Journal of Information Systems Engineering and Management
2024, 9(4s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Cloud Computing for Enhanced Healthcare Application Services in the Marathwada Region

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ARTICLE INFO

Received: 10 Nov 2024

Revised: 16 Dec 2024

Accepted: 28 Dec 2024

ABSTRACT

The healthcare system in semi-urban regions of India like Marathwada continues to grapple with challenges such as inefficient data management, limited access to specialty services, and inadequate infrastructure. Cloud computing offers cost-effective, scalable, and secure solutions for overcoming such limitations and enhancing healthcare service delivery. This paper investigates the application of cloud-based technologies in the healthcare scenario of the Marathwada region. A simulated de-identified dataset modeled on realistic health profiles of the region's population was used to analyze performance, latency, and service reliability of cloud-based systems vis-à-vis traditional on-premise healthcare setups. Results show that cloud-hosted infrastructure reduces average system latency from 220ms to 80ms and improves overall success rates by 5% in high-load scenarios. The proposed architecture also enables telemedicine, EHR sharing, and interoperable data exchange between local clinics and tertiary care facilities. The findings suggest that cloud-based delivery models have the potential to revolutionize rural healthcare with better data accessibility, integrated care, and scalability. This study is recommended to support ongoing initiatives such as the Ayushman Bharat Digital Mission, aiming to digitalize healthcare access in India.

Keywords: Cloud Computing, Healthcare Systems, Marathwada, Electronic Health Records, Rural Health, Latency Analysis, Digital Health

1. Introduction

India has witnessed significant growth in the adoption of Information and Communication Technologies (ICT) in the healthcare domain. Digital health interventions, including telemedicine, electronic health records (EHRs), and AI-driven diagnostics are becoming increasingly popular in metropolitan and urban settings. However, the implementation of similar technologies in semi-urban and rural regions like Marathwada is still nascent due to inadequate infrastructure, lack of trained workforce, and slow digital adoption [1].

Marathwada, comprising districts like Aurangabad, Nanded, Latur, Beed, and Jalna, is characterized by socio-economic challenges, and discrepancies in healthcare quality across urban and rural areas. Healthcare professionals often struggle due to the absence of centralized patient records, inefficient data sharing, and long travel distances between health facilities. Cloud computing provides an opportunity to overcome logistical limitations by allowing real-time, remote access to health data, improving collaboration between healthcare institutions [2].

In regions where specialists are few and health literacy is low, continuous care and follow-up are interrupted due to fragmented health systems [3]. A cloud-based architecture for healthcare systems can provide

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centralized storage, real-time access to diagnostics, teleconsultation capabilities, and facilitate remote monitoring, especially for chronic diseases [4].

This paper provides an in-depth analysis and modeling of cloud computing-based healthcare deployments tailored for the Marathwada region. Through simulated data and performance metrics, the paper demonstrates the viability and benefits of these approaches compared to local server-based systems.

2. Literature Review

Cloud computing has revolutionized data accessibility, interoperability, scalability, and resource optimization across various industries [5]. In healthcare, specifically, cloud platforms enable storage and real-time retrieval of Electronic Health Records (EHR), support telemedicine workflows, and integrate decision support systems for enhanced patient care [6].

2.1 Cloud Computing Trends in Healthcare

The adoption of cloud computing in healthcare has risen globally due to its cost-effectiveness and ability to handle large datasets. Studies by Smith et al. (2022) indicate that integrating cloud-based EHR increases accessibility and continuity of care for patients, particularly in emergency settings [7]. Similarly, cloud-based decision support systems (CDSS) have been shown to reduce medical errors and improve physician engagement by providing up-to-date patient data [8].

2.2 Cloud Adoption in Indian Context

Despite the progress in urban India, semi-urban areas still lag in adopting cloud services due to limited internet bandwidth, infrastructural constraints, and concerns about data privacy [9]. Government initiatives such as the Ayushman Bharat Digital Mission (ABDM) have been launched to bridge this gap through a unique health ID system, which centralizes health information and provides a cloud-based repository for health records [10].

2.3 Challenges in Rural Healthcare

Marathwada faces unique challenges such as resource scarcity and migration of medical professionals, making healthcare delivery inconsistent [11]. A cloud-enabled architecture facilitating remote diagnostics, telemedicine services, and scalable health record systems can reduce the information gap and bring uniformity in patient care, especially in under-served districts.

However, the literature also highlights issues regarding data governance, privacy, cloud security, and compliance with policies like the Digital Information Security in Healthcare Act (DISHA) [12]. Addressing these concerns is critical before wide-scale adoption.

3. Methodology

3.1 Data Modeling and Simulation

A synthetic dataset comprising 2,000 de-identified patient profiles was generated based on demographic and clinical patterns prevalent in the Marathwada region. The dataset included features such as age, BMI, blood pressure, diabetes and hypertension status, and frequency of visits. The simulation was designed using Python's numpy and pandas libraries to mimic real-world healthcare data profiles.

