

## Active-Active Architecture in Commercial Banking: A Technical Framework for Continuous Operations

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**Abstract:** Global commercial banking institutions are confronted with increasing requirements for uninterrupted operational availability as financial markets execute globally across time zones with a need for non-stop transaction processing capacity. Classic active-passive design models, although offering underlying failover facilities, introduce major operational limitations such as obligatory maintenance down times, lengthy recovery protocols, and less-than-optimal patterns of resource utilization that adversely affect institutional competitiveness. Active-active architectural deployments offer revolutionary solutions in which several geographically dispersed data centers process live transactions at the same time with advanced bidirectional synchronization protocols. The architectural approach avoids single points of failure while optimizing computational efficiency through intelligent workload allocation to active processing nodes. Technical deployment involves advanced data synchronization processes functioning on database, application, and network infrastructure layers, sustaining transactional consistency via real-time replication protocols and conflict resolution algorithms. Operational resilience is revolutionized by the removal of scheduled maintenance windows and the massive reduction of recovery time frames from customary hour-long periods to sub-second restoration capacity. Opportunities for generating revenue come through premium service-level agreements with guaranteed uptime commitments to corporate treasury clients, and digital channel expansion provides continuous engagement with the market and API monetization schemes. Regulatory compliance advantages include improved operational resilience models meeting supervisory expectations for stress testing and business continuity validation. Risk management enhancements include lowered operational risk exposure, improved disaster recovery capabilities, and extensive audit trail maintenance over distributed processing environments.

**Keywords:** Active-Active Architecture, Operational Resilience, Distributed Banking Systems, Real-Time Synchronization, Revenue Monetization, Regulatory Compliance.

### INTRODUCTION

Commercial banking infrastructure is under unprecedented pressure to provide round-the-clock availability as banks open themselves up to global markets with real-time payment systems, corporate treasury services, and online channels demanding round-the-clock servicing. Cross-country analysis of instant payment adoption shows that European markets have achieved over 15 billion instant payments per year, with individual countries processing up to 2.8 billion transactions per year via systems such as Poland's BLIK and the Netherlands' iDEAL platform (Górka, J. 2025). These infrastructures illustrate the important infrastructure needs where even temporary service outages can cascade through integrated financial networks, impacting corporate treasury functions, interbank settlements, and retail payment channels that together handle more than 45 million transactions at peak operating times.

Standard active-passive configurations, although offering minimum failover, bring along inherent limitations such as maintenance cycle-based planned downtime windows of 4-6 hours, 15-30-minute delay-based recovery sequences for full failover, and inefficient resource usage where idle standby systems are in place during standard operation. Comparative analysis among prominent

European banking markets suggests that instant payment schemes need sub-second order transaction processing capacity, with top implementations seeing less than 200 milliseconds average response time for end-to-end payment finality (Górka, J. 2025). The underlying infrastructure to handle these volumes needs ongoing processing capacity, as peak periods of transactions reach more than 8,500 per second during commercial settlement windows, with customary failover delays being operationally unacceptable for upholding service-level guarantees.

Active-active designs are a paradigm change where multiple processing nodes or data centers both process live transactions and do so with ongoing bidirectional synchronization, avoiding single points of failure and maximizing operational performance. Analysis of operational resilience in leading banking institutions indicates that those that have rolled out distributed processing architectures have dramatically enhanced recovery metrics, with mean time to recovery being diminished from typical ranges of 45-120 minutes to operational windows of under 5 minutes (Leo, M. 2020). These enhancements are the result of the removal of single points of failure, with active-

active configurations providing service continuity during total site failures, supporting the uninterrupted transaction streams demanded by the latest-generation instant payment infrastructures that route cross-border settlements, corporate treasury transfers, and retail payment routing without a break.

