Dynamic Adaptive Sharding framework for Healthcare Blockchain Systems

V V S Sivakumar Ethakota
Department of Computer Science and Engineering, SRM University, Andhra Pradesh, India

Dr. Kakumani K C Deepthi
Department of Computer Science and Engineering, SRM University, Andhra Pradesh, India

Abstract:

Healthcare blockchain systems have failed to achieve production deployment due to three critical limitations: (1) insufficient latency for emergency care (<200ms required), (2) limited Byzantine fault tolerance for untrusted consortiums (50% maximum), and (3) patient data exposure to validators violating HIPAA/GDPR. This paper presents the Dynamic Adaptive Sharding (DAS) Framework, the first integrated healthcare blockchain combining Zero-Knowledge Proofs (ZKPs), Reputation-Based Byzantine Fault Tolerant (RB-BFT) consensus achieving 66.7% fault tolerance, dynamic adaptive sharding with 92% load prediction accuracy, and Intelligent Service Organization (ISO) clinical context-aware routing.

Through comprehensive simulation of 7,020 realistic healthcare transactions across 24 hours, we demonstrate: (1) 1.38x-1.56x latency improvement (130ms average vs 180ms baseline), (2) 66.7% Byzantine tolerance (+33% over traditional BFT), (3) 98.69% transaction success rate with zero patient data exposure, (4) dynamic shard scaling from 5-31 shards preventing 90%+ of bottlenecks, and (5) automatic HIPAA/GDPR compliance through cryptographic enforcement.

This work enables healthcare organizations with >20M annual transactions to deploy mission-critical blockchain with a production-ready implementation as a future work. DAS Framework bridges a significant gap in which blockchain has offered but not fulfilled in healthcare interoperability, a combination of academic innovation (new consensus mechanism, built-in privacy-preserving architecture) and practical contribution (deployable healthcare blockchain, regulatory framework).

Keywords:

Healthcare Blockchain, Byzantine Consensus, Sharding, Zero-Knowledge Proofs, HIPAA/GDPR Compliance, Distributed Systems.