ORACLE

Oracle Exadata Cloud@Customer for Banking

Modernizing data management by delivering on-premises Database Cloud for critical banking environments

PURPOSE STATEMENT

This document describes how Oracle Exadata Cloud@Customer can modernize on-premises database infrastructure for banks, reducing costs, simplifying operations, and improving productivity, while also addressing the rigorous scalability, availability, reliability, performance, and security requirements of the banking industry. This document is jointly authored by experts from Oracle's Financial Services Industry group and Oracle Exadata Product Management team, leveraging multiple years of combined experience with modernization efforts in the banking industry.

INTENDED AUDIENCE

Chief Data Officers (CDOs) and data architects for banking applications, database architects, cloud architects, and database professionals interested in modernizing banking data management environments.

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Due to the nature of the product architecture, it may not be possible to safely include all features described in this document without risking significant destabilization of the code.

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INTRODUCTION

Banks are custodians of the most valuable resource of the digital economy: customer financial data. Modern banks not only provide high performance, high availability, and high security access to this data but also improve customer experience by garnering insights from this data. To benefit from the full potential of its data, a modern bank must be able to combine customer, financial, operational, and third-party data on a centrally managed and auditable data platform. Having a common data source reduces operational and compliance costs and improves data management to better serve real-time banking transactions. Centralized data management enables development of new business logic, improving time to value for innovations with analytics, machine learning, and artificial intelligence. Combining data and intelligence presents game-changing opportunities for banks but it also requires attention to cyberthreats and adherence to regulations.

Oracle can remove barriers to modernizing critical banking infrastructure while simultaneously removing risks to the most critical data management environments. This technical brief discusses contemporary data management trends and typical pain points in banking, which can be addressed by using Oracle Exadata Cloud@Customer. Just as data is critical to banking, Exadata is critical to data management, and the combination of the two in a cloud automation context is a powerful enabler for modernizing data management in the banking industry.

ORACLE EXADATA AND BANKING

Oracle Exadata has become a gold standard for database infrastructure within heavily regulated, mission critical banking environments. With advanced security and availability features, Exadata has been helping banks meet the most stringent regulatory mandates as well as the most demanding performance requirements for both analytical and transactional workloads. Common workloads span OLTP (including payments, credit card processing, core banking, online banking), and massive OLAP (including customer behavior, financial management, risk reporting, and compliance). Today, most of the world's largest financial institutions are using Exadata to run hundreds of applications including their most critical ones.

Now, with Exadata Cloud products—Exadata Cloud@Customer in the data center, and Exadata Cloud Service in the public cloud — Oracle has brought these traditional Exadata benefits to cloud infrastructure. In addition, Oracle Autonomous Database[1], which is an option available on both Exadata Cloud@Customer and Exadata Cloud Service, completely automates all database and infrastructure management with built-in self-driving capabilities. Oracle's Exadata Cloud portfolio provides banking sector customers a continuum to work with as they deploy new database services and move toward cloud infrastructure. Particularly, Exadata Cloud@Customer is an attractive option for modernization for banks since it enables agile cloud deployment and a pay-per-use model while keeping all data on-premises. Some of the worlds' top banks[2] already rely on Exadata Cloud@Customer to modernize data management without adding new risks to the most crucial banking systems.

BANKING DATA MANAGEMENT AND MODERNIZATION CHALLENGES

PRESENT STATE AND EVOLVING REQUIREMENTS

A key challenge to modernizing banking systems involves balancing near-term compatibility and continuity of operations with evolving technology and business needs. While a bank embarks on modernization efforts, care must be taken to continue supporting key applications without injecting excessive risks.

Another unique aspect of data management systems deployed in banks is that they are typically highly isolated from one another. Security and risk mitigation requirements have traditionally driven this isolation, along with historical factors like M&A activities. Organizational factors also encourage a segregated model, with newer analytical systems making different technology selections than long-standing operational systems, such as core banking systems. New systems often create their own data repositories, requiring extensive ETL between diverse systems to use the data.

