RFM

Risk Framework Management

White Paper

Credit Rating and Loan Workflow
for Business Customers

Automating the Lifecycle of Wholesale Credit Rating Models

A user-configurable software architecture for rapid time-to-market, competitive agility, and evolving regulatory needs.

Executive Summary

Financial institutions face rapidly evolving competitive and regulatory challenges and will continue to do so for the foreseeable future.

Wholesale risk management systems have often restricted competitive agility, and extended time-to-market

The RFM architecture uses highly configurable models and automates workflow transitions from model development to business production.

RFM dramatically lowers cost of ownership, facilitates exceptional product flexibility, and supports seamless, highly adaptable regulatory reporting

Table of Contents

Table of Contents

Introduction

Financial institutions (FIs) face a number of new challenges as they compete to make profitable loans in competitive and regulatory environments that are evolving at an unprecedented rate. National regulators are still formulating their responses to the 2008 Global Financial Crisis (GFC) and are progressively implementing prudential and management frameworks that are intended to improve risk management within FIs, such as those defined by the Basel Committee for Banking Supervision (BCBS)[1] and the Dodd-Frank act[2]. For the foreseeable future, most national regulators will continue to increase their oversight activities, placing greater and greater demands on FIõs information systems.

In addition to meeting ever steepening regulatory requirements, FIs are also feeling competitive pressure due to advances in information technology itself. People throughout the world have become accustomed to reaching into their pockets and running applications (or ñappsò) on mobile smart devices that give them instant access to information about almost every aspect of their lives. The internet has also enabled new business models that bring capital providers and borrowers together, bypassing traditional FIs completely. While such ñpeer-to-peerò (P2P) lenders have, to date, captured only a relatively small percentage of the overall market, they are growing at a phenomenal rate and may pose a threat some established FIs.

In response to these forces many FIs are seeing their risk management systems (RMS) in a new light. RMSs were often regarded as pure cost centers, maintained mostly to ensure the FI can ñcheck the boxò against each of its regulatory reporting requirements. However, this is changing.

Risk Management Systems are now being recognized as powerful strategic assets.

More than ever before, the future success of a FI depends on getting its IT architecture right.

In this white paper, we will examine the relationship between particular regulatory and competitive pressures, and the specific requirements they define in IT systems. Rather than attempt to discuss this generally, we will concentrate on a single line of business, namely commercial loans to small/medium enterprises

(SME). Because of certain complexities unique to SME loans, this area of activity has generally not benefited from advances in information technology to the same extent as have equivalent systems designed for retail customers.

Translating regulatory obligations and competitive pressures on financial institutions into information system requirements

Regulation

The 2008 financial crisis brought into sharp relief the potentially disastrous consequences and global scale of poor risk management in the financial sector, particularly in financial institutions classed as globally systematically important FIs (G-SIFI). These institutions compete in markets that are global, but are regulated by bodies that are still national. Government regulators around the world have responded by progressively implementing risk management principles that both strengthen prudential oversight, and are increasingly uniform among different countries and regions. By adopting risk and governance frameworks such as the BCBS[1] and the Dodd-Frank Act[2] government authorities are aiming to limit future distortions of not only their own national economies, but also of the global financial system.

Since our focus is on information management within FIs (while acknowledging that many other dimensions such as culture, process, etc. must also be included in effective risk management measures), steadily increasing regulatory oversight is manifesting itself as:

- Frequency of reporting is increasing.
- Both the scope of information that must be reported, along with the reporting granularity are increasing.
- Ad hoc reporting requests are increasing.
- To give report consumers the ability to independently audit and verify aggregated metrics, dynamic reporting formats are becoming more desirable. That is, rather than delivering reports as forms that embed static information, or templates for creating these, dynamic reporting formats are more like mini-databases with embedded metadata. The report author supplies and formats the required raw data, but in a way that gives the end user control over the way it is organized, filtered, aggregated and displayed. The increasing use of

eXtensible Business Reporting Language (XBRL) is consistent with this trend.

- Some regulators are pursuing direct feeds to FIsô information systems, enabling near real-time access to data and a degree of ñself-serviceò on the part of the regulator (for example, Austriaõs central bank, the Oesterreische Nationalbank[3]). While the overall trajectory of regulatory reporting leads to this kind of solution, it is still regarded with considerable cautiousness.

Most FIs are not, at present, well equipped to accelerate data deliveries to their regulators in the way the above points suggest will be necessary. Their information architectures have systematic limitations that prevent them from being able to continually scale their output in terms of volume, sophistication, accuracy, while being more timely and responsive. This is because:

- Reporting functions are generally carried out manually and are very labor intensive and time consuming.
- Underlying data sets lack sufficient integrity to be easily integrated into reports.
- Data sets exist in silos and easily translatable common keys for integration with other data outside the given silo do not generally exist.
- There is no common data model, nor is there an organization-wide, clearly defined data taxonomy, making integration of data from different departments with inconsistent semantics more difficult.
- Data volumes over which aggregation is required can be very large and present systems do not have adequate performance, and/or do not scale.

Customer Experience and Competition

The internet, combined with the recent widespread adoption of personal mobile devices such as smart phones, tablets, and even watches, has dramatically changed how businesses interact with their customers. In retail banking, the impact of this has been nothing short of revolutionary. Most banking transactions that once required a branch visit can now be done online and banks around the world have been developing powerful online applications for their retail and SME business customers. Less reliance on physical branches has seen the number of these diminish in vast numbers (9,481 bank branchesð about 10% of the totalð were closed in the USA in the 3 years between 2010 and 2014[4]).

Research indicates that the migration of banking functions from in-branch to online has met with enthusiastic consumer acceptance[5], with Figure 1 showing that online interactions are by far the preferred customer interaction channel for many routine functions (note that the results do not distinguish between business customers and individuals). Perhaps less well known, but very significant, is that the same study also suggested that banks are among the most *trusted* organizations. More respondents (39%) nominated their bank as the organization that they would most prefer to be the custodian of their digital identity (ñnot trusting anyoneò came second at 32% and the government third at 15%).

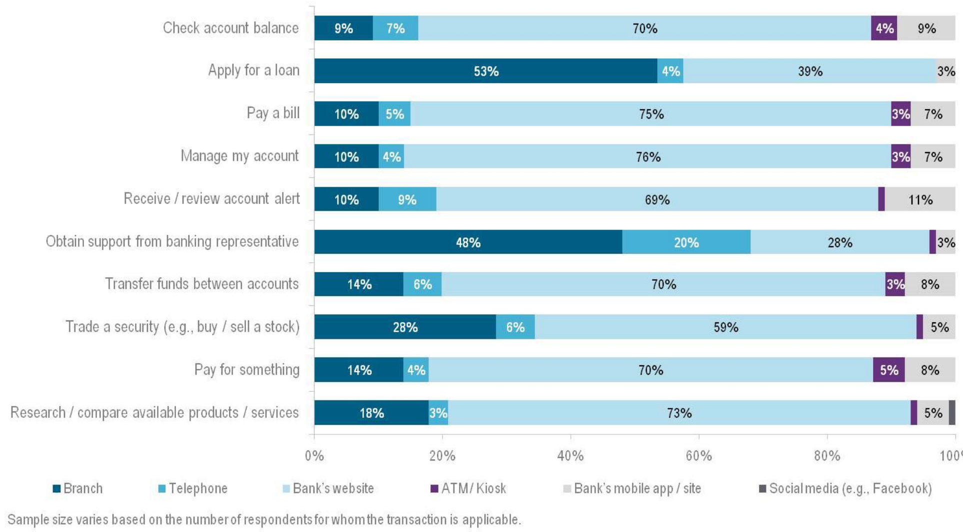


Figure 1. Preferred channels among US banking customers (Source: See Endnote 5).

Given that customers prefer to conduct many of their transactions online, and feel most secure doing so when using their bankôs application, FIsô ability to deliver a highly positive, online experience that their customers perceive as safe has become a major competitive factor.

