Transforming Risk Systems with Accenture & Amazon Web Services, Inc. (AWS)

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Financial institutions are under huge pressure to balance regulatory compliance with business growth at the same time as needing to reduce costs. This pressure is often most keenly felt within risk management functions. This document provides an overview of the challenges along with our cloud reference architecture – the Accenture Risk Calculation for cloud solution (ARC) – that helps financial institutions rise to the challenge.

Financial Institutions Today

Financial institutions, including banks, insurance companies, and brokerage firms, face an ever-increasing challenge to balance regulatory compliance with customer needs and business growth, while improving cost-efficiency. Regulators provide firm guidance and establish specific thresholds but it's left to financial institutions to prove that the risks they are taking are within their capital reserves and that they will be able to withstand future shocks to the financial system and political landscape.

New regulatory requirements demand an ever-increasing level of flexibility for conducting risk calculations to meet the enhanced transparency and performance levels demanded from a highly regulated environment. This is driven by the need for financial institutions to:

1. **Stay in continuous compliance with regulatory capital ratios** calculated through quantification of risks such as credit risk, market risk and liquidity risk, among others, as the rules evolve.
2. **Manage increased volume and complexity of risk calculations,** such as:
   - Fundamental Review of the Trading Book Internal Model Approach (FRTB IMA) calculations—Value at Risk (VaR-ES) and Standardized Approach (SA).
   - Increased stress testing demands through both increased range of scenarios run and the frequency of calculation.
   - Periodic calibration and validation of calculations—that is, selection of market risk stress period, profit and loss (P&L) attribution.
3. **Manage and protect increasing volumes of data.**
4. **Provide consistent and timely reporting:** Portfolio- and institution-wide reporting.
5. **Reduce overall costs:** Operating, IT, change management.
6. **Better align with strategic goals:** Strengthen profitability despite tighter margins, improved insight to reduce impact of crises, reduced time-to-market.

While financial institutions continue to extend their calculation grid capacity and refine their requirements, the value-added benefits of more advanced analytics such as applying artificial intelligence (AI) to risk management and event-driven calculations remain a distant aspiration. It is imperative that financial institutions remain responsive to an evolving regulatory environment, agile in their approach, and willing to adopt cutting edge technologies as they face new and innovative competition from new directions.

The Cloud-based Solution

Given the challenges facing financial institutions, we strongly believe that cloud solutions are rapidly becoming an essential part of the architecture, just as they have in many other industries. Key benefits for any cloud solution include:

- **Speed and agility:** Cloud transforms the way businesses innovate and help create new business models by pushing out changes quickly.
- **As-a-Service economics:** Capitalizing on the new economics of the cloud, pay for what you consume, reduce costs and help increase revenues.
- **Built to evolve:** Building a capacity to support today's business needs while being flexible to cope with tomorrow's unknown demands.

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Benefits of the cloud particularly relevant to financial institutions also include:

- Support for regulatory technology (RegTech) initiatives with cost-effective, agile solutions.
- The ability to offer client-centric solutions through innovation carried out by improved DevOps capabilities.
- Increased flexibility to respond to market volatility, business seasonality, and meet Service Level Agreements (SLAs) under unforeseen demand.
- Increased flexibility to enter and exit markets, product categories, and third-party relationships.
- Capacity to analyze massive amounts of data with increased security and controls.
- Increased agility to manage additional regulations or ad-hoc scrutiny by the regulator.

Accenture and AWS Partnership

The focus for many financial institutions that choose to move to the cloud is on a cohesive, integrated approach—from on-premises hardware to a hybrid or full public cloud adoption. A hybrid world demands hybrid skills; the most valuable talent is very often the architect who understands the functions and roles of all the pieces, and who knows how they all work together. The more heterogeneous the cloud environment, the more the organization needs to design and economically operate a mosaic of "best-in-class" capabilities to make the journey to the cloud, and to experience its full power and potential. That's where Accenture in combination with AWS come in.

Accenture and AWS help financial organizations worldwide stay compliant through cloud agility, improved enterprise architectures, and transparent controls which support much needed computation headroom (capacity and capability) and agility. Accenture and AWS in collaboration have the capabilities to work with financial institutions on all aspects of cloud migrations—from strategy through implementation and operation.

For cloud transitions, Accenture can support financial institutions in the following ways:

INDUSTRY FOCUS

- Vertically integrated Cloud services to address industry specific needs.
- Our completeness of coverage is unique to Accenture and we invest in:
  - Tailored services
  - Focused messaging
  - Use cases

TOOLS & ASSETS

- Intellectual property for Cloud services.
- Focus on tools for Cloud Operating Model and Management.
- Common client user interface, integration across tools and with Application Development Tools.

ECOSYSTEM

- Industry recognized no.1 integrator for the top three hyperscale providers including AWS.
- Highest number of certified people.

OUR PEOPLE: "INNOVATION ENGINE"

- Our talent has vast, deep industry, technology and functional experience and knowledge.
- Born in the cloud – integrated experience.
- Hands-on and out-of-the box thinkers.

END-TO-END CAPABILITY, SIZE & SCALE

- Cloud services that cover the full life cycle of business, and applications from ideation to deployment.
- Accenture has the largest portfolio of Cloud services.

