Technologyforecast

Unlocking hidden transformation value

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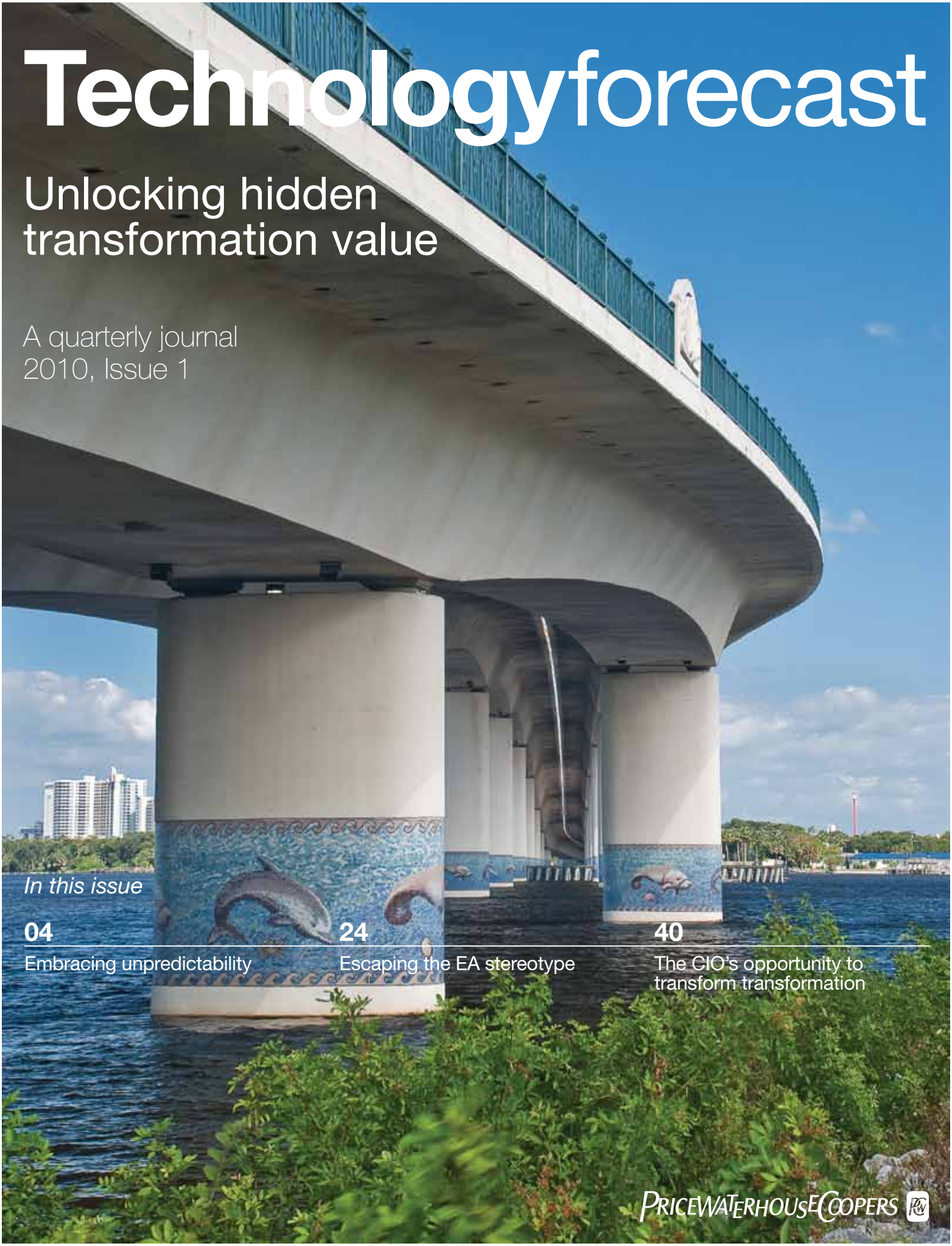

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PricewaterhouseCoopers

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Mathematics and modeling in general have taken a beating during the downturn, especially when it comes to economics. Nobel Laureate Paul Krugman, an economist himself, put it this way: “The economics profession went astray because economists, as a group, mistook beauty, clad in impressive-looking mathematics, for truth...” Later in the same *New York Times* article, Krugman concluded that “economists will have to learn to live with messiness. That is, they will have to acknowledge the importance of irrational and often unpredictable behavior.”

As any businessperson will realize, the problem Krugman alludes to isn’t the use of mathematics or models per se. In business, as in all other complex aspects of life, the problem is relying on bad models that don’t allow for unpredictable behavior—what modelers call the “emergent properties” of complex systems. Every company is itself a complex adaptive system. Often it’s the unpredictable behavior of that complex system that leads to value creation in a company. For that reason, especially when it comes to today’s rapidly changing business environment, how enterprises address the “messiness” factor can lead to success or failure.

People use models all the time, whether it’s a drawing on a napkin, a diagram in a drawing tool, the formulas in a spreadsheet, the output of an enterprise architecture tool, or a full-blown simulation study. Models are a necessary abstraction, a simplification of the real world people have to create to accomplish any objective that involves any degree of complexity. They’re essential—otherwise, the complexity is overwhelming. That’s especially the case for large enterprises. Models simplify to allow understanding—their primary role. Because they simplify, they can’t be totally accurate. Sometimes they’re obviously inaccurate, but helpful anyway. As statistician George E. P. Box observed, “All models are wrong, some are useful.”

Models not only simplify but explain complex behavior and help predict outcomes. Predicting outcomes to the extent possible—for instance, a range of the likely outcomes, ranked in order of probability—is essential to transformation efforts. During a time when many of our clients face the need to transform to survive and simultaneously reposition themselves for future growth, a sound overall approach to modeling becomes indispensable.

In this issue of the *Technology Forecast*, our annual enterprise architecture issue, we look at modeling and simulation from an architectural and transformation standpoint. As usual, during the research phase for the project, we first reviewed architecture, transformation, and modeling quite broadly. What we learned from this first exploratory research phase was that companies are using models in a wide variety of ways to help with a wide

variety of decisions. Some of those decisions involve how to launch entirely new businesses. And some of the best decisions being made are supported by models that look at companies as complex adaptive systems.

For that very reason, our lead article for this issue, "Embracing unpredictability," focuses on the rich modeling and simulation techniques companies are beginning to use to make space for and encourage emergent properties, the unpredictable behavior that can create value. As data become more available and companies can take greater advantage of them with more powerful computing capability, agent-based modeling, which studies the behavior of individual actors in a complex environment, is becoming more prevalent. Though we use fundamental innovation as a primary example of how agent models can be used, they're useful for a variety of transformation efforts.

"Escaping the EA stereotype" looks at modeling from an enterprise architect's point of view. To date, EAs have had a value proposition that has been almost entirely IT focused. Because IT costs have spun out of control, the tools that emerged to support the EA primarily focused on IT financial and asset management. But this is changing. New tools and additional features of existing tools have started to move the needle for the EA function, opening up the possibility of a new, more business-unit-centric role for EAs. EAs are also taking advantage of the new power of semantic technologies to help solve the interoperability issues that plague many transformation efforts.

When we started our research, we expected to find that CIOs and enterprise architects would be playing key roles in improving enterprise transformation effectiveness. This is because we figured modeling was the special domain of enterprise architects. What we found instead is that business modeling has been happening mostly without the direct contribution of IT. "The CIO's opportunity to transform transformation" explores how CIOs can have more of an impact on transformation efforts by anticipating and harnessing the power of complex adaptive system models, as an adjunct to the modeling efforts the IT department is already involved with.

In addition to these features, we include interviews with four people who underscore both the leading edge and established practice in these areas:

- Dr. William Rouse of the Tennenbaum Institute at the Georgia Institute of Technology explores why most transformations fail and how modeling and simulation can help.
- Dr. Mark Paich of Decisio Consulting describes how modeling enterprises as complex adaptive systems can pay off in transformation initiatives.
- Tannia Dobbins, an enterprise architect at AMD, sheds light on the practicalities of enterprise architecture in today's cost-conscious business environment.
- Michael Lang of Revelytix and Brooke Stevenson of Spry describe how fixing data description problems can improve your odds of transformation success.

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As always, we welcome your feedback and your ideas for where we should focus our research and analysis in the future.

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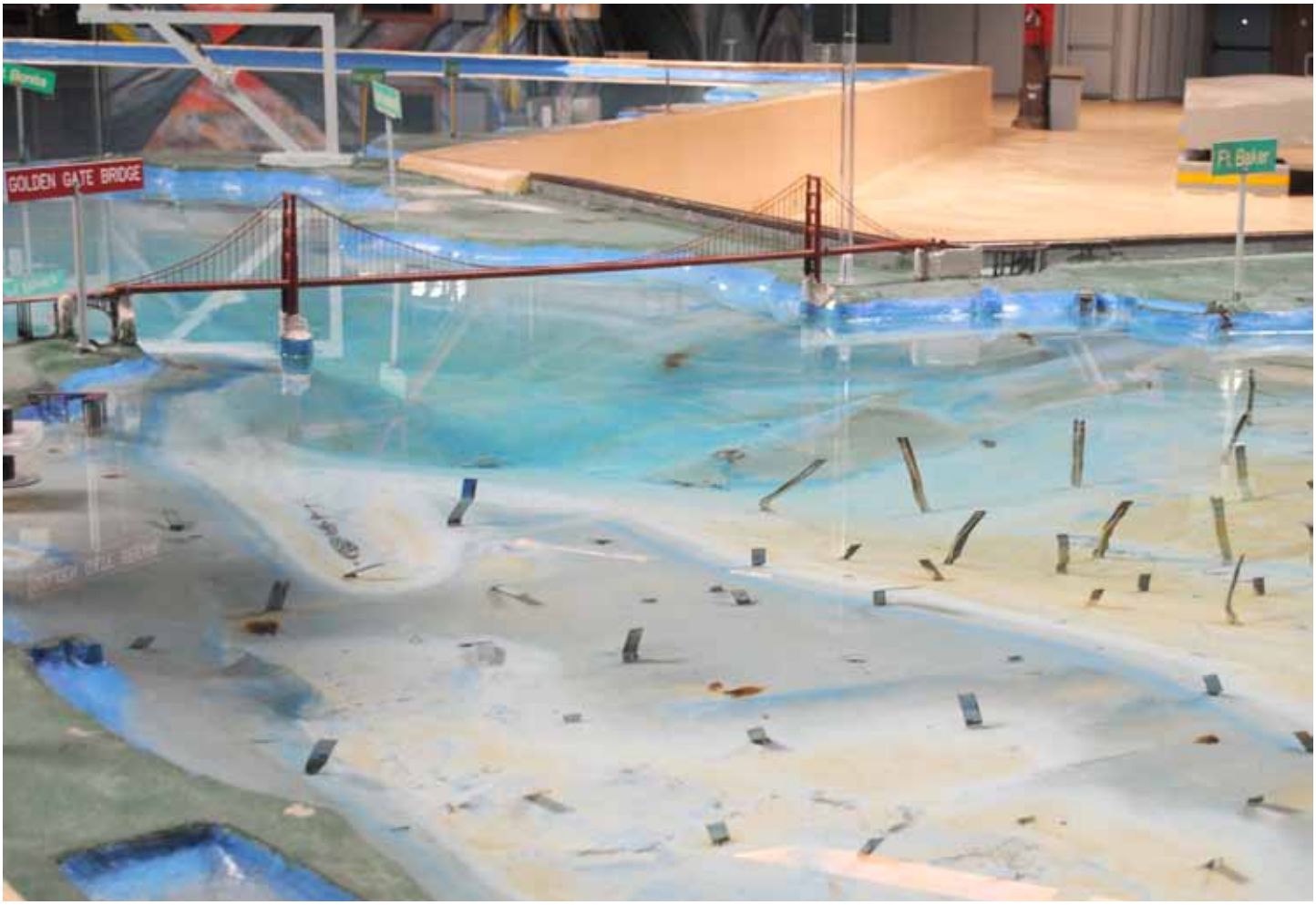
Embracing unpredictability

Where will your company's next innovation come from? You may never be able to guess the answer, but new modeling tools can foster the right environment for success.

By Bo Parker, Chris Wasden, and Alan Morrison



Enterprises need to use models that adequately capture how organizations actually function.

Enterprise transformation is hard. It's so hard that most transformation initiatives fail to deliver full value or fail to meet time and cost targets. One major reason these initiatives fall short is that they don't take into account the interactions, beliefs, attitudes, decision rules, and reward structures that cause changes in human behavior. This article focuses on how to guide and shape organizational change in ways that do take account of these factors.

PricewaterhouseCoopers' research on the success factors behind good transformation efforts has inevitably led us to models. There are many ways to define models, but for our purposes we mean the methods organizations use to simplify and address complex problems of all kinds. Enterprises know they can get more value out of their transformation efforts with the help of models, but enterprises need to use models that adequately capture how organizations actually function.

Most modeling efforts don't acknowledge that enterprises are complex adaptive systems, systems that evolve in response to complex human interactions. Lacking this perspective, these efforts fail to make room for value-creating behavior that's emergent, or unpredictable. Accurately anticipating and controlling the outcome of transformations requires that organizations model both their deterministic and emergent properties. One company that exemplifies the truth of this statement is 3M.[1] The 3M example we use throughout this article focuses on the emergent property of innovation, something 3M is renowned for. But the truth is that transformation initiatives should make room for all significant emergent properties of organizations, regardless of the type of transformation effort.

The 3M example: lessons from an innovation-oriented company

In the early 2000s, the company 3M launched a Six Sigma effort to cut waste and improve efficiency. About time, critics said, and Wall Street rewarded the company by driving up its stock price. After instituting new efficiencies, installing a new regime, and reducing the workforce by 11 percent, 3M's costs were down

1. Brian Hindo, "At 3M, A Struggle Between Efficiency And Creativity," *BusinessWeek*, June 11, 2007, http://www.businessweek.com/magazine/content/07_24/b4038406.htm, accessed October 12, 2009.

and profits were up. In the minds of many, discipline had been restored to a company that had become bloated and inefficient.

Most observers didn't realize that 3M's adoption of Six Sigma methods had an unexpected downside: top line growth stalled. Specifically, revenue growth from innovative new products ceased to materialize the way it used to. Transforming 3M through Six Sigma diminished the creativity and business success of its fabled research and development (R&D) department. It jeopardized an eight-decade tradition of developing market-creating products, such as waterproof sandpaper, Scotch tape, and the ubiquitous Post-it notes. To 3M's credit, it rectified the problem, and now 3M has restored its reputation as a rare example of a company with a built-in mechanism for reinventing itself.

As the 3M experience chastened a legion of Six Sigma black belts, it also highlighted that what is good for business transformation isn't always good for value creation, especially when the established R&D processes focus on market-changing fundamental innovation. Before a management team launches a full-scale effort to radically transform operations, it needs to know how the journey might impact the less tidy but essential aspects of innovation processes, culture, and social networks. In short, enterprises need to understand the messy nature of emergent properties.

This issue of the *Technology Forecast* explores the impact of process-oriented transformation on emergent properties, and examines several powerful enterprise modeling techniques that can improve the prospects for process-oriented transformation. Of particular interest are the use of new agent-based modeling (ABM) methods and value network analyses that can help identify emergent properties such as innovation. Although the use of these models during transformation efforts can improve the likelihood of success for many different kinds of emergent properties, our focus is on the more difficult fundamental innovation behind long-term value creation, the same sort that has fueled 3M's success. We also examine some of the modeling tools and technologies in depth in the article, "Escaping the EA stereotype," on page 24, and we offer insight into how the CIO can incorporate those modeling tools and technologies into transformational efforts. (See "The CIO's opportunity to transform transformation"on page 40.)

Value creation in complex adaptive systems

3M is not alone when it comes to uneven transformation results. Historically, successful enterprise transformation is the exception, not the rule, according to Dr. William Rouse, executive director of the Tennenbaum Institute at the Georgia Institute of Technology. He reviewed a 200-year period of company histories in three industries and concluded: "When it came to fundamental transformation, almost everybody failed."

Why? Because most enterprises haven't sufficiently acknowledged or don't fully understand that they are complex adaptive systems (CAS). And value creation, as the 3M example underscores, is very complicated in a CAS. A CAS creates value in ways that cannot be directly understood or engineered with Six Sigma or similar process-oriented methods; one-size-fits-all transformation tactics don't apply to CAS.