With growth in business, keeping up with all this data transformation is an ongoing challenge.
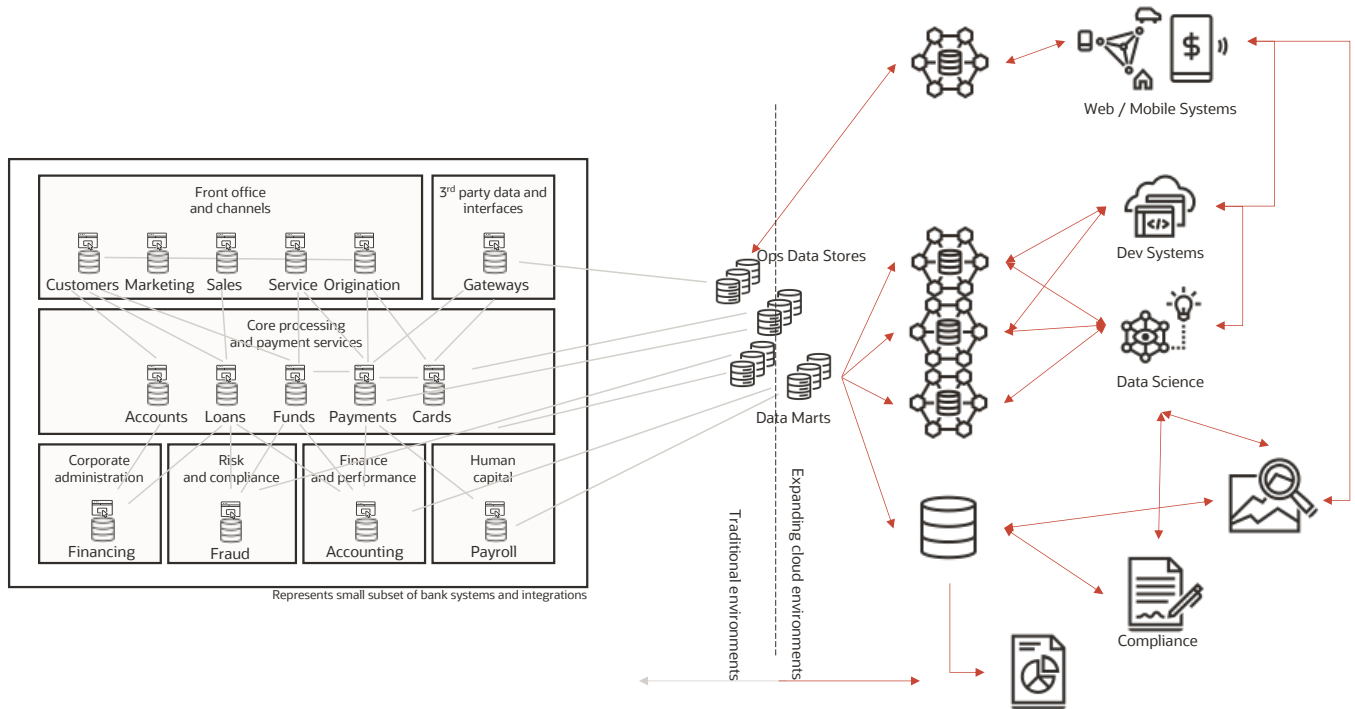

Figure 1: Present state of a typical bank's data management architecture.

In addition, with regulators and consumers continuing to drive increasing requirements for continuous, near-real-time access to data, and organizations seeking to make critical decisions based on up-to-the-minute data, the level of effort required to transform and unify disparate data sources may increase significantly.

To summarize, as banks consider modernization initiatives, they must pay special attention to ensure that they choose solutions that have minimal disruptions on existing systems while they also pursue initiatives to reduce data silos.

IDEAL FUTURE STATE

As banks increasingly turn to the cloud to modernize their IT models and better address changing customer requirements, traditional boundaries between isolated workloads will become increasingly blurred over time due to trends discussed previously. While core banking operations need to be processed with appropriate SLAs in place, it is equally important to fulfill security and regulatory compliance, risk analysis, and other monitoring requirements in a timely fashion. Additionally, customer expectations and regulatory mandates drive near-real-time analytics initiatives, which in turn drive adoption of agile cloud infrastructure models and automation. The consumption of cloud services by developers and data scientists with increasing adoption of a microservices framework will continue to drive needs for streamlined data management throughout the banking industry.
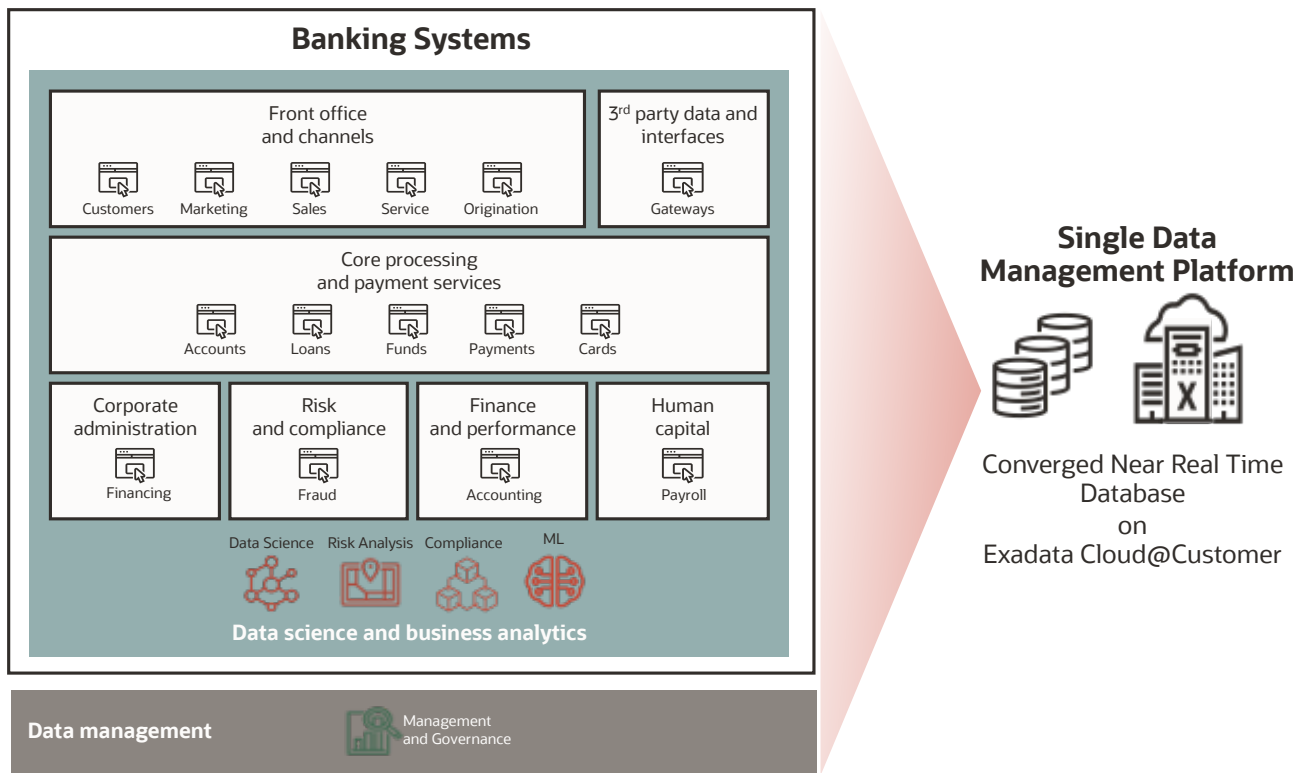
Figure 2: Optimized future state reduces sprawl from the data management architecture.

