

Cloud Computing in Financial Technology: Applications and Challenges

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Abstract

In the rapid development of Financial Technology (FinTech), cloud computing technology has played a crucial role. This paper aims to explore the applications of cloud computing in the field of FinTech, including payment systems, banking operations, investment management, insurtech, and regulatory technology. At the same time, this paper will also analyze the challenges brought by these applications, such as data security and privacy protection, regulatory compliance, technological dependence and risk management, and technological integration and migration issues. Through an in-depth analysis of these challenges, this paper aims to propose effective solutions and best practices to promote the healthy development of cloud computing in FinTech. The importance of the research lies in the fact that with the continuous innovation of FinTech, cloud computing has become a key factor in driving the transformation of financial services, and understanding and addressing related challenges is crucial for ensuring the stability and security of the financial system. The structure of this paper will be unfolded according to the technical foundation of cloud computing, application cases, challenge analysis, solutions, and future trends, to provide a comprehensive perspective.

Keywords: cloud computing, financial technology, fintech, payment systems, banking operations, investment management, insurtech, regulatory technology, data security, privacy protection, regulatory compliance, technological dependence, risk management, technological integration, migration issues

1. Introduction

The rise of Financial Technology (FinTech) marks a significant transformation in the financial services industry. With the development of emerging technologies such as internet technology, big data, and artificial intelligence, FinTech has become an important force in driving financial innovation. Against this backdrop, cloud computing technology, with its advantages of elasticity, scalability, and cost-effectiveness, provides strong technical support for the development of FinTech. Cloud computing has not only changed the technical architecture of financial institutions but also promoted the emergence of new business models, such as mobile payments, online banking, and intelligent investment advisory services.

The development of cloud computing technology has had a profound impact on the financial industry. It enables financial institutions to launch new services more quickly, process large amounts of data more effectively, and improve business flexibility and efficiency. In addition, cloud computing also provides opportunities for FinTech startups to enter the market; they can quickly deploy applications through cloud services and reduce initial investment costs. However, the application of cloud computing has also brought a series of challenges, including data security, compliance issues, technological dependence, and migration difficulties, which require financial institutions and technology providers to face and solve together. (Armbrust, M., et al., 2010)

The purpose of this study is to deeply analyze the application of cloud computing in FinTech and explore how to effectively address related challenges. The problem statement will focus on how cloud computing changes the

way financial services are provided and the risks and challenges brought by these changes. The research scope will cover multiple application areas of cloud computing in FinTech and explore corresponding challenges and solutions. Through the discussion of these issues, this paper aims to provide valuable insights and suggestions for practitioners and decision-makers in the field of FinTech.

2. Foundations of FinTech and Cloud Computing

2.1 The Origin and Development of FinTech

The Origin and Development of FinTech: The term Financial Technology (FinTech) first emerged in the 1980s, and with the rapid development of information technology, FinTech began to gradually change the way financial services are provided. Initially, FinTech mainly focused on improving the efficiency and accessibility of financial services through technological means, such as Automated Teller Machines (ATMs) and electronic payment systems. Entering the 21st century, with the popularization of the internet and smartphones, FinTech entered a new stage of development, giving rise to innovative financial models such as mobile payments, online lending, crowdfunding, and blockchain. These innovations not only improved the convenience of financial services but also brought new participants and competitors to the financial industry.

Main Business Areas of FinTech: FinTech covers multiple areas of financial services, including but not limited to:

- **Payment and Transfer:** Mobile payments, online payment platforms, digital wallets, etc.
- **Personal Financial Management:** Personal financial analysis tools, budget management applications, etc.
- **Lending Services:** P2P lending platforms, online loan services, etc.
- **Investment and Wealth Management:** Online trading platforms, intelligent investment advisory services, robo-advisors, etc.
- **Insurtech:** Usage-based insurance (UBI), online insurance comparison and purchase platforms, etc.
- **Blockchain and Cryptocurrencies:** Cryptocurrencies such as Bitcoin, Ethereum, and blockchain-based financial services.
- **Regulatory Technology:** Using technology to improve compliance efficiency, such as Anti-Money Laundering (AML) and Know Your Customer (KYC) solutions.