The underlying technical architecture facilitating these capabilities needs advanced synchronization facilities that keep transactional consistency among geographically dispersed processing nodes while providing regulatory compliance across jurisdictions. Active-active configuration-running banking institutions report utilization gains where distributed loads clock 75-85% efficiency in all active locations, as opposed to legacy active-passive deployments running at 40-50% during standard configurations (Leo, M. 2020). This increased usage directly supports the scalability demands of instant payment systems, in which transaction levels vary by 300-400% between low- and high-usage processing intervals, calling for infrastructure able to dynamically adjust processing capacity without degrading service or with long recovery windows that would undermine operational continuity pledges.

## TECHNICAL ARCHITECTURE AND IMPLEMENTATION FRAMEWORK

### Core Infrastructure Components

Active-active configurations in banking deployments necessitate advanced data synchronization mechanisms running at the database, application, and network levels, with contemporary banking architecture analysis identifying enterprise-class implementations commonly utilizing service-oriented architectures that host more than 500 simultaneous microservices dealing with transaction processing, customer management, regulatory compliance, and risk assessment functions within distributed processing environments (Singireddy, D. 2025). The architecture uses real-time replication protocols that ensure transactional consistency among geographically dispersed sites without sacrificing immediate failover capability without data loss, using enterprise service bus implementations that handle more than 2.8 million messages within an hour at peak operating times while preserving message delivery guarantees and ordered processing needs essential for financial transaction integrity. Load balancing algorithms dynamically distribute transaction loads between processing nodes, equipped with sophisticated

routing mechanisms that route payment processing, account updates, and regulatory reporting throughout active nodes according to present capacity metrics, where in-depth banking architecture analysis proves that adequately configured systems attain processing throughput in excess of 15,000 transactions per second and response time less than 200 milliseconds for customer-facing operations (Singireddy, D. 2025).

The infrastructure architecture combines legacy mainframe systems with contemporary distributed computing platforms using standardized API gateways that convert traditional batch-based processing to real-time transaction streams, facilitating integration patterns for enabling smooth data flow between core banking systems, payment processors, and regulatory reporting platforms without compromising transaction integrity or audit trail requirements. Sophisticated implementations take advantage of application-aware load balancing, which takes into account transaction types, regulatory needs, and data residency restrictions, with system integration frameworks handling more than 150 various internal and external system interfaces that together process daily volume exceeding 45 million individual transactions such as account updates, payment authorizations, regulatory submissions, and customer service interactions requiring sub-second response times to provide competitive service levels (Singireddy, D. 2025).

### Synchronization and Consistency Models

The technical underpinnings depend on eventual consistency models supplemented by strong consistency assurances for material financial transactions, utilizing distributed database designs in which transaction processing systems uphold ACID properties at more than one site of processing through advanced concurrency control techniques that address multiple access to common financial data while avoiding race conditions, deadlock situations, and data corruption likely to jeopardize transaction integrity or regulatory requirements (Traiger, I. L. 1982). Multi-master database configurations provide simultaneous write across sites, concurrency in transaction processing based on timestamp ordering protocols, two-phase commit strategies, and distributed lock management systems that synchronize access to shared resources while ensuring transaction serialization requirements needed for financial correctness and audit trail maintenance.

Data versioning systems maintain histories of transactions between nodes so that audit trails are preserved during failover situations and employ distributed consensus protocols that guarantee transaction order and consistency even during network partitions or site failures that might otherwise undermine data integrity (Traiger, I. L. 1982). Network-level synchronization protocols provide sub-millisecond latency across active sites via dedicated communication paths supporting

distributed transaction coordination, with synchronization methods that manage concurrent updates of shared account balances, regulatory report data, and customer data while supporting strict consistency requirements to ensure that all processing nodes have identical views of key financial data, enabling operational continuity even for hard failure modes involving multiple sites down or network connectivity loss.