Combining many of the currently single-purpose data management systems into a unified platform can avail many benefits, including:

- Near-real-time, synchronized analytics
- Centralized governance
- Consistent security implementation
- Ensured compliance
- Reduced duplication of data
- Immediate, continuous payments
- Reduced or eliminated capital expenses
- Operational and organizational efficiencies
- Improved productivity and customer experience

EXADATA CLOUD@CUSTOMER AS A CATALYST FOR MODERNIZATION

Many Database-as-a-Service (DBaaS) platforms are available in the market that can help modernize data management. The advantage of Exadata Cloud@Customer is that it is also suitable for privacy, security, and regulatory compliance within the banking sector in addition to delivering modern DBaaS. It overcomes key challenges to modernizing banking data management infrastructure, reducing risk even as it modernizes data management. The following sections provide further details.

ENHANCED BUSINESS AGILITY WITH CLOUD ON-PREMISES
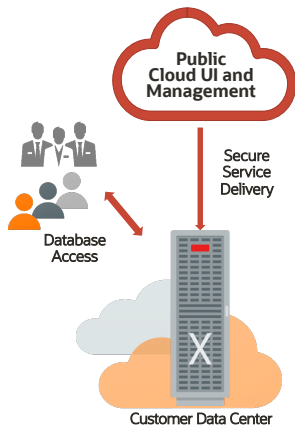
One foundational benefit of Exadata Cloud@Customer is that data physically resides in the customer's data centers, avoiding data sovereignty concerns while maintaining low latency to existing on-premises systems. In addition, the underlying infrastructure is managed by Oracle, so specialized skillsets for managing the Exadata infrastructure are not necessary. Database administration is simplified because users login to the Oracle Cloud Infrastructure console, or can use a rich API library, both of which enable automation without having to deal with specialized, low-level infrastructure tasks. Customers get the performance benefits of Exadata with Oracle alleviating the learning curve associated with implementing and managing it.

See the Exadata Cloud@Customer Data Sheet[3] for further details of its architecture.

Figure 3: The architecture of Exadata Cloud@Customer provides the best of both cloud and on-premises characteristics for highly regulated organizations.
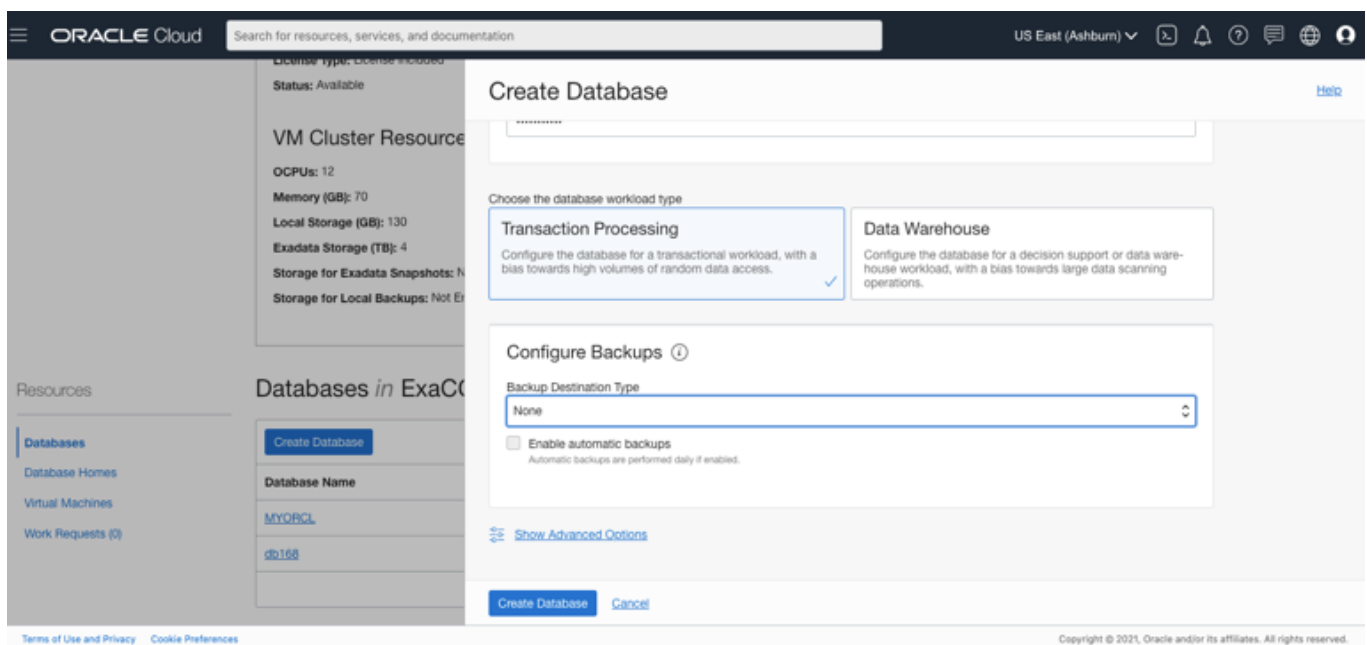
Figure 4: Routine tasks such as creating new databases are completed quickly and easily with cloud automation.