2.2 Overview of Cloud Computing Technology

Definition of Cloud Computing: Cloud computing is a model for providing computing resources over the Internet, including servers, storage, databases, networks, software, analytics, and intelligence services. Users can access these resources on-demand without the need to directly manage the underlying hardware. (Armbrust, M., et al., 2010)

Models and Service Types of Cloud Computing:

- **Infrastructure as a Service (IaaS):** Provides virtualized computing resources, such as virtual machines, storage space, and network resources.
- **Platform as a Service (PaaS):** Provides a platform for application development and deployment, including database management and development tools.
- **Software as a Service (SaaS):** Delivers applications over the Internet, allowing users to use them directly without installation and maintenance.

Key Advantages and Features of Cloud Computing:

- **Scalability:** Quickly scale up or down resources according to business needs.
- **Cost-effectiveness:** Pay for what you use, reducing upfront investment.
- **Flexibility:** Access services anytime, anywhere, improving work efficiency.
- **Reliability:** Cloud service providers are responsible for maintenance and upgrades, ensuring the stability and security of services.
- **Data sharing and collaboration:** Facilitates data sharing and team collaboration.

2.3 The Integration of FinTech and Cloud Computing

How Cloud Computing Supports FinTech Innovation: Cloud computing provides a flexible and scalable platform for FinTech, making financial innovation possible. Financial institutions can use cloud computing to quickly deploy new services, such as online banking platforms, mobile payment systems, and intelligent investment advisory services. Additionally, the elasticity and scalability of cloud computing also enable financial

institutions to cope with market fluctuations and business growth. Cloud computing also offers powerful data analysis and processing capabilities, which are crucial for big data analysis, risk management, and fraud detection in FinTech.

Demand for Cloud Computing in FinTech: The demand for cloud computing in FinTech is mainly reflected in the following aspects:

- **High-performance computing:** Financial transactions and analysis require high-performance computing capabilities.
- **Data storage and processing:** FinTech needs to process and store large amounts of transaction data and user information.
- **Security:** The sensitivity of financial data requires cloud computing to provide strong security guarantees.
- **Compliance:** FinTech needs to comply with strict financial regulations and compliance requirements.
- **Global coverage:** The globalization of financial services requires cloud computing services to have a wide geographical coverage.

By combining cloud computing technology and the needs of FinTech, financial institutions can provide more efficient, secure, and convenient services, and also develop new business models and revenue sources. However, this integration also brings new challenges that require the joint efforts of financial institutions and technology providers to ensure the effective and secure application of cloud computing in FinTech.

3. Case Study Analysis of Cloud Computing in FinTech

3.1 Payment Systems

Mobile and Online Payment Solutions: In the payment sector, cloud computing provides a scalable platform that enables payment services to process a large volume of transactions quickly while maintaining system stability and security. Mobile payment solutions, such as Alipay and WeChat Pay, leverage the elastic computing resources of cloud computing to achieve high-frequency, high-concurrency payment processing capabilities. These platforms can also store and process vast amounts of user transaction data, supporting user profiling and risk control. (Buyya, R., et al., 2009)

Case Study: Alipay, WeChat Pay, etc. Alipay and WeChat Pay are two giants in China's mobile payment market, both of which rely on cloud computing to support their massive user base and transaction volume. Alipay uses the big data processing capabilities provided by cloud computing to implement real-time transaction monitoring and risk control. WeChat Pay, through the cloud computing platform, offers users convenient social payment and lifestyle service payment functions. The success of these payment platforms demonstrates the key role of cloud computing in payment systems, including processing capacity, data security, and user experience.

3.2 Banking Services

Cloud Banking Services and Product Innovation: The application of cloud computing in banking services has propelled the digital transformation of banking services. Cloud banking services, such as online banking and direct banking, achieve 24/7 service capabilities through the flexible and scalable IT resources provided by cloud computing. These services enable customers to access bank accounts anytime, anywhere, and perform operations such as transfers, payments, and investments.

Case Study: Online Banking, Direct Banking, etc. Online banking services, such as HSBC Online Banking, utilize cloud computing platforms to provide customers with secure online banking services. Users can manage accounts, make transfers, and payments through websites or mobile applications. Direct banks, like Simple Bank, operate entirely on cloud platforms, offering a clean user interface and intuitive banking services without the need for physical branches. These cases show that cloud computing enables banks to provide a broader range of services at a lower cost while improving operational efficiency and customer satisfaction.