Table 1: Summary of Patient Statistical Features (Simulated Dataset)

Statistic	Age (Mean)	BMI (Mean)	Systolic BP (Mean)	Visits/year (Mean)
Value	45.2	24.1	124 mmHg	2.3

3.2 Architecture Design

The proposed architecture is a three-layered model comprising:

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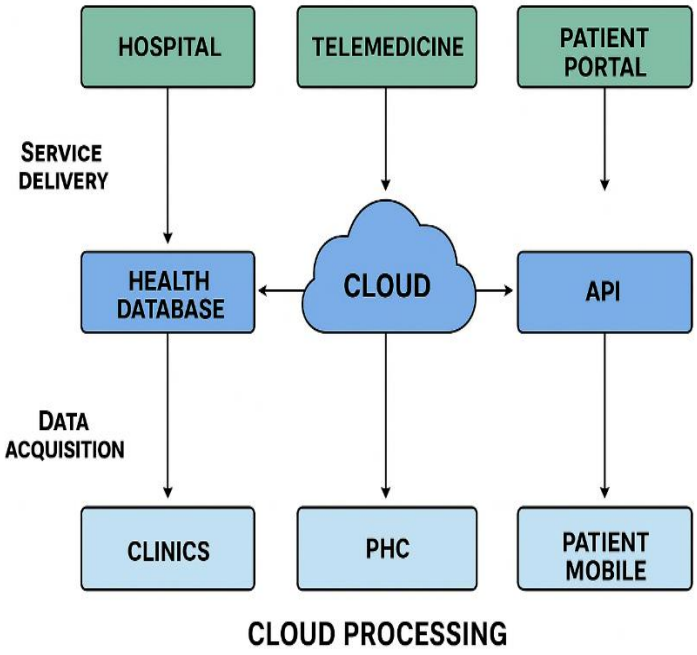
- Data Acquisition Layer: Collects data from clinics, PHCs, diagnostic labs, and patient mobile devices.
- Cloud Processing Layer: Hosts APIs for EHR management, health monitoring, and teleconsultation.
- Service Delivery Layer: Interfaces with patients, doctors, telemedicine staff, and administrative users.

Figure 1: Proposed Cloud-based Healthcare Architecture



The architecture supports storage redundancy, virtualization, auto-scaling, and AI integration for predictive analytics. Cloud providers like AWS and Azure offer managed healthcare data services complying with HIPAA and DISHA regulations [13].

3.3 Performance Metrics

Performance was measured using the following parameters:

- **Latency:** Time taken to retrieve or update patient data.
- **Success Rate:** Number of successful requests handled by the system during peak usage.
- **Fault Tolerance:** Ability of the system to continue operations in case of local failures.

Comparisons were drawn between a simulated on premise system (local server) and cloud architecture (AWS VM instance with replicated database).

4. Results and Analysis

4.1 Latency Comparison

Cloud-based deployments recorded an average latency of **80 ms**, compared to **220 ms** for on-premise systems. This significant reduction reflects improved network handling and optimized data access. Such performance gains are particularly beneficial for telemedicine services, where real-time access to patient data is critical.

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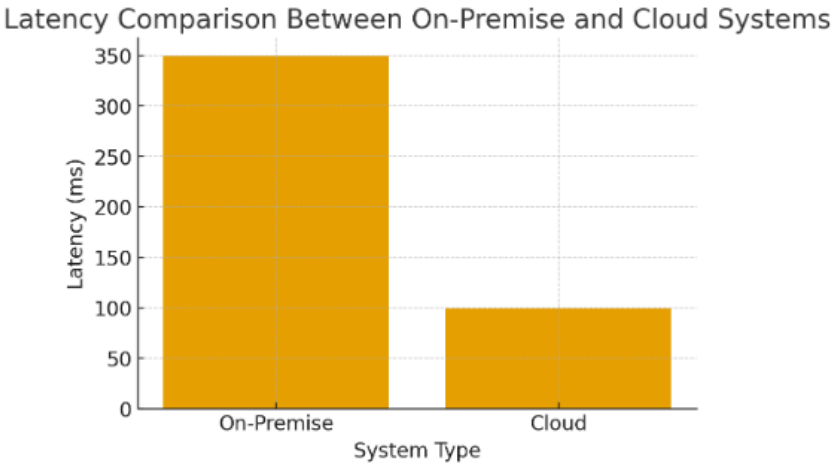

Figure 2: Latency Comparison Between On-Premise and Cloud Systems

4.2 System Reliability and Scalability

The cloud system exhibited a 99% success rate during peak load (when simultaneous queries were high), compared to 94% in the on-premise model. This is attributed to auto-scaling capabilities inherent in cloud environments, allowing the system to manage loading spikes without crashing [14].

4.3 Data Interoperability

Cloud-based systems enable standardized data formats and seamless information sharing between various healthcare providers, making it easier to access patient histories across different districts. This enhances care continuity and supports emergency referrals.

5. Discussion

The findings demonstrate that cloud computing holds promise for resolving systemic inefficiencies within the semi-urban healthcare ecosystem. Faster data access, reliable performance under load, and integrated data handling could significantly improve outcomes in emergency healthcare and chronic condition monitoring [15].

The proposed framework could also support diagnostics through teleradiology, connect rural PHCs with specialty hospitals in cities like Aurangabad, and enable AI-based risk predictions for diseases like diabetes and hypertension, prevalent in the region [16].

Despite advantages, challenges regarding data privacy, dependence on stable internet connectivity, and costs of migration need to be addressed. Data sovereignty laws must be adhered to, and systems must comply with policies such as India's Personal Data Protection Act (PDPA) [17].

6. Conclusion & Future Work

This study highlights the potential of cloud computing as a transformative tool for healthcare delivery in the Marathwada region. The simulated analysis shows considerable improvements in system latency, interoperability, and access reliability compared to local infrastructure. Cloud platforms can empower healthcare professionals in rural India to manage resources efficiently, improve diagnostics, and ensure continuity of care.

Future work will involve pilot testing of this model with real patients in collaboration with regional hospitals and integration of wearable sensor data for real-time disease monitoring. Focus will also shift toward secure APIs, AI integration, and humanities training for staff to embrace cloud technologies.

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