Exadata Cloud@Customer provides a pure cloud consumption model in an OPEX-based subscription service. Oracle installs and maintains all hardware in your data center, including Exadata infrastructure patching, on your behalf. The simple fee structure varies with usage, much like what you would expect in a public cloud service, even though data remains on-premises. This allows banks to focus resources on strategic data management projects and keep up with emerging regulatory requirements while also facilitating data management for modern DevOps environments, data science initiatives, and other strategic projects. Also, the high degree of compatibility between Exadata Cloud@Customer and Exadata Cloud Service simplifies a full transition to the public cloud from Exadata Cloud@Customer, when and if that time comes. Exadata Cloud@Customer facilitates an immediate start on the path to cloud with minimal disruption to ongoing operations.

AUTONOMOUS DATABASE FOR MAXIMUM MODERNIZATION

As new applications are developed and existing applications overhauled, increasingly hands-off maintenance paradigms need to be employed as banks strive towards efficiency and agility goals. Autonomous Database[4] is Oracle's strategic cloud database solution, built on a suite of self-driving, self-securing, and self-repairing capabilities. It uses machine learning and automation to eliminate human labor, human error, and manual tuning, thereby reducing cost and complexity while ensuring higher reliability, security, and operational efficiency. Autonomous Database is available with Exadata Cloud@Customer as

the underlying infrastructure. It is the ideal database deployment option for banks that are seeking modernization without the costs and complexities associated with routine maintenance activities, while leveraging the performance, security, and high availability characteristics for which Exadata is well known.

PRIVACY, SECURITY, AND COMPLIANCE

CLOUD SECURITY

Regulation is top-of-mind for anyone involved in banking data management. All regulations and guidelines, such as the European Union's GDPR, the FFIEC in the US, the Australian Prudential Regulation Authority, the Monetary Authority of Singapore, and many more, cover a broad set of aspects regarding the business of banking. Data privacy and data sovereignty are always important requirements. A major concern for many banks is how to meet the large variety of regulations from global, national, regional, and state jurisdictions. Important judicial rulings such as the Schrems II case have further heightened banks' vigilance for data privacy. Great security is the basis for strong compliance.

Exadata Cloud@Customer was built from the ground up to help with privacy, security, and compliance requirements. Oracle Cloud Infrastructure (OCI) provides a public cloud-based control plane featuring a convenient console and modern REST API. OCI also offers many unique advantages from a cloud security perspective. For example:
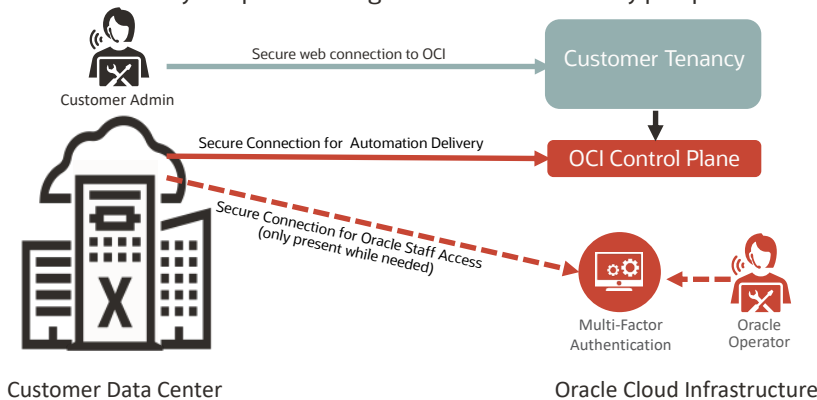
- The use of compartments[5] facilitates hierarchical management of users and access to resources within an OCI tenancy
- Robust network isolation, as described in Oracle Cloud Infrastructure Security Architecture[6]
- Special security features and safeguards related to hybrid cloud product model, discussed in Oracle Gen 2 Exadata Cloud@Customer Security Controls[7]

Figure 5: High security approach for control plane and operator access.