GLOBAL DELIVERY NETWORK

- Capability in > 40 innovation and delivery centers, across 40 industries delivering excellence with Accenture's Global Delivery Network.

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Source: Accenture, September 2017

The Accenture AWS Business Group engineers and develops agile, enterprise cloud solutions to help financial services firms rapidly migrate, develop and manage their applications in the AWS Cloud and deliver significant and faster business results.

Source: Accenture, July 2017

The Challenges for Investment Banks

Financial institutions are making significant, targeted investment in strategic risk management systems to rationalize their overall risk architecture, and improve their enterprise data architecture and controls. Our experience indicates these changes have resulted in significant cost savings and improved agility while reducing the overall number of risk systems to manage.

However, for many, this process has not yet been completed. That's because their in-house compute grids are constantly stretched to their limits. Demand for additional and updated calculations continues to increase due to the numerous challenges of an exclusive on-premises environment, including:

- Large upfront investment and maintenance required to run on an on-premises grid.
- Limited compute grid capacity, which results in long run times for simulations.
- Standardized hardware offerings that limit grid and compute type.
- Limited datacenter capacity, resulting in simulation backlogs or inadequate risk calculations.
- Regulatory and market fluctuations requiring flexible compute capabilities.
- Financial instruments requiring flexible compute resources for development and testing.
- Lower than desired historical success rate of large scale change programs to upgrade legacy applications.

As a typical use case for the industry, FRTB regulations bring significant changes to the existing Basel III regulations for calculating the market risk of the trading book. FRTB aims to align the computational methodologies and bring consistency and comparability across institutions and jurisdictions.

Depending on the risk appetite, a financial institution can use either the SA based on sensitivities, or a combination of SA and IMA, which can be calculation and data intensive.

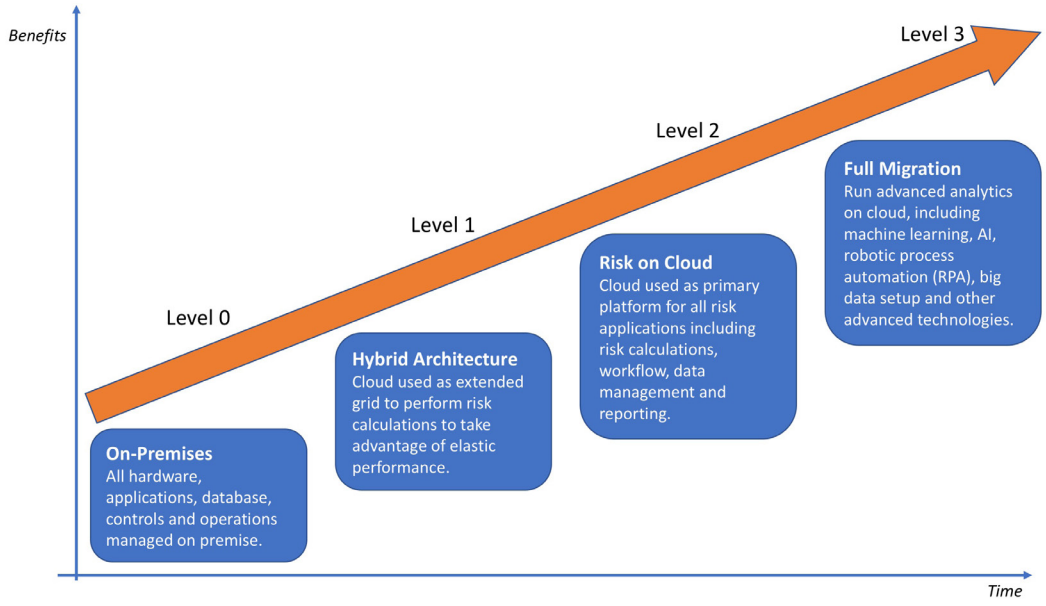
As an estimate, a modeled portfolio of 1 million positions would require approximately:

- 3 billion calculations for the IMA approach alone.
- 30 million calculations for SA approach daily.

These numbers include multiple iterations of VaR calculations for each position, for current and stress period market data, and consideration of up to 10 risk factors per instrument for sensitivity calculations.

Migrating Through Maturity Levels Using the ARC Approach

A transition from an on-premises setup to using a public cloud can provide much needed computational headroom and create the desired agility while eliminating many of the previously mentioned challenges. The journey to the cloud for risk calculation use cases can be managed in a way that is compatible with the current risk platform strategy of any financial institution. Simultaneously, it can help control costs, and retain full data security and confidentiality (see below for the adoption stages to an effective cloud journey).



Source: Accenture, July 2017

Areas of Focus at Each Level of Migration for Risk Calculations

Level 1 Focus:	Providing computational headroom with minimal architectural disruption by modifying key risk management systems. This allows an organization to use public cloud on a burst basis at times of high throughput requirements. The existing workflow management should be updated to include management of risk calculations on the cloud alongside the on-premises calculations. In addition, specific training and controls are required for data and calculations being performed on the cloud, including data confidentiality, security, and auditability.
Level 2 Focus:	Utilizing the full agility of the cloud by moving the full set of risk systems and applications to the cloud. This is likely to be part of a strategic move across the financial institution. The work already carried out by many financial institutions to rationalize existing risk and data architectures should simplify the transition, but it would require extensive planning to determine the optimal approach for all applications, including legacy ones, where the financial institution has limited internal expertise in such migrations.
Level 3 Focus:	Defined by the complete migration of applications and data to the cloud, and the introduction of advanced analytics and data processes such as AI, event driven or real-time calculations, and intelligent automation.

