Making complexity manageable

What do you do when complexity *can't* be avoided?

Agile management teams need new technologies to support smarter and faster decision making. But capitalizing on opportunities to innovate with new technologies is difficult in today's enterprise environment because of the overwhelming complexity created by generations of previous technology investments.

To confront the costs of complexity, both management and their IT organizations are approaching it in sophisticated new ways. When enterprises successfully manage that complexity, their appetite for innovation through technology investments will accelerate.

More than 75 percent of about 1,400 global CEOs surveyed by PricewaterhouseCoopers (PwC) in 2006 said the level of complexity in their organization is higher than it was three years earlier. (See Figure 1.) Some level of complexity is an inevitable by-product of doing business today, so the challenge becomes how to keep complexity at a manageable level.

What creates this complexity? Expansion into new territories, mergers and acquisitions, and the launch of new products and services have been the primary sources, according to these CEOs. Moreover, complexity creates such a drag on enterprise performance that nearly 80 percent of the CEOs said that reducing unnecessary complexity was a personal priority.

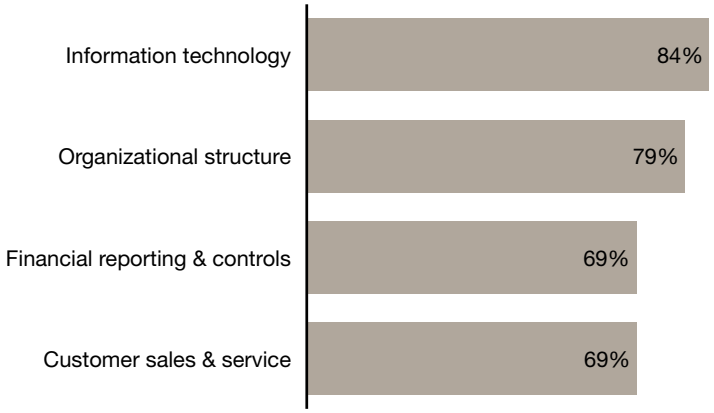

Figure 1: **Primary focus areas for CEOs to reduce complexity**

Source: PricewaterhouseCoopers survey of 1,400 global CEOs, 2006

The CEOs' primary focus areas were information technology (84 percent), organizational structure (79 percent), financial reporting and controls (69 percent), and customer sales and service (69 percent).

For many, it's no surprise that the IT function is the highest-priority complexity challenge. First, IT echoes business as it is now integral to all business functions. As businesses and business processes have become complex, so has IT. Second, IT complexity occurs not only in the operations, but also in the architectures, applications, and data solutions deployed in the IT environment.

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The three dimensions of IT complexity

In IT, complexity can be seen as a result of three principle dimensions as shown in Figure 2. These are:

- **Number of entities.** The large number of products and solutions, either hardware or software, that make up the overall IT system. The larger the number, the more complex the system. Monitoring, managing, and maintaining a large number of IT entities takes considerable human and specialized resources.
- **Degree of heterogeneity.** The lack of standardization among the various entities as they are sourced from several vendors and by different parts of the enterprise. This means that entities behave differently and require specialized knowledge and skills for their implementation, integration, and operation.
- **Number of interconnections.** The frequency with which the entities are integrated or interconnected to each other for the purposes of automation or other needs. Integration among these parts means they have unique dependencies and connections, making it onerous to introduce changes or quickly diagnose the system if a problem occurs.