OPERATOR ACCESS CONTROL

Despite the benefits of cloud computing, banks often need special security safeguards for cloud operator access to ensure compliance with regulations and policies. Operationally, a goal of Exadata Cloud@Customer is to avoid human operator intervention into customer systems as much as possible. Software updates and other maintenance activities are highly automated. However, whenever operations cannot be completely automated or if problems arise, Oracle operators can get involved with appropriate security protections and customer authorization in place. Exadata Cloud@Customer uniquely provides advanced operator access control features built with banking use cases in mind. Operator Access Control[8] gives customers fine-grained access controls over necessary operator activities. Access for Oracle operators can be approved by customers on an on-demand basis or pre-approved to a specified level based upon customer policies. This allows Oracle Cloud Operators to do only the sets of actions that a customer has explicitly allowed without seeking further permissions.
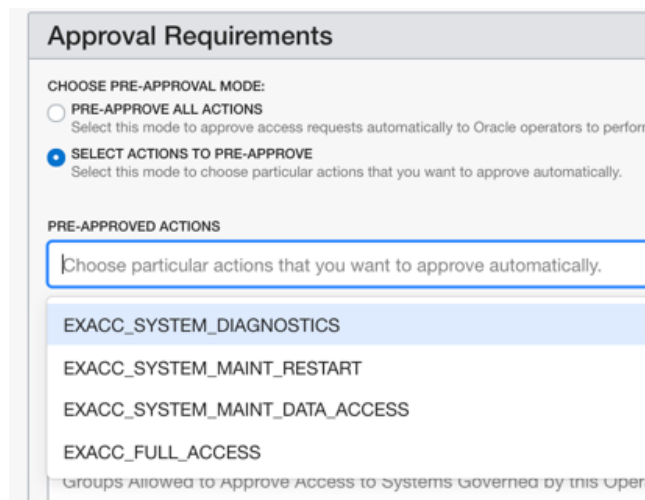
Figure 6: Customers can implement fine-grained approval policies that control access by Oracle Cloud Operators.

Monitoring and auditing features make every Oracle Cloud Operator command entry visible to customers and logged for auditing purposes. Also, the customer can completely terminate the operator session in real-time, if needed.

ORACLE DATABASE SECURITY

Of course, the core Oracle Database security features are just as important as those mentioned earlier for the cloud. Exadata Cloud@Customer incorporates and expands the security features of Oracle Database. Customers can benefit from features such as Transparent Data Encyption, Data Masking, Database Vault, and others that are available with Oracle Database. Transparent Data Encryption, for example, is enabled by default. At the Database level, customers can manage security themselves to reduce data exposure risk to any outside party. Oracle Database provides a robust, trusted data management security toolset at the data plane.
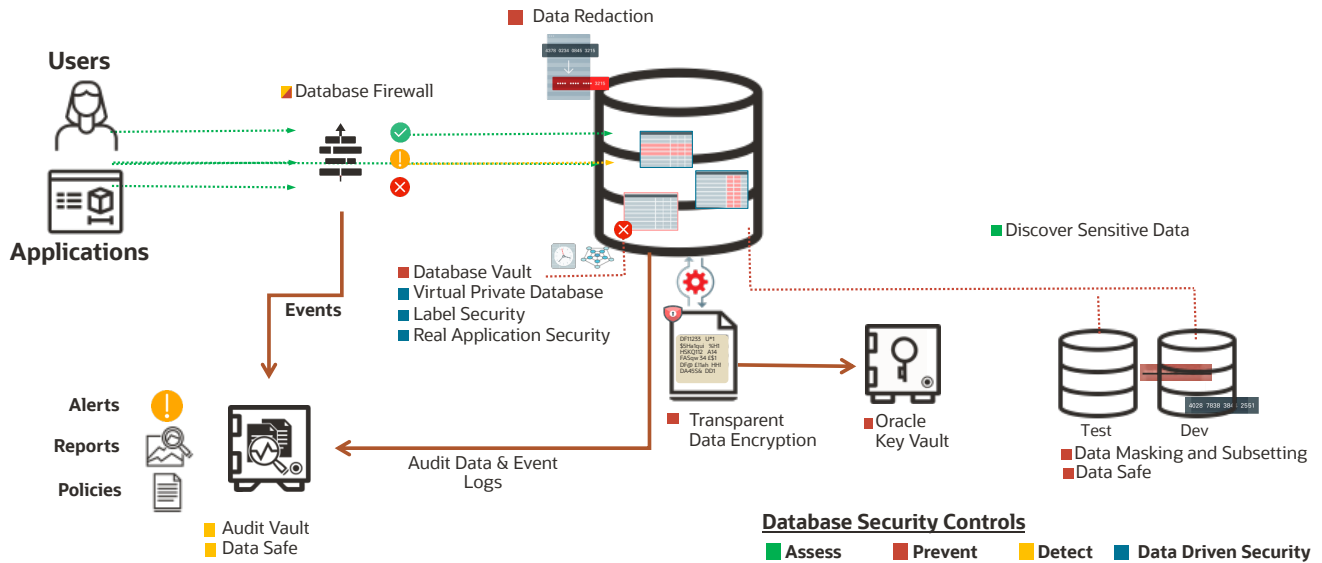

Figure 7: Oracle Database has a comprehensive set of security features that are relied upon within the banking industry.