3.3 Investment Management

Application of Cloud Platforms in Asset Management and Investment Analysis: In the field of investment management, cloud computing provides powerful data processing and analysis capabilities, allowing asset management companies and investment advisors to quickly analyze market trends and formulate investment strategies. Cloud platforms can also store large amounts of historical and real-time data, supporting investment decision-making.

Case Study: Robo-Advisory Services Robo-advisory services, such as Wealthfront and Betterment, use machine learning and big data analysis tools provided by cloud computing platforms to offer personalized investment advice and asset management services to customers. These services analyze customers' financial conditions and

investment objectives to automatically adjust investment portfolios to achieve the best investment returns. The success of robo-advisory demonstrates the application potential of cloud computing in investment management, especially in improving investment efficiency and reducing costs.

3.4 Insurtech

Application of Cloud Computing in Insurance Product Design and Risk Assessment: In the field of insurtech, cloud computing enables insurance companies to develop new insurance products, such as Usage-Based Insurance (UBI) for car insurance, and provide more accurate risk assessments. The big data processing capabilities of cloud computing platforms allow insurance companies to analyze a large amount of user behavior data, thereby designing insurance products that better meet customer needs.

Case Study: UBI Car Insurance, Health Insurance, etc. UBI car insurance prices based on the driver's driving habits and mileage, relying on cloud computing platforms to collect and analyze real-time vehicle data. In the health insurance sector, companies like Oscar Health use cloud computing platforms to analyze users' health data and provide personalized health insurance plans. These cases showcase the application of cloud computing in insurance product design and risk assessment, enhancing the personalization and precision of insurance services. (Buyya, R., et al., 2009)

3.5 Regulatory Technology

Application of Cloud Computing in Compliance Checks and Reporting: Regulatory technology (RegTech) uses cloud computing technology to improve the compliance efficiency of financial institutions. Cloud computing platforms can store and process large amounts of compliance data, automate compliance processes, reduce manual intervention, and lower compliance costs.

Case Study: Anti-Money Laundering (AML) and Know Your Customer (KYC) Anti-Money Laundering (AML) and Know Your Customer (KYC) are two important areas of financial regulation. Cloud computing platforms, such as Thomson Reuters World-Check, provide compliance check services, helping financial institutions identify and report suspicious transactions while automating customer identity verification processes. These services leverage the elasticity and scalability of cloud computing to process large amounts of compliance data, improving the efficiency and accuracy of compliance checks. These cases indicate that the application of cloud computing in regulatory technology not only improves compliance efficiency but also strengthens financial security.

4. Challenges Brought by Cloud Computing

4.1 Data Security and Privacy Protection

Data Breach Risks and Privacy Violation Issues: In cloud computing environments, the risks of data breaches and privacy violations are significantly increased. Sensitive data stored by financial institutions in the cloud, such as personal customer information and transaction records, may become targets of cyber attacks. For instance, in the 2018 SingHealth data breach, personal data and clinical information of 1.5 million patients were illegally accessed and copied. Such incidents not only lead to substantial economic losses for financial institutions but may also damage their reputation and customer trust. (European Union, 2016)

To address these risks, financial institutions need to take a series of measures, including but not limited to:

- Implementing end-to-end data encryption to ensure the security of data during transmission and storage.
- Adopting strict access control and authentication mechanisms, such as Multi-Factor Authentication (MFA).
- Regularly conducting security audits and penetration tests to identify and remediate security vulnerabilities.

Cloud Computing Security Frameworks and Compliance Standards: Financial institutions need to adhere to a range of cloud computing security frameworks and compliance standards, such as ISO 27001, PCI DSS, and GDPR. These standards provide guidelines for data protection, security controls, and privacy compliance. For example, financial institutions can adopt the Cloud Security Alliance (CSA) Cloud Controls Matrix, which offers a comprehensive set of security controls to help organizations assess and manage security risks in cloud computing environments.

4.2 Regulatory Compliance

Legal and Regulatory Challenges of Cloud Computing Services: The transnational nature of cloud computing services presents challenges for laws and regulations. Different countries and regions have varying legal requirements for data storage, processing, and transmission, and financial institutions must ensure that their cloud computing services comply with the regulations of all relevant jurisdictions. For example, the EU's GDPR requires that the processing of personal data must follow the rights of data subjects, such as the right of access

and the right to erasure, and institutions that violate GDPR may face heavy fines.