High Level Summary:

	Level 0 On-Premises	Level 1 Hybrid Architecture	Level 2 Risk on Cloud	Level 3 Full Migration to Cloud
Major Features	• Traditional architecture managed on-premises • Multiple Front Office (FO) calculators with separate feeds to Back Office (BO) aggregation	• Extended traditional architecture with burst to cloud (on-demand resources) capability for key calculators	• All risk systems & applications on cloud • Full data on cloud • Functional architecture consistent with simplified traditional approach • Majority of costs Opex-based	• Advanced analytics, machine learning and other forms of AI, event-driven or real-time calculations, improved automation • Use of utility capabilities (e.g. market data management)
Focus Areas	• Data consolidation • Batch processing • Simplified risk calculations • Regulatory compliance • Auditability	• Complexity of risk models • Performance • Ad-hoc calculations • Elasticity of resources • Infrastructure costs	• Scalability of models • Reliability with load variations • Total cost of ownership (TCO) • Value creation	• Advanced modelling and analytics • Real-time calculations and reporting • Big data, AI, machine learning, etc. • Automation • Flexibility and scalability
Key Benefits	• Well understood architecture	• Significantly increased computational headroom • Flexibility to respond to irregular demands on cost-effective basis	• Highly agile architecture with ability to spin up multiple environments at will • Improved data quality and control • Improved risk and capital visibility	• Advanced analytics in an agile environment to increase value propositions to the clients • Reduced IT, headcount and change costs
Key Challenges	• Lack of agility – adding capacity is slow and expensive • Capex-based • Issues in data management • Legacy systems	• Burst capacity (elasticity of resources) limited to modified applications only • Operation complexity with processing across two modes	• Restricted to current functionality • Limited implementation of advanced analytics • Limited real-time processing	• Data intensive • Lack of universally accepted standards
Cost Reduction	*	**	*****	*****
Flexibility & Capacity	*	***	*****	*****
Functionality	**	***	****	*****

