational data from unauthorized access. Additionally, the system employs preprocessing techniques to handle inconsistencies, such as missing or outdated information, improving the accuracy of shared healthcare data. By leveraging cloud infrastructure, the platform offers scalability, seamless information exchange, and enhanced accessibility, ultimately strengthening healthcare service delivery and crisis management.

This adaptive and technology-driven solution ensures continuous healthcare support, promotes efficient resource allocation, and empowers healthcare professionals with real-time insights for better decision-making while prioritizing security and data integrity.

2. LITERATURE SURVEY

John Zaki et al., 2022 [1] This study presents a cloud-based microservice framework for healthcare software development, emphasizing system scalability and integration. The framework enhances system responsiveness by breaking down applications into modular microservices, enabling flexible development and deployment. The paper highlights the benefits of cloud computing in healthcare by improving interoperability, but it does not specifically address real-time healthcare service monitoring. Additionally, it lacks automated doctor attendance tracking, medicine availability monitoring, and emergency resource coordination, which are critical for ensuring continuous and efficient healthcare service delivery.

Jane Doe et al., 2025 [2] TepiSense is a machine-learning and social-computing enabled epidemic surveillance platform that monitors and forecasts disease epidemics in real time. The platform offers responsive public health input through the mining of large amounts of data in order to pick up on growing health trends. The system greatly depends on the use of data from social media, which comes with accuracy bounds and misinformation implications. Moreover, it does not involve real-time tracking of healthcare resources, which means it lacks sufficiency in handling doctor availability, shortage of medicines, and urgent resource allocation.

Anirban Ray et al., 2024 [3] This study responds to the interaction design principles in mHealth applications used to design COVID-19 interventions based on usability, accessibility, and integrity with engagement. Although the study presents a lot of information about UI/UX design for health applications, it is limited to the pandemic's digital interventions. It is not considering cloud planning of healthcare resources, monitoring of the presence of doctors in real time, or computerized alerts in the case of a lack of resources, so it is not as flexible towards broader healthcare service management.

Manish Kumar et al., 2024 [4] The system introduces an FSRNCA and FLANN-based predictive model for estimating death rates using publicly available health data. It has very high precision in identifying at-risk populations and therefore contributes significantly to public health planning. The model utilizes public records of health data alone, which is its weakness in some regions where public health data might be incomplete or unavailable. Further, it does not have real-time monitoring of healthcare and automated alerts, making it less efficient at timely resource management in healthcare organizations.

3. System Architecture

The architecture of the proposed system is based on a cloud platform that ensures security, scalability, and effective data exchange. The system consists of different modules interconnected with one another, and every module caters to specific operation needs. Role-based access control is used to limit unauthorized access while providing user-specific functionality. Attendance tracking allows medical staff to mark their availability, which is stored and retrieved dynamically through API calls. Resource management enables administrators to make and approve medical supply requests through a simplified process, ensuring prompt restocking of supplies. The dashboard centralizes critical performance metrics into a convenient interface to facilitate simpler monitoring and decision-making. Finally, security components like encryption, hashed credentials, and secure API endpoints protect sensitive information from potential cyber attacks.

4.METHODOLOGY

4.1 User Authentication and Access

User Authentication and Control is essential to ensure secure access to the system. User authentication involves users logging in to the system via their password and email address, which are securely stored in an Azure SQL Database. Additional layer of security, passwords are hashed before they're saved, hence making them resilient to unauthorized attempts at access .Authentication is performed by Azure Functions, which authenticate against user credentials and provide role-based access tokens for authorized interaction within the system. Role-based access control ensures that various classes of users with varying privileges are defined. System activity is controlled by DDHS administrators, resource requests are authorized and audited, and physicians' availability are queried through an interactive dashboard. PHC staff view attendance records, available stocks are controlled, and resources ordered, and Sub-Center staff view local attendance and order resources. Sensitive data are safe and security attacks reduced by applying strict access control.

