REFERENCE ARCHITECTURE

Financial Services
Agile Banking & Insurance

Multi-Cloud Strategy Drives Financial Services Digital Transformation

Financial organizations can gain agility, flexibility, and efficiency while meeting security and compliance needs by defining a multi-cloud strategy powered by Intel® technology

This document provides a starting point for developing a financial services multi-cloud strategy.

If you are responsible for...

- **Investment decisions and business strategy**
  You will learn how multi-cloud can solve the business challenges of today's financial services organizations by providing agility, flexibility, and efficiency while meeting security and compliance needs.
- **Figuring out how to transform your organization's infrastructure to support a multi-cloud strategy**
  You will learn about the architecture components and how they work together to create a cohesive business solution.

Executive Summary

Financial organizations are discovering the advantages of a multi-cloud architecture, where they can choose from a variety of internal IaaS and PaaS offerings as well as externally provided cloud services, potentially from multiple cloud service providers. In many cases, private clouds can be more cost-effective than public clouds. However, hosting some non-differentiating services in the public cloud can enhance business agility. With the right multi-cloud architecture, financial organizations can choose the combination of services that make the most sense while providing developers and operators with common frameworks and tools such as authentication mechanisms, compliance audits, performance monitoring, APIs, and so on. In addition, a multi-cloud strategy provides business model flexibility by enabling financial organizations to quickly take advantage of technology innovations such as serverless computing (also known as function as a service), blockchains, and breakthroughs in artificial intelligence.

In this document, we first explore how a multi-cloud approach can address the regulatory and marketplace challenges faced by the financial services industry. We then look deeper into a multi-cloud solution strategy, powered by Intel® technology. Using this information, financial organizations can take the next step toward unleashing the power of cloud computing.

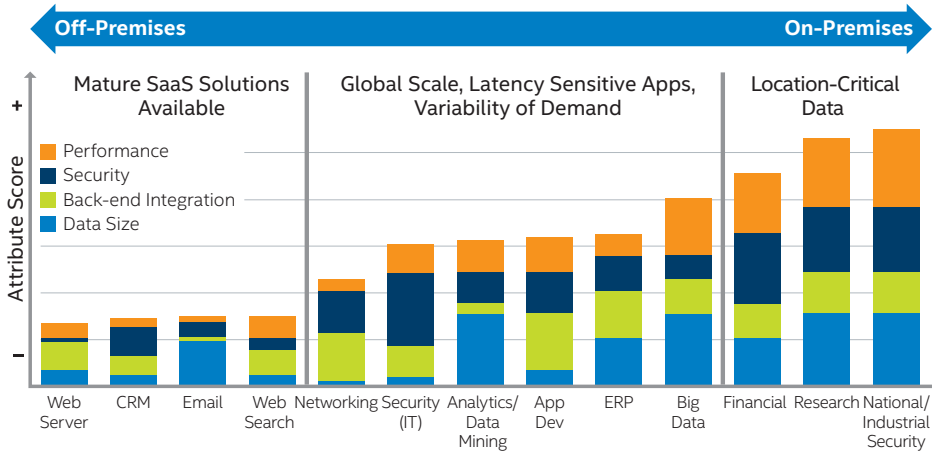

Figure 1. Cloud focus areas by workload.

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Semantics of Cloud Computing

Hybrid cloud—focuses on the solution deployment model, and represents a computing environment that combines public cloud(s) and private cloud(s). Data and applications can be shared between these clouds, allowing organizations to seamlessly scale from on-premises to off-premises infrastructure. Hybrid cloud is a subset of multi-cloud.

Multi-cloud—focuses on combining best-of-breed solutions and services from different cloud providers, including public, private, and/or hybrid cloud solutions, to create the most suitable solution. Multi-cloud addresses interoperability and portability and provides flexibility with respect to price-points, services offerings, capabilities, and geographical locations. Different teams can choose offerings, regardless of deployment model, that meet their needs. For example, one team may need office-oriented services while another team may need high-performance computing and big data services. Each of these teams will naturally gravitate toward different cloud providers. Done well, multi-cloud creates consistency across the company, independent of the services being consumed.

Private cloud—computing services offered over the Internet or a private internal network and only to a defined group of users.

Public cloud—computing services offered by third-party providers over the public Internet.