**Table 1.** Technical Architecture Components and Implementation Requirements (Singireddy, D. 2025; Traiger, I. L. 1982)

| Component Category      | Core Elements                     | Implementation Requirements                 | Operational Characteristics             |
|-------------------------|-----------------------------------|---------------------------------------------|-----------------------------------------|
| Data Synchronization    | Real-time replication protocols   | Bidirectional synchronization across sites  | Maintains transactional consistency     |
| Load Balancing          | Intelligent routing algorithms    | Dynamic workload distribution               | Capacity-based traffic management       |
| Database Configuration  | Multi-master architecture         | Simultaneous write operations               | Conflict resolution mechanisms          |
| Network Infrastructure  | Sub-millisecond latency protocols | Dedicated fiber connections                 | Quality-of-service prioritization       |
| Application Integration | Service-oriented architecture     | Microservices coordination                  | Enterprise service bus implementation   |
| Consistency Models      | Hybrid consistency frameworks     | Strong guarantees for critical transactions | Eventual consistency for secondary data |

### Operational Resilience and Performance Optimization

Active-active deployments radically revolutionize operational resilience by removing planned maintenance windows and lowering mean time to recover from historical ranges of 4-8 hours to operational windows less than 15 seconds, with frameworks for enhancing resilience showing that distributed banking architectures deliver availability levels in excess of 99.995% uptime by implementing multi-layered redundancy systems that involve automatic load transfer facilities, adaptive protection mechanisms, and real-time monitoring systems for detecting anomalies within 2-3 seconds and invoking correctives in autonomous mode (Dwivedi, D. *et al.*, 2023). The architecture loads computational workloads across numerous active sites so that resource bottlenecks occur at none of them during peak transaction periods like month-end processing that can create volumes 340% above normal operations, seasonal payment spikes like holidays that boost processing requirements by 280-320%, and quarterly regulatory reporting cycles that necessitate concurrent processing of more than 12 million transaction records for compliance filing while sustaining real-time customer service functionality.

Sophisticated resilience models use predictive maintenance algorithms that compare system performance data, equipment condition indicators, and environmental variables to predict impending failure 72-96 hours in advance, allowing proactive replacement of components and optimization of systems that avert service outages while preserving ongoing operational capability (Dwivedi, D. *et al.*, 2023).

Capacity planning is increasingly predictable when workload distribution offers fine-grained insight into patterns of resource utilization throughout the distributed infrastructure, with resilience extension systems utilizing intelligent grid technologies rematched for financial infrastructure that support dynamic reconfiguration of processing resources in accordance with real-time patterns of demand, equipment availability, and performance optimization needs that ensure processing efficiency higher than 85% even under sophisticated failure conditions involving multiple component failures or network connectivity problems. The decentralized architecture allows maintenance activities to be carried out at individual locations without service disruption, with rolling maintenance schedules facilitated by technological advancements such as automated

switching systems, network topologies with self-healing, and distributed energy storage equivalents in computational processing that offer backup capacity during maintenance periods without any interruption to customer-facing services (Dwivedi, D. *et al.*, 2023).

Performance optimization is achieved through context-aware transaction routing, taking into account network latency readings refreshed every 500 milliseconds, processing capacity statistics such as queue depths kept under 200 pending transactions per node, and regulatory data residency requirements enforced through geographically dispersed processing facilities that ensure sub-100 millisecond response times for customer-facing operations while complying with local data protection laws (Nutalapati, P. 2019). Latency reduction methods in distributed financial networks bring substantial performance gains with the deployment of edge computing structures, placing processing resources from 50-100 kilometers around key financial hubs, lowering network round-trip times from common 15-25 milliseconds to optimized latencies under 3

milliseconds for high-frequency trading processes and real-time payment processing (Nutalapati, P. 2019). Treasury management systems are advantaged by minimized settlement delays with distributed processing architectures that utilize parallel computing frameworks to execute settlement calculations, regulatory checks, and counterparty confirmations concurrently, which collectively decrease end-to-end settlement times from conventional 45-90 minute windows to 8-15 minute processing cycles. Corporate customers enjoy steady response rates of under 200 milliseconds for account inquiries, payment initiation processing within 1.2 seconds with all validation processes, and balance reporting that reflects up-to-date figures in real-time with latency levels under 50 milliseconds through the use of in-memory database technology, network protocols that are optimized, and distributed caching features that ensure data consistency across multiple processing points while accommodating commercial settlement period transaction volumes that range by 180-250% (Nutalapati, P. 2019).