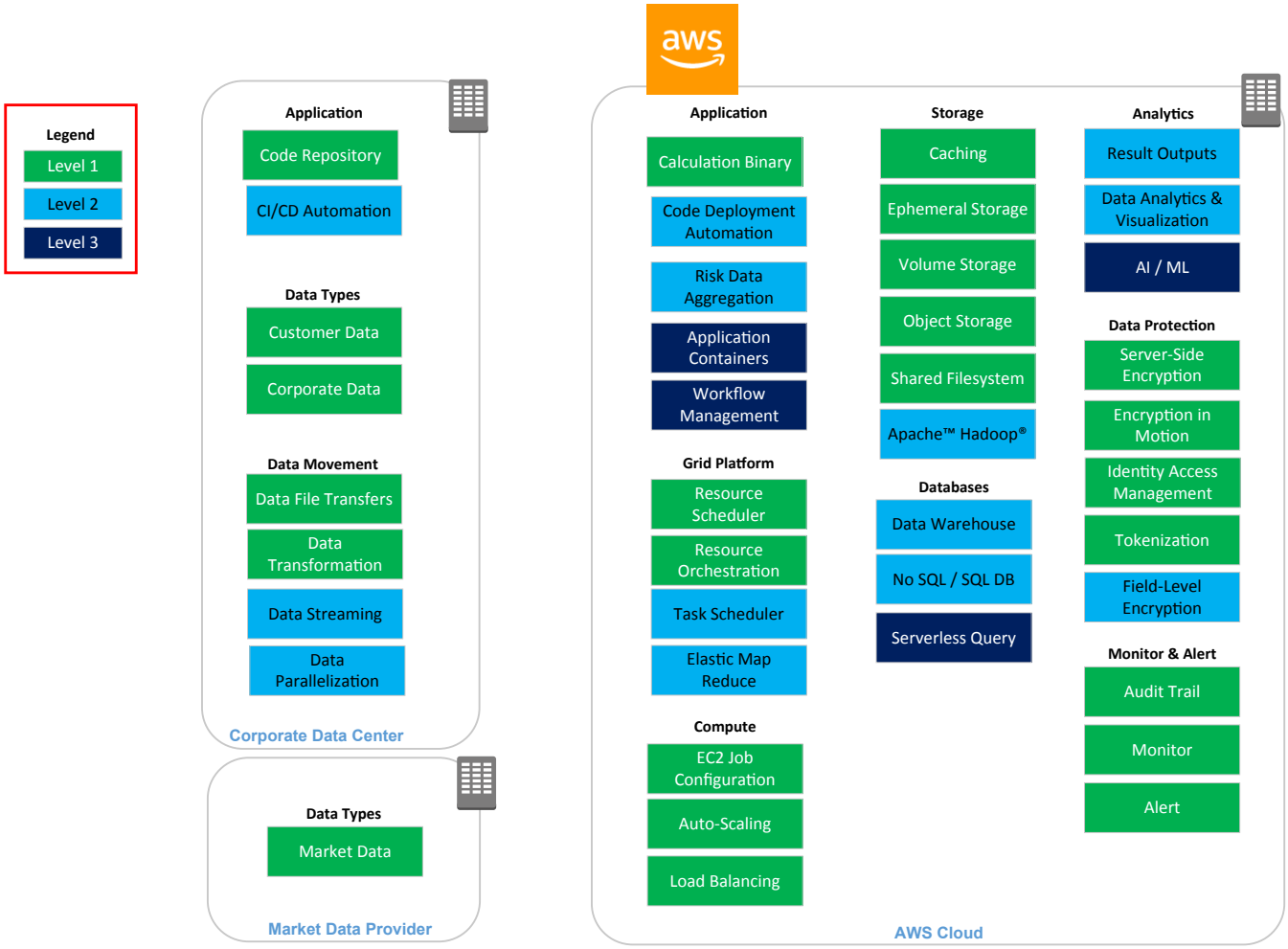
Legend: * Very Low ***** Very High

Source: Accenture, September 2017

The ARC Architectural Roadmap and Technical Requirements

Migrating through the ARC maturity levels requires an understanding of the functional components of the architecture along with an understanding of the technical requirements of these components.

The following diagram illustrates the functional components, their target on/off premise location, and the maturity levels that ought to be achieved.



Source: Accenture, September 2017

When transitioning through the maturity levels of the ARC roadmap, financial institutions should be aware of the technical requirements for their risk management solution, along with the appropriate AWS solutions. These include the following:

Software Development Life Cycle (SDLC) & DevOps: Consider the opportunities for more test environments that can be created and removed simply and quickly as required. For instance, setup the target architecture and perform an optimization test before deployment to production. Note that model binaries for market and credit risk may need to be deployed daily. Consider "Infrastructure as code" and continuous integration/continuous deployment (CI/CD) as these can result in huge benefits, but do consider how current procedures and tools would need to be changed. Optimal usage of AWS CloudFormation and AWS OpsWorks tooling will be very beneficial in this regard to increase automation and re-use.

Ingress and Egress from AWS:

- For passing market and credit risk data into the AWS Cloud, this will be a combination of model, trade and market data (stress/current/historical), while for credit risk it will be trade, counterparty, collateral, netting rules and market data. Data sets will be large — many gigabytes (GB) per day not being unusual.
- Level 1(L1) data out will include all the VaR strips for all the variants of the calculation. With aggregation and statistic calculations still being done on-premises, a large volume of data will be sent back to the financial institution. Once at Level 3 (L3), data sent back is minimal.

Calculation Logic & High-Performance Computing (HPC):

- HPC allows financial institutions to solve complex risk calculations requiring a large amount of compute, high throughput and low latency networking in a predictable manner. This need for massively parallel architectures, which scale up and down in a cost-efficient manner is a key benefit to considering a move to AWS.
- To implement HPC, high-performance compute grids (HPG) are highly effective and proven. This involves the use of a compute cluster controlled by a director/controller with jobs submitted to a manager/broker. The client sends the task/job to the broker who in turn submits the work to a configurable number of engines/workers.
- The calculations often occur at each region's end of trading days and as per regulatory requirements need to be completed within 24 hours. For stress testing, the same applies, but these are typically less frequent with more flexible running times.
- The preference among banks is likely to be to shorten current processing durations so that more cores are used than currently used on-premises. There is no one-size-fits-all for this, but for a larger investment bank (IB), this can be upwards of 100K high spec CPU (central processing unit) cores to process the risk calculations over 1-2 hours a day across all asset classes. Given the parallel nature of risk calculations, there can also be significant benefits realized by utilizing GPU (graphic processing unit) instance families, with processing times markedly reduced using CPU/GPU mixed model approaches.
- Consider the following for Amazon Elastic Compute Cloud (EC2) instance types:
  - R4, ideal where a lot of data is required in memory.
  - C4, ideal for pass by value calculations and where there's a high degree of parallelism.
  - P2's use of GPUs can be ideal when combined with other instance types.
- Given the variety of EC2 instance types and the ability to spin up test environments relatively easily, financial institutions can quickly experiment with different combinations of instance types to get the ideal HPC environment for a given budget. The ability to change the EC2 types quickly provides users with the ability to cater for changing requirements in the future.
- With the cloud being used as an extended grid for risk calculations, L1 requires the effective use of AWS Cloud resource scheduling and orchestration along with the appropriate scheduling of the application tasks. This also requires the use of the appropriate load balancing and auto-scaling AWS features to automatically manage spikes in compute cycles in a cost-effective and timely manner.

As we migrate to L3, there is a natural evolution to consider big data ecosystem architectures converging with burst compute characteristics, especially as: a) more data will reside on the cloud; b) the performance and capabilities of the key technologies catch up and overtake traditional grid architecture; and c) they allow a financial institution to manage its calculation grid and big data analytics requirements in a consistent highly performant, reliant, and secure manner.

Storage:

- The binaries and static data should be stored in a highly accessible manner and close to where the compute will be performed. AWS S3 is a good candidate for this.