CONVERGED DATA MANAGEMENT AND DATABASE CONSOLIDATION IMPROVEMENTS

One distinct difference between Oracle Database and other data management solutions is Oracle's converged database approach supporting multiple data models, data types, and workloads with one unified data platform. In contrast, other database cloud providers often advocate different, specialized data management systems for each specific data type or use case. However, as banks drive toward real-time fraud detection and analytics, the proliferation of specialized systems required by other cloud providers leads to isolated data silos, which require time-consuming (and costly) data extraction and manipulation, and impede real-time data processing. The benefits of a centralized, consolidated, live data set that supports multiple use cases, as enabled by Oracle Database on Exadata Cloud@Customer, are becoming clear. Benefits include:
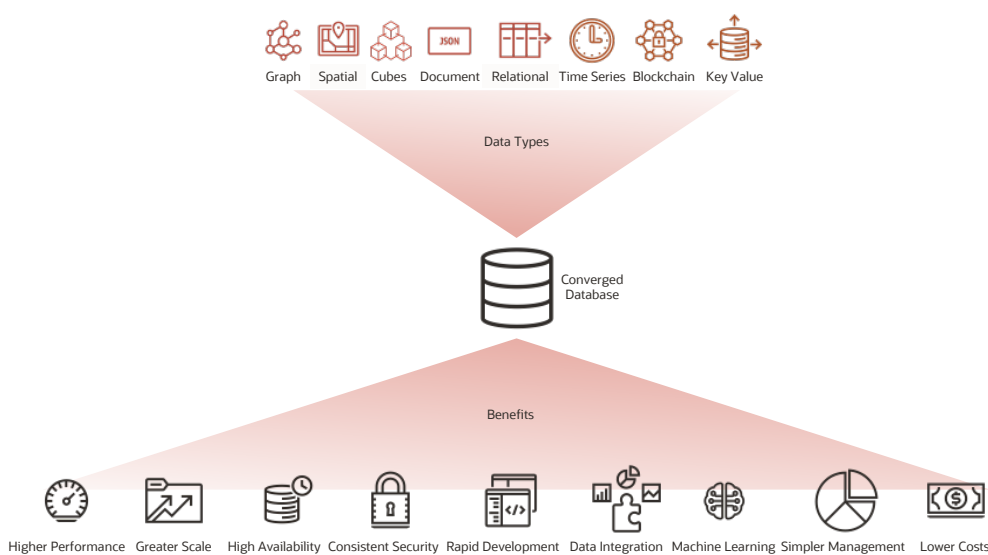
Figure 8: Oracle Database can centralize data management for a wide variety of data types.

- Better concurrent access to near-real-time data
- Economic and operational efficiencies
- Consistent, centralized privacy, security, and compliance governance

In addition to Converged Database[9] capabilities, extremely high consolidation densities are enabled by the underlying Exadata platform which further enhance operational efficiencies (see "Best Practices for Database Consolidation[10]").

Many of Oracle's customers are already leveraging Oracle Database's converged data management capabilities, moving specialized data from special-purpose databases into Oracle Database for production to take advantage of the integrated advanced security and availability features. Combining converged database with high database consolidation improves manageability, governance, and efficiency and also enhances real-time data initiatives.

INTEGRATED CAPABILITIES FOR EXTRACTING DATA INSIGHTS

Oracle Machine Learning[11] is a unique feature of Oracle Database. Typically, data management systems are isolated from data science and machine learning environments, adding complexity and lag time due to data export and manipulation. Oracle Machine Learning offers numerous advanced algorithms[12], as well as the ability for users to create more of their own in the language of their choice (Python, R, etc.). Algorithms can be run directly against the database by the Oracle instance itself. Users leverage simple SQL commands that any data scientist or developer can easily integrate into their workflows. Customers can consolidate advanced machine learning functions directly into the data management platform.
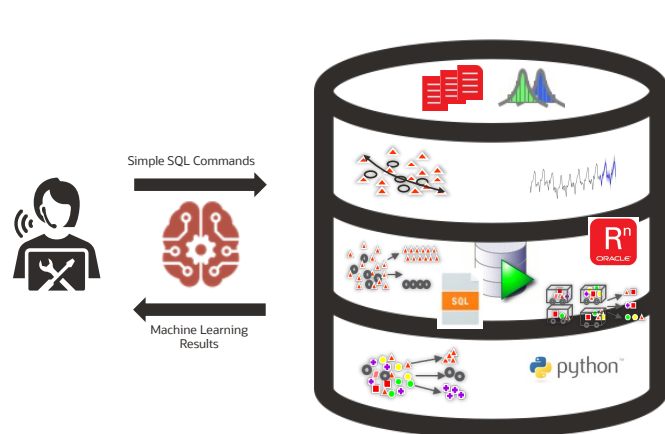
In addition to simplicity, the Oracle approach eliminates expensive specialized hardware, unnecessary storage redundancies, network costs associated with maintaining multiple external environments and costly cloud bills solely for analytics. Being able to run sophisticated machine learning algorithms on a consolidated, live data set avoids lags and frequent sync points with complicated and computationally intensive ETL operations. This moves organizations closer to real-time analytics goals for compliance, monitoring for illicit activities, or risk analyses in a way that competing approaches of isolated machine learning and data management environments cannot match.

Figure 9: Oracle facilitates running machine learning directly on the database, without dedicated environments and specialized hardware.