Introduction

Competing in a world where technology plays an ever-increasing role in the daily lives of customers, financial services institutions must embrace change like never before. Finding new ways to better service customers while continuing to meet compliance and regulatory demands now and in the future requires a fundamental reshaping of traditional IT infrastructure and a business agility that comes only with a scalable and agile cloud infrastructure guided by a multi-cloud strategy. After exploring some of the business challenges facing financial institutions, this document will explain the components of a multi-cloud solution architecture, and how Intel and fellow collaborators in the IT industry can help financial services organizations with their digital transformation.

The financial services landscape is changing dramatically. In addition to widespread economical volatility across the globe, financial organizations face a number of challenges:

- **Compliance and regulatory pressures.** Financial services is one of the most heavily regulated industries. The number of individual regulatory changes that banks must track on a global scale has more than tripled since 2011, to an average of 220 revisions per day.[1] Governance, risk, and compliance (GRC) costs account for 15 to 20 percent of the total "run the bank" cost base of most major banks.[2] Banks are looking for ways to reduce these costs by rethinking their IT infrastructure.
- **Increasing competition.** Historically, financial services were available only from banks and credit unions. But today, consumers can get access to financial services from any number of technology companies. Global funding of FinTech startups and challenger banks reached USD 17.4 billion in 2016.[3]
- **New customer expectations.** Over 50 percent of millennials do not think their bank offers anything unique.[4] These customers want better experiences, new services, and better value from their banks. In addition, customers have become more willing to purchase services from a variety of providers, and no longer implicitly trust traditional financial services firms.

Technology transformation is the only way to meet these challenges. According to PWC's *Retail Banking 2020: Evolution or Revolution?*, "Technology will change everything – becoming a potent enabler of increased service and reduced cost."[5] Traditional financial services infrastructure (Figure 2) and IT processes are not cost-effective; they limit banks' agility and flexibility and therefore can stunt business growth.

Current State of Financial Services Infrastructure Hampers Operational Efficiency

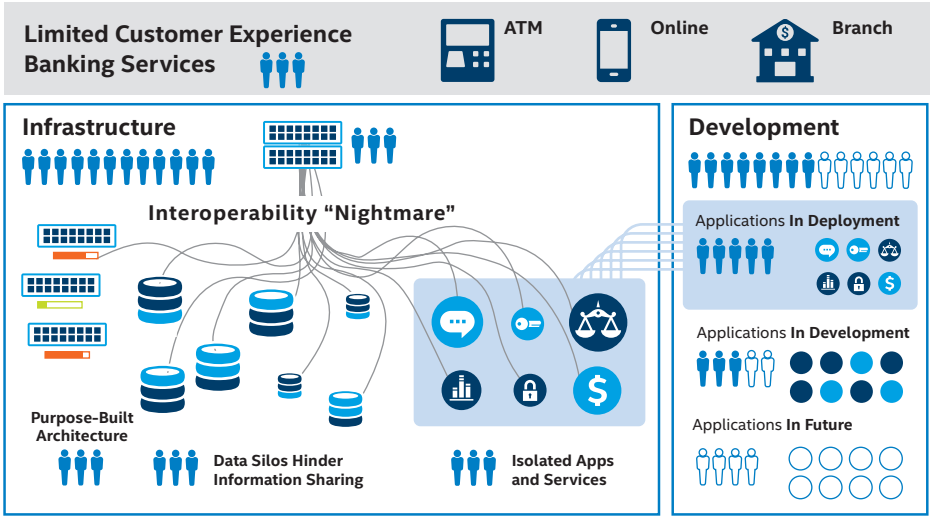

Figure 2. The current financial institution infrastructure is characterized by manual orchestration, islands of management, resource and data silos, many proprietary enclaves, and vendor lock-in.

Cloud computing provides a platform for innovation, but "cloud computing" does not necessarily mean "using the public cloud" (see the sidebar, "Semantics of Cloud Computing"). In fact, recent research reveals that in many circumstances, a private cloud can be more cost-effective than using the public cloud, depending on several variables including resource utilization and management efficiency.[6] A well-defined and implemented multi-cloud strategy can mitigate cloud-computing risks, as recently described by the internationally renowned bank, Banco Bilbao Vizcaya Argentaria (BBVA).[7] With an effective multi-cloud strategy, banks' existing investment in infrastructure is a strategic asset that can be better utilized by first creating a modern private cloud (Table 1). Then, as business requirements dictate, additional on-premises—and off-premises—private clouds can be added, in addition to potentially using services from one or more public cloud service providers (CSPs).