Another source of competition arising from the internet is the recent emergence of online peer-to-peer (P2P) credit/investment providers. Using the well-tested ñcut-out-the middle-manò business model, P2P lenders/investors allow owners of capital to lend funds /issue securities to borrowers ñdirectlyò without a traditional FI mediating the transaction. For lenders/investors who are prepared to take on more of the risk burden and due diligence responsibility than a traditional FI investment would require, the P2P solution can offer higher returns. Whether P2P and other new business models are as disruptive in the financial services sector as companies such as Ebay, Uber, and Airbnb have been in their industries remains to be seen. Also unknown is how much new modelsô success will depend on capturing existing business from established FIs, and how much from opening new markets that FIs do not currently serve.

Impacts on information systems: (a) Business requirements

The variety of sources from which FIs are being pressured to adapt, ranging from regulators to customers to competitors, all ultimately drive a common, consistent set of needs that information management solutions must meet.

1. Speed and responsiveness

(a) Regulators will continue to require more information, more often. For example, giving a team of analysts a week to create a monthly Liquidity Coverage Ratio (LCR) report will no longer be possible, as regulators have expressed their intention to have LCRs calculated daily. FIs must be able to compile and aggregate complex data sets quickly[6].

(b) Customers have come to expect responsiveness in two distinct ways, both of which have ramifications on how FIs manage their information:

i. *Online applications with fast interactive response.*
When a user selects an application screen it must appear almost instantly. Data retrieval and application processing must perform well and must scale.

ii. *Rapid fulfillment*
Functions that require offline processes must provide the customer with a response as quickly as possible. For instance, two week turn-arounds for loan applications should become same-day decisions. Back office processes must become as efficient as possible to support expedited timeframes.

2. Flexibility and agility

(a) Regulatory requirements are still changing rapidly and FIs require information systems that can quickly adapt to new data requirements, output formats and timeframes.

(b) Competitive success for FIs will to depend more and more on how quickly they can operationally respond to challenges from competitors and to market opportunities. Presently, even simple product changes can take many months to reach the market because of labor-intensive system implementation lifecycles. Rapid development/rapid deployment techniques are essential. The extent to which information systems can provide strategic support depends on their ability to rapidly create new data structures and support new processes in respond to new business situations, and to do so within the FIôs overall information architecture framework.

3. Accuracy and completeness

a) Regulatory reporting requirements will demand that operational systems keep more accurate and complete data, especially if more sophisticated data interchange formats are adopted (e.g. see endnote 3).
b) Customer confidence in the FI will continue to depend on accurate and complete data records about the customerôs accounts. In addition, higher levels of data quality support more effective decision making, especially in risk-based products such as credit facilities, both at the tactical and policy levels.

4. Security

Information security is essential for FIs. Best practices have been defined by many bodies, and are continually reviewed. Any information system implemented by a FI must satisfy both regulated and recommended security requirements.

5. Accountability

a) Regulators are tightening audit standards and increasing punitive actions that can be taken against non-compilers (e.g. see Consultation Paper 8/15 from the UK Prudential Regulation Authority (PRA)[7]). The key to accountability is establishing systems that automatically create and maintain high quality data, highly granular change journals, and a metadata architecture that clearly allows the ñprovenanceò of any aggregate statistic to be traced back to each data element that contributed to it.

b) Both competition and customer preference is driving the number of ñself-serviceò transactionsð that is, those where a customer only interacts with their FIôs systems with no human contactð dramatically upward. While self-service generally lowers error rates, precise and complete audit data is vital to resolve disputes, and to support forensic identification and diagnosis of any anomalous transactions.

Impacts on information systems: (b) Required changes to existing architectures in response to changing business requirements

The above set of business needs can be translated into a set of system capabilities which, in turn, become the principles that shape the information system architectures FIs need to deploy.

1. Automation

A number of factors have resulted in FIs having grown large, skilled labor forces and, a culture of responding to information needs by utilizing manual labor. Historically, this approach was justifiable because:

- The building blocks for IT automation were not present, such as a common data model, high quality data, and interfaces that allowed easy automated access to data sources.
- The output of information requests was most often static reports containing high-level, aggregated data.
- The timeframes for developing responses were long enough to allow manual approaches
- There were few competitive forces on FIs driving them to automate information retrieval and analysis.

Given that the latter three points no longer hold, FIs must ensure that any information architectures they develop support highly automated processes for the retrieval of data, both on a recurring basis and to meet ad hoc requests.

2. Applications with flexible, multi-format data binding without central IT or vendor involvement

FIs deploy many applications to support their many lines of business. These typically access multiple sources of data, and often communicate with one another. Consistent with the historical tendency for labor-intensive, bespoke solutions referred to above in point 1, data and application integration has often been ad hoc. Consequently, enterprise information systems are brittle; a minor change to one system can initiate a cascade of changes to other affected systems requiring a major IT project and, usually, specialized consulting from the various system vendors. Strategic use of IT in such an environment is, at best, difficult; tactical useð to respond to competition from more nimble alternative sources of funding, or to exploit market opportunitiesð is all but impossible.

Line-of-business applications should include flexible data binding interfaces that that are controlled by *user-specified configuration*, rather than programming. A well-constructed data binding interface of this type automatically propagates changes to data bindings (connection details, schema structure, data type and domain constraints, etc.) to the application with no code changes required. When such systems are in place, IT systems become nimble, delivering to their business users the agility to quickly respond to tactical opportunities.

3. Ability to deal with imperfect data

The vast majority of data that FIs possess is produced as a result of their day-to-day operations. These data sets are tightly coupled to the applications that produce and maintain them and their nature presents FIs who wish to use their information systems as a strategic asset with a number of challenges:

a) Organization and semantics of data vary between applications. Business systems need to be able to easily interface with data whose structure differs from that used by the system. As with point 2, above, data mapping should be user-configurable.

b) They quality of data present in each field of a given data set is usually determined by the needs of the application that created and maintains that data set. Integrating such data sets requires that processes be created to handle missing, incomplete, or inconsistent data.

c) The data sets in question are often very large. Performing any of the above tasks is typically resource- and time-consuming.

These factors have further contributed with the human labor-based culture described in the above points.

To reap the full benefits of integration and deliver the level of agility required by business units, applications should be able to handle the data imperfections described here. As with item 2, accommodating imperfect data should not require the intervention of either centralized IT, or the vendorôs consultants.

4. Consistent data model with integrity enforcement

5. User-configurable, self-documenting models

Risk management functions, such as credit risk rating or estimating exposure to losses, have quantitative models at their core. These models are some of the most valuable intellectual property created by a FI, as they ultimately determine the loans that the FI accepts or denies, the FIôs required liquidity levels, and many other business parameters at every point along the strategic to tactical spectrum.

For the reasons outlined in the points above, making modifications to risk models has historically been a very cumbersome process. A further difficulty arises from most risk management systems being architected around models that are essentially hard-coded into the software, or require significant vendor input to change, making it difficult, expensive, and time-consuming for FIs to lending into new verticals where new risk models are needed, or to react tactically to changes in the markets they already participate in.

In keeping with the previous points, FIs seeking agile risk management systems need models that are highly configurable by the FIôs quantitative analysts, not the risk system vendorôs programmers. Given the regulatory and audit requirements risk models must meet, the modeling system should embody the ñself-documentingò paradigm now popular in many software languages (e.g., in Java and C#). Ideally, when a model is complete, production of the required documentation should be an automatic process.

6. Rapid Analyze-Verify-Deploy capability without central IT or vendor involvement

The biggest source of inertia when credit risk models are updated is not typically due to the work done on the model itself. Individual quantitative analysts have a variety of flexible tools at their disposal and are highly skilled in the data engineering techniques necessary to build innovative models in a timely fashion.

