IBM Research

SERVICES SCIENCE: A NEW ACADEMIC DISCIPLINE?

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AGAINST A BACKDROP of "I/T doesn't matter anymore" rhetoric and "what's the next big thing?" anxiety, a tangible opportunity has arrived for business leaders and technologists alike: the remaking of the corporation by the transformation of its chief components -- strategy, process and people/workforce. Unlike previous conjectures ("the virtual corporation," etc.), this is not a prediction or theoretical exercise for one very good reason: technical capability and business need are finally aligning.

From a technology perspective, the combination of enormous computing capacity, ubiquitous network connection, and emerging technical standards are making possible practical solutions to formerly intractable business problems. For businesses, the need to grow revenue in a time of globalized opportunity, competition and shortened product cycles (caused primarily by the unrelenting march of commodification) has moved interest in information technology from a potential cost-reducer and productivity-enhancer to full-fledged partner in the remaking of companies.

Information technology deployed in support of business has arrived at a natural step in its march of increasing automation -- it has "moved up the stack,"

having improved manufacturing processes, then clearly defined business processes (payroll and accounting), discrete personal productivity applications (word processors, spreadsheets, mail and calendar) and business transactions (online buying, selling). It now remains for automation to move into higher level business functions, with an important caveat: it will no longer be sufficient to automate single processes in a vacuum. To reap the benefit -- in fact, to make this approach work at all -- it must achieve a new level of integration among technologies and business processes (standards-based technology within and across processes). And it must go a step further: no longer can automated functions simply replace human steps, especially in the realm of decision-making and judgment, but *integration* must include processes, technologies and the people managing and acting upon them.

Services are central to this evolution, though in a form more intertwined with I/T than the now-established emergence of a services economy might imply. The services sector category has, since its inception, been a miscellaneous catchall -- what is neither manufacturing nor agriculture is services. Thus, the sector in its current incarnation can accommodate everything from so-called professional services workers (medical, consulting, information technology, etc.) to food service employees, fitness trainers and manicurists. While everything in this services bucket shares a common trait -- the primary product is not something tangible, but a service performed -- the category's all-inclusive nature obscures the specific opportunity emerging today: not only are businesses themselves increasingly offering services instead of products, they are managing themselves

as a portfolio of internal services, in many cases deciding which services they perform best, and which could be handled better by an external specialist.

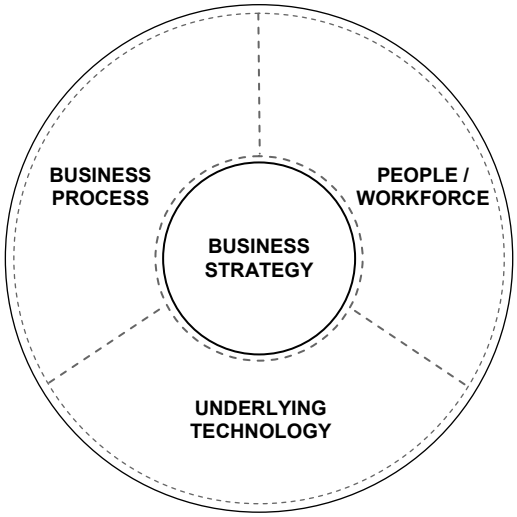
In fact, the development of new business models, processes, strategies and workforce management methods can itself be viewed as a series of services. Hence IBM describes this new area collectively as business performance transformation services (BPTS), and views it as at least a $500 billion dollar potential market -- in effect, a chance to use technology to wrest greater efficiencies from the world's economic structure.

But while business need and technical capability may be aligning, the intersection is still nascent. The complex issues surrounding transforming businesses at a fundamental level require simultaneously developing both business methods and the underlying technology. They also suggest the need for a more scientifically rigorous approach to areas previously treated more like an art form, and demand an agenda for research and academic programs to support the needed skills development.

As a first step in exploring this intersection and its implications, over 100 distinguished business and engineering school professors, IBM scientists and consultants gathered in May 2004 at a two-day summit entitled "Architecture of On Demand Business." What follows is part summary and part conclusion of their discussions. The central thought emerging from the summit was a consensus that a new academic discipline may be required to fuel the next wave of innovation, a discipline that draws on current work going in pockets of business, engineering and computer science schools. Dubbed "services science" during the summit, it is,

in reality, an attempt to move business practice and planning into the realm of science, and scientists into the world of business. While this will draw heavily on research into services (as opposed to manufacturing), it might be more accurate to think of it as "business services science" or, perhaps, "business transformation science," since it will need to explore the current and future processes of business as well as its human, technological and strategic elements.