To gain maximum benefit and agility from cloud computing, it is imperative to simplify core platforms, moving from purpose-built architectures to easily scalable, affordable architectures, as well as to deploy platform as a service (PaaS) and function as a service (FaaS) capabilities. Such an approach increases workload portability from cloud to cloud and results in consistent performance. A multi-cloud strategy relies on a new IT culture and skill sets to deliver business agility through the use of methodologies, frameworks, and technologies such as DevOps and automation of manual processes. It also lays the foundation for next-generation PaaS, known as serverless computing, or FaaS.

Table 1. Modernizing the Private Cloud

YESTERDAY'S GEN 1 PRIVATE CLOUD Based on Technologies from 2008 to 2013	TODAY'S GEN 2 PRIVATE CLOUD Based on Current Technologies
Basic virtualization with some elasticity and self-service	Advanced virtualization of compute, networks, and storage using virtual machines and containerization technology
Key technologies were VMware*, Eucalyptus*, CloudStack*, and OpenStack*	Key technologies include OpenStack, Cloud Foundry*, Kubernetes*, Mesos*, VMware, and Microsoft Azure Stack*
Immature technology required significant technical resources	More mature technology means easy deployment and management (using container orchestration in many cases) with small teams
Delivered cost saving only through large-scale deployments	Even small-scale deployments can provide cost savings and significant return on investment (ROI)
Limited commercial ecosystem	Mature, broad ecosystem of technology providers and system integrators
Primarily on-premises deployments	Supports dynamic, agile, multi-cloud strategy
Challenges centered around technology and talent	Challenges centered around culture and process

A multi-cloud architecture can accommodate many business requirements efficiently by using infrastructure as a service (IaaS) and PaaS, which is enabled by software-defined infrastructure (SDI). For example, financial organizations can run traditional, non-cloud–native applications as-is, but at the same time unlock the potential to develop cloud-native container-based and FaaS solutions that take advantage of a microservices architecture.

Solution Overview and Benefits

Imagine the ability to start development of a new service using a private cloud in one data center where the infrastructure is provided and managed by vendor A, then seamlessly moving that application to a different data center whose infrastructure is provided and managed by vendor B. Or, an application, while hosted on-premises, might take advantage of one service from public CSP 1 and another from public CSP 2. Another scenario that demonstrates the multi-cloud value is the ability to deploy a solution on multiple clouds simultaneously and dynamically move workloads based on cost and user experience. For example, using a CSP that is close to users can reduce latency. This is the type of flexibility and agility that multi-cloud promises.

While the financial services industry can be cautious in adopting external cloud services, 85 percent of all enterprises now use at least more than one cloud service, while only nine percent use a single public cloud and another five percent use a single private cloud.[8]

The ideal multi-cloud architecture (Figure 3) relies on SDI (abstracted computing resources), which in turn facilitates delivering "everything as a service." SDI provides a broad set of APIs for managing the underlying infrastructure. PaaS solutions can use those APIs for tasks such as container orchestration. Developers can use those APIs to deploy their applications and focus on customer and business needs without worrying about infrastructure (sometimes referred to as "infrastructure as code").

While not strictly necessary, a multi-cloud environment also benefits from a DevOps "fail fast, succeed fast" culture. This approach uses continuous integration/continuous deployment (CI/CD) to make many small changes to applications or services on a continual basis, compared to massive redeployments just a few times a year. Developers are delighted with the opportunity to do what they do best—develop—while customers are delighted with a responsive customer experience.

SDI enables financial organizations to combine internal IaaS, PaaS, and FaaS with externally provided IaaS, PaaS, FaaS, and software as a service (SaaS). For example, financial organizations can keep core capabilities on-premises and offload non-differentiating capabilities to an off-premises private cloud, or to a public CSP. For example, when developing a service, data analytics may be run on-premises, but the speech-to-text aspect may be hosted on an off-premises private cloud, while the robot advisor might be hosted on a public cloud. The APIs enable an a la carte approach to internal and external resources and portability across multiple cloud environments.