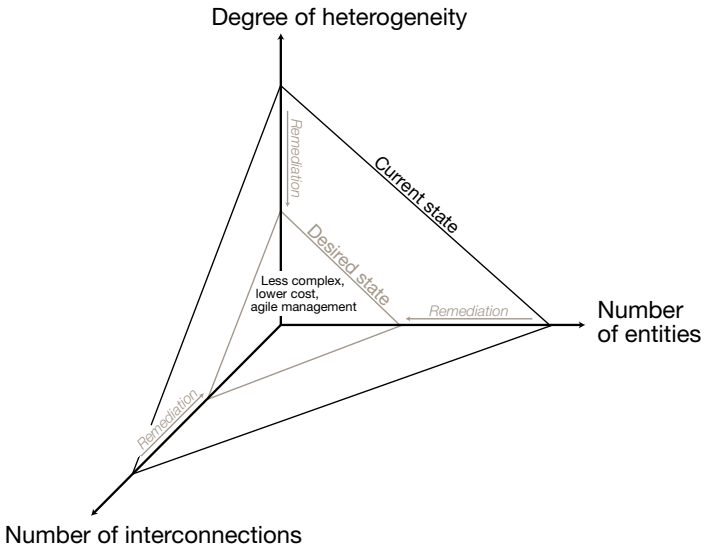

Figure 2: **Three dimensions of complexity**

Source: PricewaterhouseCoopers, 2008

As a result of these dimensions, complexity increases when enterprises interconnect a large number of nonstandard heterogeneous parts (infrastructure or applications or data) to carry out necessary business functions.

Many trends have contributed to the complexity within IT environments. (See Figure 3.) Enterprises have adopted several generations of architectures and solutions over the years, thereby adding layers of technologies from many vendors.

Those technologies and solutions often duplicated functionalities in different business units and spanned various operating systems, hardware platforms, and versions. Complexity increased as most systems became subsequently integrated for business efficiency and process automation. Complexity increased further as enterprises increasingly extended their IT systems to suppliers, partners, and customer IT environments.

Additional complexity stems from incompatible, duplicated, and poor-quality data that applications store and share. Furthermore, business continuity requirements and rising customer demands forced data centers to focus on nonstop operations, including hot-swap backup data centers. This trend has multiplied the number of IT assets that must be integrated and managed.

For competitive reasons, enterprises often developed custom innovations in-house, especially those that used emerging technologies. Competition or market conditions required fast action that couldn't wait until technology solutions were standardized or simplified, and as a result, complexity increased further.

"Of course, you have to innovate, and if you do it fast, you will add complexity. But, in parallel, you have to clean up those things where it's not worth any longer to differentiate yourself against others," suggests Henning Kagermann, CEO of SAP. (For more of Kagermann's thoughts, see the interview on page 13.) While most enterprises have embraced technology as part of their efforts to differentiate themselves, they have not been serious about the cleanup that Kagermann is talking about.

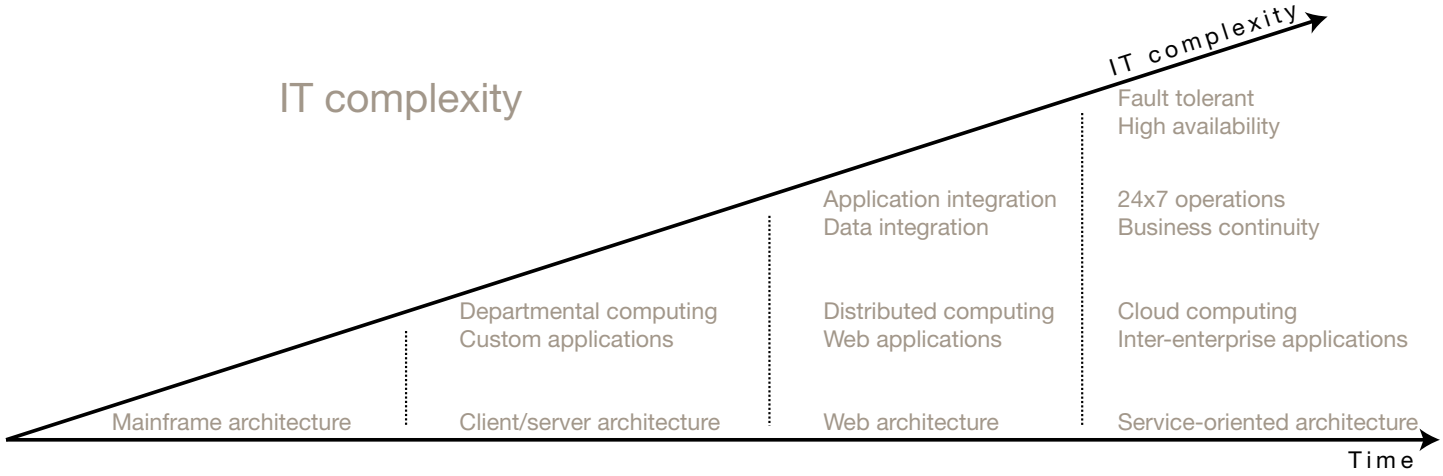

Figure 3: **IT complexity over time—The adoption of new architectures and the imposition of new business requirements have continued to increase complexity.**