Most business transformation efforts focus on reengineering, mainly for efficiency. However, these seemingly well-planned and well-executed efforts often lead to unanticipated consequences that influence innovation and other emergent processes. Enterprises need different transformation approaches for their R&D organizations; for example, approaches (such as agent-based modeling) that can protect and nurture valuable interactions and increase R&D's overall innovative capacity. The use of such techniques in the right cultural context increases the likelihood of profitable, fundamental innovation.

Indeed, the reason for 3M's failing was made clear by a new CEO, George Buckley, who was not involved in the initial Six Sigma effort. "You can't put a Six Sigma process into [R&D] and say, well, I'm getting behind on invention, so I'm going to schedule myself for three good ideas on Wednesday and two on Friday," he noted in a *BusinessWeek* article. "That's not how creativity works … Invention is by its very nature a disorderly process."[2]

2. Ibid.

Innovation-driven transformation is not always based on a grandiose vision, but sometimes on a more prosaic goal. Betsy Burton, a vice president at Gartner, describes a relatively straightforward transformation goal articulated by an executive at a European telecom carrier. This executive wanted a single view of the customer, regardless of the service provided by his company—broadband Internet, wireless, or landline. "All we want to do this year with our enterprise architecture effort is to make sure that customer experience and customer intimacy across all those lines of business are consistent," he told Burton.

That's a difficult operational challenge that many large enterprises face, but identifying innovation to meet that challenge and creating an environment that fosters true transformational innovation are two separate things.

If long-term growth is the goal, as it ought to be, there are only two paths to achieving it: fundamental innovation and growth through acquisition. Amazon's cloud computing services and 3M's Post-it notes are examples of the first path, each generating an entirely new cycle of organic growth. In contrast, many companies Rouse cites as conducting successful transformation efforts, such as UPS and Thomson, acquired their way to new markets and new long-term growth potential.

They did so because at some point any market achieves relative stability; even top performers hit a ceiling for revenue growth when their innovation is only incremental and tied to a specific product area. Once mature markets plateau, the companies serving them are forced to find ways to renew themselves. And Rouse's research indicates that the most common way large companies successfully renew themselves is by acquiring companies that have footholds in growth markets. Companies buy their way into new market growth potential, which is not an easy strategy to execute either. But that strategy does have a higher probability of success than fundamental innovation.

Exploitation and exploration strategies for innovation

Since senior executives may be loathe to tap the volatile financial markets for acquisition funding these days, they should focus more on innovation. Fundamental innovation can lead to huge game-changing opportunities, but it is fraught with the risk of failure. The less risky approach is incremental innovation—take what an organization and the companies it acquires already produce, and extract more value from it. The two types of innovation require entirely different approaches: exploitation for incremental, exploration for fundamental. Both kinds of innovation require that enteprises protect and nurture emergent properties, particularly during transformation efforts. (See Figure 1.)

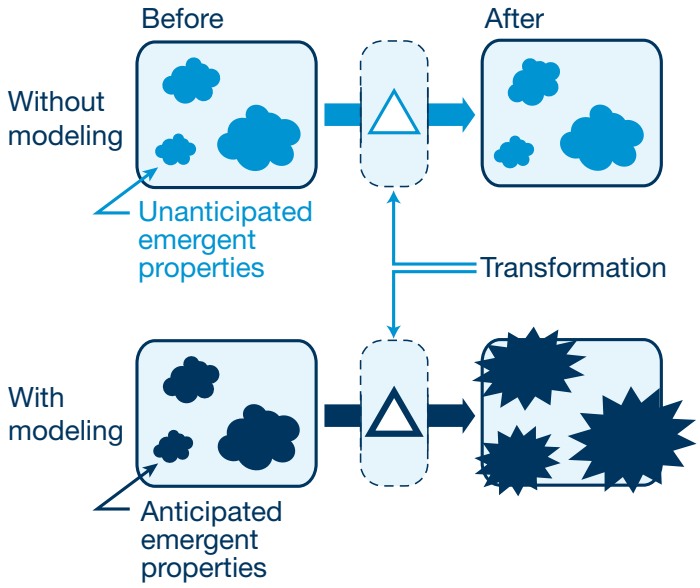


Figure 1: **The effect on emergent properties during transformation efforts, with and without modeling**

A "fast failure" method can weed out the likely losers and cultivate the more likely paths to success.

The incremental approach leads to an exploitation strategy that could include extending the brand, expanding into new geographical markets, adding distribution channels, improving existing products or services, and/or improving the way the organization functions. The history of the personal computer industry is an example of incremental technological improvements: small but many continual advances led to more affordable, portable, powerful, and user-friendly PCs.

The incremental approach is a natural strategy for services as well as products. Dr. Marijn Janssen, an associate professor at Delft University of Technology in the Netherlands, has simulated the impact of shared services on 500 Dutch municipalities to help them study a shared services initiative to improve efficiency as well as reduce costs.

In one simulation, the City of Rotterdam photographed license plates of expensive cars, identified the owners from driver's license records, and then checked whether the owners were receiving government support forbidden to individuals above a certain income level. Once Rotterdam creates such a service, it can then become available to the other municipalities via a shared services approach. The benefits of the incremental innovation could accrue to all other municipalities in the Netherlands.

Creating fundamental innovation that succeeds in the marketplace is extremely difficult, especially for large enterprises, but new tools and management techniques can reduce the risk and increase the return on investment (ROI). One of the new strategies for companies that seek to nurture fundamental innovation is to assume a high failure rate and accelerate it. A "fast failure" method can weed out the likely losers and cultivate the more likely paths to success. Fast failure is one of many innovation-nurturing techniques at odds with logical, step-by-step improvement processes such as Six Sigma.

From the point of view of transformational efficiency, fast failure and other fundamental innovation techniques seem wasteful. In the language of Six Sigma, innovation efforts that do not directly result in successful new products or services are "errors" to rectify. Some of those responsible for Six Sigma at 3M most likely had this perception. Because incremental innovation has a higher probability of being developed into successful products, efficiency efforts often discourage the fundamental variety. Rather than discourage fundamental innovation, companies need to treat the two paths differently.

Fundamental innovation most often leads to success when management acknowledges its hit-or-miss nature and makes room for it. This rationale is behind Google's 20 percent rule, which allows engineers to spend one of every five working hours on exploration—that is, developing products or services they're most passionate about.[3]

Exploration and the need for social networks

The Google-style exploration strategy is not effective in an organization that neglects to manage its internal social interdependencies. At 3M, for example, the collaborative R&D culture uses social networking tools to facilitate connections among researchers working on seemingly disparate products, such as dental impression materials and a new putty for auto body repair, according to the June 11, 2007, *BusinessWeek* article.

Fundamental innovation becomes more likely when companies have an efficient way to distribute the knowledge created by failures during persistent and rapid trial and error. But the trend in recent decades toward flatter organizational structures may pose another hurdle to fundamental innovation. Larger enterprises that have achieved flatness have a tendency

3. "The engineer's life at Google," Google Jobs, http://www.google.com/jobs/lifeatgoogle/englife.html, accessed November 24, 2009.

to accumulate overly dense interconnections among groups. These emergent, overly dense interconnections—think of it as too many cooks in the kitchen—become roadblocks that thwart the ability of innovators to move their new products or services through development, out of their working groups, and into the marketplace.

Hierarchical organizational structures have been much maligned in the last two decades, but Eric Beinhocker in the *Origin of Wealth* argues that a certain amount of hierarchy can help avoid overly dense interconnections by limiting an individual's span of control—flatter organizations usually increase the span of control for any one person. In contrast to the command-and-control nature of older hierarchies, the neo-hierarchical structures of today's successful enterprises allow more autonomy at the division level and below. This autonomy is particularly important for R&D.

Enterprises that continue to innovate effectively even after they've grown have successfully blended the best of old management techniques with the new to protect their valuable innovation supply and distribution networks. This hybrid organizational structure will not have the top-down responsiveness of a pure command-and-control hierarchy, but it can preserve the grassroots-level innovation most often associated with divisions and business units that act autonomously.[4]

The opposite of overly dense social network interconnections—a problem that appears to be as prevalent—is the lack of interconnections that should exist. Social networks today emerge as the chance result of random variations in the personality of employees, and this result has direct and indirect consequences on management policies and guidelines.

New social network analysis tools make structural relationships more transparent and help management understand hierarchies and social networks. These tools also help management strike the right balance between hierarchy and flatness to optimize for value creation rather than leave it to chance. "The real value of analyzing the social network begins when you can validate whether or not essential human interactions are even happening at all," says Verna Allee, CEO of ValueNetworks.com, which offers products and services for analyzing and optimizing value networks.

Allee's colleague, CTO Oliver Schwabe, developed a tool to analyze data from human resources (HR) modules in enterprise resource planning (ERP) systems, project management systems, and the like to help organizations see where social interactions occur and where the work gets done. After analyzing the output, the ValueNetworks.com team delivers a role-oriented process map to help its clients diagnose and address social network snags and gaps.

Modeling these emergent social networks within enterprises as well as the social networks that extend to a company's business partners and ecosystem also can be fruitful. As research by Allee, Rouse, and others has shown, the flow of information, knowledge, and value through an organization does not resemble a linear series of process maps and is not likely to be defined by organizational hierarchies. These tools help companies to understand exactly how the flows work, and to invoke policies and technologies that support those flows.

Lessons from evolution

ValueNetworks.com is part of a larger movement that advances a more holistic view of how organizations create value through fundamental innovation. Rather than solely using a process-oriented approach, one that's well suited for optimizing workflows, for instance, enterprises can add a social network layer to pinpoint valuable interactions.

A more comprehensive approach allows companies to model their organizations as evolutionary or complex adaptive systems, and study the way individual actors or "agents" within the system interact. Studying this interaction then helps companies to anticipate various outcomes, including the creation of surprising opportunities. These methods of modeling CAS resemble those used to study biology, geology, and other scientific disciplines.

Beinhocker makes a persuasive case that economies are part of the living world and evolve in the same way that systems in the physical world do. He points out that exploration strategies designed to support fundamental innovation have a higher likelihood of success when they emulate the traits of biological evolution:[5]

4. Eric Beinhocker, *The Origin of Wealth* (Boston: Harvard Business School Press, 2007), 150–155.

5. See Beinhocker on biological evolution, pp. 187ff, and economic evolution, pp. 279ff.

- **Variation.** Variations in products and services, a high tolerance for the unconventional, and patience with R&D's efforts to find the right application for an innovation are proven strategies that mimic the biological evolution characteristic of variation.

  For example, 3M's Post-it notes began with the development of a semi-sticky, reusable adhesive by Spencer Silver in 1968. Silver spent several years trying to interest colleagues in developing applications. Colleague Art Fry eventually attended one of his talks. Fry, who sang in a church choir, had a nagging problem with his hymnal—he kept losing his place because his bookmark always fell out. This prompted Fry to come up with the Post-it notes idea in 1970 using Silver's adhesive. He used his "bootlegging policy" time (a 15 percent 3M precursor to Google's 20 percent allowance) to develop it. 3M launched the product in 1977.[6]

- **Selection.** In biological evolution, effectively narrow selection criteria such as the ability to run faster improve the odds of success. In an enterprise, establishing narrow selection criteria requires a creative ability to anticipate success, which implies a deep understanding of potential new markets and customers.

  In 3M's case, Silver and Fry's inspiration for Post-it notes implied an ability to meet specific but not obvious consumer needs by providing a novel product that was simple to use and reuse, cost-effective, and mass producible.

  Equally important is the willingness to rapidly prune initiatives that lack any clear prospect of market success. Too many companies spend on innovation without adequately considering the market fitness of the innovation. These companies would be better off allocating this investment to the first stage of variation.

- **Replication.** Multiplying successful variations helps companies fully seize an opportunity. Replication is most closely associated with consumer products companies that are in the habit of brand extension. After its initial innovations with sandpaper, 3M, for example, came up with the sanding sponge.[7]

CAS modeling and how it relates to innovation

Modeling human organizations as CAS is not new. Corporations have been doing this since Dr. Jay Forrester of the Massachusetts Institute of Technology (MIT) founded the field of system dynamics in the 1950s. Forrester studied the behavior of individuals in organizations within the context of what he called feedback structures—in other words, circular processes changed by decisions that cause further changes, which then cause further decisions.

By the late 1990s, Forrester's extensive research on enterprise system dynamics strongly supported his belief that many of the problems organizations suffer from are self-inflicted. Bad policies, he said, cause unintended consequences. And bad polices primarily result from a poor understanding of how organizations actually behave, he argued. His prescription was better enterprise design informed by the kinds of simulations his models enabled. The understanding of intra-organizational interactions gained from organizational simulations leads to better enterprise design.[8]

There are many examples of using the system dynamics–based simulations Forrester pioneered. Dr. Mark Paich of Decisio Consulting, a former student of Forrester and a longtime modeler, worked on the General Motors (GM) OnStar telematics service and notes: "GM has not done a lot of things right in the

6. "Art Fry & Spencer Silver, Post-it® notes," *Inventor of the Week*, Lemelson-MIT Program, http://web.mit.edu/invent/iow/frysilver.html, accessed October 18, 2009; and "Post-it Brand: The Whole Story," http://www.3m.com/us/office/postit/pastpresent/history_ws.html, accessed October 18, 2009.

7. "3M™ Softback Sanding Sponges," http://solutions.3m.com/wps/portal/3M/en_US/Windows/Doors/Product-Information/Products/Abrasives/Softback-Sanding-Sponges/, accessed November 3, 2009.

8. Jay W. Forrester, "Designing the Future." Paper presented at Universidad de Sevilla in Sevilla, Spain, December 15, 1998. http://sysdyn.clexchange.org/sdep/papers/Designjf.pdf, accessed October 19, 2009.

last few years, but this is one of the ones that they have done right, which was really creating the telematics business."

A paper summarizing the project includes a long list of business model decisions GM made with the help of numerous system dynamics simulations.[9]

These decisions included:

- Launching OnStar as a service business, not as a car feature
- Making the first year of service free
- Pursuing a revolutionary rather than evolutionary approach to a telematics market that scarcely existed
- Factory installing OnStar on all GM vehicles
- Pursuing alliances with service partners such as wireless carriers

Paich says that agent-based modeling (ABM), a less mature but more promising technique, builds on the foundation of system dynamics and adds several improvements that help to analyze CAS. He also notes that ABM scales more easily: "For something like the OnStar effort, there is a whole series of things that you'd like to know. In a system dynamics model, keeping track of all that for a lot of different market segments is really hard. But with an agent-based model, it's relatively straightforward and intuitive."

With ABM, the agents can represent people, functions, organizations, and even software programs. Agents act as autonomous entities that have goal-seeking, definable capabilities. So they behave according to

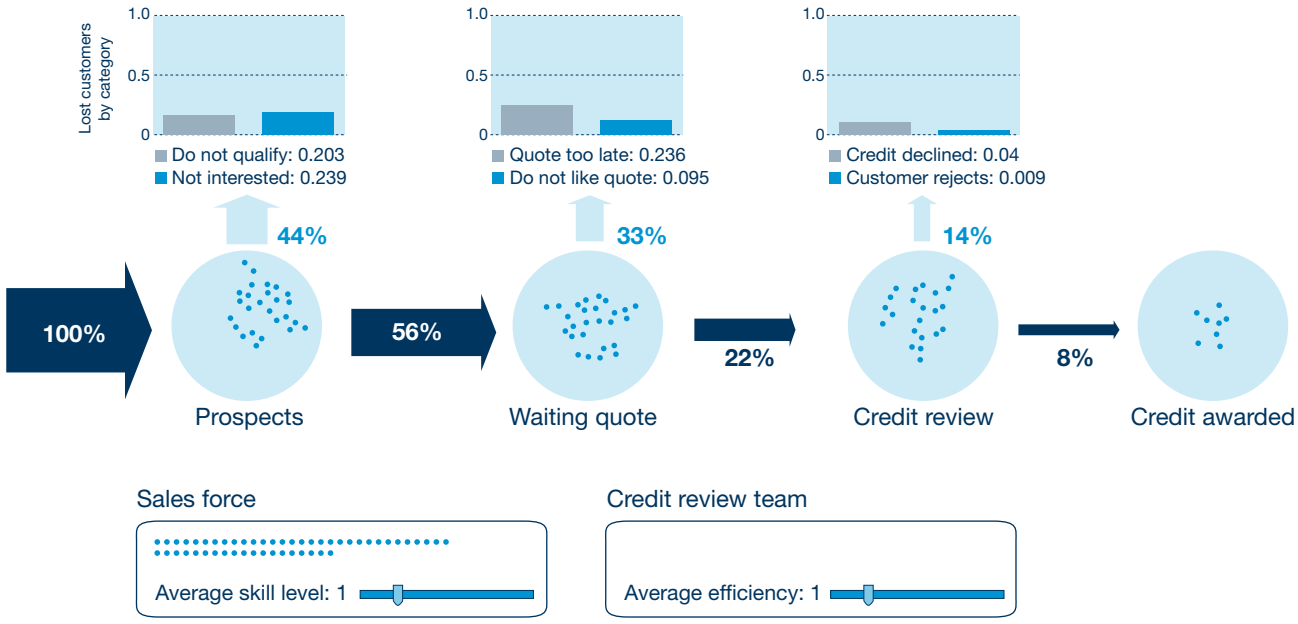


Figure 2: **A typical sales funnel**

Source: XJ Technologies, 2009

9. Vince Barraba, Chet Huber, Fred Cooke, Nick Pudar, Jim Smith, and Mark Paich, "Multimethod Approach for Creating New Business Models: The General Motors OnStar Project," *Interfaces* 32, no. 1 (January–February 2002): 20–34.

sets of rules—including rules for changing rules. In the process, they exhibit diversity.