Once developed, however, models must be tested, verified internally and, in many cases, approved by regulators before they can be deployed in normal business trading.

Often, once the quantitative work is done, each risk model must then be *re-implemented* as program code by IT staff so it will run in the enterprise software system used to manage credit.

Consequently, what is potentially the FI's single most competitively potent item of intellectual property—a more efficient credit risk model—may languish as an IT project for months or, not uncommonly, years, before its benefits can be realized.

Modern, competitive FIs need a dramatically faster deployment timeframe for making risk models available for business, once they have been verified and approved. The latter part of this white paper describes in detail an approach that achieves this.

7. High performance and scalability

One of the central characteristics of the situation FIs find themselves in today, as touched on many times throughout this white paper to this point, is the need for rapid responses to information requests. All information management decisions must take this into account. In particular, when an application is being considered for use, both its baseline performance must be well understood, as must its forward scalability path as data volumes and transaction rates increase, as they surely will.

8. Architectures and APIs that support rich, inclusive customer experiences

Given that applications are more valuable when they can bi-directionally share both data and functionality with other systems, understanding the Application Programming Interface (API) approach and capabilities of each system is critical for an effective enterprise architecture. Generally, service oriented architectures (SOA) have been shown to provide good scalability, and, most importantly, do a good job of dis-entangling dependencies between different systems. By communicating at a service level (that is, using a networking protocol wrapper to access data or run functionality), each application is shielded from the implementation details of those it communicates with, allowing applications running on different platforms, written in different coding languages, with different internal data structures, database formats, etc. to reliably interact. Furthermore, changes to applications can safely be made without leading to a cascade of integration failures.

A credit rating system architecture for business lending driven by current and future competitive forces and regulatory needs

Modern banks and other financial institutions rely on powerful IT systems throughout their operations. In addition to performing large-scale, real-time transactional processing, enterprise computer systems are central to policy definition and enforcement, governance and oversight, auditing, and almost every other function that banks perform.

One of the most critical functions FIs perform in the economy is quantification of risk, especially credit risk. This is a complex task that must balance such factors as:

- The desire of lenders and investors to seek the maximum return that is commensurate with the probability of loss,
- The desire of borrowers to pay the minimum interest, again consistent with the probability of default,
- To ensure that loans are only authorized when the probability of default is low enough to protect both borrower and lender,
- To ensure liquidity levels are always sufficient to cover draws on the FIs cash reserves,

- To manage variations in the wholesale cost of money,
- To manage variations in the value of assets used as collateral,
- To securitize certain groups of loans, and sell them to investors rather than lenders.
- To do all of the above and more, and make a profit.

To be successful, financial institutions have to become exceptional risk managers,

which means not only analyzing data and embedding the results in their decision frameworks, but doing so promptly;

"speed to market" is one of the keys to success in financial services,

and will become even more so for the reasons outlined in the earlier sections of this white paper.

While most FIs have seized the initiative in their consumer lending operations, supported by many powerful software and data tools that are readily available, the technology that supports lending to SME businesses (or ñwholesaleò lending) is typically less well advanced.

Systems that lift the customer experience for small business borrowers to a level that is comparable to consumer lending will determine which financial institutions succeed in this line of business and which ones languish.

Challenges facing wholesale credit risk management systems

1. Tracking the SME Borrower Group Structure

Rating the likelihood that a prospective borrower will default on their payments is the central prudential pillar of lending. For individuals, this is relatively straightforward as most individualsô finances follow a similar pattern. They earn income through labor and investment, they incur expenses, they own assets, they have debts. In addition, third party credit scoring firms keep lengthy histories of individualsô past performance as users of credit. This collection of information gives lenders the ability to accurately model the risk of lending to any given individual.

So too with large corporations, the public disclosure, reporting and auditing obligations they are under, along with in-depth analyses by ratings agencies, means that a lender has access to detailed information relevant to the riskiness of a potential loan. Furthermore, since the loan amount (and therefore, margin on the loan) is likely to be much larger than a consumer or SME loan, the lender can afford to dedicate resources specifically to the risk analysis phase of a given loan.

Rating SMEs for loans or credit facilities, however, falls into a risk rating gap that exists between consumers and large corporations. Like consumer loans, SME loans are not large enough to support a dedicated research and modeling team. But, unlike loans to individuals, the features of an SME that determine its credit-worthiness do not fit a ñone-size-fits-allò template; they depend very much on the particulars of the business and of the industry sector it is in. The true nature of the net financial risk carried by an SME can often only be discovered by navigating a complex web of relations between the business itself, its customers, suppliers, and competitors, its owners and investors, parents, subsidiaries, and sibling companies, along with other interested parties. And, unlike public corporations, this complexity is not always well documented or even legally well-defined.

It is often the case that when determining the credit risk of a small to medium sized business, the FI must actually assess the combined risk of a <u>group</u> of entities, the relationships among which can be complex and subtle, and change over time.

Such ñgroupò risk management is one area where existing credit rating systems for SMEs often fall short. Limited by the capabilities of software packages not designed to deal with this level of complexity, FIs often re-purpose unused fields as proxies for tracking the details of the group logic. This has a number of negative consequences for the FI:

- Poor performance of the lending business. Either more loans go into default than planned, or fewer loans are approved than the risk policy actually allows.
- Poor data contributing to inaccurate reporting, and management and regulatory oversight of the FIs overall risk position.

- Inability to correctly propagate default status to the actual entities that are in default when loans with ñgroup ratingsò stop performing. Since other members of the group may also be customers of the FI, and/or members of other groups, a group model that is too simplistic results in distortions of default statistics.
- Inability to trace history of groups over time, along with the entities that make them up, as these evolve.

2. Acquisition and structure of financial data for spreading

A key tool in credit rating is the financial spreading of the entity, or entities to be rated. The credit rating system should be able to automatically draw data from the spreading system, and should do so in a way that takes into account the rating entityôs group structure discussed in point 1, above. Furthermore, the integration between rating and spreading should support the time-dependent nature of rating events. Over time, the circumstances of individual entities will change, as will the composition of rated groups. As each rating event is performed, the spreading information that was current at the time must be retrievable.

3. Flexible, industry-specific rating models

A key tool in credit rating is the financial spreading of the entity, or entities to be rated. The credit rating system should be able to automatically draw data from the spreading system, and should do so in a way that takes into account the rating entityôs group structure discussed in point 1, above. Furthermore, the integration between rating and spreading should support the time-dependent nature of rating events. Over time, the circumstances of individual entities will change, as will the composition of rated groups. As each rating event is performed, the spreading information that was current at the time must be retrievable.

4. Unknown structure and format of supporting data

Many factors contribute to the assignment of a credit rating, some quantitative, others qualitative. Given the huge variations among businesses seeking loans, a FIôs loan management and credit rating systems will have to handle limitless variety in the layout and structure of the documentation supplied to support the application.

RFM wholesale credit risk management key concepts

The RFM system addresses the requirements and challenges identified in the previous sections of this white paper offering FIs a new generation of competitive agility, flexibility, and cost-effectiveness in wholesale credit rating. It introduces the new concept of ñrapid model deploymentò, dramatically reducing the time-to-market lag when new products or features are developed.

To understand how RFM works, consider the following two risk measures:

Probability of Default (PD)
PD is an estimate of the likelihood that a customer will go into default. Most FIs use information provided during the loan application process (e.g. financial statements) to calculate a customerôs PD, and then in turn use this to assign a credit rating. The model that underpins this process is highly proprietary to the FI and forms one of its most powerful competitive assets.

By itself, PD does not fully determine the risk to which the loan exposes the FI, because FIs normally require borrowers to secure the loan with collateral. In the event of default, collateral may be liquidated to offset the loss suffered by the FI. Taking this into account provides the next measure of risk.