Source: PricewaterhouseCoopers, 2008

Business impact of IT complexity

Years of technology absorption have steadily worsened the complexity problem. This complexity has an undesirable impact on business in two principal ways:

- **Higher cost.** The continual management of patches, upgrades, new versions, and complex interfaces in the environment requires specialized skills. Industry estimates suggest that more than 70 percent of IT budgets are spent on ongoing operations and maintenance, leaving few funds for innovations and adoption of more-efficient and emerging solutions that drive enterprise competitiveness.
- **Lack of agility.** The ability to respond quickly to changing business requirements and market opportunities decreases. Many IT infrastructures are now brittle because of numerous integrations and associated dependencies. Most changes are onerous, require exhaustive testing to initiate, and take too long. They also increase the risk that a critical function may not work as before or may have an unexpected effect on another part of the system.

Despite those impacts, most organizations have not addressed the issue directly because more-compelling areas for IT spending have taken priority. For example, regulatory compliance, new process automation, and new business opportunities have higher priorities. Additionally, fear of breaking what is already running has also kept enterprises from addressing the issue.

As awareness and the impact of IT complexity grow, however, some companies are beginning to address complexity directly. Hewlett-Packard Co. (HP), for instance, is working hard to reduce complexity in its own IT operations and plans to cut ongoing operations and maintenance costs from 70 percent of its total IT budget to 20 percent, according to Forrester Research. HP intends to simplify IT on multiple dimensions: from 85 data centers to 3; from more than 5,000 applications to 1,100; from more than 21,700 servers to 14,000; and from 762 data marts to a single view of the enterprise.

Complexity remediation

Although there is no off-the-shelf solution to address complexity, many of the emerging technologies and architectural approaches can mitigate IT complexity when implemented appropriately. The adoption of those new technologies and approaches will accelerate during the next decade.

In broad terms, IT systems consist of infrastructure, application, and data layers, as detailed in Table 1. The three layers of IT face different challenges and will benefit from different approaches to complexity remediation. Because managing IT across these three layers is a responsibility shared among the business units, so is complexity remediation. The following discussions explore the approaches enterprises adopt to reduce complexity.

Reducing complexity with virtualization and cloud computing

Virtualization is the aggregation of IT resources and their physical characteristics so as to make them available to applications and users in an on-demand manner. Virtualization helps organizations optimize resource utilization. The resources can be servers, storage, or other network components.

In a non-virtualized environment, servers typically are dedicated to specific applications. Server utilization can average below 20 percent or 30 percent depending on the hardware platform. Declining hardware costs encouraged IT organizations to overprovision in order to accommodate peak loads. Dedicating additional hardware to an application was easier than optimizing utilization. However,

Remediation focus	Organizational groups involved	IT complexity remediation approach	Applies to
Infrastructure layer	Can be pursued by enterprise IT alone	Virtualization and cloud computing	Servers, storage, networking, operating systems
Application layer	Business unit and enterprise IT	Application rationalization and application portfolio management (APM)	Legacy applications, vendor applications, middleware, Web services
Data layer	Business unit and enterprise IT	Master data management (MDM)	Databases, business intelligence solutions, data warehousing solutions

Table 1: **The three layers of IT face different challenges and will benefit from different approaches to IT complexity remediation. Note that Table 1 highlights only some of the approaches to complexity remediation. Other approaches and technologies not listed here can be brought to bear in each of the layers.**

In many ways, virtualization of IT infrastructure is a return to the mainframe era, when computing was offered as an on-demand, centralized service coupled with a system of controls and usage-based charges.

while hardware costs were flat or declining, operations and management costs rose significantly as the number of servers to manage increased.