Agent models make it possible to create compelling visualizations that are based on actual and likely future behavior given various scenarios. The example AnyLogic simulation from XJ Technologies in Figure 2 models the sales function of an organization.

By incorporating detail about individual salespeople, sales targets, process times for quotes, and other variables, this model provides a concise, dashboard-like decscription of the nature of the sales pipeline, how it is managed, and what the sales outcomes are.

This kind of planning is becoming more common, particularly when companies are on the verge of making a major transformation investment. In the case of a university hospital client, for example, PricewaterhouseCoopers (PwC) used the AnyLogic tool to simulate patient flows and other activities to help the hospital determine the level of operating suite expansion and investment it needed. Before PwC developed the simulation, the hospital had estimated it would need 20 new operating room suites. The dynamic simulation model PwC developed helped the hospital realize that 12 to 15 new operating room suites were optimal, saving considerable capital expense. (See Figure 3. In this figure, Scenario three provides the optimal balance of patient flow and cost.)

Agents more accurately represent how individuals working together interact. Views of this kind of interaction are crucial to innovation-related decision making. Executives frequently say their most valued assets walk in and out the door every day. But no other form of enterprise modeling characterizes the autonomous nature of employees or their interactions as well as ABM does. Instead, the most commonly used methods focus on processes, or on abstracted quantitative measures such as financial metrics or market share.

ABM also can frame agent behavior in a probabilistic way that reflects messy reality. For example, decision rules comprising models of agent researchers can be

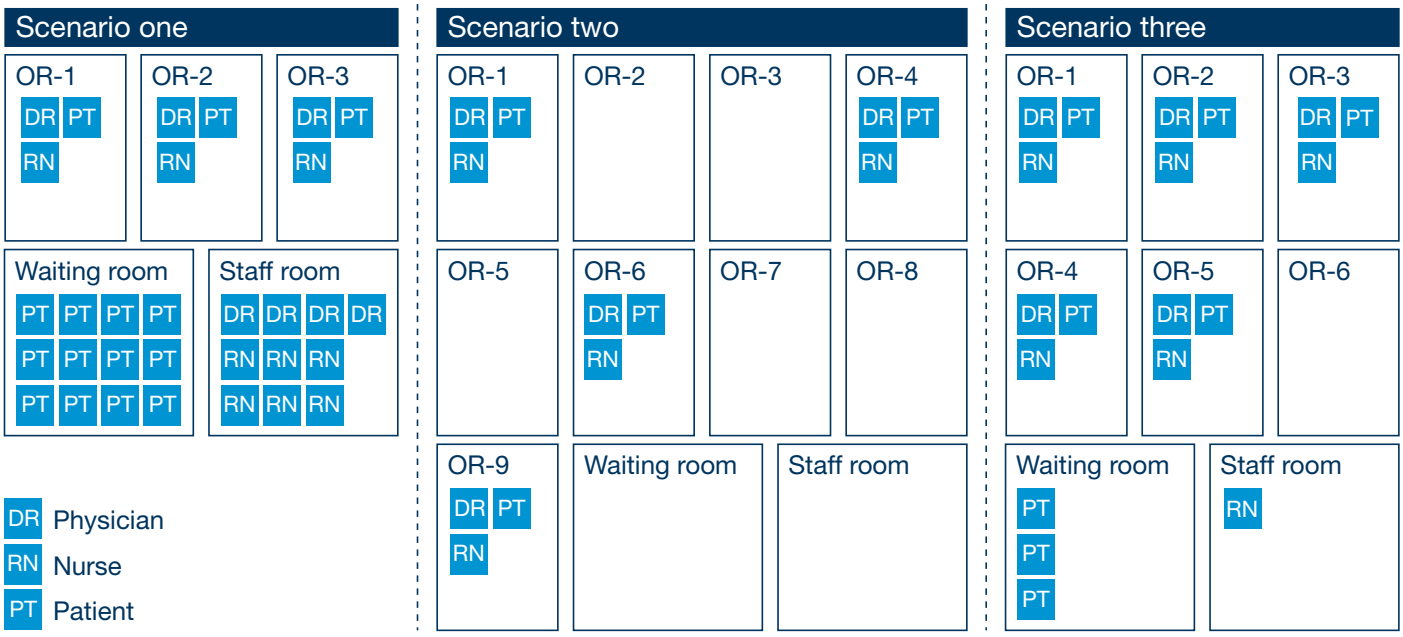


Figure 3: **An agent model of a proposed hospital expansion plan**

Source: PricewaterhouseCoopers, 2009

included that set the probability that different researchers communicate and share complementary knowledge needed in product design. In contrast, other approaches, such as business process modeling, are deterministic and fail to bring motivations and behavioral variability into the analysis.

Finally, techniques like ABM more accurately simulate the unique results of interaction—their emergent properties. Emergent properties are best described by the phrase "the whole is greater than the sum of its parts." When individuals at companies such as 3M interact and valuable outcomes result, it's not the individuals alone creating value—it's the emergent properties of their interaction.

The time dimension of ABM is a another critical element in capturing the results of interactions. A computerized run of the ABM starts by giving initial states, or starting sets of characteristics, to agents and any properties of interest in the environment. The model then steps through time, and agents interact with each other and with their environment. The interactions result in changes to both the agents and their environment.

Each agent follows simple and straightforward decisions that reflect real-world decision heuristics. By aggregating hundreds or thousands of individual interacting agents into the model, it's possible to create synthetic versions of real-world complex adaptive systems.

What if 3M had used Six Sigma and ABM?

The following discussion highlights how 3M might have used ABM to anticipate the impact of the Six Sigma initiatives on fundamental innovation. An ABM analysis might begin with a ground-level, detailed assessment of how researchers actually do their work. It also could recognize that innovations occur as a result of complex, path-dependent sequences of individual decisions that researchers make about where to seek additional knowledge. At any point in the sequence, the alternatives facing a researcher may be few, but the number of possible paths across the entire sequence could be exponentially large. Only a few, if any, of these sequences will result in a successful innovation.

For example, an ABM exercise within 3M prior to the Six Sigma exercise would have incorporated something like the following:

- **Gather background information**—Those conducting the exercise would interview key employees and managers (agents) in the innovation process. They would try to learn the employee decision rules about effective knowledge-seeking strategies and beliefs about what management expects and how that is expressed in 3M's reward structure. Stepping backward from a successful innovation through the sequence of knowledge-seeking steps that contributed to the creation of the innovation could be valuable. Analyzing data that describes employees, management policies, and innovation outcomes (patents, product introductions, incremental versus fundamental innovations) would also prove helpful.
- **Develop agent models**—The information gathered in the previous step would be used to develop models of the different agents, describing their capabilities, goals, decision rules, and behaviors. The agent model requires parameters that define random variation in agent properties and behavior. A good modeler would be able to take concrete examples of decisions, capabilities, and goals derived from interviews and establish these parameters and their likely range of action.
- **Incorporate key metrics and policies**—Key metrics of interest, particularly emergent properties such as successful innovations, and management policies regarding the R&D function would be incorporated in the model to define the environment that the agents interact with and that constrains interaction. Metrics could include the number of innovations per unit time of different types, number of successful innovations, budget, performance appraisal dynamics, and patient flows.
- **Test model structures**—Through an iterative process, various model structures would be tested

for their ability to predict past metrics of interest. The structure that produced the best fit with the innovation metrics of interest would be chosen.

- **Set values for variables**—The changes defined by any major transformation, such as the anticipated Six Sigma process, would be used to set values for variables in the agent model.
- **Predict new values**—A simulation run of agents in the proposed transformed environment (one with Six Sigma in place) would predict new values for the key metrics—innovations of different types of success levels.

If the model effectively captured the impact of the changed environment on individual agent behavior, then it would demonstrate the emergent nature of fundamental innovations. Management might have concluded that Six Sigma transformation was not appropriate for all aspects of 3M, especially its world-class R&D operation.

Conclusions

In a similar way, ABM can help companies avoid unanticipated and undesired changes to many emergent properties, not simply its innovative potential. But ABM is not a magic bullet. The quotation "All models are wrong, some are useful" from statistician George E. P. Box has found new life since the financial downturn.[10]

CAS models, like all enterprise models, have strengths and weaknesses. Much of the activity in an enterprise follows a linear, logical path, and CAS models are inefficient for surfacing and managing such processes. Thus, deterministic models of the sort described in the article, "The CIO's opportunity to transform transformation," on page 40 are complementary and necessary for the effective management of large, complex enterprises. A combination of models with different value propositions, together with a management team that understands how each model is uniquely wrong, but useful, will create the best guidance for managing and transforming the enterprise.

As a whole, enterprises comprise business activities that range from those with predictable and deterministic outcomes to those with highly unpredictable outcomes. And they exist in rapidly changing market and regulatory environments that demand adaptability. Organizations need to recognize the value of predictable and unpredictable outcomes, and they must optimize management methods for these disjoint sets of outcomes.

Modern management practices are particularly good at arranging for the efficient and effective execution of activities with deterministic outcomes. But they're just getting started when it comes to activities that are path dependent and unpredictable. The new modeling tools will help.

10. George E. P. Box and Norman R. Draper, *Empirical Model-Building and Response Surfaces* (New York: Wiley, 1987), 74, in "George E. P. Box," Wikiquote, http://en.wikiquote.org/wiki/George_E._P._Box, accessed November 3, 2009.

Tools for modeling complex adaptive systems

Interest in agent-based modeling (ABM) to explore emergent properties of complex adaptive systems (CAS) has been growing. Most of the early activity has been supported by modeling tools from open source communities. Commercial tools are available as well. The number of tools associated with ABM is at least 50—too numerous to cover here. Here are a few of the more popular and innovative ones available.†

AnyLogic

This commercial product developed by XJ Technologies in St. Petersburg, Russia, is the only tool available that supports ABM together with process-centric (discrete event) and system dynamics approaches, all within one modeling environment and programming language.

NetLogo

NetLogo is a programmable modeling environment for simulating natural and social phenomena. Developed in 1999, the tool is maintained and updated at the Center for Connected Learning and Computer-Based Modeling at Northwestern University. An extension of the Logo programming language, NetLogo allows the publication of applets to the Web that can be used for modeling purposes.

Repast Simphony

Repast stands for the Recursive Porous Agent Simulation Toolkit, originally developed at the University of Chicago. Repast has multiple implementations in several languages and built-in adaptive features such as genetic algorithms and regression. It also incorporates other modeling approaches (system dynamics) and can be used to model social networks. For geographic modeling, Repast includes support for geographical information systems.

Swarm

Swarm is a collection of algorithms associated with the Swarm Development Group, which was established to develop a vocabulary and a set of standard computer tools for the development of agent simulation models. A primary goal of Swarm is to enable researchers to focus on the substance of the modeling and avoid some of the complicated details of computer coding. Swarm has been used extensively in modeling financial systems and the complex competitive properties of markets.

† For more on the different tools available for CAS specifically and where CAS modeling fits within the broader domain of modeling, see Michael J. North and Charles M. Macal, *Managing Business Complexity: Discovering Strategic Solutions with Agent-Based Modeling and Simulation* (New York: Oxford University Press, 2007).

Using models for transformation purposes

William Rouse of the Tennenbaum Institute at the Georgia Institute of Technology explores why most transformations fail and how modeling and simulation can help.

Interview conducted by Bo Parker, Karen Schwartz, Vinod Baya, and Terry Retter

Dr. William Rouse is the executive director of the Tennenbaum Institute at the Georgia Institute of Technology, which focuses on researching and developing the knowledge and skills necessary for enterprise transformation. In this interview, Rouse provides his perspective on the value of enterprise modeling to transformation, a view informed by the institute's extensive research on the history of transformation efforts.

PwC: Can you tell us a bit about your background?

WR: I left the university for 13 years and started two software companies, the second of which had a suite of strategic planning tools for new product development and technology portfolio management. During that time, I worked with about a hundred companies, so that's how I got immersed in this—I saw how difficult it was for the companies to fundamentally change.

I did a lot of background research. In fact, my book *Start Where You Are* goes back about 200 years and looks at three industries: transportation, computing, and defense. Of course, computing in the 1800s was cash registers and things like that, not computers, but the bottom line was that when it came to fundamental transformation, almost everybody eventually failed.

There are only a limited number of big success stories, and everybody of course wants to be one of those success stories. For transformation to succeed, there has to be a perceived or experienced value deficiency, or people don't do anything. It's really rare that people just decide to change, either as enterprises or as individuals. The value deficiency can be something that is relative to what you thought you could accomplish. In other words, you may not be not failing as a business, but you are not getting where you would like to get.

The way you turn companies around is by understanding the work processes in the organization and how value is created for the organization's constituencies or markets. That often is very difficult for people to do. In healthcare, for example, people don't really think in terms of work processes; they think in terms of functions or specialties. So healthcare is a particularly thorny problem, because beyond people's reluctance to change, they also have difficulties thinking about it in a way that would enable change.

Beyond value deficiencies and work processes, a big issue is management decision making—executives' and senior managers' abilities, limitations, and inclinations to make decisions. In a lot of the companies I have worked with, the executives were not willing to make a

fundamental change decision until the need was so patently obvious that everybody would go along with it, and at that point, their resources and time were lacking.

Beyond management decision making is the social network of the organization. The social network can be a great enabler of change, or it can be like an immune system. We found that large organizations tend to get insular over time. Because the majority of the people are not customer facing, they don't see the outside world, and that begins to reinforce their beliefs about the way in which the organization achieved its success and will sustain that success in the future. Often, these perceptions aren't valid, or at least no longer valid.

So, we study those four components: value—what it means, the nature of value deficiencies, and how these deficiencies are understood; work processes; management decision making; and social networks. And we feel that those four pieces are the keystones to successful transformation.

PwC: How does the transformation methodology you've developed differ from other methodologies enterprises generally use?

WR: In contrast to what I perceive to be the typical IT-driven approach, we tend to work top down. We start from business issues and understanding the strategic intent of the executive team and the board. And then, we focus on how you can develop an enterprise architecture—not necessarily an IT architecture, but an enterprise architecture—that can enable you to pursue the intent that you have. And then we address how you understand the relationship between the as-is enterprise and the to-be enterprise, which leads to IT eventually, as information is often a key facilitator for all this.

We have been involved with many companies who walked away from very substantial IT investments when they realized they hadn't done sufficient thinking at the beginning from the top down. When you start top down, in some ways the interactions are easier to find, because you are looking at the overall context of the enterprise and how it's put together. Engineering and manufacturing, marketing, and customer support—how do those all fit together in terms of the value that the customer perceives? The interactions of these processes are critical.

PwC: In your "Models of Complex Enterprise Networks" paper, you point out that the enterprise requires a balance between a holistic view and a reductionist view. Is that one of the main reasons why transformation is so difficult?