- For L1, there may be a need to cache the data being used for the risk calculations, given that these should be completed in a timely manner. As part of this, the use of third-party in-memory databases/stores can be considered to improve access. Big data solutions will be part of Level 2 (L2), so the likes of Apache™ Hadoop® software stack would run in AWS Cloud. The move to performing data management within the cloud means that structured query language (SQL)-based and no-SQL data stores would be required for the risk input and result data, along with data warehouses/data marts utilizing the data for onward analysis and reporting. While this could happen as early as L2, L3 takes this further by promoting server-less techniques and services to query and probe large datasets without the need for complex extract, transform, and load (ETL) operations. Where ETL is required, AWS Data Pipeline is a good choice.
- For archival storage, such as for previous calculation results, AWS Glacier is recommended as a part of a storage lifecycle management strategy to chill data through the S3 access tiers and into long-term archival.

Security & Compliance:

- The ARC approach at all maturity levels should provide strong data protection, multi-factor authentication, privileges management with clear segregation of duties, use of security groups, Network Access Control Lists, infrastructure partitioning and detective/alerting controls. All of this is available and central to the AWS Cloud offering.
- The AWS environment is comprehensively controlled and is compliant with a large number of certifications such as SOC 1 Type 2, SOC 2, SOC 3, ISO 27001, and Payment Card Industry Data Security Standard (PCI DSS) Level 1. This should greatly help financial institutions address their compliance requirements. Compliance functions may also require that data reside in a particular region, something that is unlikely to be an issue given that AWS is currently located in 16 regions globally.
- The non-market data transferred to and from the calculations is always going to be company confidential and should be encrypted both in transit and at rest. Consequently, the data transmitted would require proven integrity, non-repudiation, and sender. Access to view the data should be restricted to authenticated and authorized users only. Therefore, access to user sensitive data could be made via HTTPS, file transfer via Connect Direct or client web service (CWS), part of a virtual private network (VPN). For access via the web, an additional firewall is recommended. Given the level of security required, a hardware security module (HSM) should be used to improve the management, security and performance of the key management implementation. All of this is available on AWS, although some financial institutions may wish to use some of their own mechanisms or use services from third parties, such as bring your own key (BYoK) to AWS Key Management Service (KMS). AWS Identity and Access Management (IAM) provides an excellent solution for managing users, roles, and groups, and their access rights. Firms can also use their own, or an AWS Active Directory/ Lightweight Directory Access Protocol (LDAP) service.
- Building security in every layer and defense in depth should be adopted by financial institutions, along with a policy of least possible privilege. Usage of traceability and monitoring tooling is highly recommended, such as using AWS CloudTrail to store application program interface (API) usage information, applying rules to application configuration via AWS Configuration and using AWS CloudWatch to monitor and alert anomalies.
- Network isolation is key to maintaining tight security in the cloud. For instance, clusters should be initiated via temporary access and isolated from other subnets.

High Availability and Disaster Recovery (DR):

- Given the criticality of risk functions, very high availability and a robust DR mechanism is critical, along with the need to have automated failover. Our general recommendation is for at least two load balanced availability zones (AZ) located near your data center, along with a DR site in a different region to provide redundancy.
- The HPC controllers should be able to either use leadership election to failover to another controller or have an automated mechanism for detecting an issue and moving to a passive controller. Dynamic data stored in caches should be replicated across AZs in an automated manner to avoid issues being applied to a single zone.