Using a multi-cloud strategy to determine the cloud environment best suited for a particular business need for agility, operational efficiency, data access, management, and/or compliance can provide financial organizations many benefits, some of which are listed here:

- **Affordable innovation.** As shown in Table 1 above, a modern, private cloud features the latest generation of Intel® Xeon® processors and other Intel® technologies, giving financial organizations immediate access to the latest technology and open, industry-leading solutions. If a financial organization's multi-cloud

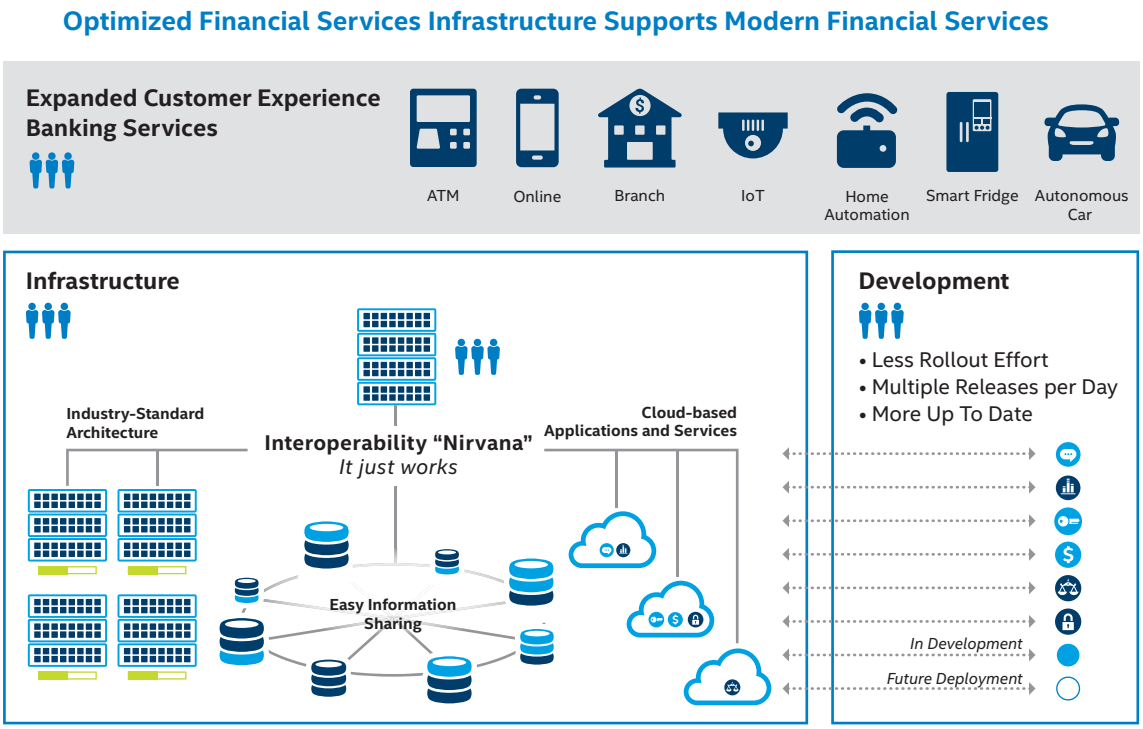

Figure 3. An optimized infrastructure is centralized and automated, using software-defined capabilities, pooled and virtualized resources, and standard, server-based platforms that can accommodate both cloud-native and traditional applications.

strategy includes public cloud services as well, these same technologies can provide the high performance and reliability that financial organizations require.

- **Cost effectiveness.** As cited earlier, in many cases private clouds can provide a lower total cost of ownership (TCO) than public clouds, depending on certain variables. A multi-cloud strategy enables financial organizations to optimize their use of private cloud services and public cloud services to minimize costs and lock-in risks.
- **Scalability.** Private and public cloud resources are characterized by auto-scaling, self-healing, and constant optimization. Both private and public cloud resources can be scaled up or down as needed, on demand.
- **Standardization, centralization, and automation.** A standard SDI framework provides a common backbone for applications that can be centrally managed and updated, making it easy to integrate and streamline processes and applications.
- **Improved regulatory compliance.** Instead of a patchwork of security and GRC solutions, an effective multi-cloud strategy establishes a common compliance framework across multiple clouds. This is true for both government-mandated compliance as well as internal policy adherence.

Solution Architecture Details

Figure 4 expands on Figure 1, showing a detailed view of a multi-cloud solution architecture.