WR: Right. We have a wonderful case study going on right now in healthcare, and we are totally immersed in this, working with our partners in Mayo Clinic, Emory University, and other places. Everybody—all the different providers, the device companies, the pharmaceutical companies, the insurance companies, the hospitals, the integrated health systems—they are all seeing it from their perspective and arguing for change or a lack of change from that point of view. There isn't really anyone taking a holistic perspective.

The bottom line was that when it came to fundamental transformation, almost everybody eventually failed.

We can take that broader view to find out where you can actually gain leverage. In the end, you do have to do some reductionist work—you have to get down there and make stuff happen—but the question is can you pick the places where you will actually get the biggest leverage in the whole enterprise, and for that you need a more holistic view. It's been very rare to find any instances where people have totally reengineered a large enterprise from the bottom up—even tried, never mind succeeded.

PwC: Is getting a holistic view difficult? How are enterprises getting better at it, and does modeling fit in at all?

WR: Sometimes you gain the holistic view by talking with key stakeholders of the executive team and key customers, and it can initially be a fairly qualitative model. When we try to become quantitative, often we start with some simple analytic models that portray the relationship between the enterprise and its markets or constituencies. How they provide value, how value flows, the costs, and the revenues are associated with these flows. And from those simple analytic models, we get initial insights to some of the key tradeoffs.

Then we start scaling up the analytic models. Pretty quickly at some point, we can no longer deal with the models analytically, and so we have to go to organizational simulation to be able to simulate the enterprise. We have found success in simulating the social network in the organization—not just the business processes, but also who knows who and who relies on who. We have been able to show how you can make major improvements in the organization by exploiting those relationships. In the case of one major company we work with, we showed them how to use their social network to reorganize the flow of projects through the organization, and with zero investment, they could achieve a 50 percent reduction in time to market, just by exploiting what they already had.

We are modeling the work processes in the enterprise, but we are overlaying it with the social network, which then allows you to portray who works with who, who relies on who, and who will go to who to get additional information or help.

PwC: So the organizational simulation that you alluded to is leading to more of a complex adaptive system view of the organization?

WR: Yes. In healthcare, you really have to take the view of a complex adaptive system. That's the only way you can constructively decide how you might address change, because you can't command a complex adaptive system.

Once we go from our analytic model, which might be algebra and a few other kinds of calculations, there are three directions we can go: a discrete event simulation, a system dynamics simulation, or an agent-based simulation. For the Air Force, we're working on how to combine those three simulations in a seamless way, rather than trying to force all the phenomena in the organization into one representation.

PwC: Would you compare and contrast each of those simulations?

WR: Discrete event simulation has the best off-the-shelf tools, tools that are very mature. There the key thing is the timing and flow of events, which could be people or products or information. In terms of control information, you are really looking at how capacities are allocated over time. By contrast, with the system dynamics approach, you are more concerned with feedback loops.

With the discrete event simulation, you might look for the steady-state, optimal solution to allocating resources. With the system dynamics simulation, you are looking for the time variations of the response. There are well-developed tools for this—they have been around a long time. However, they often don't seem to be as useful to get a really fine-grain representation that the discrete event simulations allow, in terms of off-the-shelf tools. The agent-based approach allows you the greatest level of granularity, but the tools are not as mature.

We learned it can be very useful to use those representations and convert the simulation into a game. This way, executives can play with the organization and try things out. For example, we have a game called Health Advisor in which you manage 500 patients. You are not a doctor, you are just a health coach, and you

are helping these patients get through the healthcare system. We are using that game to study how different levels of information and different levels of incentives impact what people do. With an online game, you can study a large number of people playing the game. Or, if you are only concerned with simulating an enterprise, you can do what-if experiments in the virtual enterprise first and then port them to the full-scale enterprise.

Once you get to a certain scale, you might want a mixed representation of discrete event, system dynamics, and agent-based simulations. Only recently have tools emerged that allow you to manage that well. One of the problems with these large models is that the maintenance of the model becomes an enormous cost. I was on a DoD [US Department of Defense] senior advisory group for modeling and simulation a few years ago, and they were spending a lot more money on the maintenance of agent-based models than they were in creating models, because they were so handcrafted. We need to get beyond that.

PwC: Where do emergent properties enter the picture?

WR: Usually we can spot some emergent properties from the modeling exercise. For example, in one modeling project we expected that as your workforce became more and more competent, even though they may be more expensive, you would get better performance. So, as a benchmark in this model, we had everybody be maximally competent. You could never afford to hire that workforce, but that was our reference. And then, as people played around with the model, we were surprised to find that in this company—at least in the mix of projects they had—a blend of half expert and half entry-level personnel got almost the same performance as having everybody maximally competent. We did not expect that, but it reflected the fact that many things that needed to be done in the organization did not require maximal competency.

PwC: One final question. Where in the organization does model-keeping reside? It seems to us that enterprise architects are the most active modelers within most organizations, but they don't generally play a very strategic role. In your experience, where are you seeing the modeling capability emerge within corporations?

WR: We work with a lot of executives here at the university or in consulting, and the goal is to have the chief modeler, if you will, be pretty high up—a vice president or higher. I don't mean that they are out there coding. I mean that they are so into this, they are champions for the model-based approach. Sometimes it's the top person, sometimes it's the CFO, sometimes it could be the chief technology officer. And, if all goes well, the model-based approach becomes one of the main ways the executive teams think things through.

PwC: Are you saying that this role is usually somebody with more of an operational or a strategic role? Not the CIO?

WR: Well, while this is a representative sample, our advisory board at the Tennenbaum Institute includes 18 people, all of whom are vice president or higher at major companies and some smaller companies. They are all very IT- and model-oriented, but are more likely to be CEOs, CTOs, or CFOs, rather than CIOs. ■

Using simulation tools for strategic decision making

Mark Paich discusses how modeling enterprises as complex adaptive systems can pay off in transformation initiatives.

Interview conducted by Bo Parker

Dr. Mark Paich is a principal at Decisio Consulting and a former student of Dr. Jay Forrester of the Massachusetts Institute of Technology (MIT), who pioneered the field of system dynamics. In this interview, Paich describes Decisio's involvement in the development of the AnyLogic simulator, an XJ Technologies product designed to facilitate complex adaptive systems modeling approaches, including both system dynamics and the more recent agent-based modeling. Paich provides examples of Decisio's success in using AnyLogic and other simulation tools to help executives at large enterprises make major transformation decisions.

PwC: How did you get involved with the development of AnyLogic?

MP: I've done a lot of work in what would be called the system dynamics tradition, which has many elements common to agent-based modeling but works at a higher level of aggregation. Some of the observations I can offer are system dynamics-based, but still apply to agent-based modeling.

We got involved in AnyLogic's development because we saw some limitations to the system dynamics framework we wanted to try to address. Some of what worked out really well with system dynamics can be done better now with agent-based modeling.

PwC: How did you come to this conclusion? Can you give some examples?

MP: We're seeing an explosion in the availability of data. All kinds of data sets are now becoming available through corporate information systems and various systems that provide the kind of information you can now use to build agent-based models. Whereas before, we would really be scrounging for data in a lot of cases. Now, so much more is available. The primary challenge is to make sense of all of this very detailed, disaggregated data.

We do a lot of work in pharmaceuticals, and we build models to look at the dynamics. These are agent-based models in some cases, and system dynamics models in others, to look at the launch of new pharmaceutical products and who might adopt various projects. You can now get a tremendous amount of data from different kinds of databases dealing with pharmaceuticals that were just never available before. And that's just one example.

PwC: So the data are available for a variety of reasons, but are reporting and regulatory the primary reasons?

MP: I think so. On the pharma side, we regularly use a massive database that came from General Electric. That database includes health-related information on how humans behave, what drugs they take, when they switch, and that kind of thing. Those data have been instrumental in calibrating a number of different models that we've had.

Not only that, but corporations do a much better job now of keeping track of information about specific products. I'm now able to get data on the profitability and sales of products that I couldn't have gotten 10 years before.

There is a tremendous opportunity out there. Let me give you an example. The one that I've done that probably is best known was a system dynamics model—it could also have been an agent-based model—that helped with the design of the General Motors [GM] OnStar business.

We all know that GM has not done a lot of things right in the last few years, but this is one that they did right. We used a dynamic model to help design GM's entry into the telematics business, which was really creating the telematics business. That telematics business was OnStar. A system dynamics–like model was behind a good bit of the original strategy and GM's decision to expand it over a lot of vehicle lines. All of that is written up publicly.[1] We also were a finalist for the 2001 Franz Edelman Award for Achievement in Operations Research and the Management Sciences.[2]

OnStar is an example of where you essentially can use some of the dynamic modeling tools to practically design a business model from scratch. GM made a lot of changes and alterations to it over time, which is what you'd expect. But to originally convince the folks inside GM that this was a viable opportunity and that the basic concept was right, I think the model was pretty instrumental.

We could have done some things with agent-based technology if it existed, but it didn't. Since then, we've learned how to integrate the market research that so many companies perform into these kinds of dynamic models. And, you can do that on an individual level with the agent-based models. AnyLogic has good tools for this. You can do it relatively easily.

I'm sure you've seen things like conjoint analysis choice models. That kind of data and information can be integrated directly into an agent-based model, and you can get the full range of heterogeneity between different kinds of consumers.

PwC: What is the value of adding an agent-based modeling [ABM] approach to a model you have already established with system dynamics?

MP: There are a couple of things. One is that you are able to get a higher level of granularity, which can be important in some cases. For example, in the OnStar case, you want to keep track of a lot of different pieces of information about individuals. You would like to know what kind of GM car they drive. You would like to know various demographic data. You would like to know a whole series of things. In a system dynamics model, keeping track of all of that for a lot of different market

1. Vince Barraba, Chet Huber, Fred Cooke, Nick Pudar, Jim Smith, and Mark Paich, "Multimethod Approach for Creating New Business Models: The General Motors OnStar Project," *Interfaces 32*, no. 1 (January–February 2002): 20–34.

2. See "2001 Edelman Award Winner" at http://www.informs.org/article.php?id=1009, accessed November 14, 2009.

segments is really hard—you get a combinatorial explosion—but with an agent-based model, it's relatively straightforward and intuitive. You can keep track of a lot more information about the individual actors in the system.

PwC: So when you aggregate and use the system dynamics approach, you get a combinatorial explosion. Is this because of the variety of factors that are relevant to the model?

MP: Yes. If you have a lot of demographic factors, a lot of descriptors in those individuals, you can hit the combinatorial explosion pretty quickly.

PwC: With an ABM approach, you can express that variety as individuals.

MP: Right. You just express it directly. You set the characteristics of individuals and just replicate them directly.

The other thing that agent-based models get you is the ability to get at what I call a social network, or the word-of-mouth effect. For a variety of products, and everybody knows this, the social network influences what people around you buy and do. It has a tremendous impact on what you decide you want to buy. Ultimately, the social network will be very, very important, but we're just starting to develop the data.

You have consumers that are connected together in networks. You want to find a leverage point where you can influence key actors in that network, and then produce a tipping response that changes the attitude or buyer behavior. There are strong positive feedback loops running, so if a certain number of people adopt a product or a technology or change their attitude about a product or technology, they talk to others and influence others, and you can produce the cascade effect.

PwC: It's one thing to understand that social networks have a strong impact. How would the act of modeling itself surface the key information that you would need to know?

MP: That is the state of the art. But let me tell you what we did for a major manufacturer looking to change the attitude toward its products very quickly, and specifically in the Los Angeles area in California. We had data on what products people had from the competitors and what people had products from this particular firm. And we also had some survey data about attitudes that people had toward the product. We were able to say something about what type of people, according to demographic characteristics, had different attitudes.

PwC: So you matched attitudes with the types of products they had?

MP: Exactly. We synthesized this information into an agent-based model. We calibrated the model on the basis of some fairly detailed geographic data to get a sense as to whose purchases influenced whose purchases. Now, there were some leaps of faith there because we didn't have direct data that said, "I influence you."

You would like to know a whole series of things. In a system dynamics model, keeping track of all of that for a lot of different market segments is really hard—you get a combinatorial explosion—but with an agent-based model, it's relatively straightforward and intuitive. You can keep track of a lot more information about the individual actors in the system.

We performed some statistical analysis on the model, and what came out of it was a targeting strategy. It said that if you want to sell more of this product, here are the key neighborhoods. We identified the key neighborhood census tracts you want to target to best exploit the social network effect.

PwC: So the model provided a substitute for what a social network analysis approach that actually had that data would have told you directly?

MP: In part. We made some assumptions about what the network would look like, based on studies that have been done on who talks to whom. Birds of a feather flock together, so people in the same age groups who have other things in common tend to talk to each other. We got a decent approximation of what a network might look like, and then we were able to do some statistical analysis.

By the way, the statistical analysis of agent-based modeling is a big frontier. We performed some statistical analysis on the model, and what came out of it was a targeting strategy. It said that if you want to sell more of this product, here are the key neighborhoods. We identified the key neighborhood census tracts you want to target to best exploit the social network effect. Our study said that if you did the targeting that way, it would be five times more effective than a random targeting, and the number of marketing messages and level of expenditure would be the same. The company has not done this targeting yet, but I understand they are getting close to having one of their major divisions actually do it.

I have to admit that this stuff is way out on the bleeding edge, but it's going to get better. We were inventing the statistical techniques a lot as we went on, but I think they can get a lot better, and I think we learned a lot in the process. But the basic idea is really important: try to find a place to intervene that creates a tipping point and then a cascade. ■

Escaping the EA stereotype

With the corporate spotlight on transformation initiatives, enterprise architects have a crucial strategy role to play.

By Karen Schwartz and Alan Morrison

To seize this opportunity, EAs need to reach beyond their standard toolsets to methods that go beyond recordkeeping, IT asset management, and fractionalized governance.

It's a story many C-level executives can relate to: A multinational manufacturing company, in business for decades, has growing pains. It has been stuck in the business model of its early years, when it was run by a core group of engineers focused on step-by-step product innovation at all costs. Now far larger and more complex, the company has little visibility into its processes, its relationships with suppliers and customers, and what it needs to do to move forward purposefully and efficiently.

Executives at the multinational know where they need to be, but they are frustrated about how to get there. They know that their business processes and IT infrastructure must be in sync. However, they face many familiar challenges in achieving that objective: changing corporate culture, lack of communication among stakeholders, no holistic view of systems and the linkages between them, staff pulled in different directions, and an incomplete understanding of the importance of enterprise architecture.

In companies like these, transformation initiatives are an opportunity for enterprise architects (EAs) to become involved and add value in a new way.

To start this process, EAs need to be pragmatic from both an IT and a business perspective during transformation efforts. Although most EAs have traditionally focused on the IT side of things, that's not the current trend. A good EA these days takes a holistic view across business, information, application, and technology dimensions to look for potential areas for improvement (such as costs, efficiencies, and better customer engagement, among other things).

For example, when assessing high customer churn at a telecommuications carrier, a good EA would first look at business processes such as order taking, fulfilment, and billing, and then review how well call centers, logistics, and customer relationship management (CRM) systems support these processes.

It could well be the case that the technology is fine, and the real problem is poor training in the call center. Conversely, it could be an IT problem—perhaps customer data are fragmented or the systems are old and take too long to respond to queries.