To meet these challenges, financial institutions can take the following measures:

- Establish a cross-departmental compliance team responsible for monitoring changes in the global regulatory environment and ensuring the compliance of cloud computing services.
- Collaborate with legal advisors to conduct compliance assessments and risk assessments of cloud computing services.

Compliance Issues with Cross-National Data Storage and Processing: Cross-national data storage and processing involve issues of data sovereignty and privacy protection. Financial institutions need to ensure that their cloud service providers comply with data localization requirements, such as storing the data of EU citizens within the EU. In addition, financial institutions also need to consider the compliance of data cross-border transfers, such as the EU-US Privacy Shield.

4.3 Technological Dependence and Risk Management

Dependency on Cloud Service Providers: The dependency of financial institutions on cloud service providers may lead to single-point-of-failure risks. If a cloud service provider experiences a service disruption, financial institutions may be unable to access their critical systems and data, thereby affecting business operations. For example, the 2017 Amazon S3 service disruption paralyzed many websites and services that relied on it. (European Union, 2016)

To reduce this dependency, financial institutions can:

- Choose multiple cloud service providers to implement a multi-cloud strategy.
- Establish disaster recovery plans and backup systems to ensure rapid service recovery in case of problems with cloud service providers.

Risk Management Strategies in Cloud Computing Environments: Financial institutions need to develop comprehensive risk management strategies in cloud computing environments, including identifying, assessing, and mitigating risks. This includes:

- Regularly conducting risk assessments to identify potential risks in cloud computing environments.
- Formulating risk mitigation measures, such as data backups, system redundancy, and security monitoring.
- Establishing emergency response plans to deal with security incidents in cloud computing environments.

4.4 Technological Integration and Migration Challenges

Migration of Traditional Financial Systems to Cloud Platforms: Migrating traditional financial systems to cloud platforms is a complex process involving changes in technology, personnel, and processes. Financial institutions need to assess the cloud compatibility of existing systems, plan migration strategies, and ensure the integrity and consistency of data. For example, financial institutions may need to refactor existing applications to adapt to cloud computing architectures. (Armbrust, M., et al., 2010)

To successfully complete the migration, financial institutions can:

- Adopt a phased migration strategy, first migrating non-core systems, and then gradually migrating core systems.
- Collaborate with professional cloud service providers to obtain migration support and consulting services.

Integration of Cloud Computing with Traditional IT Architectures: The integration of cloud computing with traditional IT architectures involves the unification of technical interfaces, data formats, and business processes. Financial institutions need to ensure seamless integration between cloud computing services and traditional IT systems to achieve smooth transmission of data and business processes. For example, financial institutions may need to develop adapter layers to connect cloud computing services and traditional IT systems.

To achieve effective integration, financial institutions can:

- Adopt standardized data formats and interfaces to facilitate integration between different systems.
- Establish cross-departmental collaboration mechanisms to coordinate the integration of cloud computing with traditional IT architectures.

By deeply analyzing the challenges brought by cloud computing and taking corresponding measures, financial institutions can ensure the robust application of cloud computing technology while minimizing associated risks.

5. Solutions and Best Practices

5.1 Strengthening Data Security and Privacy Protection

Adopting Advanced Encryption Technologies and Access Controls: In the field of FinTech, data security and privacy protection are of paramount importance. Data security in cloud computing environments can be achieved by employing end-to-end encryption technologies, which means that data is encrypted during both transmission and storage. For instance, cloud service providers like AWS and Azure offer a variety of encryption services, including static data encryption and data-in-transit encryption. Additionally, financial institutions should implement strict access control policies, such as Multi-Factor Authentication (MFA) and the principle of least privilege, ensuring that only authorized personnel can access sensitive data. (European Union, 2016)

Establishing Best Practices for Data Privacy Protection: Financial institutions should establish a comprehensive set of data privacy protection policies and procedures, including data classification, data usage policies, and user consent management. These policies should comply with international data protection regulations such as GDPR and CCPA. For example, financial institutions can use Privacy Impact Assessments (PIA) to evaluate the impact of new services or products on user privacy and adjust product design accordingly. At the same time, financial institutions should regularly provide data privacy training to employees to raise their awareness of privacy protection.