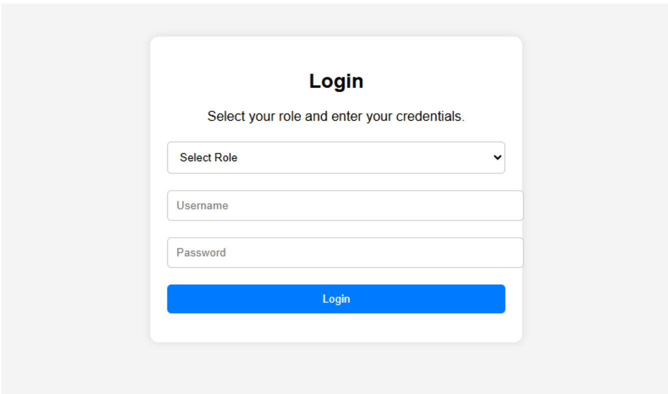

Fig -1: User's Login with Authentication

4.2 DOCTOR'S ATTENDANCE MANAGEMENT

Attendance Monitoring and Data Tracking Monitoring of attendance is a critical feature for the accurate recording of the presence of health personnel. Doctors document their attendance through a web interface with selection

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from Present, Absent, or Available status fields. Their credentials are first authenticated by the system before registering the attendance entry so that any valid personnel will be made present. Timestamp is applied on every record which gets stored within the database to get analyzed afterwards. Attendance reports come to DDHS Dashboard from Azure Functions as API calls for getting real-time availability across several healthcare centers under it. This allows decision-makers to look at trends and send personnel appropriately. Regular automatic attendance reports provide easy performance review and monitoring for compliance. Being able to have real-time access to the availability of the doctors ensures that services for patient care are hampered by surprise absenteeism, making the health overall better.

This model is to provide the real time doctor availability in the PHC (Primary Healthcare Centre) and also in the Sub-centres. If a Doctor or the Physician is not available at the time of duty then a Substitute doctor would replace at the time of duty. The complete record of the attendance would be shared to the DDHS and they would appoint a Substitute doctor at the place of the absent doctor . This model tracks the absenteeism of the doctor and provides an alert to the DDHS for the Substitute to be provided within a given shorter period of time.

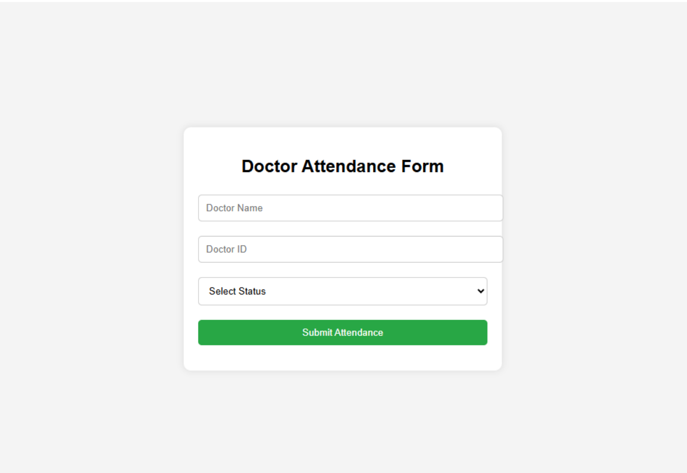

Fig -2: Doctor's Attendance login Page

4.3 RESOURCE REQUEST & INVENTORY MANAGEMENT

Resource Request and Tracking Efficient management of resources is imperative to allow smooth healthcare service delivery. The system supports submission, verification, authorization, and monitoring of requests for resources through a formal process. PHC and Sub-Center officials design requests by inputting item descriptions, requested quantities, degrees of urgency, and reasons. The requests are processed using Azure Functions and stored in the ResourceRequests Table in Azure SQL Database with a pending status. The DDHS Dashboard lists all pending requests to facilitate administrators in reviewing and acting on them. When approved, requests are sent to the Inventory Table, and automatic updates are made to stock levels to show recent changes.The system has real-time monitoring of the inventory, monitoring stock, expiration dates, and use patterns. Automatic alerts inform administrators when the supplies fall below predefined levels to facilitate timely restocking. The system also creates restocking requests when stocks reach critical levels to reduce disruptions in medical resource availability. The smooth integration of these features attains optimal supply chain efficiency to avoid shortages and keep healthcare facilities well-stocked at all times.

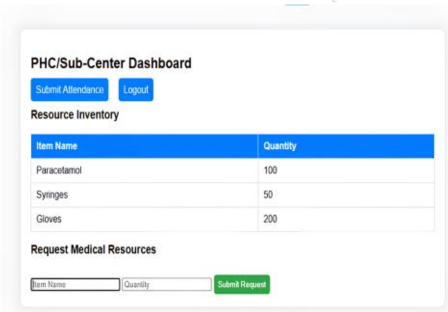

Fig -3: Inventory Management for PHC's and Sub-Centres

4.4 DDHS DASHBOARD (Centralized Monitoring System)

DDHS Dashboard is the focal face for observing health. It aggregates information from various resources and provides a total picture of attendance of doctors, request statuses, and status of stock. The dashboard presents real-time attendance reports with visual indication of the number of doctors labeled as Present, Absent, or Available at the various healthcare centers. Concurrently, it tracks the resource requests, labeling them as Pending, Approved, or Rejected, to facilitate administrators to take rapid decisions. Data retrieval is facilitated by Azure Functions so that the information observed is up to date. Real-time notifications and alerts help in administrative control by making it clear to key stakeholders resultant updates. By providing an integrated monitoring system, the DDHS Dashboard improves operations efficiency due to the capacity of health administrators to manage resources efficiently and offer seamless system use.