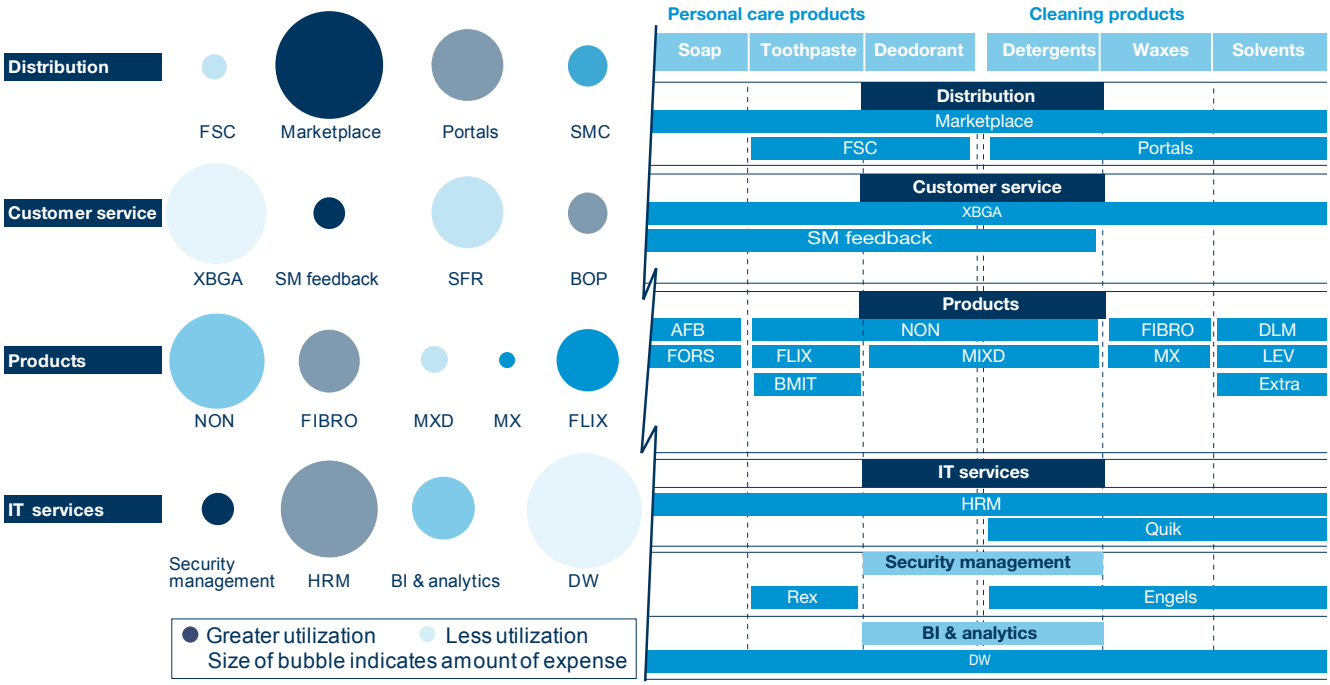


Figure 1: **Contrasting good versus poor visualization**

Source: PricewaterhouseCoopers, 2009

Architecture helps EAs start at the business activity level and then move down into business processes to try to find the root causes of underperformance. Only then does improvement become possible. Once an architect understands the root causes, developing a good to-be state becomes an effective next step.

Overall, EAs must think outside their traditional frameworks. They need to reach beyond their standard toolsets to methods that go beyond the recordkeeping, IT asset management, and fractionalized governance that relate only to applications and technologies.

More importantly, they need to use expanded toolsets in a way that's helpful for long-term evolutionary change, not short-term fixes. The problems of companies like the multinational manufacturer didn't arise overnight. EAs can't help fix those problems simply by filling in cells in a modeling tool, running a series of diagnostics, and generating diagrams that spell out the problems in EA terms. EAs need to communicate their findings clearly, succinctly, and when they're needed, preferably in graphs that are easy to understand or in simple visualizations. This article explains how.

The limitations of traditional EA approaches

Culture and tools each bear some of the blame for the failure of traditional EA approaches to pay off sufficiently. On the cultural side, while both IT organizations and business strategists have worked hard to effect change, they have often done so only within their own silos.

IT leaders, for the most part, have used enterprise architecture tools to try to deliver value to the IT organization. They typically start with a detailed characterization of the as-is state of that organization. According to Gary Delooze, an enterprise architect at PricewaterhouseCoopers, the EA's natural tendency is to say, "Let's capture all the detail we can and start

"We don't know how to tell our business leaders the ways we are enabling the business capabilities they need—what X means to revenue generation, for example." —Tannia Dobbins of AMD

modeling it until we've got a fantastic understanding of the as-is architecture."

The tools EAs have traditionally used for this exercise are designed to make the data collection easier, but these tools lack good visualization capabilities. Unfortunately, that is the very functionality that will facilitate the business-relevant messages hidden in the architecture details. Given this shortcoming, here's what happens, says Delooze, "You take the rudimentary visualization capability that the tool gives you, and then you export that into something else and spend a lot of time conforming the output into something that you can sell to the business." Some of the improved EA tools are enabling better, more business-friendly visualizations. (See Figure 1.)

Effective enterprise architecture tools must be able to not only model the impact of business changes, but also show the potential impact of those changes in ways that business leaders can appreciate. This means that both the tools and the people who use them must use business language and employ visualization as much as possible.

Most tools being used for enterprise transformation don't have the strong visualization capabilities needed to envision how change will impact different parts of the business. Being able to convey these complexities is crucial to getting key stakeholders to fully understand enterprise interdependencies and their impact on what's being attempted.

Speaking simply and directly, and spelling out the value of a proposition is imperative. "We don't know how to tell our business leaders the ways we are enabling the business capabilities they need—what X means to revenue generation, for example," says Tannia Dobbins, an enterprise architect in the Strategy and Architecture group for chip maker AMD. "So we can have short-term gains, but we'll never make the long-term leap unless we make the connections. There is no more tolerance for fiefdoms and silos in communication."

If companies can expand their idea of what's possible and combine that thinking with new and emerging modeling techniques, enterprise architecture can break out of the mold it's in.

Expanding and unifying the EA modeling toolset

Enterprise architecture tools have existed for years and, in large part, have generated value for companies, but they have primarily focused on delivering value to the IT organization. Other parts of the organization—namely business strategists and business unit leaders—have been on their own, with their own tools and processes.

Betsy Burton, a vice president at Gartner, says, "Our children's children will laugh at us for having ever separated business from IT. They are going to look at this Chinese wall that we built between business and IT and just think that we were wacko. Technology is becoming much more integrated into how people are working. We've crossed over the threshold from IT pushing things on to the business to business pulling what they need, sometimes from IT, and sometimes from wherever they happen to be using it."

This integrated environment is the one IT must operate in today. What this implies for architects is a need for a united set of tools that allows business leaders to study the ripple effects of any potential action on the business, as well as the friction points, overlaps, and

patterns that will occur. IT staffs at companies using the new enterprise architecture modeling tools effectively work side-by-side with business staffs and involve them in the modeling process. They refer to business standards, where before they would have had to describe the value of architectural standards.

Enterprise architecture models that have been around since the 1980s still provide some value in this unified context, because they present guidance that can enhance the transformation process. The Framework for Enterprise Architecture, developed by John Zachman and first introduced in 1984, is a schema that attempts to integrate the who, what, how, when, where, and why of organizations. Over the years, this framework has evolved into a 30-cell matrix.[1] (See Table 1.)

Zachman's ideas and those of open standards frameworks such as The Open Group Architecture Framework (TOGAF) now function mostly as a methodological starting point for architects.

Contemporary tools use these frameworks as points of reference for their meta-models, as in Avolution's ABACUS or Sybase's PowerDesigner. Figure 2 illustrates how ABACUS takes TOGAF version 9 as a base and extends it, contrasting the as-is state with the to-be state.

Any basic enterprise architecture toolset, in essence, creates a portfolio for change by being able to model the as-is and to-be technology and application states of any scenario. Meta-modeling capabilities like those of ABACUS and PowerDesigner empower architects to expand their toolsets and make them more business friendly. ABACUS also has business process modeling and simulation capabilities. With these capabilities, IT and business analysts have a richer view. They can better see the gaps between the two states and then identify the projects that will fill those gaps. Creating and analyzing important metrics also become simpler.

	Why	How	What	Who	Where	When
Contextual	Goal list	Process list	Material list	Organizational unit and role list	Geographical location list	Event list
Conceptual	Goal relationship	Process model	Entity relationship model	Organizational and role relationship model	Location model	Event model
Logical	Rules diagram	Process diagram	Data model diagram	Role relationship diagram	Location diagram	Event diagram
Physical	Rules specification	Process function specification	Data entity specification	Role specification	Location specification	Event specification
Detailed	Rules details	Process details	Data details	Role details	Location details	Event details

Table 1: **Zachman Framework**

Source: Wikimedia Commons, October 2009[2]

1. John P. Zachman, "The Zachman Framework Evolution," April 2009, http://www.zachmaninternational.com/index.php/ea-articles/100#maincol, accessed October 23, 2009.

2. File: Zachman Framework Model.svg, Wikimedia Commons, October 3, 2009, http://en.wikipedia.org/wiki/File:Zachman_Framework_Model.svg, accessed October 23, 2009.

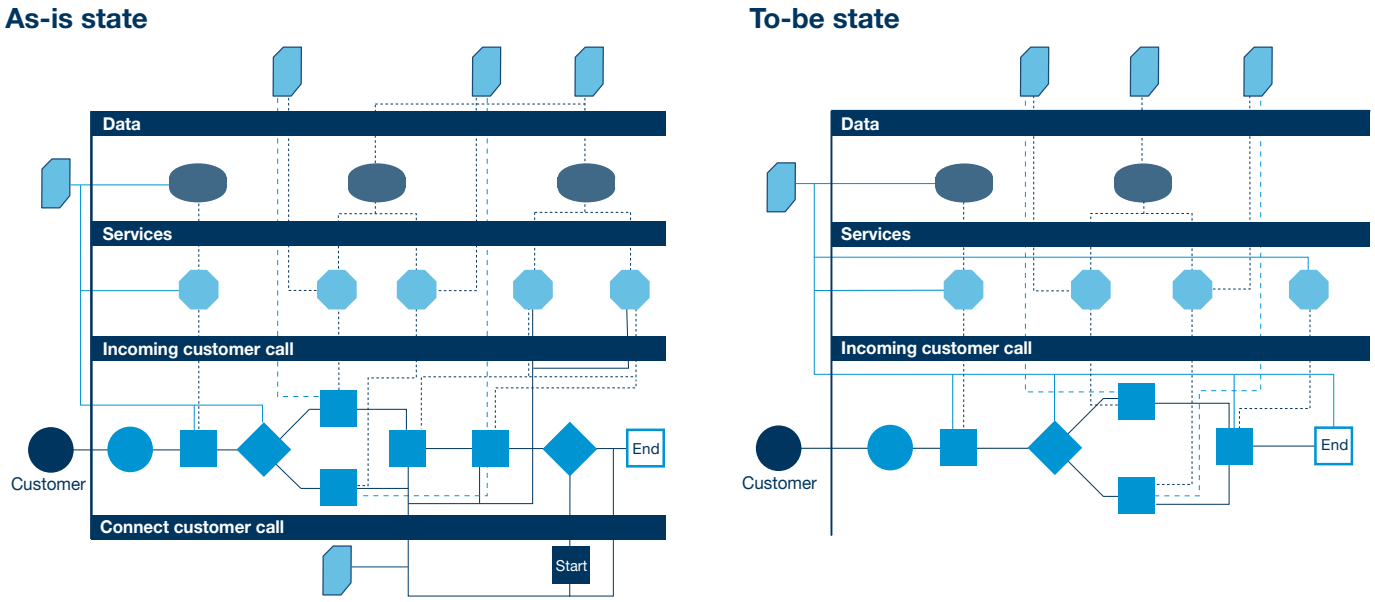


Figure 2: **ABACUS TOGAF 9-based meta-model**

Source: Avolution, 2009

Light at the end of the tunnel

The ABACUS model is both active and passive, making it more useful for modeling various possibilities, says Avolution founder Dr. Tim O'Neill. That is, models are built to answer specific questions, incorporating all possible information, from servers to tools to personnel.

The usefulness of the ABACUS model is illustrated by London Underground, the company responsible for the transport system in the United Kingdom's capital city. London Underground recently inherited a previously spun-off unit dedicated to system maintenance. During the eight years that the London Underground Metronet Rail unit relied on external service providers, the unit acquired thousands of applications and processes that weren't aligned with those of London Underground. Executives now must find a way to reconcile those differences.

"We need to create an extensible model to ask what-if questions," says Dr. Nigel Dix, chief architect of London Underground Information Management. "At a basic level, we could ask how much it would cost if we were to replace a section of the network, but we want to be able to ask more complex questions, like, 'If we replace this application with another, will our users be unhappy?' The challenge is being able to come up with the right set of metrics to enable us to incorporate that as a piece of analysis."

London Underground relies on the ABACUS tool to catalog and compare the systems and functions of its main organization with a merged Metronet Rail unit. The catalog identifies 2,300 applications, as well as new architectures, new people, and new functions. The process started when Dix's team began to apply enterprise architecture principles, along with the ABACUS tool and the PESTEL framework,[3] to the IT asset function. The goal is to streamline IT processes and relationships.

3. PESTEL refers to political, economic, social, technological, environmental, and legal factors. The framework functions as a way to think broadly about each of these factors from an architectural perspective. See "PESTEL analysis of the macro environment," in *Gillespie: Foundations of Economics*, http://www.oup.com/uk/orc/bin/9780199296378/01student/additional/page_12.htm, accessed October 23, 2009.

"We wanted to collect sufficient, tangible information to be able to look at our costs and TCO [total cost of ownership] so we could start to make some informed decisions about where we wanted to place our bets."—Dr. Nigel Dix of London Underground

"We wanted to collect sufficient, tangible information to be able to look at our costs and TCO [total cost of ownership] so we could start to make some informed decisions about where we wanted to place our bets," Dix says. "It's been a significant amount of work to collect all of the information from the variety of sources we have, so that we can build an acceptable TCO model and framework to get some insight into what we're actually paying for."

To accomplish its goal, London Underground is developing a model that attempts to expose the value logic. With this framework, Dix hopes to be able to run scenarios and simulations about what might happen to costs if a system is replaced or a business process is changed.

"The idea is to be able to model ahead of time what we would expect the impact to be on a TCO model," Dix says. "Rather than heading down a particular road because it looks the brightest, we want to try to model what would be the most sensible set of approaches to take to get maximum benefit."

This strategic approach to application rationalization makes room for follow-on innovation opportunities that IT can bring to the business. After freeing up budget, IT could raise the issue of the business benefits that are now available from the deployment of social networking and collaboration tools. The IT department will in general be much more aware of the capabilities of such tools than the business, and the EA can show how these tools could help optimize business processes.

Better prescription for an HMO

Other companies in need of enterprise transformation prefer proprietary, open standards–based, meta-modeling solutions—and are developing their own capabilities.

Take, for example, Midwest Health Plan (MHP), a midsized health maintenance organization (HMO), whose leadership knew the only way to improve processes and responsiveness would be through a comprehensive modeling capability. Faced with a dearth of solutions, the CIO chose to use a series of commercial applications in conjunction with TOGAF.

The framework helped MHP describe the business, data, application, and technology architecture. Open standards such as TOGAF also facilitated and normalized the architecture information gathering process. TOGAF, for example, had many of the standard concepts necessary to help analysts diagram their critical processes, says Dr. Dorin Andreescu, a principal at General Project Management Systems and Solutions, which specializes in business performance management systems.

"We're trying to accelerate the business transformation by following our capability model, which we developed starting with the descriptive model, and we're involving the businesspeople in using these models," says MHP CIO Refaat Shulaiba.[4]

Also important, Andreescu stresses, is a modular, phased approach, which reduces risk and creates

4. TOGAF includes several interlinked models, including the Business Capability Model. See "Welcome to TOGAF 9," http://www.opengroup.org/architecture/togaf9-doc/arch/index.htm, accessed October 23, 2009.

short-term wins. By using this approach, executives can more quickly size up opportunities and implement a way to take advantage of them.

Another part of developing the model involves identifying, measuring, and managing key performance indicators, key quality indicators, and key risk indicators. They, too, must be integrated into the model. Modeling will not be effective unless this key indicator output is in a form that business leaders can quickly understand and relate to.

Once the key indicators have been identified, the model must overlay them with the people, processes, and technology that enable them. The model can then use that information to analyze what levers drive those key indicators and how they affect each other and business decisions.

Viewing the whole stack

What businesses need—and what's emerging slowly—is a whole-stack view of the enterprise that can be abstracted to strategies, competition, and markets while retaining the details and interconnections among the concepts, business processes, and IT infrastructure that deliver the operation.

A whole-stack view enabled by advanced modeling tools transforms the EA role from a passive to active

The expanded EA role within the context of PricewaterhouseCoopers TRANSFORM

When enterprises decide to embark on a transformation, the architect's challenges are numerous. PwC's TRANSFORM methodology addresses each phase of a transformation plan, including assessment, design, construction, implementation, operation, and review.

