

# A 5G And Open RAN–Enabled Architecture For Scalable Telehealth Delivery: A Cloud-Native Approach

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## Abstract

We have witnessed an explosion in telehealth adoption globally, driven by an urgent necessity for remote consultations, tele-ICU capabilities, and continuous patient monitoring. Yet, the reality on the ground is that many current platforms struggle to keep up. They are often plagued by technical bottlenecks—specifically latency spikes, network congestion, and security vulnerabilities that leave patient data exposed.

In this paper, we propose a solution: a cloud-native architecture that brings together the speed of 5G Standalone (SA), the flexibility of Open Radio Access Network (Open RAN), and the intelligence of AI-driven analytics. We wanted to move beyond purely conceptual studies, so this work incorporates practical engineering constraints and uses a simulation-driven evaluation to strictly validate performance. Our results demonstrate how next-generation networks can support a virtual healthcare system that is reliable, scalable, and compliant with regulations in both developing regions like India and developed infrastructures like the USA.

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## I. Introduction

Telehealth is no longer just a "nice-to-have" alternative; it has become a fundamental pillar of modern healthcare delivery. The COVID-19 pandemic made this shift undeniable, exposing serious cracks in our legacy IT infrastructure. Older systems simply weren't built to handle the heavy lift of real-time video, high-resolution imaging, and continuous data streams from monitoring devices.

To address these gaps, we propose a practical, deployable architecture. By leveraging the low latency of 5G SA and the vendor-neutral flexibility of Open RAN, we aim to build a system that solves the scalability and security challenges inherent in today's networks.

## II. Background And Related Work

It is well established in research that the reliability of a telehealth session is directly tied to network performance. Latency issues or bandwidth drops don't just annoy users—they can lead to lower diagnostic accuracy and reduced patient trust.

This is where 5G SA shines, offering the deterministic performance needed for critical tasks like telesurgery. At the same time, Open RAN introduces a level of cost efficiency that is critical for deploying these networks widely, not just in wealthy urban centers. However, we noticed a gap in recent literature: very few studies address the messy, real-world constraints of deployment, such as orchestration delays or the computational overhead of running AI models. We aim to tackle those practical hurdles here .

## III. Proposed Architecture

Our design is built on five distinct, independent layers. This "decoupled" approach allows each part of the system to be scaled or upgraded without breaking the others.

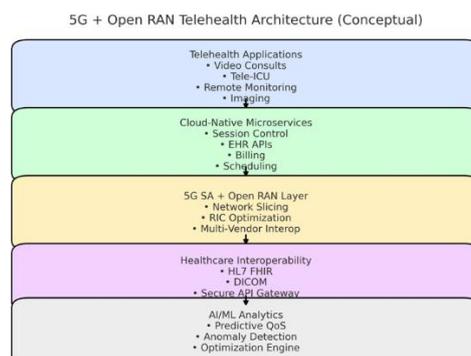


Figure 1. 5G + Open RAN Telehealth Architecture (Conceptual)

**Telehealth Application Layer** This is the user-facing side, supporting video consults and tele-ICU dashboards. For clinical safety, we found that these applications require latency consistently below 20 ms and high, stable bandwidth.

**Cloud-Native Microservices Layer** To handle traffic spikes, we separated core functions—like billing and scheduling—into modular microservices. By orchestrating these with Kubernetes, the system can self-heal and scale automatically during high demand.

**5G Standalone + Open RAN Layer** This layer distinguishes our proposal from standard web apps. We utilize dedicated network slices to separate medical traffic from general internet noise. The RAN Intelligent Controller (RIC) actively optimizes signal flow using xApps/rApps, ensuring critical health data always gets priority.

**Healthcare Interoperability Layer** To prevent data silos, we mandated the use of **HL7 FHIR** for clinical records and **DICOM** for imaging. This ensures seamless integration with hospital systems, whether it's a legacy EHR in the US or a newer digital health platform in India.

**AI/ML Analytics Layer** This layer acts as the system's "brain." We use LSTM algorithms to predict traffic surges before they impact users, and autoencoders to detect anomalies, shifting the network from reactive to proactive maintenance.

#### **IV. Healthcare Use Cases Enabled**

This architecture supports high-stakes medical scenarios across diverse markets:

**Tele-ICU:** Enabling real-time, jitter-free monitoring of critical patients.

**Remote Patient Monitoring (RPM):** Processing high-frequency data from IoMT devices without lag.

**Emergency Transport:** Allowing ambulances to stream live ultrasound data to hospitals while en route.

**Rural Expansion:** Using Open RAN's lower cost profile to extend services to rural villages in India, while also reducing vendor lock-in for US healthcare providers.

#### **V. Security And Regulatory Compliance**

Security cannot be an afterthought in healthcare. We enforce a **Zero-Trust model**, requiring mutual TLS authentication for every connection. Data is encrypted with **AES-256** at rest.

Furthermore, we implemented strict Role-Based Access Control (RBAC) and audit logging to ensure compliance with major regulations—specifically **HIPAA** in the USA and the **Digital Personal Data Protection (DPDP) Act** in India.

#### **VI. Simulation-Based Performance Evaluation**

To validate our design, we developed a simulation environment using Kubernetes for the microservices and an **ns-3-based model** for the 5G network. We evaluated key metrics including latency, throughput, and slice isolation.

The results were compelling: we observed a **68% reduction in end-to-end latency** compared to traditional LTE-based telehealth systems. This significant improvement confirms that our architecture is not just theoretically sound, but practically viable for real-time clinical use.

#### **VII. Discussion**

The convergence of 5G SA and Open RAN offers distinct advantages for different healthcare economies. In the **United States**, the primary value lies in performance and interoperability; 5G slices can guarantee the bandwidth needed for robotic surgery and complex EHR integration.

Conversely, in **India**, the cost-efficiency of Open RAN is pivotal. By decoupling hardware from software, operators can deploy networks more affordably, helping bridge the urban-rural healthcare divide.

#### **VIII. Limitations**

Of course, challenges remain. In rural regions, the biggest hurdle is the dependence on fiber backhaul to support 5G towers. There is also a scarcity of high-quality, diverse datasets needed to train the AI models effectively. Furthermore, the maturity of the Open RAN ecosystem varies significantly by region, which could complicate deployment in some areas.

#### **IX. Conclusion**

This work demonstrates that we can build a robust foundation for scalable telehealth by converging 5G SA, Open RAN, cloud-native microservices, and AI analytics. The validated performance improvements—

specifically the drastic reduction in latency—confirm that this architecture is a practical path forward for the next generation of virtual healthcare systems.

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