When a developer makes a resource request (such as for a container in the production environment) or begins to develop a service, the request is routed through an SDI orchestration layer that applies pre-defined policies to determine how to place the workload. Based on the policies, the request is then passed through the controllers for compute, network, security, and storage and through the core network onto the appropriate platform (private and/or public), where the actual resources are allocated and made available through virtualization. A simple change to these policies can instigate the shifting of resource assignment, such as from one private cloud to another, or from a private cloud to a public cloud, or from public CSP A to CSP B.

Since everything is software-defined, data is available from every step—telemetry and operations information is constantly exchanged and analyzed. This data can be used to monitor the health of the entire infrastructure, to continually optimize the infrastructure to meet SLAs, and to support advanced analytics associated with

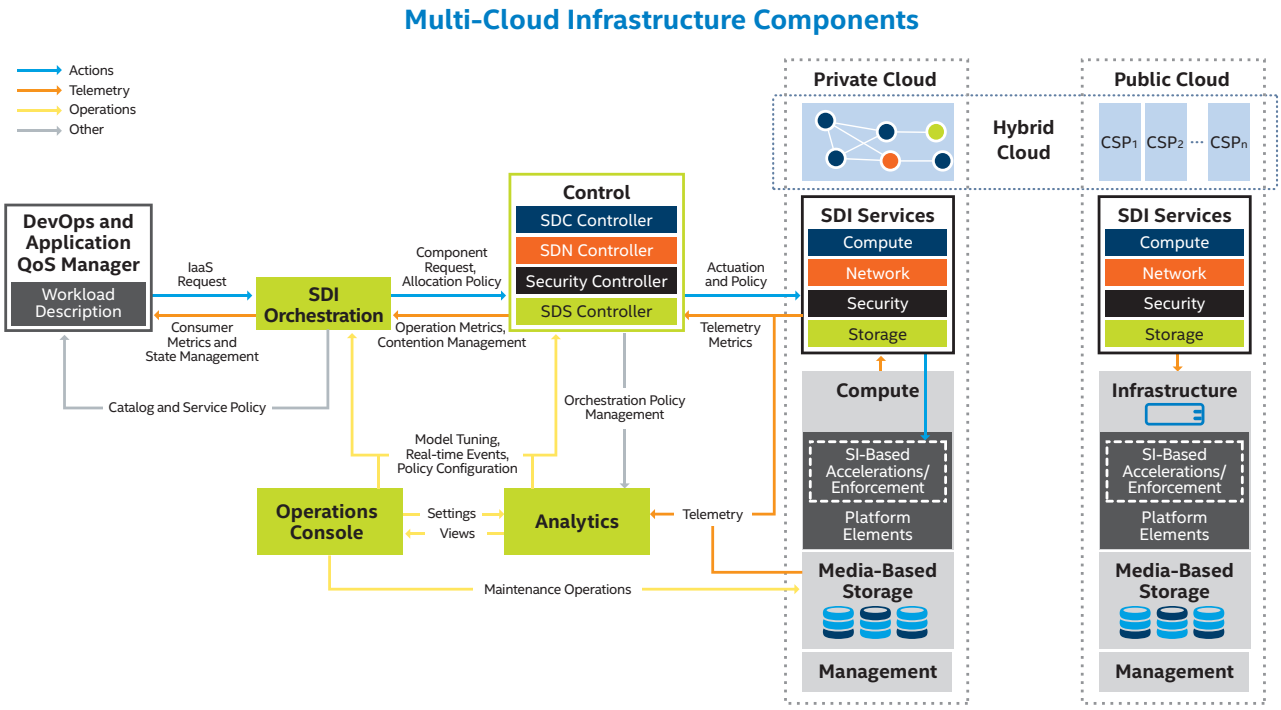

Figure 4. The multi-cloud solution architecture uses software-defined infrastructure (SDI) and platform components based on Intel® technologies to create a seamless, coherent environment where workloads can be run using the combination of services that make the most sense, using a common framework and tools.

cybersecurity intelligence. With full integration, if a resource fails (such as a server or network), security controls can transition with the workload or the virtual machine (VM), and can even restrict a workload to transition only to specific locations.

Multi-Cloud Transformational Capabilities

There are certain capabilities that make a multi-cloud strategy attractive. These are discussed below, although an in-depth coverage is beyond the scope of this reference architecture.