Design management is often at the top of an architect's list of concerns at the beginning of a program. TRANSFORM's design phase anticipates an expanded EA role by emphasizing these objectives:

- **Consistency**—How to synchronize all the moving pieces and maintain consistency throughout the program. Much depends on an architect's ability to provide end-to-end visibility into the transformation process and ensure the components of the project are joined in a consistent, fully coordinated way.
- **Balance**—How to provide as much emphasis on the business architecture as the other parts of the enterprise architecture. The expanded EA role requires as much awareness of business requirements as IT requirements.
- **Momentum**—How to keep the project moving forward when the program is a complicated matrix of roles, responsibilities, and resources, particularly when nearly everyone involved has plenty of day-to-day responsibility already, and transformation is an additional hat to wear.
- **Resource management**—How to manage the financial, time, and human effort dedicated to the program.
- **Communications**—How to maximize the give and take between the architect and the various stakeholders involved in the program, and ensure the long-term viability of a program that requires months or years to come to fruition.
- **Results**—How to establish and meet milestones and reward accomplishments that link back to the goals and objectives of the organization.

From the beginning, PwC partners with clients with the intent of enabling them to manage their own transformations successfully. The success of TRANSFORM becomes evident once the program sponsor has the confidence and ability to own the program and achieve these design objectives.

Tannia Dobbins, an enterprise architect at AMD, puts the consistency challenge this way: "We try to define capabilities in a way that is systematic, but if you have five people in a room, they are going to think of capabilities differently." Once an architect gains exposure to the knowledge that comes from doing many different kinds of transformations, she can forge the kind of consensus Dobbins alludes to that is essential to maintaining momentum in a long-term initiative.

"What we have provided for DoD in the pilot tests is a road map showing that if you describe things with enough precision and in a language that's executable, you can achieve all three goals—interoperability, integration, and analysis—with one technique."—Michael Lang of Revelytix

participant in enterprise transformation efforts. Senior management will eventually expect answers to questions such as, "How fast can we transform our infrastructure to support our new strategy?" Few EAs can offer reasonable estimates today.

Achieving that goal, however, is unlikely with one tool. Organizations will need to use a set of tools, along with various open standards–based tools.

A semantic wiki to the rescue

Revelytix is making headway in creative ways. The company has developed a collaborative semantic wiki tool based on the Worldwide Web Consortium's Web Ontology Language (OWL) and Resource Description Framework (RDF). This semantic wiki tool has been hosted on the Web as a free editing tool for several years.[5] The editor can be combined with business process modeling techniques and the business process management suite from Vitria to create an enterprise architecture analysis tool, for example. (*Technology Forecast* 2010, Issue 2, will focus on trends in business process modeling tools and techniques.) One output of the semantic modeling tool is executable semantics compatible with the Open Management Group's (OMG) Business Process Modeling Notation standard.

Focusing on visual relationship mapping helps address the business communication issue at the heart of better interoperability. The problem is that people often use different words to describe the same or related concepts. Revelytix focuses on harmonizing these differences into a common vocabulary. The company helps bridge the communications gap not only between IT staff and business analysts, but also between different parts of the business itself. The result is more effective communication, and, in turn, more effective business transformations.

The leaders of Revelytix have used the technology to build an enterprise architecture tool for the US Department of Defense (DoD), spearheaded by its Business Transformation Agency.

"What we have provided for DoD in the pilot tests is a road map showing that if you describe things with enough precision and in a language that's executable, you can achieve all three goals—interoperability, integration, and analysis—with one technique," says Michael Lang, co-founder of Revelytix. The next step, Lang adds, is to make the artifacts useful and to use them in the analysis.

New trends in core EA tools

In addition to new tools and perspectives from companies such as Revelytix, traditional enterprise architecture tools, especially those from some of the forward-thinking market leaders, are maturing beyond their traditional focus to tackle some of these difficult issues.

Troux Technologies, which has focused on enterprise architecture, continues to expand its reach to allow businesses to create the types of integrated views and analyses described in this article. Today, Troux provides more than a repository; it provides a suite of strategic planning applications that helps businesses understand how their IT resources, business capabilities, and business strategies intersect and interrelate.

Troux's suite aims to find information wherever it is within the organization and correlate it to appropriate

5. For more information, visit http://knoodl.com.

other data and systems. “We can tell you very specifically that these are the ten data items that you need to do this type of analysis, and we can tell you if it exists in your organization, and where,” says Bill Cason, CTO of Troux.

Troux’s product suite also includes capability maps—essentially generic visualizations of how systems, applications, and other enterprise assets tie together. The Troux suite allows users to create new visualizations to test various scenarios. The optimization module, an optional add-on, focuses on automating information about applications, contracts, and Web services. “If we have ideas about business capabilities or goals or projects within the company, we have those objects in our repository so you can capture the goals and strategies of a company,” Cason says. “And not only that, but we can capture the projects that are out there and map those two things together.”

For example, a manufacturing organization could model its IT infrastructure architecture by using capabilities in the Troux suite. An analyst could drag and drop visual representations of various pieces of factory floor equipment and IT components, run scripts that would determine whether specific scenarios would operate properly, and generate estimates of operational costs. This type of process can and is used to reduce the time and cost of manufacturing processes.

AMD relied on Troux products extensively to understand which technologies it has, their life cycles, and where they are being used within the organization. Next, AMD’s Dobbins says, is to understand what those technologies’ manufacturers are doing with regard to their product life cycles to gain a better understanding of obsolescence. After that, Dobbins’ team will tackle the company’s application portfolio—the goal is to understand overall IT costs and how to drive those costs down.

Troux is able to link its repository into a configuration management tool already in place, Cason says. With that capability, a business could evaluate whether there was enough rack space in the data centers, whether more power supplies were needed, whether it had underutilized equipment, and much more.

Redefining the EA role

Expanding the use of enterprise architecture methods and models for strategic decision making and execution is no simple feat. There is no one right answer or single model to adopt, and there is no single level of detail, formality, or scope that applies in all circumstances.

This means that enterprises need to redefine their modeling efforts to meet the needs and scope of their specific transformation efforts. Of course, they don’t do this randomly or inconsistently. As suggested earlier, the best method is to develop (over time) a meta-model of the business that indicates which models apply where, along with some basic criteria that determine the level of detail, formality, and scope—the same processes companies would apply to a large systems project.

The successful approach to enterprise architecture models has another key dimension: getting the right cultural understanding among a company’s modelers, which will earn them an appreciation of their value to the business. At a modeling tool level, this language problem also exists in the guise of inconsistent semantics, the issue Revelytix addresses with its toolset.

The successful approach to enterprise architecture models has another key dimension: getting the right cultural understanding among a company’s modelers, which will earn them an appreciation of their value to the business.

Attribute	Old	New
Working relationships	Just with IT	Lives and enjoys working with the business side
Education	Narrowly focused science or engineering background	MBA in addition to BSEE
Attitude	Excessively detail oriented	Grasps the big picture while cognizant of details
Gray zone	No such thing—binary glasses see only on or off	Life is a gray zone
Toolbox	One IT-oriented modeling tool	Several tools
Culture	Focused on IT	Embraces an ROI world

Table 2: **Meet the new enterprise architect**

But the cultural challenge goes beyond having a common language; it often involves understanding that the mindset that makes IT successful in its domain can hinder its success in business-oriented modeling activities. The traps mentioned previously are common manifestations of IT blind spots.

People with an engineering or science mindset, which includes many EAs, often err on the "too detailed" side. There's no easy answer to how much detail is enough; that comes with judgment and experience. That's why it's critical to have a strong working relationship with the business team in any modeling work. (See Table 2.) Good business analysts will know the hot spots in the enterprise that would benefit from more detail and where less will suffice.

IT organizations that have embedded business analysts (whether from business or IT) and that encourage IT staffers of all disciplines to understand and engage with the business are better prepared to leverage advanced modeling tools. They are far likelier to have much of the business context already in place. (See the sidebar, "Turn the enterprise architect function to your advantage," on page 46.)

Another mindset EAs may need to overcome is that people with an engineering background tend to dislike uncertainty and gray areas. They often exclude the uncertainty or force the model to limit the range of possibilities and replace grays with white or black. This frustrates business users, who often deal with unknowns and variations that all human systems encounter (they are, after all, fundamentally trying to model human behavior, whether it's for a marketing campaign, new sales strategy, product adoption, or acquisition). Dehumanizing the model to achieve precision both annoys the business staff and, more importantly, blinds the model to the human context it is designed to explore.

In other words, there is a place for judgment, guesses, and unpredictable outcomes, and the models need to accommodate those where possible. If these gray areas cannot be modeled, they need to be captured in some way so business staff can rely on intuition and experience where the model cannot help—rather than miss the possibility in the first place and never account for it.

Opportunities and challenges for EAs

The history of enterprise architecture reflects a desire on the part of enterprises to clean up the mess in IT. For many organizations, IT has been out of control, with data centers full of systems and applications of uncertain ownership and minimal standards.

Tools that emerged to support the EA in the IT era have been IT centric. Their function has been to help the EA collect and maintain data about IT elements. There has been little support for connecting those elements to business processes, capabilities, and strategies. And even less for helping the business to model its strategic options and how IT facilitates or constrains those options.

This is changing. New functionality from vendors has started to help expand the EA function, which will lead to a business era in enterprise architecture. Instead of simply exploring the impact on IT of maintaining different servers, newer tools incorporate business capabilities when modeling the impact of consolidating CRM systems, for example. The EA function, which historically has been almost entirely focused on IT, now has the potential to be a true partner with the parts of the business focused on future opportunities, challenges, and threats.

EAs can use modeling tools supported by rich data to capture the IT and business process capabilities and constraints that define the business as-is. Then, augmented by the ability to simulate and test alternative models for running the business, EAs can create rich visualizations and accurate estimates of the costs of change and the future costs of operations.

Another mindset EAs may need to overcome is that people with an engineering background tend to dislike uncertainty and gray areas. They often exclude the uncertainty or force the model to limit the range of possibilities and replace grays with white or black.

What EAs encounter during transformation initiatives

Tannia Dobbins of AMD sheds light on the practicalities of enterprise architecture in today's turbulent and cost-conscious business environment.

Interview conducted by Bo Parker, Karen Schwartz, and Alan Morrison

Tannia Dobbins is an enterprise architect with Advanced Micro Devices (AMD). In this interview, Dobbins talks about what enterprise architects can expect when a large enterprise confronting multiple challenges undergoes a transformation effort.

PwC: What were AMD's transformation plans to begin with, and where is it in its efforts?

TD: We began our most recent transformation efforts here not long after Ahmed [Ahmed Mahamoud, CIO of AMD since March 2008] joined us. We had a model—a governance framework from the corporate executive board—that we relied on for goals and objectives. Among other things, the goals covered business alignment, service and project demand management, and portfolio management from a project perspective. The goals also covered a delivery capability, sourcing strategy, role alignment—internally as well as with those of suppliers and providers—retooling, and retention. The process was pretty prescriptive in terms of metrics, dashboards, monitoring, and minimizing risk to the business during the transformation process, and there was general agreement that this was a target state, if you will.

To move us toward the target state, our CIO said some things that were spot on. Things like: We need transparency. We need visibility into everything we are doing. IT is a black box.

But at the end of the day, everybody had their day job and they were trying to do transformation at the same time. So while we might have had somebody writing the transformation program, there was limited bandwidth. That was one challenge.

Another challenge was that nobody could really say, "What do I do differently at the end of the day? I understand my to-be state, and I understand where we are today, but I don't know what that means as far as me doing my job any differently tomorrow." In other words, we were not very prescriptive in helping the frontline people to do their jobs differently.

PwC: The implicit framing seems to be IT transformation, as opposed to AMD transformation.

TD: I separate what our business does versus how IT works with the business. What I discuss stops short of transforming our organization in terms of our markets, things like that. That's really completely on the business

side of the spectrum. There is a whole group of people that does nothing but that. But I can shed some light on what the business does in automation.

When I look at IT holistically, the challenge is really transforming ourselves to better look across our portfolio, prioritize or reprioritize our spend, and reallocate our assets to meet the needs of the business.

PwC: What metrics have you been using for this effort?

TD: We realized the metrics we had been using were overly narrow and didn't provide a broad enough enterprise view. So we embarked on an initiative to look at our corporate KPIs [key performance indicators] from the board on down, and we ended up reducing the number of KPIs from 49 to 15. Those now include KPIs like customer share of wallet, turnover asset ratio, and costs of goods sold, many of which are pretty standard financial metrics.

If those are the KPIs, then what are the levers that can have a positive impact on those KPIs? That sort of analysis led us to review the data we had available, and that review in turn led us to take a fresh look at our systems.

Fundamentally, the systems should enable business outcomes. If we embark on a project, we need to answer the questions: What is the business going to do differently tomorrow? How are we enabling the business capability that they need? If it's all from a technical perspective and we don't know how to talk in business terms, we won't know how to tell them what the project means to revenue generation or to the ability to get to the market 30 days sooner with a product.

PwC: You can't make that leap unless you make those kinds of connections.

TD: Exactly. The good part about all this is that our organization realizes that that's a problem. We have yet to overlay the KPI strategy with the people, the processes, and the technology that needs to happen to enable it.

PwC: At some level, this is a learning and knowledge development task, isn't it?

TD: Yes, very much so.

PwC: People need to understand the problem and figure out the best way to solve the problem. What tools can help with that?

TD: Like most organizations, we started with the easy stuff, which was the technology stack. We looked at the problem from an architecture perspective—the enterprise view—from the strategic intent of the organization, down through capabilities and functions, all the way down to the IT stack supporting everything above.

We are a Troux shop. We have a very straightforward mapping and asset management effort under way, and soon we will understand where we are with the life cycle road map, where the vendors are in our space, and what risks are associated with our asset base. So in the application portfolio area, we've made a lot of headway.

In terms of strategy-level projects, or the capabilities being delivered, we are trying to define capabilities in a systematic way. But if you have five people in a room, they are going to think of capabilities differently. One of

It's very, very difficult to take a topic like an architecture strategy and get the stakeholders to buy into the overarching strategy. You cannot underestimate the importance of communicating the value proposition.

the biggest challenges is having different tools for our business process modeling and our business mapping. These two systems don't integrate. Fortunately, our CIO recently made the case to get rid of one of them. Why that's important is now clearly understood, so now there is just work ahead of us to bring all this stuff together.

It's very, very difficult to take a topic like an architecture strategy up to a level where the aha moment occurs, so that the stakeholders can buy into the overarching strategy of what you are trying to do without getting bogged down in the details to make it happen. The topic is complicated, and it hits every part of your organization. You cannot underestimate the importance of communicating the value proposition.

PwC: You said that you are using Troux and that you had made some good progress on the technology stack. Can you give us some specifics?

TD: Sure. For the most part, we have all the components of the Troux suite. Troux also has a product called Standards, which provides standard categories based on a technical reference model, which in turn provides a view of the asset life cycle across the categories.

We have pretty much built out our technical reference model, and we have teams standing up or that have stood up to take advantage of it. We now are in the process of defining our internal life cycle of all our IT assets. We can determine which assets should be retired, including the percentage that hadn't been articulated before. I would say we are about halfway done.

The next piece is to understand what the manufacturers are doing with those life cycles. So we really need a good understanding of the target obsolescence for their products, and whether those are still preferred products on our end. We need to make sure our road maps include that information, so that we can eliminate unneeded assets. This effort is maturing, but the age-old challenge is to keep it current, so we will need to maintain good focus there.

Then there's the application view and understanding our application portfolios. We have focused on ensuring that all our application portfolios are well understood, so we can eliminate duplication in those assets. We have been working with our contractual people to understand what we really need to purchase, what the terms and conditions on the contracts are, how many licenses we have, how do we buy them, and are there opportunities for consolidation—at least contractually, if not by eliminating duplicate capability entirely.

We may have 1,500 applications defined in our repository today. Our leadership now is really focused on understanding our shadow IT pieces of our application portfolio. So in enterprise transformation terms—not just IT—we can take a compelling case back to our CFO and say, "You have 18 tools across your entire organization that do the same thing." We are trying to get to that view, trying to understand the shadow pieces and the cost information associated with them.