5.2 Addressing Regulatory Compliance Challenges

Establishing a Cloud Computing Compliance Framework: To address regulatory compliance challenges, financial institutions need to establish a cloud computing compliance framework that includes compliance requirements for cloud service providers, compliance standards for data storage and processing, and continuous monitoring of the use of cloud services. For example, financial institutions can require cloud service providers to comply with compliance standards such as PCI DSS and SOC 2 and conduct regular compliance audits.

Cross-Border Cooperation and Regulatory Coordination: As FinTech services often span national borders, cross-border cooperation and regulatory coordination become particularly important. Financial institutions can collaborate with regulatory authorities to jointly develop compliance standards and regulatory frameworks for cross-border cloud computing services. For instance, the EU-US Privacy Shield was established to protect privacy in transatlantic data flows. Financial institutions should actively participate in these collaborations to ensure that their cloud computing services meet the regulatory requirements of various countries.

5.3 Risk Management and Business Continuity

Setting Cloud Service Provider Selection Criteria: When choosing cloud service providers, financial institutions should establish strict selection criteria, including the availability, performance, security, and compliance of the services. These criteria can help financial institutions evaluate and select the most suitable cloud service providers for their business needs. For example, financial institutions can require cloud service providers to offer Service Level Agreements (SLAs) that specify service availability and performance metrics. (Barberis, J., 2018)

Establishing Business Continuity Plans and Disaster Recovery Strategies: Financial institutions should establish Business Continuity Plans (BCP) and Disaster Recovery (DR) strategies to address potential system failures and disaster events. These plans should include key steps such as data backups, system recovery, and business process resumption, and be regularly tested and updated. For example, financial institutions can leverage the multi-region deployment capabilities of cloud service providers to achieve geographically distributed backups of data and applications, enhancing system resilience.

5.4 Technological Integration and Smooth Migration

Adopting Microservices Architecture and Container Technology: To achieve smooth technological integration and migration, financial institutions can adopt microservices architecture and container technology. Microservices architecture breaks down complex applications into a series of independent services, each of which can be deployed and scaled independently. Container technology, such as Docker and Kubernetes, provides a consistent runtime environment, simplifying the deployment and management of applications. These technologies can help financial institutions quickly migrate existing applications to cloud platforms and achieve technological modernization.

Developing Cloud Migration Strategies and Project Management Plans: Financial institutions should develop detailed cloud migration strategies and project management plans to ensure the smooth progress of cloud migration. These plans should include key elements such as the scope, objectives, timeline, resource allocation, and risk management of the migration. For example, financial institutions can adopt a phased migration strategy, first migrating non-core systems, and then gradually migrating core systems. At the same time, financial institutions should establish a Project Management Office (PMO) responsible for coordinating and managing the entire migration process, ensuring the project is completed on time and within budget.

By implementing the above solutions and best practices, financial institutions can effectively address the challenges brought by the application of cloud computing in FinTech, ensuring the healthy development and secure application of cloud computing technology.

6. Future Trends and Outlook

6.1 Development Trends of Cloud Computing Technology

The Rise of Edge Computing and Distributed Cloud: With the proliferation of IoT devices and the development of 5G technology, edge computing is emerging as a new computing paradigm that complements cloud computing. Edge computing processes data near the source of the data, reducing latency and increasing response speed, which is particularly important for financial services that require real-time processing, such as high-frequency trading and real-time payment systems. Distributed cloud extends cloud services to different geographic locations, including edge nodes, providing users with computing power closer to the data source. Financial institutions can leverage edge computing and distributed cloud to provide faster and more reliable services while reducing costs. (Barberis, J., 2018)

Integration of Cloud Computing with Artificial Intelligence and Big Data: Cloud computing platforms are becoming the center for the application of artificial intelligence (AI) and big data technologies. Cloud service providers offer a range of AI services and tools, such as machine learning platforms and natural language processing services, making it easier for financial institutions to develop and deploy AI applications. At the same time, the elasticity and scalability of cloud computing provide strong support for big data analysis. Financial institutions can use cloud computing platforms to store and process large amounts of data, conducting in-depth data analysis and mining to discover new business opportunities and risk points.