Loss Given Default (LGD)
Loss Given Default is a measure of the loss that the FI will suffer if and when a loan goes into default. In such circumstances, the loan may be re-negotiated, the assets securing the loan may be liquidated, or some other recovery action taken. LGD scenarios are often complex, since collateral or guarantees may come from a number of different sources.

EAD (Exposure at Default)
An additional component required to estimate the losses when a default occurs is the Exposure at Default arising from the defaulted customer, this is also a very complex component as it can carry may contingencies depending on the complexity of the customers facilities, which can range from a simple Term Loan to Structured Credit.

We will focus our attention on PD and LGD as they are the areas of currently are most sophisticated in the use of models.

1. Existing Approaches to PD and LGD Systems

As described above, FIs need to be able to respond to competitive pressure while maintaining regulatory compliance. Doing both of these successfully depends on accurate measures of both PD and LGD. These parameters are usually estimated via sophisticated modeling frameworks, usually implemented as follows:

PD

Most PD systems are either home-grown, or based on a particular vendorôs product, usually with significant customization. Home-grown systems vary in robustness. Some are collections of ad-hoc tools that began (and may still remain) as desktop applications implemented on platforms like Microsoft Excel® or Access®. At the other end of the home-grown spectrum are complex custom-built enterprise IT systems in which the institution has made a significant investment.

Vendors typically offer enterprise systems, and are often selected over in-house implementations because of perceived lower cost and shorter implementation time (although this does not always turn out to be the case).

Each of these approaches has its shortcomings:

- Ad-hoc systems generally have poor performance, reliability, security, and scalability characteristics, and often remain dependent on the particular staff that developed them. This represents an increasingly unacceptable risk to the institution.
- Home-grown enterprise systems are expensive and time-consuming to develop and operate. Often, they are developed to a fixed set of requirements and cannot easily adapt to changes in the FIôs business needs.
- In either of the above situations, business rules are commonly hard-coded, buried in the systemôs core code, and are difficult to find, manage, and change.
- Vendor solutions in their ñout of the boxò form usually provide only a subset of the FIôs ultimate needs, incurring considerable customization and integration time and cost before they become operational. Furthermore, vendor solutions are typically built around an assumed workflow and processes that may differ significantly from the way the FI does business. This usually requires that the FI pay the vendor to create a ñspecial versionò specifically for the FI, and to then retain the vendorôs services to update that version every time the FIôs business requirements change. This

is often expensive, and tends to follow the vendorȯs timetable, rather than the institutionȯs.

The typical lifecycle of a PD model or Credit Rating (CR) change is summarized in the timeline shown in Figure 2, below.

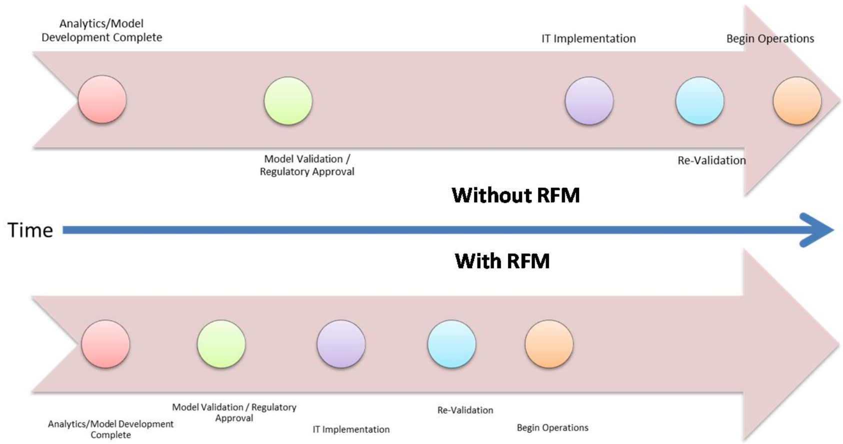
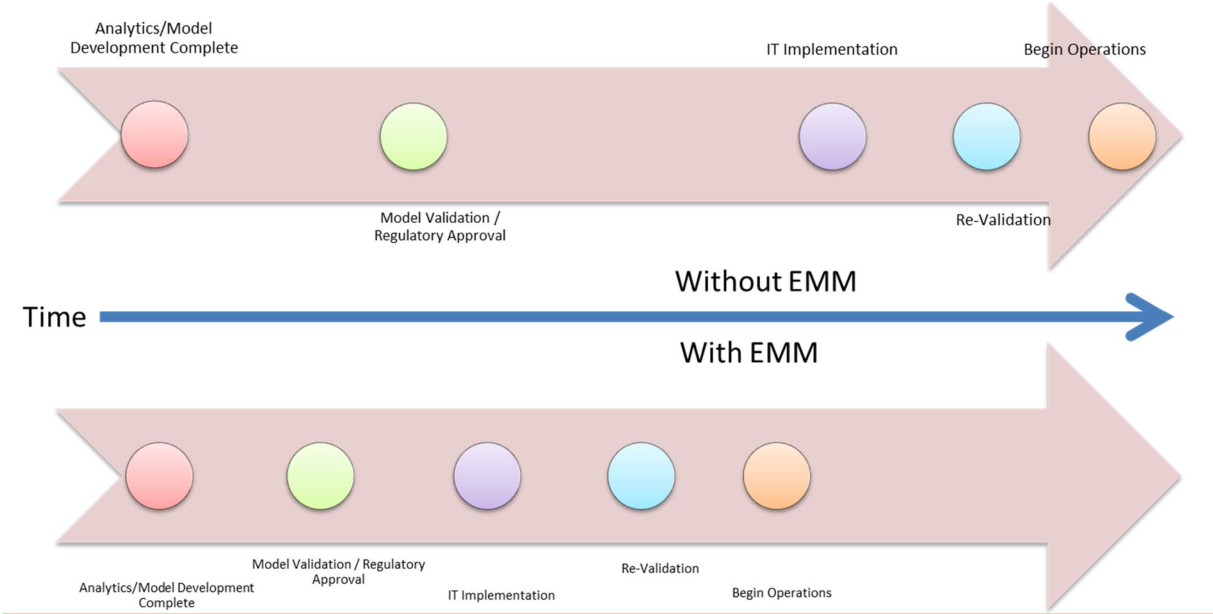
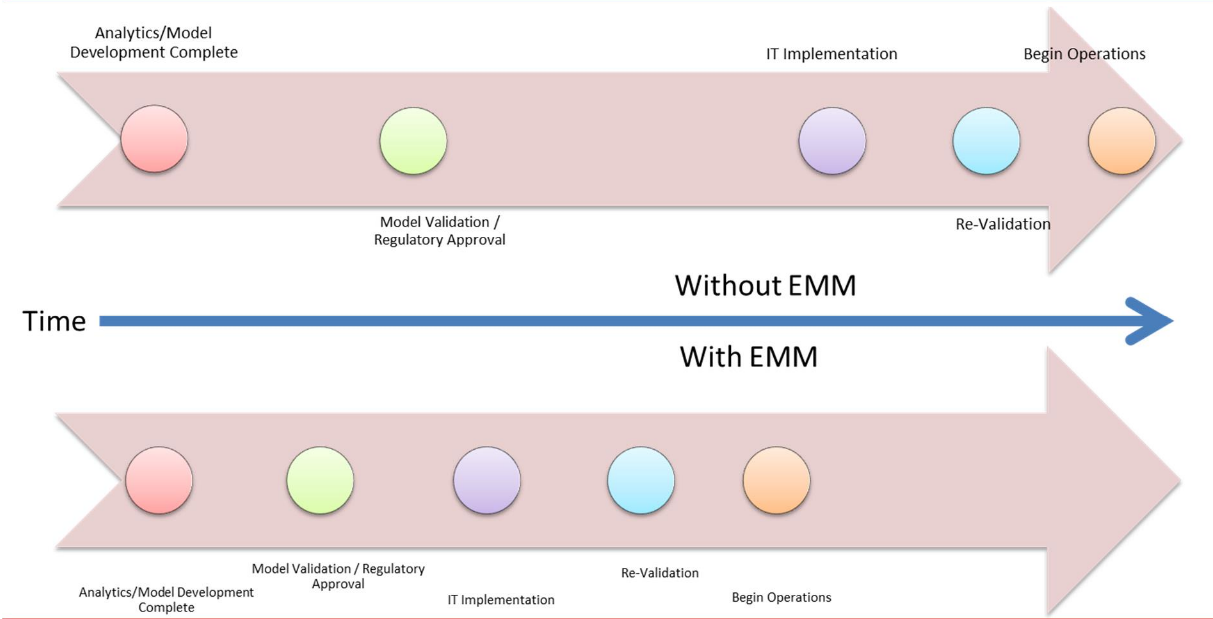


Figure 2. Comparative timelines for PD or CR model changes using the traditional vs. RFM approaches





The above illustration shows that at a typical FI not using RFM, two years can pass between beginning the process to change a model, and its deployment into production operations. The top two contributors to the time required are model validation and IT implementation. Consequently, these two phases represent the greatest opportunity for improvement.