Data Types & Data Movement

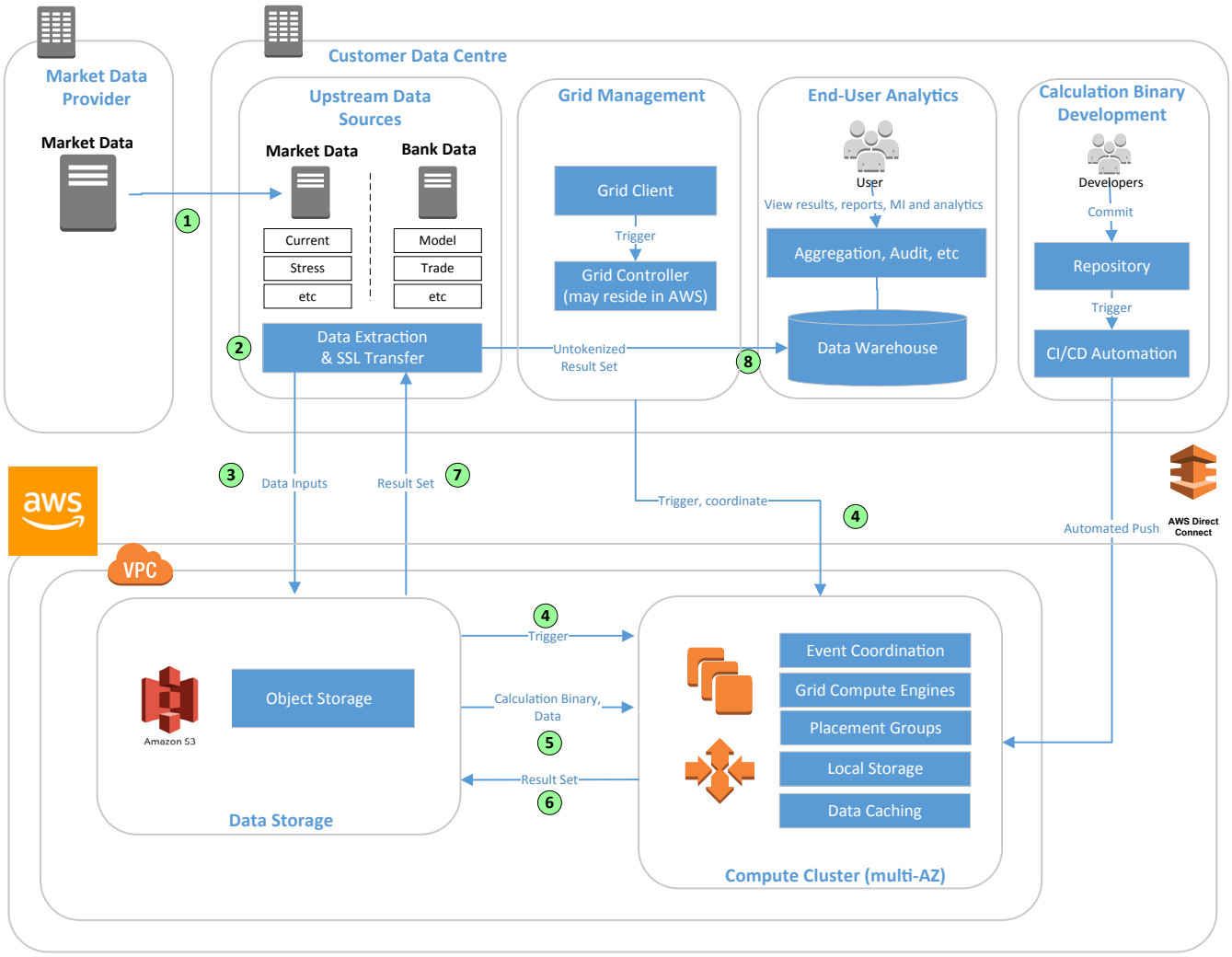
- The data required for the calculations will initially be sourced from the corporate data center. This would be transformed and transferred to AWS as part of an L1 adoption.
- As part of L2, the risk calculation engine can start to consume data directly from other cloud-hosted providers, negating the need to use the financial institution as a pass through. The ability to move from daily data transfers to real-time can be realized as part of L2. This would allow for more timely risk calculations by smoothing out the processing spikes, while facilitating the early detection of issues. Other areas for consideration include:

Analytics: The risk calculation outputs are sent to the financial institution within L1, but reside in the AWS Cloud from L2 onwards. This data is analyzed and visualized as part of the transition to L2 with users viewing the results, reports, and management information via access to AWS. Advanced analysis in the form of machine learning and AI would be performed in the AWS Cloud as part of the move to L3.

The ARC Technical Architecture

Having discussed the requirements and potential solutions for migrating a financial institution's risk management function to the cloud, in this section we delve into suggested technical architecture solutions.

The diagram below is a high-level illustration of ARC technical architecture for Level 1.



Source: Accenture, September 2017

L1 displays a common model for migrating an on-premises style risk calculation grid to AWS. An Amazon Machine Image (AMI) will be built within the Amazon Virtual Private Cloud (VPC) along with the required grid management and quantitative analysis software deployed on EC2. Note that there are three options available for the HPG implementation. Depending on maturity levels within L1, firms may choose one of the following:

1. Deploy additional compute within the cloud to complement an on-premises grid solution. This should provide benefits such as being able to cope with spikes/bursts in activity beyond what the current on-premises solution can cater.
2. Deploy all the compute grid on the cluster but keep the controller on-premises. This provides more cloud benefits such as dynamic auto-scaling. This is shown in the previous diagram.
3. Deploy the whole HPG solution within AWS to enhance the wide-ranging benefits of the cloud.