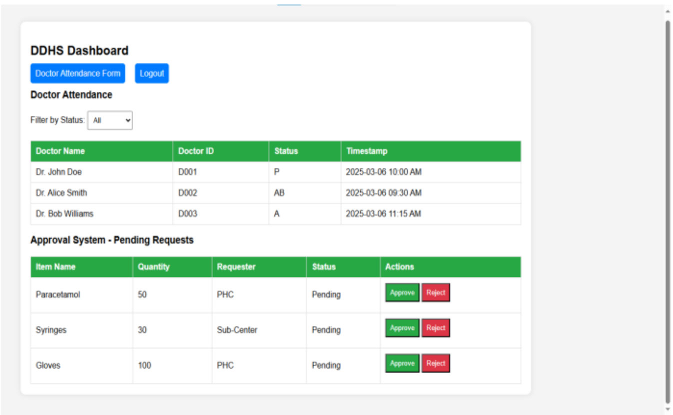

Fig -4: DDHS Dashboard Centralized for monitoring

4.5 SECURE AND SCALABLE CLOUD INTEGRATION

Cloud-Based Scalability and Security The app uses cloud-based characteristics to offer improved security, scalability, and performance. Protected health information is kept in an Azure SQL Database with security access controls in place that keep unwanted changes out. User accounts are protected by password hashing and encryption controls to prevent that private information is encrypted Restricted API endpoints add authentication controls to inhibit data disclosure and unauthorized operations.Scalability is enabled through serverless Azure Functions enabling the system to handle more users without sacrificing performance. CI/CD pipelines, controlled by GitHub Actions, deliver seamless updates that don't break continuous operations.Azure Static Web Apps provide a lightweight and effective front-end, improving user accessibility and reducing latency. Disaster recovery processes, such as failover operations, ensure system availability and reduce the risks of downtime. Real-time monitoring through Azure Application Insights enables automatic logging of performance and error incidents, enabling proactive maintenance of the system. These security and scalability features make the system resilient, flexible, and immune to future challenges.

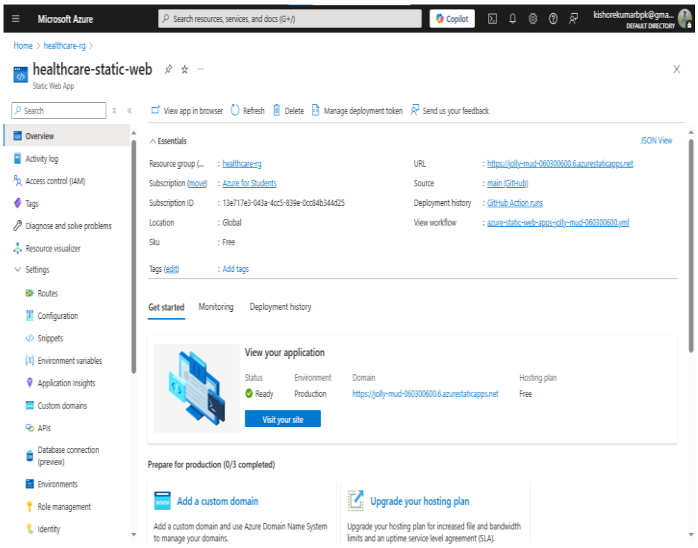

Fig 5-: Cloud Integrated Interface

5. IMPLEMENTATION

The deployment of the system involved meticulous planning and smooth integration of various cloud services so that real-time updates and data consistency could be achieved. Due to the fact that the system involves large-scale data, performance management while being efficient proved to be a challenge. To overcome this challenge, a serverless architecture was implemented, enabling resources to scale dynamically in line with demand. Not only did this improve performance but also maintain operational costs in check.

Real-time synchronization among distributed systems was another vital area of consideration. The architecture utilized cloud-native message queuing capabilities and event-driven design patterns to garner fast data movement and updates between the different components. Database performance was also ensured through a mix of SQL databases for structured storage required and NoSQL databases for fast data access.All query latencies as well as general performance were improved using indexing, caching, and partitioning schemes.