An additional key feature of interest included in converged database is Oracle Graph Database and Graph Analytics[13]. Graphs capture relationships and connections between data entities, making it easier to explore those connections and draw new conclusions. In banking, a common use case is fraud detection. There is no need to set up a separate database and move around large datasets. Analysts and developers can perform such analyses in an integrated manner, with additional benefits of enterprise-grade security, ease of data ingestion, and strong support for multiple data workloads

Another advantage of both Oracle Machine Learning and Graph Database and Graph Analytics is that data is much more secure. Banks do not need to create separate copies of data in separate data stores with differing security capabilities. New copies of data inevitably create new security vulnerabilities, and new data stores provide more attack points for cybercriminals. Banks can leverage the advanced security tools and security management practices of Oracle Database for all operational and analytics use cases. This centralized security management saves work in securing and managing data sprawl while avoiding associated security risks.

EMBRACE INNOVATION WITHOUT RISKY AND COSTLY DISRUPTION

While all banks want to innovate and modernize systems, risks and speed of innovation always need to be considered. Banks already leverage Oracle Database and rely on it for business-critical applications. When assessing any infrastructure modernization for these environments, zero migration risk and fast and easy migration speed are always goals. Exadata Cloud@Customer reduces migration risk with the Oracle Database environment, the gold standard in banking. Its ability to consolidate data management effectively, providing appropriate availability characteristics for all workloads, has evolved as a result of ongoing R&D efforts and Oracle investment in the Maximum Availability Architecture[14] (MAA) portfolio. Many Oracle Database customers have come to leverage MAA features and MAA architectures which have become a critical part of banks' data management environments. Exadata Cloud@Customer provides continuity in these cases, avoiding risk and delays associated with re-configuration.
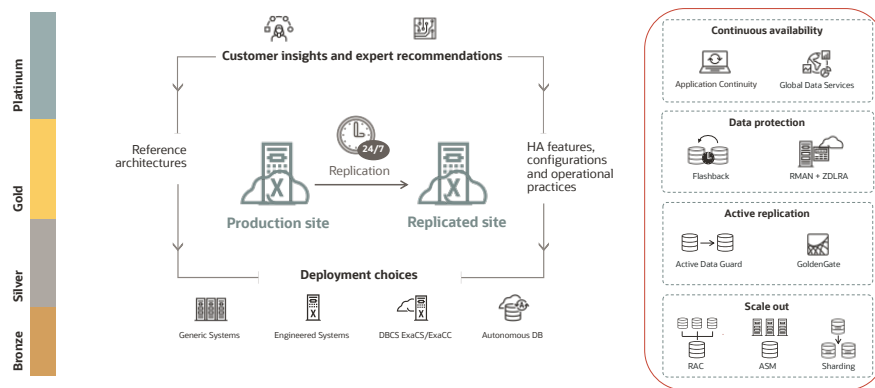

Figure 10: Oracle Maximum Availability Architecture.

Because Exadata Cloud@Customer uses the Oracle Database, compatibility with existing Oracle Database environments is ensured, offering:

- No compatibility risk to existing databases
- No change to existing applications which can continue to function normally
- Built-in automated MAA best practices that enable true enterprise availability characteristics
- Unparalleled Exadata performance under workload consolidation
- A fast and easy transition to a Cloud Architecture

Compatibility and continuilty with current Oracle Database environments is critical, for example, for core banking applications such as Oracle FLEXCUBE, or other similar applications which have been optimized for availability or functionality by leveraging strengths and features of the Oracle Database tier.

With Exadata Cloud@Customer, modernization and innovation can be achieved without adding risk to critical environments. Other vendors' solutions typically require changes to applications and data models that take years and incur significant expenses and risk. Exadata Cloud@Customer is the only enterprise cloud solution that can facilitate a rapid and risk-free transition to an agile cloud architecture for banks.

CONCLUSION

As banking systems are evolving at an unprecedented rate, embracing automation and cloud model is a must. At the same time, data integrity, availability, security, and compliance are not negotiable for any critical banking data management system. Exadata Cloud@Customer offers the benefits of cloud modernization along with enterprise security and availability rigor to remove risks to modernizing the most critical data management environments of the banking industry.

APPENDIX A – WORKLOAD CHARACTERISTICS AND CHALLENGES

EMERGING CHALLENGES WITH TRADITIONAL ARCHITECTURES

Traditional architectures are beginning to present contemporary data management challenges that need to be considered and addressed over time, including:

- Segregated data repositories, requiring complex interdependencies between isolated systems
- Decentralized governance
- Lack of near-real-time visibility for analytics
- Lack of synchronization between systems
- Heavy, complex transformation operations
- Multiple instances of the same data in different formats on distinct systems

MISSION-CRITICAL OPERATIONAL SYSTEMS

Operational systems, which include core banking and payment systems, tend to be transactional in nature and are highly critical to bank operations. Security, availability, and data integrity are paramount. Traditionally, these systems have been highly siloed, kept apart from other systems to the extent possible. While isolation has its advantages in terms of risk, it is becoming less realistic to rely on this approach given other modern challenges.