- **Pooled but isolated resources.** Containerization is necessary for portability between private and public cloud infrastructures. Compared to VMs, containers isolate applications and libraries that share the same OS, providing a smaller footprint and more effective use of compute resources. Containers can spin up in mere seconds and are easy to use. Several Linux* and Microsoft Windows* distributions are available, as are telemetry providers and other solution vendors that offer container support.
- **Marketplace agility.** Software-defined networking (SDN) and network function virtualization (NFV) can simplify management of a financial organization's multi-cloud environment. Through simplified configuration management, SDN and NVF can enable financial organizations to efficiently and quickly provide enhanced functionality to their customers while strengthening security and increasing operational efficiency. Like containerization, SDN and NFV enjoy a varied ecosystem.
- **Flexible storage offerings.** A single financial services organization can have thousands of different workloads. Some workloads are latency-sensitive and require "hot" storage (needing a high volume of input/output (I/O) operations per second). These might include customer relationship management and enterprise resource planning workloads. Other workloads have middle-of-the-road ("warm") storage requirements—they are not super sensitive to latency, and yet they require decent performance. Examples include data analytics, server virtualization, and email. Still other workloads are suitable for "cold" storage because they are not performance-sensitive, such as archiving and backup. Software-defined storage (SDS) uses APIs and telemetry to dynamically assign and adjust assignment of storage resources.
- **Reduced cybersecurity risk.** For the financial services industry, information security is of paramount importance. Breaches are associated with astronomical penalties and reputational damage. And yet, cyberterrorism is on the rise and attackers are increasingly sophisticated. Whether in the private cloud or the public cloud, organizations must use the appropriate technology to secure workloads on a trusted platform and encrypt data throughout its lifecycle (in motion, at rest, and in use). Financial services organizations also require high performance—they cannot afford performance hits if they are to remain competitive in today's marketplace.

"SDN and NFV technologies offer great opportunities for us to consolidate and provide agility to our business systems. The technology transition of NASDAQ's existing network infrastructure components, from dedicated purpose-built devices to virtualized high-performance servers that provide multiple network functions, will enable NASDAQ to realize the anticipated benefits of SDN and NFV of agility, reduced time to market, capital and operational savings."[9]

— Kenneth Kirk,
Director of the Networking Architecture Group, NASDAQ

Architecture Design Considerations

The "perfect" multi-cloud strategy is a balancing act between business, technical, ecosystem, and additional considerations. Understanding how technology can help meet business requirements for agility, performance, management, security, integration, and so on is also critical in defining a cloud strategy. For example, specific technology choices must be made in the areas of operations, software and hardware, and security and compliance.

- **Compliance.** As mentioned earlier in this document, financial services organizations are subject to a mind-boggling array of GRC regulations. Compliance in the financial services industry focuses on many issues, some of which include multi-tenancy, data sovereignty, third-party risk management, and data access and lineage.
- **Interoperability and portability.** In the multi-cloud environment, container-based technologies and microservices can help facilitate interoperability and portability. When designing containerized applications, also build in agility for accommodating different data formats, using standards such as the Cloud Native Computing Foundation (CNCF) and guidance from the Enterprise Cloud Customer Council (E3C).

- **Governance and operation.** Effective cloud governance relies on the availability of risk management and data governance tools and processes that provide self-service access to the cloud service catalog and licensing management, as well as standardized processes and policies for application and workload placement. Other considerations include DevOps support for application design and development specifically for the cloud environment, as well as quality assurance and testing for clouds and cloud-centric applications.
- **Cybersecurity.** An effective multi-cloud environment must provide for resilience against denial of service (DoS) and distributed denial of service (DDoS) attacks; multifactor authentication (MFA), possibly using Fast-Identity Online (FIDO) technology; which is a capability provided by banks to protect customer's identity and is typically provided as part of a PaaS offering; robust identity management; support for on-premises key management; and advanced forensics tools.
- **Privacy and data protection.** To enhance privacy and data protection, financial organizations should plan to encrypt data everywhere: in transit (such as from one cloud to another), at rest (on-premises and off-premises), and in use (by applications or databases). Care should be taken to also protect logs and other data that can associate a customer with a particular financial services organization and to provide sufficient redundancy and data loss prevention (DLP) mechanisms, including processes that account for natural disasters (such as co-location or active-active clustering).
- **Service-level agreement (SLA) management.** Whether a cloud is private or public, on-premises or off-premises, SLAs are extremely important to define and meet because they can protect against service interruption and negative customer experiences. The chosen platform should include embedded capabilities, such as auto-scaling, self-healing, and telemetry, to help guarantee the SLA. SLAs should define the expected quality of service (QoS). QoS applies equally to physical resources such as compute, storage, and network, and to application and service response time.
- **API management.** As a foundation for consistency, all APIs should support both the Open Authorization (OAuth) and Security Assertion Markup Language (SAML) standards. At the data layer, the following financial services industry-specific specifications and protocols should be used: Banking Industry Architecture Network* (BIAN*) 4.0, Financial Transaction Services* (FinTS*), Ixaris*, and Open Financial Exchange* (OFX*). APIs should also be extensible for future API standardization and custom definition. A crucial aspect of API management is access control based on profiles, groups, and user identity.