LGD

LGD implementations usually face a different set of challenges from those that confront PD systems. The greatest of these is the wide variety of circumstances that may exist when a loan has defaulted. When this occurs, the FI must gather information from a wide variety of sources in order to support the decision making process that comes into play when loans are in distress. For example, what is the present value of the collateral securing the loan? What is the likelihood that the entity can ñtrade outò of its difficulties if the loan is restructured? The information that supports this ñforensicò analysis often comes from a wide variety of systems maintained by the FI, or, as often as not, from paper records. LGD is one of the paradigm examples of highly manual information management processes referred to earlier in this white paper.

The benefits of implementing the RFM approach to LGD can be realized along three distinct dimensions.

a) The RFM application framework either directly captures or provides links to all data that is required both to quantify LGD exposure, and support LGD decision-making. This facilitates automated access to the data, as discussed in an earlier section of this white paper.

b) Integrating the line-of-business application, its data, and the LGD modeling environment results in much more timely and complete access to LGD data, and consequently more accurate LGD modeling.

c) The RFM application framework minimizes the amount of IT and other labor required to support LGD functions.

2. Monitoring and Validation

Equally important to the model development process and the tools that support this is the model monitoring and validation process. This is an on-going feedback cycle that continually measures actual default rates, losses given defaults, and other risk related parameters, and compares these with the values predicted by the relevant models. Monitoring provides FIs with critical information to validate that the models they are using to make lending decisions are accurate representations of the true risks that actual borrowers face. In addition, even a well-tuned model will eventually drift from reality as circumstances in the world change, and a good monitoring process is essential for FIs to take corrective action in a timely manner when this happens.

While monitoring and validation is a mature discipline in retail lines of business, supported by sophisticated tools, in non-retail lines of business these functions are among the least systematized, most ad hoc and manual in credit risk management operations.

The modeling and data binding flexibility inherent in RFM's architecture allows monitoring and validation algorithms to be developed as part of the development of the PD and LGD models. Having both the forward predictive models and the monitoring algorithms share the same environment provides full traceability linking monitoring parameters to the relevant model constructs. This both provides FIs with timely assurance that their models are performing correctly, and both early warning and the necessary data when changes are required.

RFM Architecture

The primary opportunities for reaping time-to-market and cost benefits in the typical PD/CR lifecycle are apparent from Figure 2, above, with two thirds of the inception-to-deployment lifecycle taken up by the IT implementation and the model validation/regulatory approval stages.

The IT development and testing effort is a direct result of the model development and enterprise deployment occurring in distinct environments, and usually within distinct corporate silos communications between which are often patchy and unreliable. The model is built and validated by quantitative analysts who use analytics tools and belong to an organization that is ultimately the responsibility of the Chief Risk Officer (CRO). The final output of this process is then documented and handed over to a central IT organization that typically uses software development tools and reports to the Chief Information Officer (CIO). The *development and testing process is repeated* in the IT organization, as the model already implemented by the risk analysts is *implemented again*, but this time in an enterprise application server platform (such as Java, ASP.NET, etc.).

To dramatically reduce the time and effort needed to deploy model-based solutions, the model development environment and the operational production platform <u>should be unified</u>, so the costly "translation" from risk analysis to IT is no longer necessary.

This is the foundational concept of the RFM architecture.

1. Development and production environments unified by repository server

The RFM architecture has three main components:

a) World Modeler Desktop

A desktop tool, called *World Modeler*Ê which can created and edit models, import data from external sources, provide client-side version control, and perform other model-development related functions. Validation and stress testing is also performed in this environment.

b) RFM Server

An application and presentation server that can read (and, less commonly, update) the models produced by World Modeler and use this in production operations as:

- An interactive, multi-device web application
- A web-services API

Note that *World Modeler* can define the presentation characteristics of model elements, along with model logic. This additional information used by the server to automatically display the appropriate on-screen controls and views with which users can interact. Note that this presentation automation removes the IT ñtransposingò work referred to above and is a key efficiency driver in the RFM solution.

Quantitative risk departments already contain the in-house skills necessary to develop a model in World Modeler and deploy the result on an enterprise RFM server, without any central IT or external vendor involvement.

c) Model Repository Server

Linking these together is a common *Repository Server* that physically stores the models and serves them in the appropriate form to each of the environments. It also manages security, model audit, version control, linked documentation automation and related functions.

These are illustrated in Figure 3, below.

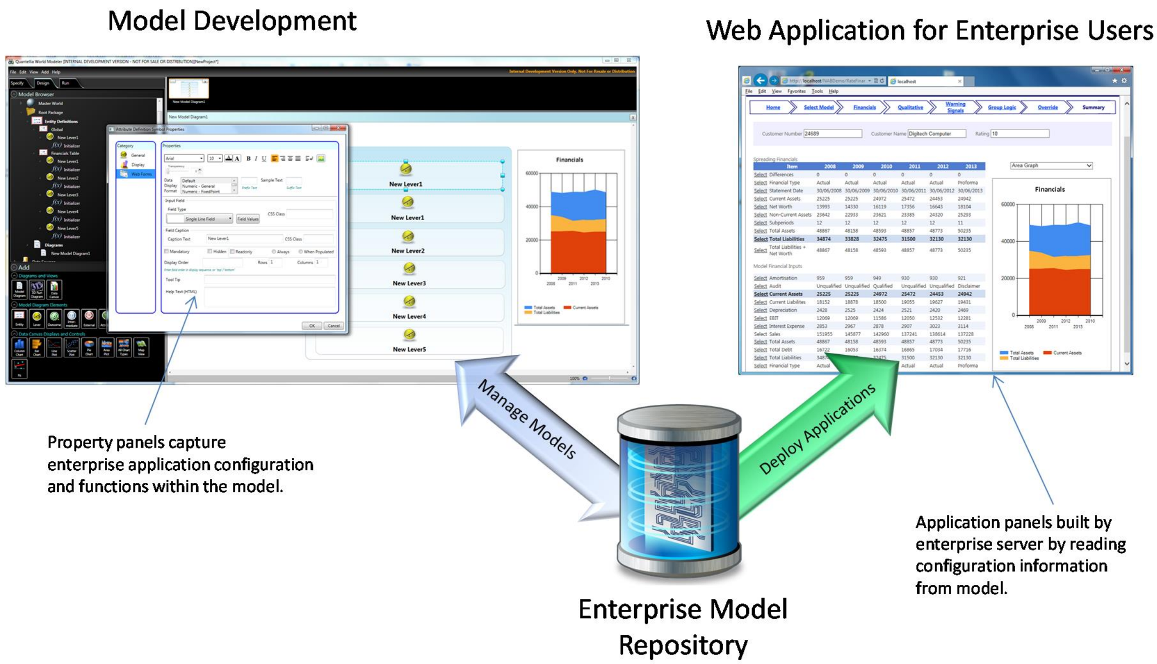
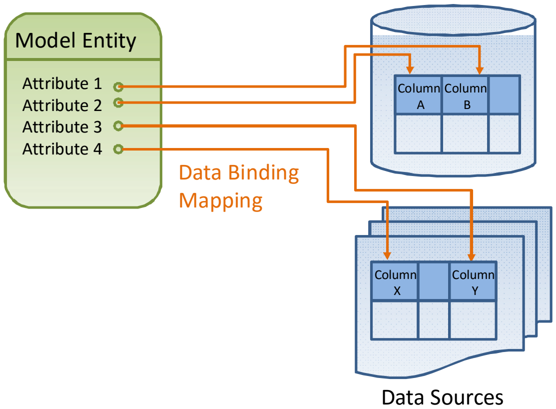


Figure 3. RFM unifies model development, version management, and deployment to business users.