**Table 2.** Operational Resilience and Performance Enhancement Capabilities (Dwivedi, D. *et al.*, 2023; Nutalapati, P. 2019)

| Resilience Domain       | Traditional Architecture   | Active-Active Architecture       | Performance Benefits             |
|-------------------------|----------------------------|----------------------------------|----------------------------------|
| Maintenance Windows     | Planned downtime required  | Zero-interruption maintenance    | Continuous service availability  |
| Recovery Operations     | Manual failover processes  | Automated detection and response | Sub-second recovery timeframes   |
| Capacity Planning       | Resource over-provisioning | Dynamic workload distribution    | Predictable utilization patterns |
| Transaction Routing     | Static configuration       | Intelligent path selection       | Latency-optimized processing     |
| Peak Load Handling      | Resource bottlenecks       | Distributed processing           | Scalable throughput management   |
| Geographic Distribution | Single-site dependency     | Multi-site active processing     | Risk diversification             |

## REVENUE GENERATION AND BUSINESS VALUE CREATION

### Premium Service Monetization

Active-active architecture allows commercial banks to provide guaranteed uptime service-level agreements higher than conventional availability measures of 99.5% up to premium levels of 99.99% availability, with brand equity studies proving that financial service providers who enjoy revenue premiums realize 8-12% higher pricing capability based on differentiated service quality, reliability warranties, and improved customer

experience that builds willingness-to-pay premiums among corporate customers who pay premium for sustained service delivery over cost savings (Ailawadi, K. L. *et al.*, 2003). Corporate treasury customers demanding on-going access to liquidity management, payment processing, and settlement services are high-value revenue streams under premium pricing models with extensive analysis indicating that brand equity in financial services translates into revenue premiums of 15-25% over competition pricing for the same volume of transactions while ensuring customer loyalty levels above 85% across enterprise banking

relationships with daily settlement volumes greater than \$25 million. The architecture facilitates differentiated tiers of service in which enterprise customers illustrate quantifiable willingness to pay increased fees for assured processing windows, and revenue premium analysis shows banks with better service reliability capturing 20-35% incremental per-client profitability on value-based pricing strategies that leverage brand equity established by consistent service delivery, proactive customer service, and assured transaction processing capabilities that remove operating risks from corporate treasury operations (Ailawadi, K. L. *et al.*, 2003).

Premium service models are advanced and involve performance-based pricing systems where revenue premiums are maintained through quantifiable service differentiation in the form of committed response times under 50 milliseconds for high-impact treasury operations, downtime-free processing commitments within scheduled maintenance windows, and express technical support that resolves system problems within 15-minute response intervals versus normal 2-4 hour resolution intervals for traditional banking operations. Revenue maximization via premium service monetization proves that active-active architecture banks can capture and maintain revenue premiums by establishing measurable value propositions that warrant increased pricing based on quantifiable business benefits such as minimized operational risk, enhanced predictability of cash flow, and settlement delay avoidance that can incur \$50,000-\$150,000 hourly losses for big corporate customers during system downtime that impacts treasury operations, foreign exchange transactions, and supply chain financing activities (Ailawadi, K. L. *et al.*, 2003).

### Digital Channel Growth

Continuous availability unlocks revenue streams from extended operating hours and global market participation, with API-driven business model transformation proving that financial services organizations adopting end-to-end digital integration strategies realize revenue growth of 35-55% through extended service delivery channels supporting 24/7 operations, real-time transaction

processing, and seamless integration with external business systems that collectively drive over 4.2 million additional API transactions a year per major enterprise client relationship (Heshmatisafa, S., & Seppänen, M. 2023). Real-time payment capabilities, cross-border settlement processing, and instant reconciliation functions generate transaction-based fee revenue through digital transformation efforts that utilize application programming interfaces to build new revenue streams, with high-performing API monetization strategies attaining average revenue per API call ranging from \$0.008 for mass-market data queries to \$2.50 for sophisticated transaction processing services while facilitating international commerce through integration functionality that processes more than 180,000 cross-border payment instructions per day that need immediate settlement confirmation and regulatory compliance verification across several jurisdictions.