Virtualization software eliminates the tight coupling that had existed between applications and the IT assets that support them. By pooling hardware resources, standardizing operating systems, and dynamically allocating resources according to application demands, IT organizations can deploy fewer servers. Average utilization across them can reach optimal levels without sacrificing either availability or performance.

In many ways, virtualization of IT infrastructure is a return to the mainframe era, when computing was offered as an on-demand, centralized service coupled with a system of controls and usage-based charges. All major systems vendors—including HP, IBM, and Sun Microsystems—as well as software vendors—such as Citrix Systems (which acquired Xensource in 2007), Microsoft Corp., and VMware—are offering virtualization solutions.

Cloud computing—server resources made available by third-party services over the Internet—leverages and extends virtualization technologies. These shared computing, storage, database, and networking resources typically are hidden behind standard interfaces that multiple businesses and users access in a multi-tenant environment.

Cloud computing is a continuation of the vision of utility computing, which suggests that IT capabilities will be accessible as a utility—much like electricity and telephony. The utility approach means that enterprises need not maintain and manage their own IT infrastructure and data centers. Instead they access Internet services as needed.

Collectively, these technologies challenge the existing economics of IT infrastructure and, over the long term, offer lower cost and simpler operations.

Cloud computing strategies are being actively pursued by vendors that already own and operate large data centers, such as Amazon, Google, and IBM. Amazon's service, called Amazon Web Services, brings together computing, storage, and database functionality over the Internet and enables enterprises to create and operate Web applications without owning any IT infrastructure.

Benefits: Lower cost and agility

Virtualization reduces operating costs by increasing asset utilization. According to a 2007 Data Center survey by Symantec Corp., more than 66 percent of data center managers say that server consolidation and server virtualization are the two strategies they are currently deploying to cut data center costs, followed by other approaches, such as automation of routine tasks and data center consolidation. Virtualization reduces costs and complexity because IT staffs require training in fewer technologies, replication of best practices from one area to another becomes easier, and IT organizations can source products from fewer vendors.

In addition to lowering costs, virtualization also brings flexibility to the IT infrastructure. The provisioning of IT assets to fluctuating workloads is more efficient. For example, on-demand scalability can speed the deployment of a new application, since no new hardware needs to be installed and configured by either IT or the end user. Also, in fast-growing businesses, the infrastructure can scale for new or existing applications by provisioning more capacity dynamically. And in turn, resources that support applications taken out of service can be put to new uses.

Cloud computing's benefits are similar to those of virtualization, but cloud computing is more comparable to utility or telecom carrier service-level agreement (SLA)

situations. By giving the responsibility for the IT infrastructure to a service provider who specializes in managing multi-tenant infrastructures, enterprises pay to have someone else manage the complexity for them. This realizes a clear benefit, but one that incurs a cost of some flexibility and customization capability.

Mainstream adoption

Adoption of virtualization solutions is expected to accelerate for the next few years. According to Forrester Research, half of surveyed enterprise IT organizations were using x86 server virtualization in early 2008, increasing to two-thirds by 2009. Among enterprises using virtualization, 24 percent of servers are virtualized today, and that percentage is expected to reach 45 percent by 2009.

Because virtualization is an emerging technology, most of the applications running in the virtualized environments thus far are non–mission critical. However, as the technology matures, adoption will spread to mission-critical applications. It will also spread from large enterprise data centers to small and midsize businesses and desktops, thereby continuing the momentum for the foreseeable future.

Emerging concerns about the power requirements of data centers are also fueling the adoption of virtualization and cloud computing. Fewer servers mean less power to run the data centers, which helps IT comply with an increasing number of green inititatives.

Challenges

Although virtualization and cloud computing reduce complexity and cost, they also create new challenges. Because servers are not dedicated to particular applications in virtualized environments, IT departments will need robust capacity and priority management processes. And they'll need controls and protocols to ensure adequate performance for specific applications. Business users accustomed to having dedicated resources will need to understand and negotiate SLAs.

The prevailing licensing practices of most software vendors that sell packaged applications are not suitable for virtualized environments. Applications are typically tied to a specific hardware or operating system. Over the long term, software licensing and pricing must evolve toward value-based pricing. (For more information on pricing models, see "Software pricing trends: how vendors can capitalize on the shift to new revenue models," available at pwc.com/cti.) Over the shorter term, however, virtualization is challenging existing licensing practices that depend on a strong coupling between application software and the hardware platform it runs on.