2. Dynamic data binding

In addition to defining functional and presentation information, each model must specify how it connects to the sources from which the model reads and/or writes data. Many of these may be external to and outside the control of the business unit performing risk rating, or even external to the FI itselfð a circumstance that typically requires time-consuming and labor-intensive bespoke integration. To completely avoid this, and instead to maximize flexibility, openness and interoperability, RFM includes a dynamic data-binding layer which is used to link models to data. Dynamic data binding allows data schemas to be optimized to meet the needs of the model, and for models to easily be connected to existing data sources with minimal data migration. Data binding is illustrated in Figure 4, both at a conceptual level, and showing the user interface in World Modeler within which users drag model elements onto data sources to create bindings.



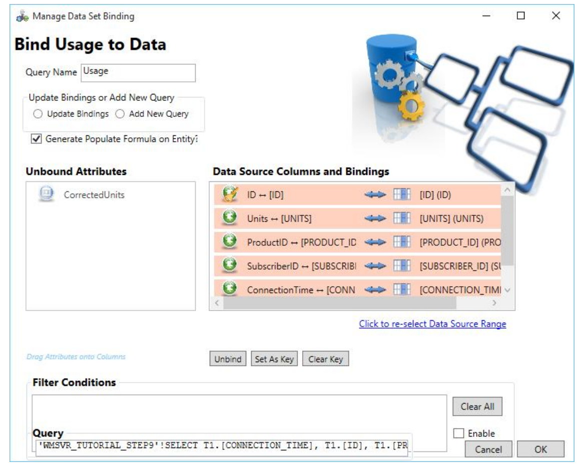
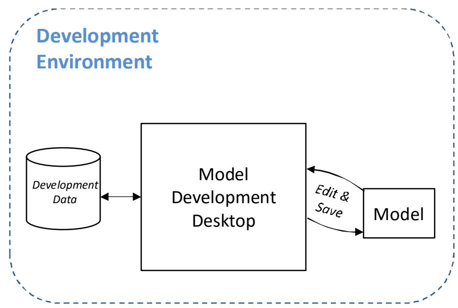


Figure 4(a). Dynamic data binding between model and data sources

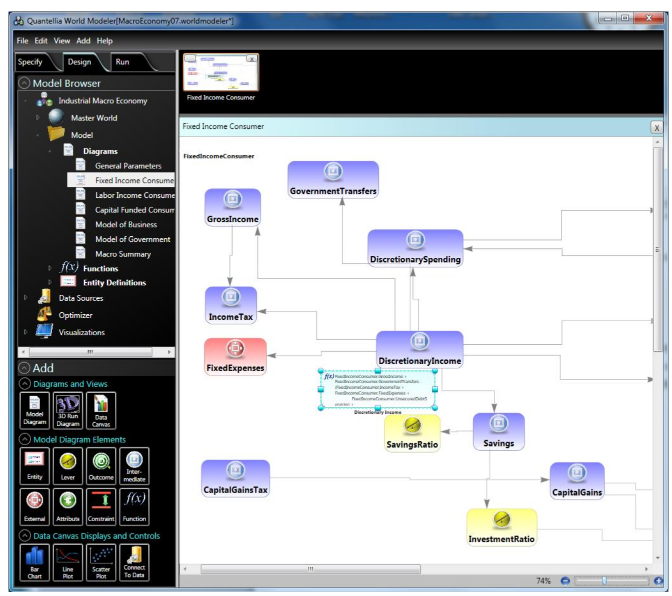
Figure 4(b). Dynamic data binding panel in World Modeler

3. Model development environment

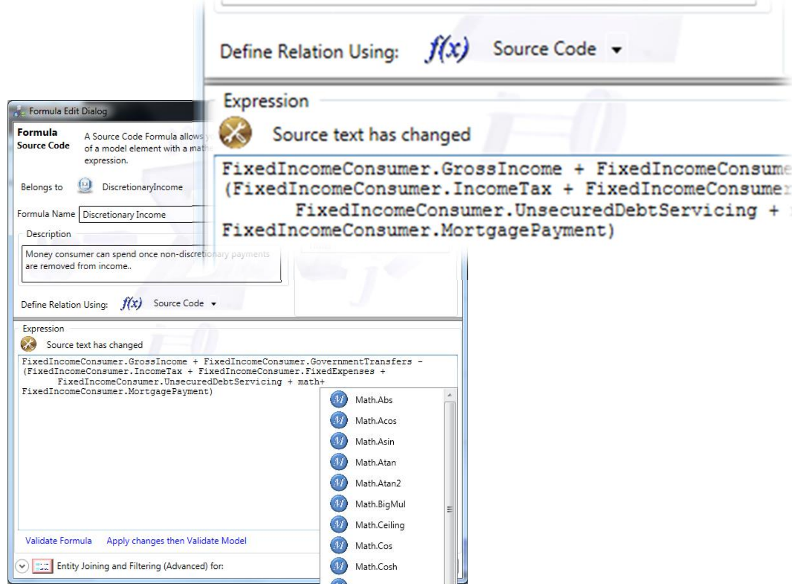
The development environment is a visual design tool for quantitative and qualitative models, and which includes desktop-execution environment for unit testing, simulation, and analysis. Visual desktop modeling is illustrated in Figure 5, below.



(a) World Modeler visual model design diagram. This not only documents the model graphically, but defines the model variables and relationships.



(b) Formula details window showing "as-you-type" pop-up list of mathematical functions which can be called by the formula. In addition to access to the full Math.Net library, user defined functions can easily be added.



(c) In cases where precise data or mathematical formulas are not known, relationships can be defined approximately by sketching a graph. This can be superseded by a formula later in the development process.

Use of approximations in the model is tracked and the uncertainty they introduce automatically propagated uncertainty through models at all stages of their lifecycle

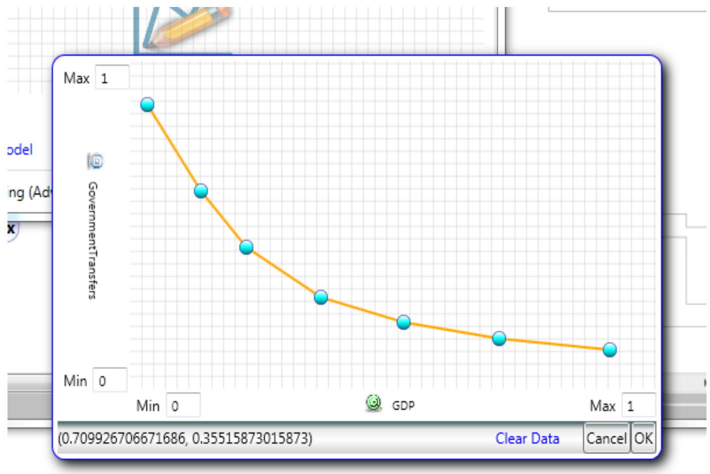
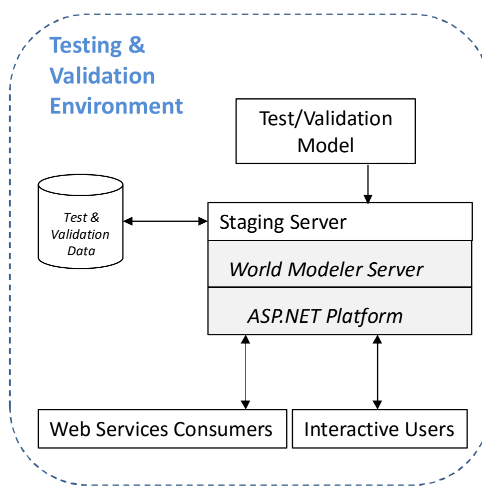


Figure 5. Model Development Environment

4. Testing and validation

The testing and validation environment manages the quality assurance and certification process for models, and automates much of the required documentation. This includes creating and managing the test data sets, controlling and executing the testing and validation process, and for reviewing, archiving and auditing



test results. Note that machine learning capabilities exist for providing greater levels of insight into the test results.