Use Case	Traditional Requirements	Contemporary Challenges
Core Banking	- Predominantly transactional workloads - Resiliency, availability, data privacy, and compliance are critical - Heavy regulatory burdens - Isolation from non-operational systems - Dependency on mainframes	- Dwindling mainframe knowledge and skill sets - Competitive pressures to improve digital experience - Regulatory hurdles for cloud adoption - Slow development on brittle systems - Increasingly frequent ETL operations - Increasingly complex demands to import / export data
Payments Engine	- Transactions batched and transmitted to clearing at discrete times of day - Uptime crucial, standby systems often used - High throughput performance needed - Isolation from non-operational systems	- Increased mobile and digital payment adoption - Meeting clearing time windows - Real time, immediate payment initiatives - Adoption of biometric payments authentication - Evolving regulatory standards (e.g., anti-fraud, anti-money laundering) - Wait times for out-of-band analytical systems

PERFORMANCE, RISK, AND COMPLIANCE MANAGEMENT SYSTEMS

In addition to OLTP systems, banks are required to perform monitoring and reporting for various purposes. From a data management perspective, these have traditionally been analytical rather than transactional systems. Some of these systems exist due to regulatory reporting requirements, others are driven by internal risk or performance management requirements. Banks need to determine how to convert many of these capabilities into real-time solutions that reduce risk, increase competitiveness, or meet emerging regulatory requirements.

Use Case Examples	Common trends	Contemporary challenges
• Fraud detection • Anti-money laundering • Know-Your-Customer • Credit risk analysis • Liquidity risk analysis • Risk adjusted finance • Value at risk • Compliance reporting (e.g., Basel II and Basel III related credit exposure risk reporting)	• Moving toward near real time analytics • Moving away from summary data analysis toward analysis of full data sets • Supporting multiple external machine learning / data science environments • Use of hybrid cloud infrastructure • Use of machine learning, artificial intelligence, and chatbots • Participation in API-driven Open Banking schemes	• Better control over cybersecurity • System sprawl due to each analytical environment requiring its own data format and data set • Frequent and increasing need to transform and clean data • Performance challenges • Differing preferences and conflicting requirements between different dev teams and data science teams • Increasing regulatory requirements • Collaboration with, and competition from challenger fintechs • The increasing sophistication of cyberthreats

APPENDIX B – MAINFRAME-TO-EXADATA MIGRATION

Many banks still rely on mainframe-based environments for some mission-critical operations. Exadata Cloud@Customer provides an excellent consolidation option. Whereas other cloud providers focus on risky "rip-and-replace" migrations, mainframe-to-Exadata migration is a common path for Oracle customers and helps to modernize these legacy environments with the following advantages:

- Lower risk mainframe-to-Exadata migration, a common path for Oracle customers
- Highly automated and innovative migration options, based on technical and business characteristics
- Equivalent AL4 availability characteristics by leveraging MAA solutions
- Superior performance than existing legacy mainframe systems
- Reduced costs and operational challenges, including staffing hurdles
- Consolidation benefits that further reduce complexity and costs, while enabling real-time initiatives
- Truly modern cloud automation, available in customer data centers

Oracle offers services to modernize mainframes to Oracle Exadata Cloud@Customer environments both directly and via our partners. Available solutions include:

- Oracle Tuxedo, which enables COBOL applications to run on modern, distributed systems, taking advantage of Oracle RAC technology for modern availability
- COBOL to Java migrations, and other migration services
- Fully managed migrations leveraging a variety of technologies

The goal of all these mainframe migration capabilities is to free banking organizations of arcane, obsolete, or mainframe-specific technologies, transitioning instead to maintainable, high quality code that runs on modern cloud enabled systems. As a result, banks maintain equivalent functionality, increase availability, and dramatically lower costs. Oracle's capabilities are unique - no other cloud vendor can offer more experience or capability in this area.

Migrating to most other cloud data management offerings in the market brings data location-related challenges. By contrast, Exadata Cloud@Customer is a comprehensive service, managed by Oracle, with data remaining on-premises at the customer site. Because your data remains on-premises and in Oracle Database, data gravity related troubles are avoided:

- Low latency to local, on-premises servers
- Avoid data sovereignty or regulatory roadblocks typically associated with migration out of the data center

- Subscription-based cloud consumption model for resources
- Overhead cost reductions related to Oracle management of infrastructure

Today, modernizing data management requires consideration of both traditional, on-premises IT along with cloud based, developer friendly services. Most vendors propose complex hybrid cloud solutions that ignore data gravity challenges. While seemingly trivial and unappealing to address on the surface, data gravity is a reality confronted in modernization for banking. Exadata Cloud@Customer helps solve the data gravity challenge while still providing an onramp to cloud. In this sense, it is not only a modernization solution for the future, but also a workable, real-world solution for running banks in the present.

APPENDIX C – SUMMARY OF EXADATA CLOUD@CUSTOMER BENEFITS FOR BANKING

Compared to other data management modernization solutions, Exadata Cloud@Customer offers a breadth of advantages:

- Compatibility with existing systems
- Exadata performance with data consolidation and converged database
- Near-real-time access to data, enabling data scientists and developers to do their jobs more efficiently
- Cloud consumption of database resources on-premises
- Full data plane in customer data centersavoids data sovereignty and data gravity challenges
- Robust security and management consolidation
- Security and data protection capabilities that simplify regulatory compliance
- Cost benefits and operational efficiencies
- Modernized data management systems for banks

Exadata Cloud@Customer for Banking

- Deliver Cloud Modernization
- Centralize Cloud Data Management
- Unlock Near Real Time Analytics
- Ensure Security and Compliance
- Maximize Availability
- Reduce Risk
- Maintain Data Sovereignty
- Enhance Operational Efficiency
- Accelerate Time-To-Value

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