6.2 The Future Development of FinTech

Innovative Directions and Potential Impacts of FinTech: The future development of FinTech will continue to focus on improving the accessibility, convenience, and security of financial services. Innovation directions include but are not limited to:

Decentralized Finance (DeFi): Utilizing blockchain technology to provide decentralized financial services, such as decentralized lending and trading.

Central Bank Digital Currencies (CBDCs): Digital currencies issued by central banks may change the circulation of money and the implementation of monetary policy.

Open Banking: By opening APIs, allowing third-party developers to access bank data, creating new financial products and services.

These innovations will have a profound impact on market structure, regulatory environment, and consumer behavior in the financial market.

New Opportunities for FinTech with Cloud Computing: Cloud computing will continue to provide new development opportunities for FinTech. Financial institutions can quickly deploy new services through cloud computing platforms, achieving agility and flexibility in business. At the same time, the global coverage of cloud computing enables financial institutions to more easily enter new markets and provide cross-border financial services. In addition, the security and compliance of cloud computing are also continuously improving, providing a solid foundation for FinTech.

6.3 FinTech Innovations Integrated with Cloud Computing

Predicting Future FinTech Application Scenarios: FinTech innovations integrated with cloud computing will create a variety of application scenarios in the future, such as:

Smart Contract Automation of Insurance Claims: Using cloud computing and blockchain technology, smart contracts can automatically handle insurance claims, improving efficiency and transparency.

Personalized Wealth Management: Financial institutions can provide personalized wealth management advice to customers through AI services on cloud computing platforms.

Real-time Risk Management: Financial institutions can use cloud computing to monitor market dynamics in real-time and respond quickly to risk events.

Long-term Potential of Cloud Computing in FinTech: The long-term potential of cloud computing in FinTech is reflected in the following aspects:

Cost-effectiveness: The pay-as-you-go model of cloud computing helps financial institutions reduce IT costs and improve resource utilization.

Innovation Accelerator: Cloud computing platforms provide a wealth of development tools and APIs, accelerating the realization of FinTech innovations.

Global Competitiveness: The global coverage of cloud computing helps financial institutions enhance their global competitiveness and expand into international markets.

Data-driven Decision-making: The big data analysis capabilities supported by cloud computing provide data-driven decision support for financial institutions.

As technology continues to advance and market environments change, cloud computing will continue to play a key role in the field of FinTech, driving innovation and development in financial services. Financial institutions need to keep up with technology trends, seize the opportunities brought by cloud computing, and also address the challenges it brings.

7. Conclusion

This paper has comprehensively explored the application of cloud computing technology in the field of FinTech and the challenges it brings, revealing how cloud computing has profoundly affected the way financial services are provided and analyzing the main issues financial institutions face when adopting cloud computing.

Application of Cloud Computing in FinTech: Cloud computing technology has brought significant changes to FinTech. It not only improves the efficiency and scalability of financial services but also promotes the innovation of new business models, such as mobile payments, online banking, and intelligent investment advisory services. The elasticity and scalability of cloud computing enable financial institutions to quickly respond to market changes while reducing operational costs. In addition, the big data processing and analysis capabilities of cloud computing platforms provide strong support for financial decision-making.

Challenges Brought by Cloud Computing: Despite the many benefits of cloud computing, it also brings a series of challenges, especially in the areas of data security and privacy protection, regulatory compliance, technological dependence and risk management, and technological integration and migration. Financial institutions must ensure that their cloud computing strategies comply with international and regional compliance standards while establishing effective risk management measures to address potential technological risks.

Practical Significance and Future Impact of the Study: The practical significance of this study lies in providing financial institutions with a comprehensive perspective on the application of cloud computing in FinTech, helping them understand the potential value and risks of cloud computing. The impact on the future is that financial institutions can develop more effective cloud computing strategies based on these insights to maintain competitiveness and ensure sustainable business development.

Future Research Directions: Future research can further explore the following directions:

- The application of cloud computing in specific financial fields, such as the deep integration of blockchain technology in payment systems.
- The development of data security and privacy protection technologies in cloud computing environments, especially with the emergence of new technologies like quantum computing.
- Coordination mechanisms for cross-national financial regulation and how cloud computing can achieve compliance across different jurisdictions.

Ethical issues of cloud computing technology in FinTech, such as algorithmic bias and accountability for automated decision-making.

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