The testing and validation functions are available in both the World Modeler development desktop, and the enterprise application server. Support for interfacing with regulatory authorities, including support for (Business Reporting Markup Language (BRML) output in the near future) are all provided.

5. Workflow and authorization control

Key to the RFM approach is a common ñmodel objectò that is modified by analysts during development, verified and approved during testing and regulatory approval (if required), and then used in day-to-day business operations. Since a single ñobjectò is automatically passed between different environments (the desktop for development, web-based applications for validation and production), major transitions can occur with ñone clickò, rather than the need to translate and re-code the model logic into the language of the platform of choice at each stage. As mentioned above, this dramatically reduces the time-to-market and effort required to develop, deploy, and maintain networks..

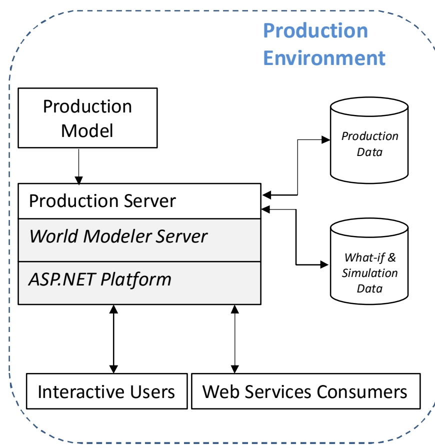
The model workflow pipeline can be secured to prevent unauthorized access to various modeling functions at each stage of the process from development to deployment. At each stage, an encrypted lock-and-key can be created either preventing certain functions from being executed in that model once the lock is enabled, or only allowing certain functions once the key has been provided. For example, before a given version of a model can be made available for formal validation, an appropriately authorized user must enable that modelôs ñValidation Keyò. Once the Validation Key is set, further changes cannot be made to that specific version of the model. Test results include the details of the Validation Key that was current when a test run was carried out, both ensuring the integrity of the testing and validation process (i.e. models are not modified during testing), and providing traceability to the source of the authorization. A similar approach can be taken to secure the integrity of models published to the production environment.

The approach to testing developed here means that Model Validation is greatly simplified. The automation of workflow, the seamless transition of models between environments, and the embedded versioning and auditing during the testing process all mean that validation resources can concentrate on inspecting test results, rather than managing hand-offs between platforms.

Due to the flexible definition of models, data, and processes offered by the World Modeler tools, RFM supports a wide variety of workflows and organizational structures. It provides a common system backbone and data model, where staff in different departments can perform role-specific functions and can interact with task-specific views of the data. It is a ñbest-of-both-worldsò solution that combines a variety of application user interfaces designed to optimize efficiency, with a unified risk model and data schema.

For example, while a risk analyst creates the model intended for production, another (e.g. the model developer) creates the approved version for the test environment. Both versions are created from the same approved model specification. This is to ensure that 1) Segregation of Duties are observed and 2) the two versions of the model act as cross-validation control sets to support error detection.

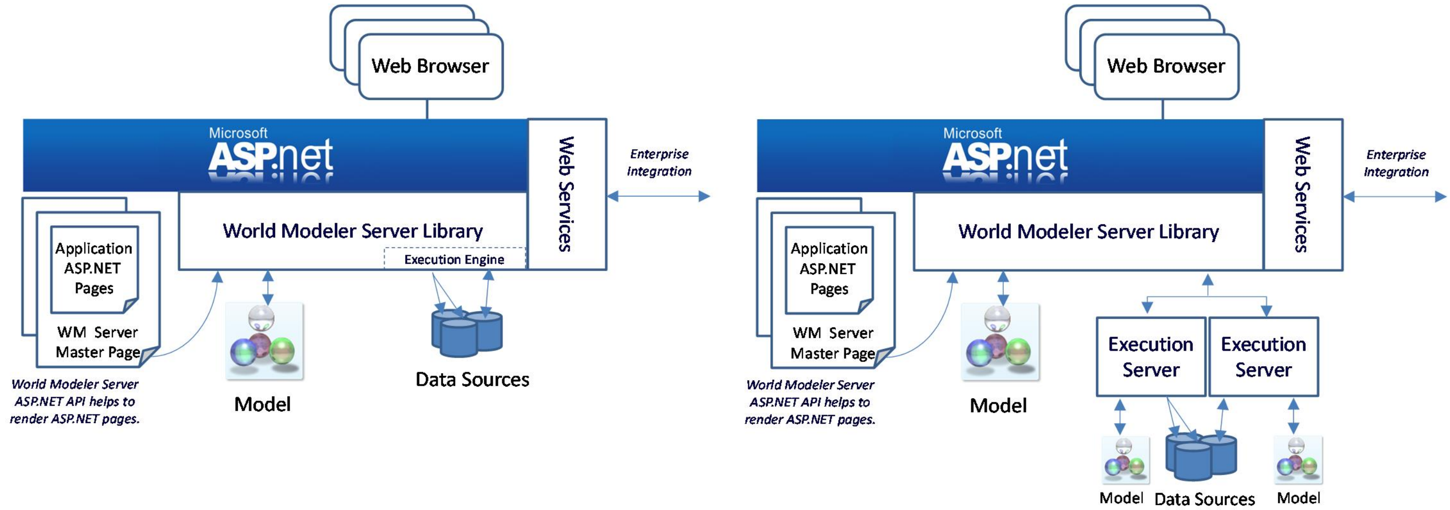
6. Production



The production environment is a scalable enterprise platform for providing a number of interfaces to the models:

- An interactive web application API based on Microsoft ASP.NET® allows model-dependent functions (e.g. credit rating, basic loan application workflow) to be run from within a web browser. Appropriately authorized users can:
    - i. select a product/associated model; provide input parameters to the model to be defined, either directly or by accessing data from external systems (e.g. spreading);
    - ii. perform calculations defined by the models;
    - iii. map the results to appropriate output to support users in their decision making and communication with their customers.
- A web services interface is also exposed, allowing other systems within the organization (provided they are authorized) to programmatically

invoke models, supply them with input parameters, and receive their output.



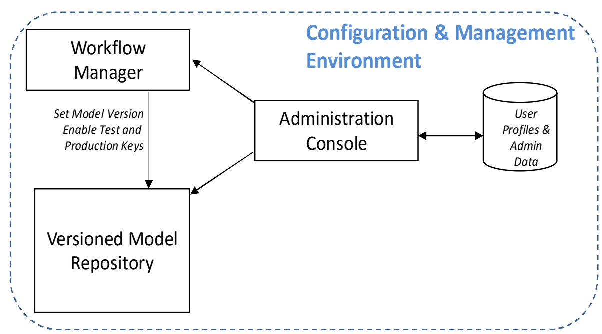
(a) **"Compact" server deployment, where model Execution Engine is loaded in-process inside the main application server.**

(b) **"Enterprise" or "scalable" server deployment, where one or more model Execution Engines are run as separate processes and can simultaneously run multiple models and access multiple sets of data sources in parallel.**

Figure 6. Logical Server Architecture of RFM, based on World Modeler™ Server.