Cultural and Skillset Considerations

Revitalizing technology is not, by itself, sufficient to digitally transform a business. New technology must be accompanied by revised data access, resource management, provisioning, compliance, governance, and operational processes, as well as new IT skill sets. Much of the operational change revolves around automation of traditionally manual processes through SDI and adoption of a DevOps framework and Agile Development methodology to speed application development.

As a financial organization modernizes its private cloud and then begins to coalesce other clouds, both private and public, IT staff must continually update their knowledge. Becoming familiar with various software tools, assessing data types and aligning them with the appropriate level of controls, and learning how to write secure code using secure development lifecycle practices are just some of the areas in which training investments can bolster a financial organization's multi-cloud endeavors.

Industry Guidance for Interoperability and Portability

The **Cloud Native Computing Foundation (CNCF)** is dedicated to sustaining and integrating open source technologies to orchestrate containers as part of a microservices architecture. The CNCF will create and drive the adoption of a new computing paradigm that is optimized for modern distributed systems environments capable of scaling to tens of thousands of self-healing multi-tenant nodes, as well as foster the growth and evolution of the ecosystem. Intel, along with nearly 100 other leading industry players, is a member of the CNCF, and is committed to creating open industry standards around a container image format and runtime.

The **Enterprise Cloud Customer Council (E3C)** is committed to developing requirements centered on common, functional architecture, detailed specifications, and technical solutions that improve enterprise cloud adoption and integration and mitigate regulatory risk. The E3C, formed in 2015, is becoming a leading voice for enterprises to drive cloud interoperability and portability across major cloud industry vendors and standards bodies.

It is especially important to consider how to best transform the corporate culture and processes to gain the most value from technology and multi-cloud capabilities. One approach, championed by Gartner[10], is to create a bimodal IT department. In this scenario, one IT group focuses on stability, batch processes, and traditional applications while a second IT group focuses on business agility, digital transformation, and an exploratory greenfield approach to DevOps-driven application and cloud-native development. Using this bimodal IT approach, a financial institution can systematically transform to a multi-cloud architecture.

Cost Considerations

An optimized private cloud architecture that provides optimal resource utilization can be less expensive than using a public cloud.[11] To gain a holistic cost picture, a financial organization must consider expenses associated with labor, software, servers, storage, network components, data center operations, and security.

Intel® Technology Can Help Build an Effective Multi-Cloud

In both the private and public cloud environments, platform components that feature Intel technology can help keep data secure and provide high performance. For example, the Intel® Xeon® processor Scalable family provides an affordable, industry-standard architecture that scales easily. Intel also provides high performance, security-enabled networking, storage, and containerization technologies, as well as a suite of products designed to enhance cybersecurity from the hardware level to the application level. Here are several Intel technologies that may be of particular interest to financial institutions developing a multi-cloud strategy:

- **Containerization.** Clear Linux* OS for Intel® Architecture combined with Intel® Virtualization Technology (Intel® VT) can enhance isolation and security.
- **Storage.** Intel® Solid State Drive (SSD) Data Center Family for NVM Express*, Intel® Optane™ SSDs with 3D XPoint™ technology, and Intel® 3D NAND SSDs can transform the economics of storage.
- **Data security.** Intel® Software Guard Extensions (Intel® SGX) can help create a hardware-based secure enclave for key management services for on-premises or off-premises cloud services.
- **Networking.** Intel's portfolio of networking products can be used to build a fast, security-enabled network.
- **Telemetry.** Snap*, an open telemetry framework, provides exposure to system data by standardizing telemetry behind a single API.