With respect to the three dimensions of complexity in Figure 2, virtualization reduces complexity primarily by reducing the number of IT entities that the IT organization needs to manage. Additionally, by standardizing on a few selected hardware platforms, virtualization also reduces the heterogeneity in the infrastructure layer. Cloud computing reduces complexity even further by taking away the need for managing an IT infrastructure altogether.

Reducing complexity with application rationalization

In most enterprises, the number of applications—whether sourced from vendors or custom developed in-house—has increased steadily over the years. It is not uncommon for large enterprises to have several thousand applications that need to be maintained, managed, and supported.

According to a study by the BPM Forum, 78 percent of enterprises larger than $500 million in revenues say they maintain and support redundant, deficient, or obsolete applications. They also estimate that more than 20 percent of the IT budget goes toward such applications.

Emerging delivery models such as software as a service (SaaS)—as popularized by Google Enterprise, NetSuite, Salesforce.com, and other vendors—also reduce application-specific complexity by eliminating an enterprise's need to manage, maintain, or upgrade applications and their infrastructure.

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In the same vein, according to the 2007 data center survey by Symantec Corp., more than 67 percent of IT managers claim their data centers are getting too complex and that they have too many applications to manage. All of these applications require version control, patches, upgrades, bug fixes, feature enhancements, and related support, which make for substantial administrative burdens on the overall IT function.

At the same time, an organization may no longer need all the applications it has. Although enterprises keep creating new applications to respond to competitive dynamics and market opportunities, most enterprises do not have a structured or mature process for retiring or modernizing older or outdated applications.

Application rationalization is the process of consolidating, streamlining, and simplifying the application portfolio. Applications that do not support the enterprise business objectives or those that are redundant get weeded out. Required functionality gets consolidated in a core set of applications with standardized interfaces or modular services. Application rationalization also brings forth a governance structure that ensures enterprisewide visibility, so that new applications get added in light of existing applications and aligned with emerging business needs.

A leading technique that can help with application rationalization is application portfolio management (APM). APM uses portfolio management techniques to track, measure, and justify the benefits of a particular application to its costs. This usually requires that enterprises aggregate pertinent information about applications and integrate it with business information to create intelligence and visibility into applications.

According to IDC, the worldwide APM market in 2006 was about $1.81 billion, and IDC expects it to grow to about $2.44 billion by 2011. Tools available from software vendors to support rationalization include IBM Rational Portfolio Manager, Planview's application portfolio optimization solution, and Serena's Mariner APM.

Trends facilitating application rationalization

Consolidation in the enterprise software industry is reducing the number of vendors from which enterprises will source applications. At the same time, vendors are providing preintegrated solutions, thereby reducing an enterprise's need for custom integrations. Less custom integration means fewer resources that the enterprise must allocate to support the integrations.

Moreover, emerging delivery models such as software as a service (SaaS)—as popularized by Google Enterprise, NetSuite, Salesforce.com, and other vendors—also reduce application-specific complexity by eliminating an enterprise's need to manage, maintain, or upgrade applications and their infrastructure. System integrators and professional services providers also offer solutions for application rationalization. Active service providers include PricewaterhouseCoopers, Accenture, IBM, Infosys, and Wipro.

Application rationalization reduces IT complexity by addressing all three dimensions in Figure 2. It reduces the number of entities by eliminating duplications and retiring unwanted applications. It reduces degree of heterogeneity by driving the standardization of software platforms and vendors. Finally, with fewer applications, there are fewer resulting interconnections that need to be managed or maintained.

Reducing complexity in data

Applications both create and consume data. As applications have proliferated over the years, so have data and databases. Data exists in departmental silos and is often duplicated, mischaracterized, or inaccurately stored.

The proliferation of data creates a major problem with regard to data quality and integrity. A survey by the Data Warehousing Institute found that 83 percent of organizations suffer problems with data because of inaccurate reporting, internal disagreements, and incorrect definitions. Problems with data quality and integrity have a negative impact on enterprises' productivity, decision-making processes, and overall market competitiveness. Such problems are critical enough to cause a surge of interest in adopting solutions and approaches that address those concerns.