7. Configuration and management

The Configuration and Management (CM) environment supports several productivity features, including ñsingle clickò transitions between different workflow states of models. The following components make up the CM environment:



Versioned Model Repository

This manages version control and access authorization to model files. Model files store the model definitions, and also the application information needed to configure the input screens in the production environment. Model files are checked out for development and maintenance, and checked in when they are ready for testing and deployment. These files are accessed in the production and validation environments by the servers requesting the current validation or production version of a model from the Model Repository Server. The Repository server keeps audit histories of models, and manages versioning and authorization of ñValidation Keysò and ñProduction Keysò that must be set before a model can be accessed from the validation or production environments.

Workflow Manager
The workflow manager is a ñlightò implementation of workflow management that tracks the status of a model as it is checked out for update or maintenance, checked in, is submitted for testing, and is transitioned to production. If more sophisticated workflow is desired, or if RFM must inter-operate with an existing workflow management platform, integration with an external workflow manager is possible.

Administration Console
This provides control and configuration access to all components of the RFM solution, including user management functions, definition of workflows and setting scheduled tasks in the Scheduler.

8. Interfaces to external systems

Interfaces to external systems can be developed as custom add-ons to the system. Typically, these are developed either as .NET-based deployment modules (i.e. assemblies), or as consumers or p of Web Services.

9. Integrated architecture diagram

The integrate architecture showing how each of the components described work together in a complete solution is illustrated below.

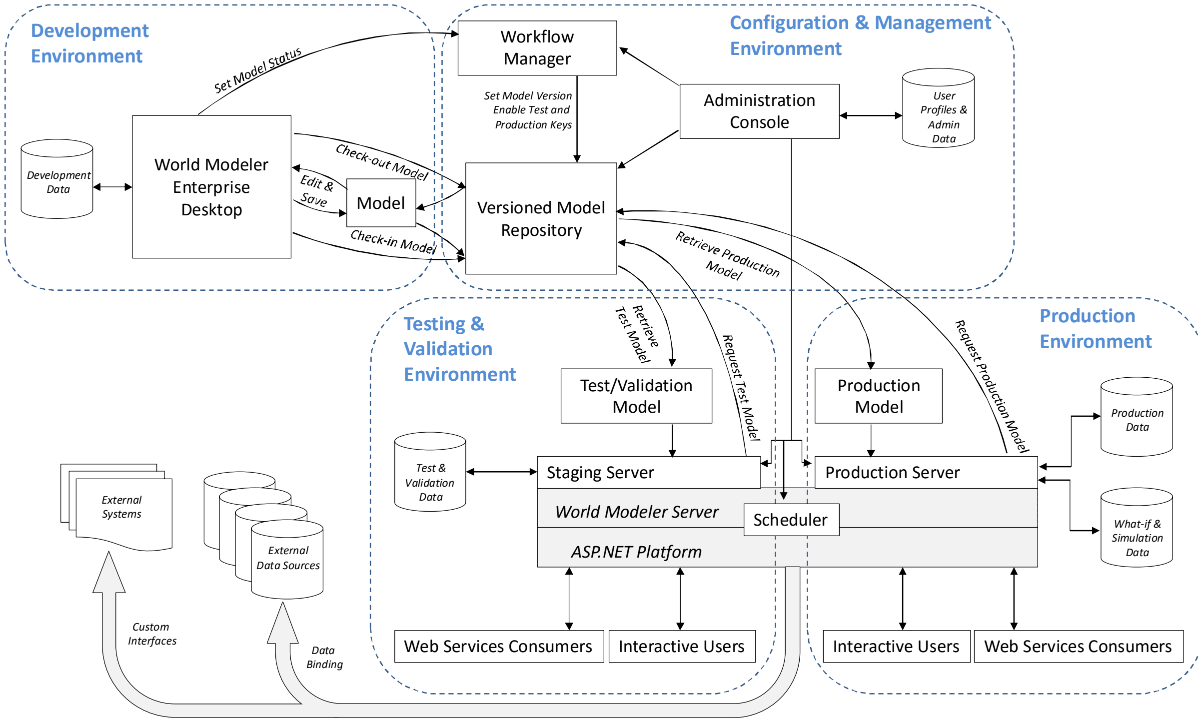


Figure 7. Integrated Enterprise Managed Model Architecture

Conclusion

The joint effects of increased regulatory oversight following the 2008 GFC, and competitive pressure resulting from technological advancements have dramatically changed the environment in which FIs of all sizes operate. This change is still under way and is likely to continue into the foreseeable future as regulators continue to increase their oversight and technology creates new opportunities. Among the areas of operation most affected by this volatility are the financial institutionsô enterprise information systems. To meet todayôs challenges, as well as ensuring that FIs are able to quickly adapt in response the continually changing circumstances, a modern, agile, and forward-looking IT strategy is essential. Systems must facilitate process automation, and be flexibleð easily changed by business unit staffð without requiring input from centralized IT departments or system vendors. This applies to the systemôs data structures, functionality and, via user-definable data abstraction, interfaces to external data sources. Furthermore, line-of-business applications need to create and maintain high quality data sets that support both scheduled and ad hoc regulatory reporting, and customer data access via interfaces to self-service applications delivered via the web and/or ñsmartò devices.

One group of applications that has often received less attention than others in many FIs are those supporting wholesale credit rating, that is, assessing credit risk when lending to small and medium-sized businesses. FIs have traditionally approached this using either home-grown systems, ranging from desktop projects that have grown out of spreadsheets or Microsoft Access® databases, to large custom enterprise systems, or vendor-supplied systems that must typically be extensively customized to meet the FIõs requirements and integrate with the remaining IT infrastructure. In each of these cases, the systems generally lack the flexibility to provide the FI with competitive agility in its wholesale lending business. Equally restrictive are the systemsô abilities to adapt to rapidly evolving regulatory requirements, or ad hoc reporting requests from regulators or other parties.

The Risk Framework Management (RFM) architecture described in this paper addresses all of the above needs. This is built on the foundational concept of a common credit risk model artefact that is accessed during all stages of the model lifecycle, from analysis and development, through testing and validation, and finally to line-of-business production. By supporting the entire lifecycle, the effort to ñtranscribeò the model at workflow hand-off points from the language of one set of tools to another is not required. This effort is responsible for the majority of time-to-market delay, and is almost completely eliminated in the RFM approach.

Endnotes

1. See http://www.bis.org/bcbs/
2. See http://www.sec.gov/spotlight/dodd-frank.shtml
3. Piechocki, Maciej and Lux, Jürgen, Reforming regulatory reporting: are we headed toward real-time?, Bearing Point Institute, Report Issue 006, 9 November, 2015, http://www.bearingpoint.com/it-it/7-11358/reforming-regulatory-reporting-are-we-headed-toward-real-time/
4. Source: Wall Street Journal, 27 January 2014, http://www.wsj.com/news/interactive/branchesB012720140127
5. Ericsson, Jörgen, Farah, Philip, Vermeiren, Alain, and Buckalew, Lauren, Winning Strategies for Omnichannel Banking, Cisco IBSG Global Research, 2012, http://www.cisco.com/web/about/ac79/docs/Cisco-IBSG-Omnichannel-Study.pdf
6. Board of Governors of the Federal Reserve System, Federal Banking Regulators Finalize Liquidity Coverage Ratio, Press Release, 3 September, 2014 http://www.federalreserve.gov/newsevents/press/bcreg/20140903a.htm
7. Prudential Regulation Authority, Engagement between external auditors and supervisors and commencing the PRAôs disciplinary powers over external auditors and actuaries ï CP8/15, 27 February 2015, http://www.bankofengland.co.uk/pra/Pages/publications/cp/2015/cp815.aspx