Intel works closely with ecosystem players in all these areas to bring innovative technology to life in a way that meets financial services organizations' needs.

Establishing a Multi-Cloud Transformation Plan

The migration to multi-cloud is not an overnight process and requires a strategic transformation plan (Figure 5). The financial organization must assess its current infrastructure, as well as the considerations outlined above, and then decide how to proceed. Financial organizations can assess their applications and evaluate SaaS to simplify their infrastructure as a first step, then start gradually introducing SDI and multi-cloud technologies and processes. Generally speaking, non-differentiating applications such as email, collaboration tools, and human resource management software are the easiest to move to SaaS. Differentiating services and core capabilities are often kept on-premises on an agile PaaS architecture built on an SDI foundation that can flex and grow with the organization's needs.

Intel's Ecosystem Connections

Intel collaborates closely with many ecosystem fellow travelers and can assist financial organizations seeking to define a multi-cloud strategy and then implement it. Here are three resources that can help along the multi-cloud journey:

- **Intel® Network Builders.** An ecosystem formed to accelerate the adoption of NFV and SDN solutions.
- **Intel® Storage Builders.** An open, collaborative environment to speed the development and introduction of intelligent, cost-effective, and efficient storage solutions, and accelerate the transformation of the data center and drive business growth.
- **Intel® Cloud Builders.** An ecosystem that provides tools, techniques, and reference architectures for planning and deploying cloud-computing infrastructures.

In Figure, 5 Cloud A refers to a traditional cloud using VMs, while Cloud B uses containers. By phase 3, the organization has an as-yet immature Cloud B that is managed by Cloud A. In phase 4, Cloud B is in production running side-by-side with Cloud A. In phase 5, the goal, Cloud A is actually running within Cloud B, and inherits the manageability and high-availability of containers.

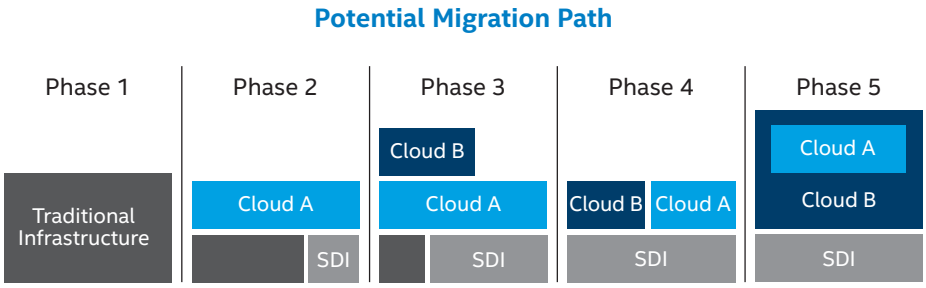

Figure 5. A phased approach for transforming a financial organization's infrastructure from the traditional approach to a software-defined, multi-cloud approach can ease the transition and provide best outcomes.

Summary

Competitive threat, regulation pressures, and other forces are driving digital transformation in the financial services industry. Innovation is a prerequisite for long-term success. To start the journey to multi-cloud and the agility it offers, financial organizations should start by modernizing their on-premises private cloud. Expanding on existing investments and developing further infrastructure capabilities are core components to effective cloud computing. With a modern SDI in place, financial organizations can then make effective use of resources and services from public CSPs in situations where that makes the most business sense.

Solutions Proven by Your Peers

The multi-cloud approach, powered by Intel® technology, provides much needed agility and flexibility for the financial services industry. This is based on real-world experience gathered from customers who have successfully tested, piloted, and/or deployed a multi-cloud approach. The solutions architect and technology expert for this reference architecture:

Bruno Domingues, Principal Solutions Architect, Financial Services Industry, Intel

Intel Solutions Architects are technology experts who work with the world's largest and most successful companies to design business solutions that solve pressing business challenges.

To learn more about developing a multi-cloud strategy, visit **intel.com/FSI** and **intel.com/cloud**, as well as the resources listed in the sidebar, **Intel's Ecosystem Connections**.

Learn More

This solution reference architecture complements product documentation and is part of an entire solution kit of content that is full of key insights and learnings:

- **Intel Cloud Computing**
- **Intel® Xeon® Scalable Processor**
- **Cloud Workload Placement Strategies**
- **Enterprise Cloud Customer Council (E3C)**

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