Another piece that we are starting to work on is really about the data. This piece relates directly to the KPIs I mentioned. As you know, we sold off our manufacturing component, we are standing up a global foundry company, and AMD will become purely a design company. So huge efforts are under way right now to understand the interactions among companies. Our portal strategy is an example—how do work requests get to our foundry company, and things of that nature.

From an architectural perspective, we're obviously concerned with what data do we have, what data do they have, what needs to be cleansed in our systems and their systems. That picture is being put together in the repository. As I mentioned, we can't get the data on the business process side out of the tool, so we decided to eliminate that tool and replatform it.

PwC: Have you thought about what tools might be useful to tackle some of those issues?

TD: Well, from a road-map perspective for projects, alignment of capability, and the like, Troux will be our front door—from the strategies all the way down to adherence to policy—in our dashboards and things like that. In terms of a day-to-day project portfolio perspective, we are going to use Clarity [CA Clarity PPM for IT Governance]. This tool will provide a view of resources, the time-tracking components related to those resources, and skills. This view will help us realize, for example, that I can't launch all five projects on this day, or if we slip one project a month, can we get more throughput? So we are looking at Clarity for that piece.

PwC: That's the more comprehensive program management function.

TD: Yes. Program management from a project program portfolio. Then there is another initiative that I'm knee-deep in, which is all about our services portfolio. Spending levels here are very important, so one objective is to understand the minimum we need to keep our environment healthy, and yet be able to redeploy our resources to provide a new capability to the business.

So, we are now redefining those services. This is the part of the transformation where we talk about the business side. From the business side, IT is a cost center, so we have to address the question: why does IT keep costing so much? If we redefine our services in business terms and let the business side know it's in their hands what to purchase from IT, we can talk about their objectives and resources. We can ask them, "Do you really want to close at the end of the year? That's probably important to you, so you probably need SAP Financials, and hence here is the cost to you to close the books." We are really trying to rewicker all that, and there are tools out there that do that.

PwC: Overall, what have been the key barriers to creating more value from transformation efforts at AMD?

TD: We talk about transformation at AMD holistically. On the journey we took during the last couple of years, we purchased ATI, the graphics processor [or GPU] company. We committed to the notion of an integrated board, in which you have a CPU [central processing unit], the GPU, and then the channels, and all of that has to come together on one board. Talk about transformation—we had to look at our engineering processes down to the nanometer. ATI had a foundry co-model, and we had a manufacturing model, and because ATI was very successful with its foundry model, we decided to go in that direction. So, if we talk about key barriers and the pace of change, for that journey it's been from A to Z. But that's another story. ■

If we redefine our services in business terms and let the business side know it's in their hands what to purchase from IT, we can talk about their objectives and resources.

The CIO's opportunity to transform transformation

Modeling can improve the odds of transformation success.

By Galen Gruman

Enterprise transformation can be a CIO's downfall. No matter what business reason—an acquisition, partnership, or new market entry—drives a transformation effort, the hammer drops on the CIO if something goes wrong. Although not responsible for the strategy behind the transformation, the CIO ends up responsible for most, if not all, of the implementation of key processes, since they are all technology-enabled and tied to existing data, applications, and infrastructure. It doesn't matter if the expectations were unrealistic; the implementation result is what gets judged.

Typically, any transformation is based on financial assumptions and is essentially a return on investment (ROI) bet. That bet is based on spreadsheet modeling by the CEO, CFO, and other business leaders. If the CIO's organization is world class, it has frameworks, such as the IT Infrastructure Library (ITIL), to identify the affected systems and track the state of implementation of the transformation. However, the key decisions—especially regarding business strategy and execution—usually are based on the intuition, experience, and assumptions of key leaders, not on any modeling efforts.

"When I help enterprises with transformation decisions, I rarely see IT people supported by modeling," says Dr. William Rouse, executive director of the Georgia Institute of Technology's Tennenbaum Institute, which researches and advises on strategic transformations.

Enterprise transformation can be a CIO's downfall.

The article, "Embracing unpredictability," on page 04 describes an approach that includes operations research, agent-based modeling, and value network analysis. These once-separate disciplines are converging, making effective modeling more accessible to the many different departments involved in transformation efforts.

These three approaches give the CIO the necessary frameworks to construct meaningful models of business and technology processes—models that include market and human factors. The overall methodology can simulate a transformation's impact before it's launched and help to create a better road map to implement the transformations worth betting on.

The CIO often takes the fall when a transformation fails, so it behooves the CIO to take the lead in exploring this methodology. Because much of this methodology fits under the technology umbrella, the CIO is well positioned to build a better framework for the business's decision-making process and IT's

CIOs need to challenge the status quo by spelling out the shortfalls of the simplistic and untested enterprise models associated with most transformations.

transformation-driven change-management process. These models and tools are young, but they're mature enough that you can start to understand, test, and deploy them—at least in parts of your work.

What a CIO can do

CIOs need to challenge the status quo by spelling out the shortfalls of the simplistic and untested enterprise models associated with most transformations. These models should be enhanced to depict the dynamic functional relationships and interdependencies across and within different parts of the enterprise ecosystem. They need to reflect an awareness of emergent properties—such as culture, social networks, and innovative potential—that will likely affect the transformation. (See the article, "Embracing unpredictability," on page 04 for more detail.)

"If you can't bring some fairly decent metrics—such as quantitative reality-based metrics—around value, then your strategy modeling is disconnected from your business," notes Gary Delooze, an enterprise architect at PricewaterhouseCoopers. At a minimum, CIOs must be able to link the connections that are missing in most transformation initiatives—the connections between strategy and the enabling processes and IT architectures. After all, those poor connections are what cause the implementation gaps even when the strategy is right.

CIOs should also rethink the use of enterprise architects, the function that could lead the exploration and development of modeling in support of transformation. Today's stereotypical enterprise architect is widely divorced from the business and its strategy. (See the sidebar, "Turn the enterprise architect function to your advantage," on page 46.)

Historically, modeling has been expensive and without tools, other than in a few areas. That's beginning to change, as the article, "Escaping the EA stereotype," on page 24 shows. CIOs can now begin laying the groundwork to take advantage of modeling in a disciplined, flexible, business-oriented way.

Deterministic and non-deterministic modeling methods are maturing, and a growing number of tools are available to take advantage of them. These tools don't require a doctorate or a programming background to use, either. Other techniques that address semantics at the data layer help solve the interoperability problems between system components and enable you to connect the efforts of disparate business activities. With these advances, you can get the detailed view and the high-level interaction view of the transformation's likely effects and the execution of transformation activities.

The current models commonly used to guide transformations are not complete and the assumptions in them are rarely tested. A conventional transformation effort may begin with a data-gathering exercise, leading to ideas and hypotheses about how to proceed, but they tend to neglect several other aspects of successful modeling: using the data to develop various competing hypotheses that explain how different parts of the organization influence each other; testing hypotheses by predicting what will happen in one part of the organization when another part has changed; and simulating future states using a model to verify that management's intuitions are valid.

The missing steps of the conventional transformation effort are iterative, feeding back to prior steps to refine the model and to determine whether the transformation strategy will achieve the expected result. This more rigorous modeling approach parallels the steps

scientists follow when attempting to understand observed phenomena.

Consider early scientific attempts to understand why a flame goes out in an enclosed space. Scientists went through the following process:

1. Gathered lots of data (systematically putting the flame in different conditions), which led to ideas and hypotheses
2. Explained what they thought caused the lack of oxygen
3. Developed an initial functional model based on that explanation
4. Predicted what would happen in an uncontrolled situation (for example, the flame goes out in caverns full of carbon dioxide and low on oxygen) that tests and validates the model against data
5. Repeated the testing to refine their understanding of the cause-effect relationship
6. Evaluated a future state in a controlled situation (for example, put the flame in an upside-down bell jar with and without taking out the oxygen)
7. Refined the model developed in step 3 to simulate the timing of when the flame goes out

Today's enterprise transformation models are mostly at step 1 (hypotheses that aren't adequately tested). Some organizations have proceeded to step 2 (models that have not been validated or used to simulate a transformation's goals and objectives).

Avoid modeling mistakes

When many people hear "modeling," they think "expensive, time-consuming effort that has only theoretical value at best." That's a mistake. Even the most informal organization models its activities. When individuals construct a vision in their minds about what they want and how things are—that's modeling. At their core, models are simplifications for decision making about transformational activities or the optimization of normal operations.

Done with insight, appropriate context, and accurate information, a model lets you describe what you have, test possible changes through simulation to choose the best options, describe the path to the transformation you want, and provide a mechanism for a reality check as you undergo the transformation journey.

The most common formal model is the corporate budget, which models the expected state of the organization and compares it to the actual state from the point of view of financial results. The corporate budget also simulates possible scenarios for strategic planning and operational optimization. Whether the organization is facing transformational change or normal change, effective use of modeling lets it move through that change in a logical way.

As fundamental as modeling is, enterprises rarely use it beyond financial and informal purposes. That's a mistake, because the lack of formal modeling increases the risk of incorrect, untested models leading to big misses in results. Modeling is critical to successful transformative efforts, but it's also useful in ongoing optimization and monitoring efforts. Continually testing against the model helps identify looming changes more quickly—the canary-in-a-coal-mine effect.

"You have to have the models that enable you to study the ripple effect of a change as well as to understand the friction points and the overlaps and the patterns that happen within that change," notes Betsy Burton, a vice president at Gartner.

Modeling itself comes with risk, mainly that of overdoing it. An organization can spend so many hours and resources trying to describe every possible factor and implication of every possible change that it never completes the model or the model becomes too complex to use. The other main risk is using models rigidly, typically picking one and applying it to all situations.

The result is often destructive, as 3M found when it forced the Six Sigma continual-process-improvement approach designed for highly repeatable tasks such as manufacturing onto its research and development (R&D) process. (See the article, "Embracing unpredictability," on page 04.) The company did wring out efficiencies

and increase profits for a few years, but it also severely reduced its pipeline of product innovations—risk taking and emergent properties underlying the innovation were strangled. After all, innovation is based on a model that is fundamentally different from that used in manufacturing. If 3M had had a basic model of its various operations and understood the model underlying Six Sigma, it might have avoided this mistake and instead applied Six Sigma only where it made sense. 3M spent several years to undo the damage.[1]

For years, the traps of trying to boil the ocean and viewing the world through just one "perfect" lens have plagued implementations of analytics, business intelligence, data warehousing, and modeling. The problem is not analytics or modeling per se, but how they're used.

Another major failure is to rely on tools alone to solve problems. Some organizations treat the modeling activity as a simple purchasing activity, in which both the business and IT staff surrender their responsibility to understand the problem and instead buy a tool in the hope it will do their work for them.

Gartner's Burton has seen many organizations make this mistake: "They adopt a tool, they fill out all the blanks, they put it on the tool, and then nobody knows what to do with it." She sees organizations make the same mistake with frameworks, adopting one and relying on it to solve their problems, rather than using it as a tool to ease the overall execution of their work. The same lessons apply to modeling tools.

The modeling framework CIOs should aim for

Your organization is complex, and your approach to modeling must handle that complexity. There is no single view, no master truth. There are only conditions, processes, assumptions, and influences for each function or activity. One or more models may apply, given the aspect of the function or activity you are studying.

Take manufacturing as an example. Manufacturers typically have a well-defined process that ensures a high degree of standardization and quality, reinforced with ongoing analysis of metrics to continually reduce variations; this is the model underlying the Six Sigma process. Manufacturers often source materials in several spot markets where availability and costs fluctuate. As a result, manufacturers also require a dynamic and adaptive model that orchestrates the market chaos to achieve a steady-state supply that can feed the highly honed manufacturing line. The strategic and operational models used depend on the specific areas in question.

Within an IT context, you may have a strict security model but a loose client-device model. At Bechtel, for example, the global megaproject builder is deploying a model that gives employees and contractors wide latitude to select the client devices they use, because managing tens of thousands of systems in an ever-changing worker context is too costly. However, Bechtel has rigid, consistent security requirements that ensure a security model can be applied to them all. To meet these requirements, Bechtel not only applied different strategic models to its technology deployment, but also developed an additional model that allowed the security and client-device models to function together—an operational model.

You've already modeled your organization this way. You just don't know it, because it wasn't a formal process, but rather a series of informal models often applied without explicit thought by different people over time. The models stitch together, either naturally as people adjust them when they bump into each other, or in ill-fitting collections of processes that people continually work around.

Rather than leave your organization's models implicit and ad hoc, PricewaterhouseCoopers recommends that you build a meta-model that defines the key functions or activities and then identifies those processes and their underlying models. Some may be highly variable or for inexact processes, such as for innovation (where you want to model emergent properties). Some may be based on human behavior, such as for sales (where you want to use agent-based modeling). Others may be highly defined and rigid, such as for accounting or physical manufacturing (where you use standard

1. Brian Hindo, "At 3M, A Struggle Between Efficiency And Creativity," *BusinessWeek,* June 11, 2007, http://www.businessweek.com/magazine/content/07_24/b4038406.htm, accessed October 12, 2009.

The trick is to approach modeling as you would good architecture: apply it in a disciplined way with a level of detail and effort commensurate with the problem being tackled.

models, such as the Basel II capital funding requirements for financial organizations, or the Six Sigma approach to quality control).

Start within IT to make this methodology initially workable. You likely have models in place (perhaps implicit) for many activities, such as the way you handle support tickets, determine upgrade cycles, manage resource contention, or handle application development or database design. Map them out, perhaps using a surveying tool such as that from Troux Technologies, and assess whether the model in use is best suited for the activity at hand. (IT operations frameworks, such as The Open Group Architecture Framework [TOGAF], Capability Maturity Model Integration [CMMI], and ITIL, all have mechanisms to start this process. Pick one.)

Then map how the models interact and where translation occurs, so you can see where model mismatches could cause problems and thus where you need to model the interactions themselves to ensure they are correct. Tools such as Avolution's ABACUS can help you integrate the different models, and tools such as those from Revelytix can help you create the semantics that bridge the gaps between models. Later, these same semantic techniques can bridge gaps between parts of the organization.

This meta-model approach within IT, if successful, gives you the ability and credibility to propose that more sophisticated modeling approaches be applied to the business beyond the usual spreadsheet-based models that are likely the norm. You might start with departments that already use sophisticated modeling, such as R&D in the pharmaceutical or energy exploration industries, because they'll readily understand the value of modeling and may more easily partner with you to convince the rest of the business.

Even if the business is skeptical, you can apply some of these modeling approaches in efforts that relate to business activities, and then reveal how you did it after delivering beyond expectations.

The trick is to approach modeling as you would good architecture: apply it in a disciplined way with a level of detail and effort commensurate with the problem being tackled. That means understanding the different types of models available and their best use, learning how to build models with the right level of detail for the problem, and developing or modifying how you access data and gather metrics across your systems to feed into the explorations you develop the models for.

During the last decade, several waves of introducing enterprise architecture into large organizations have shown the dangers of getting consumed by the details, giving architecture a reputation as a data-collection activity with no result. If implemented as naively, modeling could suffer the same reputation.

But just as good enterprise architecture has repeatedly been shown to have strong business value when done right, so too can modeling show that value—especially around critical transformation efforts.

Conclusions

The CIO is often in an odd position when it comes to modeling. Much of what is modeled is outside his or her organization, so attempts to own the activity quickly appear to be turf invasions. Some CIOs may not use modeling within their organizations as effectively as possible, so a claim of being an expert to help others is difficult to defend. And the fuzzy nature of much of the business's activities can confound the more rigid engineering mindsets of many IT experts.

On the other hand, successful IT organizations extensively model many specific technology implementation and management areas, even if they don't use modeling for managing the IT organization as a whole. And the engineering discipline that most IT staffers possess is well suited to developing accurate models and identifying relevant relationships with other factors. Plus the CIO organization typically owns the data, or the tools that monitor and access it, that feed simulations based on models. The CIO organization also has the broadest view of the enterprise's key processes and how they relate to each other.

CIOs face a real dilemma: transformation efforts may be conceived by the CEO or other business executives, but the implementation falls largely to the CIO. Even if the assumptions behind the transformation were misguided, guess who takes the fall when transformation fails? For both personal and business success, the CIO has a strong incentive to help make transformations more successful endeavors by using the emerging modeling approaches and tools.

CIOs should think through these issues and begin to develop the skills internally—an enterprise architecture function can be a great resource if it is actually connected to the business already. As the CIO organization increases its ability to successfully use modeling, it can be a strong enabler of effective modeling throughout the enterprise, while also benefiting from its internal use.