According to IDC, the worldwide market for MDM software will grow at a 20.2 percent five-year CAGR, advancing from $1.25 billion in 2006 to $3.12 billion in 2011. The associated professional services market is projected to more than double from $3.03 billion to $6.08 billion in 2011, a 15 percent CAGR.

A leading approach to reducing complexity with data is master data management (MDM). The goal of MDM is to provide an approach to creating a single, unified view of an organization's data—in other words, a single version of the truth. MDM gets at the heart of the data problem by creating a trusted source for data quality, data integrity, and data consistency.

Master data consists of information about critical resources, such as customers, products, employees, and other business assets. Critical business operations and processes depend on such data. Master data is usually centrally managed, is subject to enterprise governance polices, and is distributed and used across all systems. Vendors and service providers are actively offering solutions and services to help enterprises benefit from master data management.

The MDM market

MDM products aggregate data from disparate systems and then clean and normalize the data. The result is a single view of the data—one that can be synchronized and can be shared throughout the enterprise. Other functions include support for workflow, business rules, data models, and integration capabilities to make the right data available to the right resource at the right time.

Solutions are offered by established platform vendors such as IBM, Oracle Corp., and SAP as well as smaller niche vendors such as Informatica Corp., Initiate Systems, and Purisma. MDM-oriented professional services are offered by many of the large systems integrators as well as outsourcers such as PricewaterhouseCoopers, Accenture, IBM, Infosys Technologies, and Wipro Technologies.

According to IDC, the worldwide market for MDM software will grow at a 20.2 percent five-year compound annual growth rate (CAGR), advancing from $1.25 billion in 2006 to $3.12 billion in 2011. The associated professional services market is projected to more than double from $3.03 billion to $6.08 billion in 2011, a 15 percent CAGR.

MDM adoption

Many current business imperatives influence the robust growth prospects for MDM. Regulatory compliance requirements, for example, are encouraging enterprises to invest in systems and processes that validate and ensure appropriate controls on sensitive customer and financial data.

Remediation in action

Many new-product rollouts taught a large multinational consumer product company that complexity in its IT environment was delaying the time to market for new products and services.

This negatively affected the company's performance in a highly competitive marketplace. To improve the speed to market of new products, the company launched a remediation initiative that targeted its infrastructure, application, and data layers.

Currently, this global enterprise has more than 2,000 applications—the result of mergers and acquisitions, rollup of companies, expansion into new territories and markets, custom development, and other factors over many years. Often, the enterprise has multiple instances of a product—such as enterprise resource planning (ERP) and customer relationship management—from the same vendor. In some cases, the enterprise has different versions of the same product, and in other cases, it has the same product on different platforms.

Application portfolio management will help the enterprise to rationalize the application portfolio from more than 2,000 to a final target of about 800. It will achieve its goal by retiring nonstrategic and unused applications, removing redundancies, and standardizing on versions and platforms.

For instance, all ERP solutions are being consolidated into a single, central ERP environment using minimal customization and simple integrations to other applications. In some cases, data from older applications will be transitioned to modern architecture, and older applications will be retired.

These efforts are concurrent with the architectural transition to a service-oriented architecture (SOA) to promote modularity and standard interfaces. In addition to the focus on packaged applications, a few work streams are examining the adoption of software as a service (SaaS) for noncore functions. The transition is likely to span four to five years.

Parallel to the application rationalization tasks are efforts focused on the creation of master data and the governance policies for managing its integration and distribution. Data about customers and products is being aggregated from the existing systems and rationalized to remove differences in definitions, accuracy, and completeness. The enterprise is performing this rationalization by creating a unified view in a master data hub with a persistent relational data store built on open standards using Java 2 Platform, Enterprise Edition (J2EE).

Upfront work in application rationalization and master data management (MDM) will improve the infrastructure consolidation work stream. These efforts will shrink the infrastructure footprint by reducing the number of servers by about 25 percent.