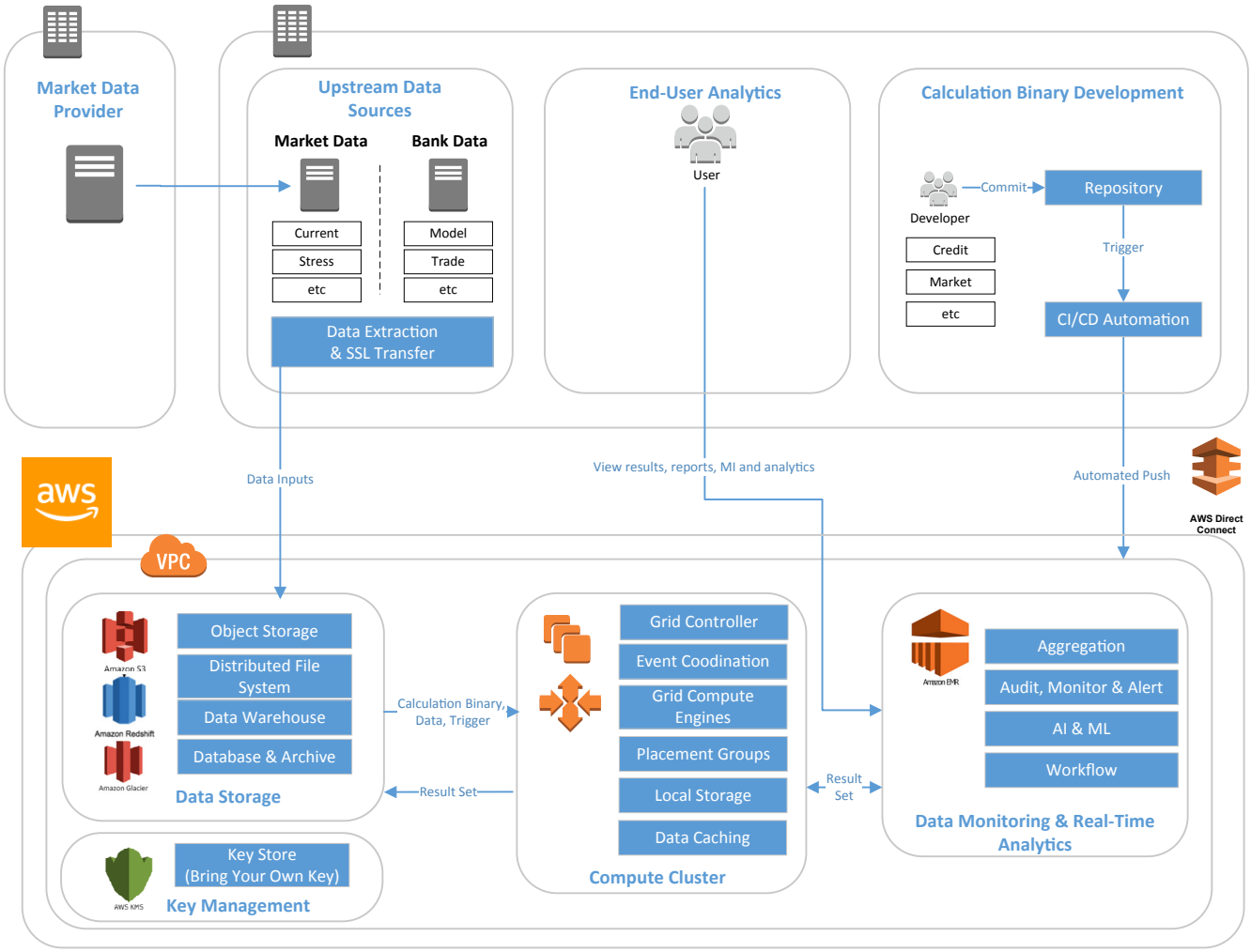
An event-driven architecture is suggested. Events such as deploying a new binary, updating data, or a trigger from a batch would be sent to a distributed streaming platform which then coordinates which job is to be executed by the HPG. The key benefit of an event-driven architecture is the flexibility to publish and subscribe, and process and distribute events in a simple and resilient manner.

AWS DirectConnect can be used for dedicated access to AWS EC2 resources with a possible combination of 1GB and 10GB links between your site and AWS. This provides more predictable latency and throughput of the large amount of data being transferred to AWS.

To help realize the cost saving benefits of moving the compute to the cloud, the AWS instances should be shut down when not required and when demand reduces. As demand increases, new EC2 instances should be started before the grid is deployed and brought online. To assist with this, financial institutions should consider cluster management tools which can coordinate the effort in a simplified, reliable manner.

With L1 centered around moving data to and from the cloud, use of AWS KMS would be vital for encryption and decryption of sensitive data. In this example, S3 is used to store data inputs and outputs as a staging area. For those calculations requiring access to large numbers of datasets, the pre-caching of data should be considered. Care should be taken to optimize compute capacity and cost. Thus, it is important to balance the use of on-demand compute resources with the use of reserved instances for a baseline of required capacity due to heavily discounted incentives. Level 3 of the maturity model involves financial institutions fully exploiting the AWS Cloud solution to perform actions such as advanced analytics.