Turn the enterprise architect function to your advantage

Stereotypically, the talent of enterprise architects (EAs) is limited to a rather narrow domain, and they are sometimes ill-informed about the business, which leads many business executives to wonder if they provide any real value. The fact is, EAs could deliver tremendous value if the CIO would radically rethink their role.

EAs have the potential to apply their analytical talent to modeling throughout the enterprise. Architecture is a model, and enterprise architecture is supposed to be the discipline that sees the big picture as-is, the big picture to-be, and the possible paths to transition between them—and then validates the transition plan and enforces its proper usage.

Good EAs do that, but historically only within the context of IT. Bad EAs create an isolated bureaucracy that collects mind-numbing details about the perfect to-be state and ends up divorced from the organization's actual functioning.

To know how fast a business can shift gears to capture a strategic opportunity, you need the knowledge that an EA should have. Yet the EA is rarely part of the strategic conversation.

How does the CIO fix the EA's business-relevancy gap when it comes to modeling? By reworking what the EA role means and how it functions.

The first step is to model the EA function and its roles in business strategy, in process design and execution, and in IT operations (where EAs typically focus). Then set the new expectations. Finally, task the EAs to model their own transformations—they should practice on themselves and within IT, by using some of the emerging tools described in the article, "Escaping the EA stereotype,"on page 24, before claiming they can help the business.

Once they're ready, EAs should meet with the business and offer to help, starting by asking what the key issues are and how the business is addressing them. That should reveal opportunities for gathering data—metrics—that might help build a model for testing various approaches. Doing this iteratively, while building a meta-model of the various specific models' interactions, is a sensible strategy for EAs.

Perhaps the scope of the EA staff needs to expand outside technology-enablement areas, into the business itself. Perhaps enterprise architecture should exist as a business function, part of strategic planning and operations. The person running the EA function needs to have a senior role—vice president or higher, argues William Rouse of the Tennenbaum Institute at the Georgia Institute of Technology. "For transformation, enterprise architecture becomes a way that execs think things through," he says. The CIO is in the best position to figure all this out, given the combination of business and engineering skills he or she should have.

A good EA also understands that many models are available and which are applicable to what areas. The challenge is that the area being modeled rarely works in isolation; having a good model of it may not be that helpful if external effects aren't considered. Yet trying to model the entire organization in one entity, much less keep the model updated, is a boil-the-ocean activity doomed to fail.

That's where an EA's skill comes in: tracing the connections among architectural components, whether they be technology systems or business processes, to determine which outside issues need to be factored in and which can be ignored. The models that the business puts together need to make that analysis.

Overcoming transformation obstacles with semantic wikis

Michael Lang of Revelytix and Brooke Stevenson of Spry discuss how fixing data description problems can help with the rest of your change efforts.

Interview conducted by Alan Morrison and Bo Parker

Michael Lang is co-founder and chairman of Revelytix. Brooke Stevenson is president of Spry Enterprises. In this interview, Lang and Stevenson discuss the linkages between data interoperability and enterprise architecture, and how Semantic Web standards are helping the US Department of Defense create a single view of the architectures in place.

PwC: How did Revelytix get started?

ML: About eight or nine years ago, I founded a company named MetaMatrix. It's since been sold to Red Hat. MetaMatrix was an early attempt to provide a model-driven solution for data integration issues. In building MetaMatrix, we built a pretty sophisticated modeling framework based on the OMG [Open Management Group] MetaObject Facility specification.

Our largest customer base became the US government, totally by accident. Our backgrounds were in the financial services industry, and we built the product thinking that we'd solve problems for the financial services industry. But the NSA [US National Security Agency] became our first customer, and then DoD [US Department of Defense] bought a bunch of the software. We wound up selling quite a bit to financial services, but quite a bit more to the government.

With that product, I think we had a fair amount of success building models of domains to facilitate the installation of disparate data sources. We would build models of data sources and models of domains, wire them together, and let you query the domain model to get information from independent data sources. And in that exercise, well, in building that company and working with our customers, it became clear that the MetaObject Facility was not a rich enough language to model everything we wanted to model. So the NSA pointed us in the direction of OWL, the Web Ontology Language.

We founded Revelytix four years ago to build a collaborative ontology editor based on the W3C [Worldwide Web Consortium] standard to OWL and the

It became clear that the MetaObject Facility was not a rich enough language to model everything we wanted to model. So the NSA pointed us in the direction of OWL, the Web Ontology Language.

Resource Description Framework [RDF], and it's been hosted on the Web as a free tool for the last three years, Knoodl.com [http://knoodl.com]. We have applied semantic modeling to a bunch of different problems.

Brooke started using it for a project at the US Army about a year ago, and in January 2009, the Army funded a pilot project that combined OWL modeling techniques with business process modeling techniques using the Business Process Modeling Notation [BPMN] to facilitate a kind of enterprise architecture analysis that they were incapable of doing at the time. That project has since been funded for a production version. So we built them a pilot in January, and we are now building a full production version.

The Business Transformation Agency [BTA] funded this production version. The Business Transformation Agency is an agency within DoD that sits above the services [Army, Air Force, Marine Corps, and Navy] and reports at the OSD, the Office of the Secretary of Defense. The Business Transformation Agency's mission is to transform the way DoD does IT.

PwC: Is this a way for the DoD to get all of its various systems on the same page, regardless of which agency or which branch of the service?

BS: Yes. The senior-level sponsor for our project right now is Dennis Wisnosky, who is the CTO and chief architect for DoD. He has a bit more of a business visionary focus, but he works for the deputy chief management officer in OSD. He wrote one of the only really thorough books on DoDAF [Department of Defense Architecture Framework], and he helped create an information model for managing the data that you would put into DoDAF, which has traditionally just been views of data.

To advance the strategy with DoDAF, to help get better systems interoperability, and to make sure we describe things using a more common methodology, Dennis is having his team publish some guidance documents for DoDAF. DoDAF traditionally has been the opposite of prescriptive. It's been a very open framework that just generally guides what descriptions you should provide in the requirements definition and acquisition life cycle or in systems development.

But now that we need to deal with this cross-program interoperability problem, they've realized that they need to be more prescriptive to get some common modeling techniques and patterns used across all the systems.

PwC: That's the same point at which TOGAF [The Open Group Architecture Framework] has found itself at release 9.0. It is getting more prescriptive as it gets more mature. It's basically gone from telling you that you should produce to moving more in the direction of telling you how to produce it.

BS: That's exactly where they are going with DoDAF. Our approach provides a strategy for putting into production a set of tools and technologies and an architecture team to help facilitate, and the governance processes to help oversee that transition.

PwC: So how are organizations like DoD approaching transformation nowadays? What modeling techniques are they using, and what problems are they confronting, including the semantics problems?

ML: We look at the fundamental problem that you're describing as one of description. The reason that enterprises can't achieve the goals that DoD is trying to achieve—and it's basically the same one you are articulating—is that access and capabilities and other

Look around any large enterprise. You'll find that they spend lots of time and money describing things. Those descriptions are all over the place, and hardly any of them are useful at runtime.

sorts of things are not described in a way that's useful to achieve the mission. I'd say there are three legs to the mission: first is interoperability, and part of interoperability is discoverability; another is integration; and the third would be analysis.

What we have provided for DoD is a road map showing that if you describe things with enough precision and in a language that's executable, you can achieve all three goals—interoperation, integration, and a different class of analysis—with one technique. The power of that technique derives from the ability to describe things with a different sort of precision than is used today. And, really, that's our entire solution about how to describe things.

PwC: And that extends from the more granular EAI [enterprise application integration] kinds of concerns up to organizational design and capability integration?

ML: Yes. It's the most granular description of the most arcane message format that your enterprise has up to the governance model that the board of directors insists be used to operate the company at the high level.

PwC: Implicit in what you are saying, then, is that there's a missing aspect of corporate or government performance?

ML: Look around any large enterprise. Governments are not at all unique in this. You'll find that they spend lots of time and money describing things. Those descriptions are in UDDI [Universal Description, Discovery, and Integration] repositories, they're in specialized metadata repositories, they're in data models, they're in Word documents, and they're in spreadsheets. Those descriptions are all over the place, and hardly any of them are useful at runtime.

Three years ago, we got started in DoD by putting forth a best practice that we call community-based vocabulary development, so that a domain (say, human resources, acquisition, or any domain within an enterprise) would have a community that could build a vocabulary that described their domain to any degree of abstraction or precision that it wished, using a single technique—the Web Ontology Language.

For the last three years, we went from fighting furious wars with the XML [Extensible Markup Language] schema people … [laughter] … I'm glad you got a kick out of that, because it wasn't funny at the time. I would say that today we have a complete and total victory. All of the domain modeling at DoD now is being done in OWL.

PwC: So you have brought the whole DoD along, is that what you're saying?

ML: I believe that's the case, yes.

PwC: That's quite an accomplishment.

ML: Now the next step is to make those artifacts useful. You have some of these domain categories available now, so how do you use them to drive analysis? Brooke figured out how to apply that technique in the domain of architecture, and it's one of the places that DoD wants to apply this technique aggressively.

BS: The senior leadership in DoD—the three stars and the four stars—are driven to transform the way that they do business. Consider acquisitions, for example. Instead of thinking about the acquisition of these big monolithic systems, they plan to think about the acquisition of capabilities expressed as services,

and the way that they build out those capabilities once they're headed down the acquisition path.

The problem is the big bureaucracy underneath that senior leadership level. To make that transition happen, the first thing they need to figure out is how to adjust the way they define requirements and the way they run the acquisition process to realize those requirements. If they can transform that part of DoD, then the rest will follow naturally.

PwC: It seems like the acquisition aspect is the critical piece, then. Each agency and branch has its own habit of acquisition that it's developed over the decades. You're suggesting that the transformation would be to get acquisition to occur in a fashion that incorporates the learning that you're imparting and that the highest levels of the DoD are on board with.

BS: That's exactly true. But you can't change everything about the way they do business, because there are huge organizations and massive policies in place. What you can change for the acquisition people, or the people who do portfolio management and analysis, is the way that they analyze what they're going to invest in and how they're going to meet requirements. And so that's where the world of enterprise architecture comes in.

Enterprise architecture, if it's functioning properly, should not just describe a system, but should describe all of the data that you need to do analysis. If you formally capture those descriptions, refocus the way you do enterprise architecture work, and collect that data that they are using for investment analysis and capability gap analysis, then you're transforming the whole way that they establish requirements and do analysis to make the appropriate investments.

PwC: Does this net out to using OWL to discipline the description process so that the semantics—the wobbliness of the semantics that have allowed the same description to be interpreted multiple ways—is ratcheted down and people strive to a common understanding of what the services are supposed to do?

BS: That's exactly right. The only addition I'll make there is that OWL is the underlying description framework that we use for everything. To help solve the description requirements challenge in a way that is natural to the business analyst or the mission analyst community—the users—we also use business process modeling. We've started with the BPMN standard from the OMG, but we use OWL to capture all the data in those BPMN models as well so that we can relate it to all of the other information artifacts that are relevant.

That is another key standard for us, because getting collaborative consensus and a formal way of describing requirements brings a lot of different parties together. The Business Process Modeling Notation gives you a nice set of semantics to do that.

PwC: We are also trying to understand how enterprise transformation and enterprise architecture frameworks contribute to value creation. We're looking at complex adaptive systems and evolution models to try to understand how that aspect of value also needs to be taken into account when you're considering a transformation, because you may inadvertently destroy value if you are not aware of the emergent value creation aspects of your organization. Have you looked at that?

Enterprise architecture, if it's functioning properly, should not just describe a system, but should describe all of the data that you need to do analysis.

RDF and OWL have a unique property. You can extend the information model arbitrarily—and I mean the word “arbitrarily”—without breaking anything.

ML: Well, we thought about it. We coined the term “emergent analytics” about a year ago. I think it’s not exactly what you’re talking about, but it’s a concept that can be realized from using RDF and OWL. We haven’t actually put this into operation anywhere, so it’s still conceptual at this point.

Several years ago, the primary driver for us to move to RDF as an information model was extensibility. All of the information models presently used are extensible only if you’ll accept brittleness. If you want to extend them beyond some point, everything built on them, then you have to rebuild the models around the new extended version of what you did. RDF and OWL have a unique property. You can extend the information model arbitrarily—and I mean the word “arbitrarily”—without breaking anything.

We hope to put the capability in place at DoD soon so that people who know nothing about each other, and practically nothing about the information model they are interacting with, can make assertions. These assertions can be facts or concepts for other sorts of things, but principally facts and concepts. Essentially, they will be able to just dump these assertions into this extensible graph of information. And if you do that on a large enough scale, information that you didn’t anticipate emerges from the graph.

If you are familiar with complexity theory and things like that, this is all part of what you would expect from this sort of an information model. Now, as I’ve said, we have not put this approach into play, but we’ve done enough work with these technologies to believe that there isn’t a reason in the world why it wouldn’t work. So it’s able to let any community of any arbitrary size make any assertions they want to make, and allow new information and new types of analysis to emerge from the graph.

PwC: There is a long history of requirements, analysis, and transferring requirements into code. What are the big differences here relative to more traditional approaches?

ML: The biggest difference is the number of people that participate in the descriptive activity. If any organization thinks it will be able to describe things to the degree of precision that we are talking to you about today, with all groups of engineers, that organization will not transform itself, ever.

To be transformative with this, you have to involve a very large number of people who know very specific things about parts of their domain. They might be the only people who know those things. The odds of an engineer getting that kind of description about something are zero. There is no possibility he is going to get it.

If you don’t involve very large communities in describing things, you can never transform the way you do business. DoD has latched onto this, and they know this is the case. The trick was that we convinced them to use OWL. After they came to that conclusion—OWL is the only technology available to achieve that goal—then it became easy.

PwC: I think we agree with you on that. OWL has distinct advantages that other techniques don’t seem to have, but there are, of course, lots of critics. I’m sure you’ve confronted a lot of them who would say that OWL is overly complicated and that the people in the organization who need to do the description are never going to get their arms around it.

ML: In my view, this is where there is an enormous disconnect between the Semantic Web crowd and us. We don't have any requirement whatsoever in what we described to you for inference and reasoning. The thing that makes OWL complicated is the inferencing and reasoning requirement.

Basically, all we are using is RDF schema. Don't tell me that any person at any skill level in an organization can't make a simple assertion, an assertion like this is a part of that, or one that says this has this color, or this has that function. That's all we are asking these people to say.

They are saying those things right now in Excel spreadsheets, they are saying them in Word documents, they are saying them in e-mail messages, and they are making those same statements in 19 different technologies. We give them a user interface that lets them make these simple assertions. But when I say assertion, I mean a simple sentence with a subject, predicate, and object. They make a simple assertion about something they know about.

PwC: And the wiki that you just showed us is their point of entry for that, correct?

ML: Yes.

BS: The other aspect of the picture we're describing is that there are now a whole bunch of communities working on this ontology development. They have ontologists who are engineering the OWL file, and they have subject matter experts who are stating facts or making assertions that fit into the ontology. The two important tricks are governing the collaborations between those two kinds of people (engineers and subject matter experts) and defining your use case for that ontology up front.

In one example, we are using the ontology to do service discovery and portfolio management. So our ontology architecture is totally driven by those two things.

If you think for some reason up front that you have to do inferencing but you don't really know what you are going to do, then that does make the ontology development a lot more complex. And most of the time that's overkill.

PwC: So in essence you are saying start small, develop this initial capability, and just use the more ambitious inferencing when you really need it and don't do the overkill.

BS: Right. That's the great thing about the OWL and RDF standards being inherently extensible. You can add that all in later, but still do a lot of really valuable things early on with a more simple use case. ■

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Subtext

Agent-based modeling	A means of understanding the behavior of a system by simulating the behavior of individual actors, or agents, within that system.
Emergent properties	Unpredictable behavior that results from the interactions of agents in a complex adaptive system. Companies are themselves complex adaptive systems, systems that often create value in unpredictible ways.
Fundamental innovation	When it involves an enterprise, a means of revenue growth resulting from novel new product or service lines that are unlike those of existing revenue sources.
Meta-modeling	The ability to "model the model," which implies the ability to change or add various types of components at various levels of abstraction.

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