By leveraging virtualization technologies, the utilization on the x86 servers will jump from about 8 percent now to 25 percent to 30 percent in the future, and utilization on the UNIX servers will increase from 30 percent now to about 65 percent in the future. Consolidation in servers is initially directed at non-customer-facing functions in the back office, such as Dynamic Host Configuration Protocol (DHCP) and Domain Name Service (DNS). Over time, consolidation will spread to other back-office and some front-office functions.

Integration of data after mergers and acquisitions requires the migration and aggregation capabilities of MDM to extract the synergies necessary for achieving financial returns.

Finally, enterprises are investing heavily in business intelligence solutions to leverage the large amounts of data that enterprises generate and store. That effort benefits from a trusted source for the data that gets processed, a key value proposition of MDM.

To succeed with MDM, many organizations will need to change their existing practices. Most important, MDM requires that IT managers and business managers agree on the semantics of the data and the underlying information. These managers need to resolve all of the inevitable internal disagreements about the definitions of data describing customers, products, employees, and other business assets.

Other IT initiatives also benefit from MDM solutions. For instance, the service-oriented architecture (SOA) approach promotes the development of services that provide data in a standardized form. These solutions provide real-time transactional and business analysis data delivered through Web services technologies that feed relevant business processes and applications. Like MDM, SOA initiatives also benefit from an enterprise-level look at data that has common definitions and is not duplicated.

Business process management systems (BPMSs) take the information feed and bring the right information to important decision-making processes in a timely manner. (See “Bringing order to chaos,” p. 59.) Incorporating MDM functionality into an SOA or BPMS investment means that trusted, high-quality data and information will be available to applications and processes.

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An effective MDM strategy can alleviate the complexity related to data by managing metadata in a central location and improving data quality and consistency for all applications.

Although enterprises can use MDM to reduce the costs associated with managing data, the key benefit in the future will be the responsiveness of IT. A centralized repository of master data means changes can be made easily and propagated efficiently across the enterprise. Effective governance practices would mean that the duplication and proliferation of bad data would be contained or eliminated.

Returning to our dimensions of complexity in Figure 2, MDM reduces IT complexity by reducing the number of data entities that need to be managed. It also reduces heterogeneity by developing common definitions and standards for data integrity. The number of connections is reduced as well, as a single version of the data eliminates the need for point-to-point connections for accessing that data.

Complexity is a double-edged sword: Complexity creates value by bringing rich new functionality and higher levels of automation to business operations. However, it can cripple an organization by causing management burden, lack of responsiveness, and out-of-control costs. Complexity also creates value when it is hidden away from the end users and accessed with simple, standard interfaces.

Hiding complexity

Virtualization, application portfolio management, and master data management consider IT needs at the enterprise level: across all silos, departments, and functions. As a result, IT assets and resources are optimized globally, with a view toward overall enterprise needs and strategy, in addition to meeting local requirements. When done right, these approaches bring the current IT house in order and prepare it for absorbing future waves of technologies and solutions in a manner that can keep complexity in check.

Complexity is a double-edged sword: Complexity creates value by bringing rich new functionality and higher levels of automation to business operations. However, it can cripple an organization by causing management burden, lack of responsiveness, and out-of-control costs. Complexity also creates value when it is hidden away from the end users and accessed with simple, standard interfaces. “Any simplification needs to focus on the user experience; that is where maximum breakthroughs will also occur,” points out S. Ramadorai, CEO of Tata Consultancy Services. (To read more of Ramadorai’s comments, please see the interview at www.pwc.com/techforecast.)

For instance, an automobile is a complex piece of machinery that has evolved in quality and convenience over the years. When automatic transmissions were introduced in automobiles, they no doubt increased complexity of the car from that of manual transmission. But the complexity of the overall driving experience was reduced because of the standard interface and automation. Most of the automobile’s complexity either is not visible or is abstracted with dials and messages appearing on the dashboard.

IT environments need to evolve in a similar manner. Unnecessary complexity must be avoided, and value-creating complexity must be harnessed and hidden behind standardized processes or interfaces. The incentives—in terms of either cost savings or increased flexibility—are in place for enterprises, vendors, and service providers to encourage this evolution.

For more information on the topics discussed in this article, contact