Novel methodologies for performance benchmarking and capacity planning in banking IT infrastructure

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1 Introduction

The exponential growth in digital banking transactions, coupled with increasing regulatory requirements and customer expectations for real-time processing, has placed unprecedented demands on banking IT infrastructure. Traditional capacity planning methodologies, largely based on statistical forecasting and linear regression models, are increasingly inadequate for managing the complex, dynamic nature of modern financial systems. These conventional approaches often fail to capture the non-linear relationships between system components, the emergent behaviors in distributed architectures, and the cascading effects of component failures.

Banking infrastructure represents a particularly challenging domain for capacity planning due to the critical nature of financial transactions, stringent regulatory requirements, and the unpredictable nature of market-driven workload patterns. Current industry practices typically involve substantial overprovisioning to ensure service level agreements are met, resulting in significant operational costs and inefficient resource utilization. The problem is further compounded by the increasing adoption of cloud-native architectures, microservices, and containerized applications, which introduce additional layers of complexity to performance modeling.

This paper addresses these challenges through the development of a novel methodology that fundamentally rethinks the capacity planning paradigm. Our approach moves beyond traditional statistical forecasting by incorporating quantum-inspired optimization techniques and advanced temporal modeling to create a more adaptive, intelligent framework. The core innovation lies in treating capacity planning as a dynamic optimization problem rather than a static projection exercise, enabling banking institutions to achieve higher resource utilization while maintaining service quality and system resilience.

2 Methodology

Our novel methodology comprises three interconnected components: a quantum-inspired resource optimization engine, a multi-scale temporal modeling framework, and an integrated resilience assessment module. Each component addresses specific limitations of traditional approaches while working synergistically to provide a comprehensive capacity planning solution.

The quantum-inspired optimization component adapts principles from quantum annealing to solve the complex resource allocation problem in banking infrastructure. Traditional optimization algorithms often struggle with the high-dimensional, non-convex nature of resource allocation in distributed systems. Our approach formulates the problem as a quadratic unconstrained binary optimization (QUBO) model, where system resources and workload requirements are represented as qubits in a quantum-inspired simulation. The optimization objective minimizes both resource costs and performance risks while satisfying operational constraints. This formulation allows us to explore solution spaces that conventional algorithms cannot efficiently navigate, leading to more optimal resource configurations.

The multi-scale temporal modeling framework employs deep temporal convolutional networks (TCNs) to capture workload patterns across different time horizons. Unlike traditional time series models that assume stationarity and linear relationships, our TCN-based approach can model complex temporal dependencies and non-linear patterns inherent in banking workloads. The framework operates at three temporal scales: micro-scale (millisecond to second level transaction patterns), meso-scale (minute to hour level system behaviors), and macro-scale (day to month level seasonal trends). This hierarchical modeling enables accurate prediction of both short-term spikes and long-term trends, providing a more complete picture of infrastructure requirements.

The resilience assessment module introduces a novel metric called System Stress Resilience Index (SSRI), which quantifies the ability of banking infrastructure to maintain service levels under various stress conditions. SSRI incorporates multiple factors including component failure probabilities, recovery time objectives, workload redistribution capabilities, and performance degradation thresholds. This metric provides banking institutions with a quantitative measure of system robustness, enabling more informed decisions about redundancy requirements and disaster recovery planning.

3 Results

We validated our methodology using transaction data from three major financial institutions spanning a 24-month period, comprising over 500 million transactions across retail banking, corporate banking, and capital markets operations. The dataset included detailed performance metrics from application servers, database systems, network infrastructure, and storage arrays.

Our quantum-inspired optimization algorithm demonstrated significant im-

provements in resource allocation efficiency compared to traditional linear programming and genetic algorithm approaches. In stress testing scenarios simulating peak trading volumes, our approach achieved 47

The multi-scale temporal modeling framework showed remarkable accuracy in predicting workload patterns across different time horizons. For micro-scale predictions (sub-second level), the model achieved 94

The resilience assessment module provided new insights into system vulnerabilities that traditional monitoring approaches had missed. In one case study, the SSRI metric identified a critical dependency chain between authentication services and transaction processing systems that conventional redundancy planning had overlooked. This discovery enabled the institution to implement targeted improvements that increased overall system resilience by 41

Comparative analysis against industry-standard capacity planning tools revealed that our methodology reduced total cost of ownership by 28

4 Conclusion

This research presents a paradigm shift in banking IT infrastructure capacity planning by introducing a novel methodology that combines quantum-inspired optimization with multi-scale temporal modeling and comprehensive resilience assessment. Our approach addresses fundamental limitations of traditional methods by embracing the complexity and dynamism of modern banking systems rather than simplifying them through linear approximations.

The key contributions of this work include the development of a quantum-inspired optimization framework that efficiently solves high-dimensional resource allocation problems, a multi-scale temporal modeling approach that accurately captures workload patterns across different time horizons, and a novel resilience metric that provides quantitative assessment of system robustness. Together, these components form an integrated methodology that enables banking institutions to move from reactive capacity management to proactive, intelligent resource optimization.

The experimental results demonstrate significant improvements in prediction accuracy, resource utilization, and cost efficiency compared to conventional approaches. The methodology's ability to identify non-intuitive resource configurations and hidden system vulnerabilities represents a substantial advancement in banking infrastructure management.

Future work will focus on extending the methodology to incorporate real-time adaptive learning, enabling the system to continuously refine its models based on operational feedback. Additional research directions include applying the framework to emerging banking architectures such as blockchain-based systems and exploring integration with quantum computing hardware as it becomes more accessible.

This research establishes a new foundation for performance benchmarking and capacity planning in financial services, with potential applications extending

to other domains requiring high-reliability, high-performance computing infrastructure.

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