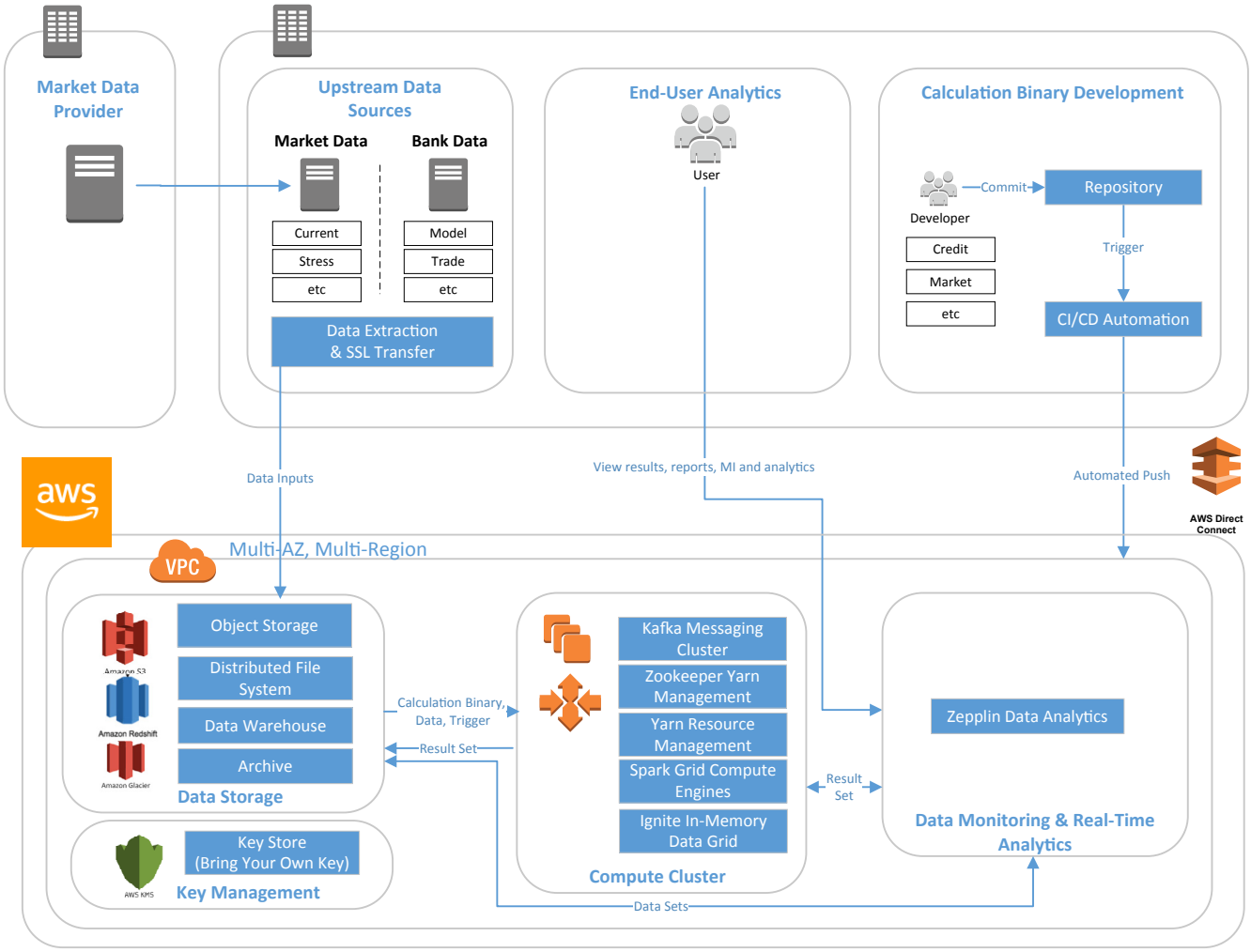
The diagram that follows illustrates the high level technical architecture for Level 3.



Source: Accenture, September 2017

The transition in maturity from Level 1 to 2 to 3 introduces several proven, reliable, functional, and performant technologies. How all these technologies are to be configured and optimized for usage by the financial institution's risk management function requires the experience and know-how of the Accenture and AWS teams.

As an example of a Level 3 technical architecture, Accenture and AWS have worked together to implement the following.



Source: Accenture, September 2017

In the Level 3 implementation, the key features are as follows:

- Apache™ Hadoop® YARN is cluster node manager coordinating and submitting commands to the engines/ nodes in an optimal manner.
- Apache Spark™ provides the high-performance scale-out compute engine using the micro-service jobs.
- Apache Ignite™ provides the in-memory computing platform for keeping the data close to the compute engines, and is backed up to disk as required.
- Apache Kafka™ receives events, such as data updates, job completion and batch, and publishes these to consumers such as Apache Spark™ stream jobs. This can be installed both on-premises and within the cloud to coordinate between any remaining financial institution publishers or consumers of the risk management function.
- Apache Zeppelin™ provides advanced interactive data analytics and visualization to allow financial institution users to fully exploit their risk management data.
- Resilience and high availability is provided by deploying the architecture across availability zones and across regions as required.
- Data in transit is encrypted by SSL (Secure Sockets Layer), at rest it's encrypted within S3 and EBS.
- Historical data required for compliance is transferred to Glacier.

Conclusion

Financial institutions are under increasing pressure to balance regulatory compliance with business growth, all while being under pressure to reduce costs. Risk management is a clear example of this. Given the maturity of the AWS Cloud solution, now is the time to begin, or even accelerate the journey-to-cloud for financial institutions, to help transform their businesses and meet business and compliance needs. With Accenture and AWS, the migration path consists of three levels:

1	2	3
Migrating the risk calculation computation to the cloud	Deploying all risk applications and systems to the cloud	Full migration to the cloud using advanced analytics and artificial intelligence capabilities

For more information

For more information, visit https://www.accenture.com/us-en/service-aws-cloud.

Steve Murphy, Senior Managing Director
Accenture Operations, Financial Services, United States
stephen.m.murphy@accenture.com

Graeme Hughes, Managing Director
Accenture Consulting, Financial Services, United Kingdom
graeme.hughes@accenture.com

Ashley Davies, Managing Director
Accenture Consulting, Finance & Risk, United States
ashley.davies@accenture.com

Peter Williams, Global Technology Lead
AWS Financial Services Partners
willpe@amazon.com

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ABOUT AWS

For 11 years, Amazon Web Services has been the world's most comprehensive and broadly adopted cloud platform. AWS offers over 100 fully featured services for compute, storage, databases, analytics, mobile, Internet of Things (IoT) and enterprise applications from 44 Availability Zones (AZs) across 16 geographic regions in the U.S., Australia, Brazil, China, Germany, Ireland, Japan, Korea, Singapore, and India. AWS services are trusted by more than a million active customers around the world – including the fastest growing startups, largest enterprises, and leading government agencies – to power their infrastructure, make them more agile, and lower costs. To learn more about AWS, visit http://aws.amazon.com.

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