API monetization models become feasible because outside systems can effectively integrate with perpetually accessible banking services via standardized digital interfaces that facilitate ecosystem partnership models, allowing banks to capture revenue from embedded finance opportunities in enterprise resource planning systems, supply chain management systems, and e-commerce marketplaces that need effortless financial service integration (Heshmatisafa, S., & Seppänen, M. 2023). API-based business models driving digital channel expansion allow banks to become part of platform economics that extend revenue streams beyond the usual transaction processing to encompass data monetization services, integration consulting charges, and white-label financial service licensing worth more than \$15 billion per annum in addressable revenue potential for banks that fully implement end-to-end digital transformation strategies that are based on continuous availability infrastructure supporting always-on API services, real-time data synchronization, and instant settlement functionality necessary for contemporary digital commerce ecosystems (Heshmatisafa, S., & Seppänen, M. 2023).

**Table 3.** Revenue Generation and Service Monetization Framework (Ailawadi, K. L. *et al.*, 2003; Heshmatisafa, S., & Seppänen, M. 2023)

| Revenue Stream Category | Service Components            | Client Segments            | Value Proposition               |
|-------------------------|-------------------------------|----------------------------|---------------------------------|
| Premium Service Tiers   | Guaranteed uptime commitments | Corporate treasury clients | Enhanced availability assurance |

|                          |                                |                              |                                  |
|--------------------------|--------------------------------|------------------------------|----------------------------------|
| Digital Channel Services | Extended operating hours       | Global market participants   | Continuous market access         |
| API Monetization         | External system integration    | Enterprise resource planning | Embedded finance capabilities    |
| Transaction Processing   | Real-time settlement services  | Cross-border commerce        | Instant reconciliation           |
| White-label Solutions    | Banking-as-a-Service offerings | Fintech partnerships         | Infrastructure service licensing |
| Performance Guarantees   | Priority transaction routing   | High-frequency trading       | Latency optimization commitments |

### Regulatory Compliance and Risk Management

Financial regulators more and more require operational resilience models that call for firms to be able to prove continuous service capacity in stress situations, with cyber complexity analysis showing financial services sector systems have interdependence behavior whereby single component failure can propagate through networks to impact between 15-20 interconnected subsystems, leaving institutions having to have operational resilience capabilities that can absorb concurrent failures of multiple system domains while performing daily transaction volumes in excess of 2.5 million operations without service decline throughout unfavorable cybersecurity incidents or infrastructure outages (Goldsmith, D., & Siegel, M. 2010). Active-active configurations offer compliance benefits via distributed processing that ensures service continuity in the event of site-level failures, allowing banks to meet regulatory requirements for business continuity that respond to cyber complexity issues in which conventional centralized infrastructure results in single points of failure susceptible to coordinated attacks, network intrusions, and system compromises that can impact overall organizational operations in 30-45 minutes of detecting initial breaches. Requirements of data residency in multiple jurisdictions become manageable with geographically dispersed active nodes that support local processing with global connectivity, where cyber complexity frameworks acknowledge that distributed architectures offer a greater security posture due to isolation features that eliminate the lateral movement of cyber threats across processing domains, confining potential attack surfaces to single sites and not enterprise-wide system exposure (Goldsmith, D., & Siegel, M. 2010).

Sophisticated regulatory compliance implementations utilize distributed architectures to meet stress testing demands imposed by banking supervisors who assess institutional strength by

way of thorough cyber complexity exercises such as advanced persistent threats that are capable of remaining undetected for 200-300 days while incrementally eroding system integrity, distributed denial-of-service attacks constituting traffic levels of over 500 gigabits per second capable of overwhelming conventional centralized processing infrastructure, and refined social engineering campaigns launched against multiple personnel spread across various operational domains in unison. Operational risk management models make it obligatory for banks to show knowledge of cyber complexity interdependencies that transcend internal systems, external service providers, and regulatory reporting networks, with active-active architectures delivering quantifiable resilience benefits through isolation features that confine security incidents within individual processing nodes while ensuring operational continuity over the rest of the infrastructure components (Goldsmith, D., & Siegel, M. 2010).