Security was a key concern in deployment since processing sensitive data involved strict encryption procedures and access controls. End-to-end encryption procedures were used to protect information during transit, and robust authentication procedures ensured only approved users accessed sensitive data

In spite of these precautions, the intricacy of handling real-time processing of data over a distributed system presented several challenges. Despite that, the utilization of a cloud-native technology facilitated the degree of flexibility and fault tolerance required in order to support the needs of the system with success. Down the line, the use of AI-driven predictive analytics could serve to further advance performance by discerning trends within data usage and balancing resource utilization accordingly. It would then help the system to respond smartly to changing workloads, and it would facilitate long-term scalability and efficiency.

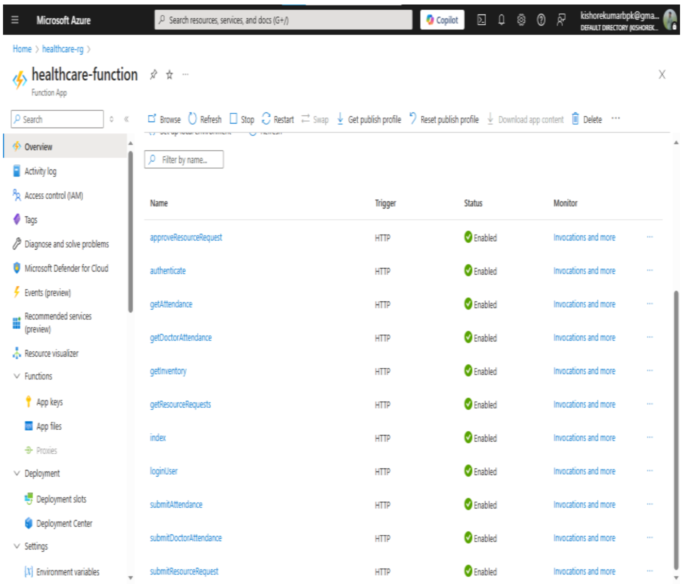

Fig 6 -: Backend Homepage

6. RESULT

The implementation of the system has brought about dramatic enhancements in role-based access control, attendance monitoring, and resource management. Alerts and real-time monitoring have streamlined decision-making processes with transparency in healthcare administration. The attendance monitoring module has reduced absenteeism to the optimal level by providing administrators with instant visibility into staff availability. The resource request and inventory management system have reduced shortages to a minimum by allowing timely approvals and real-time inventory levels. In addition, the cloud-based architecture has ensured higher security, scalability, and resiliency so that the system can support expansions in the future. The increased efficiency from the system helps enhance healthcare service provision and overall operation efficiency.

7. FUTURE ENHANCEMENT

The system is more built, some of the major improvements can be integrated to ensure that it is more functional and easily used. With its current web-based incarnation, development will later involve converting it to a real-time mobile app, which will be simpler and more accessible for persons with mobility. This will enable seamless interaction and updates, improving overall user experience and productivity.

The other major enhancement will be enhancing the inventory system. The system can only currently deal with a finite list of medications, but future updates will attempt to incorporate a complete database of all the drugs on the market. This will improve inventory management, increase availability, and provide more accurate tracking of medical supplies.

Besides this, a feature-rich doctor tracking system will also be included within the system so that location-based real-time monitoring can be enabled. This would automatically flag doctors as present or absent depending upon their locations so that attendance management of staff is made easy and the operating efficiency is maximized. All of these functionalities would highly enhance the system's functionality, and the system would be a much smarter and better solution for real-time healthcare management.

8. CONCLUSIONS

The effective implementation of this system highlights the ability of cloud-based solutions to manage big data with real-time efficiency. Utilizing a serverless architecture, the system achieved a balance between performance and affordability, allowing seamless scalability on demand. Distributed cloud services integration offered real-time synchronization, while database optimization techniques enhanced data retrieval and processing rates.

Security was a top priority from start to finish with robust encryption and access controls to keep the sensitive data out of reach. Challenges of working with real-time data processing and synchronization of the systems were solved by the cloud-native approach using the required flexibility and redundancy.

In the future, the system can be developed with AI-based predictive analysis to maximize resource utilization and enhance decision-making. Improvements in cloud computing and machine learning on a continuous basis can help turn this platform into a more intelligent and responsive solution, thereby making it sustainable in the long run as well as efficient in data processing.

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