Risk management advantages include decreased operational risk exposure via removal of single points of failure, with cloud-based enterprise systems analysis showing distributed architectures in finance and healthcare realizing improved security posture through adoption of zero-trust security models, multi-factor authentication schemes, and encrypted data transmission standards that combined decrease successful cyber attack rates by 65-80% relative to traditional centralized processing environments while retaining transaction processing throughput in excess of 10,000 operations per second during periods of peak operations (Subramanyam, S. V. 2025). Increased disaster recovery features achieve regulatory recovery time targets by utilizing cloud-based infrastructure with automatic failover functionalities within 5-10 seconds, geographic redundancy across diverse availability zones with more than 500 kilometers distance between them, and data replication controls that provide below 30 seconds recovery point objectives for mission-

critical financial operations such as payment processing, account adjustments, and regulatory report submissions. Enhanced audit trail retention throughout distributed systems helps ensure regulatory compliance through immutable logging practices adopted in cloud computing environments that preserve chronological transaction order throughout numerous processing sites, with audit features providing forensic analysis requirements through extensive data retention for 10-year durations while upholding data privacy compliance across various regulatory

domains (Subramanyam, S. V. 2025). Stress testing is enhanced through cloud-based testing platforms supporting simulation of extreme conditions such as total data center outages, protracted cyber attacks on 40-60% processing infrastructure, and sophisticated attacks on multiple system components with a need to provide service availability of more than 99.8% throughout testing schedules lasting 96-120 hours to meet regulatory needs for validation of operational resilience (Subramanyam, S. V. 2025).

**Table 4.** Regulatory Compliance and Risk Management Advantages (Goldsmith, D., & Siegel, M. 2010; Subramanyam, S. V. 2025)

| Compliance Domain        | Regulatory Requirement                 | Active-Active Solution              | Risk Mitigation Benefit         |
|--------------------------|----------------------------------------|-------------------------------------|---------------------------------|
| Operational Resilience   | Continuous service demonstration       | Distributed processing capabilities | Stress scenario validation      |
| Data Residency           | Jurisdictional processing requirements | Geographically distributed nodes    | Local compliance maintenance    |
| Business Continuity      | Recovery time objectives               | Automatic failover mechanisms       | Service restoration assurance   |
| Audit Trail Preservation | Transaction history integrity          | Immutable logging across sites      | Forensic analysis support       |
| Cyber Security           | Attack surface minimization            | Isolated processing domains         | Lateral movement prevention     |
| Capital Requirements     | Operational risk reduction             | Single point of failure elimination | Regulatory capital optimization |

## CONCLUSION

Active-active architectural patterns are a core innovation in commercial banking infrastructure design, away from legacy failover-based models to real-time processing paradigms that remove operational exposures while generating great business value. Technical advancement needed for effective adoption includes multi-layered protocols for synchronization, smart transaction routing mechanisms, and distributed consensus algorithms that preserve data integrity across geographically spread-out processing sites. Operational advantages broaden beyond availability enhancements to include planned capacity management, improved performance optimization, and maintenance execution without service disruption. Capability for revenue generation appears in differentiated services based on guaranteed availability commitments that facilitate premium-priced models for corporate treasury customers while accommodating extended digital channel operations for transaction-based fee income capture from extended market engagement. Regulatory benefits are complete compliance with operational resilience

requirements, stronger stress testing capabilities, and better risk management frameworks that lower operational risk capital costs by means of measurable improvements in system reliability. The architecture shift allows financial institutions to break free from conventional infrastructure constraints, transforming high availability needs from operational overhead to competitive differentiation that fuels sustainable revenue expansion. Financial institutions with active-active architectures put themselves in a good position for digital transformation, regulatory compliance, and marketplace opportunities that require around-the-clock availability of services in global financial networks.

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