This report is organized along a simple conceptual model of a business:



A Conceptual Model of Major Business Components

SECTION ONE: OVERVIEW

I. Introduction

On May 17 and 18, 2004, IBM Research and Business Consulting Services (BCS) brought together academic participants from the fields of business, operations research and technology to examine the changing business environment and explore the case for the development of "services science," a new academic discipline capable of defining the skills needed by the 21st century workforce.

Some of the elements of the changing business environment noted were:

- CEOs around the world are focusing firmly on revenue growth again, rather than looking to cost reduction for business gains; they are recognizing the significance of organizational agility and responsiveness; and they are seeking urgent action to address critical people issues. Major challenges on their agenda include: **top-line growth**, **responsiveness as a new key competence and challenging the organization within**. (Source: IBM Business Consulting Services CEO Survey, 2004.)

- The emergence of an information services economy where the cycle from discovery of an innovation to selective practice to scale-up to commodification is shrinking dramatically.

- The global nature of competition: multiple points of intersection among business, government and academia, and in industries ranging from biotechnology to transportation, energy, telecommunications, I/T and the public sector around the world.

- A shift in the balance of power between companies and their customers: among other causes, the shrinking cycle time from innovation to commodity puts the onus on companies to find new ways to differentiate their offerings and create new value to hold onto customers.

- Information technology advances that continue to produce faster processors, increased storage capacity and abundant bandwidth with an exponential growth in the number of networked and embedded devices.

Given this environment, co-hosts of the summit -- Ginni Rometty (general manager of IBM's BCS organization) and Paul Horn (IBM senior vice president and director of Research) -- hypothesized that services science could be a new approach to driving innovation at the intersection of business and technology expertise. They cited several reasons for this belief:

- It could bring together ongoing work in the more established fields of computer science, operations research, industrial engineering, mathematics, management sciences, decision sciences, social sciences and

legal sciences to create new skills and markets that offer high-value business performance transformation services (BPTS).

- With the rise of standards, and the ubiquity and reliability of the Internet making it easier and less costly to conduct transactions within enterprises as well as among enterprises, technology can enable new types of intra- and inter-company services.

- Software is becoming increasingly componentized and is therefore a candidate to be delivered as a service over a network. The evolution of a service-oriented architecture (SOA) -- a system for linking and making such services available as independent Web-based services accessed in a standardized way -- aims to make this a reality.

- But by itself, technology is insufficient to help companies create new and innovative business designs, services and products to differentiate and grow their business and respond to quickly changing environments. Tighter integration between technology and business process will help, but the integration must be organic. In many cases, it will be a new technology that will enable a new business design and a new business design that will, in turn, illuminate new areas for innovation.

- This approach -- the melding of business and technology -- requires significant expertise, but it's obvious it won't be possible to pair a Ph.D. researcher with each possible opportunity. New skills and combinations of skills for a closer partnership of technical and business disciplines must begin at the university level, along with methods to scale the application of these skills. Services science could provide skills, train a workforce and devise models and methods for scaling.

To frame the discussions, the summit participants relied upon IBM's definition of *on demand* to highlight the business characteristics that this emerging discipline would have to enable for companies and their workforces: ***responsiveness, variability, resiliency*** and ***focus.*** They also considered two reasons the timing was right for such an approach and a discipline to support it: the changing nature of business and the current generation of technology.

The nature of business (or, as some prefer to describe what businesses are evolving into, an extended enterprise) is becoming more strategic rather than transactional as companies seek and measure more than cost advantage. They are looking for partners that help them migrate from products to solutions, reduce costs and make them variable, and increase the speed to market. They are also organizing their enterprises into core and non-core activities, focusing on core components and measuring the return for all pieces.

The current generation of technology makes it possible for an extended enterprise to outsource its infrastructure, or rely on others for marketing and sales, and still be in control.

The participants considered the current state of -- and implications for -- the services science discipline in the areas of:

- business strategy
- business process
- people / workforce
- underlying technology

II. BUSINESS STRATEGY

A. Business Strategy Modeling

Business strategy may mean different things to different people, but studying the general category has begun to illuminate aspects of strategy, including tracing cause and effect relationships between strategic decisions and their outcomes. To explain these dynamics and guide future decisions, many conceptual frameworks have been proposed. Despite these efforts, business strategy remains more art than science (if we define science as a repeatable method based on a model of the world that yields predictable results, a model from which predictions can be derived and then tested, and art as a complex human skill based on knowledge and experience). The reasons for this static state include:

- Limited understanding of the complexity of business dynamics
- Non-deterministic and "people" aspects of businesses
- Difficulty in running controlled experiments in a functioning business
- Dependency of a business strategy's success on execution and other variable external factors

Business strategy frameworks (simplified models of complex business functions) may help nudge art closer to science. Models with sufficient detail and structure allow quantitative analysis, but with sufficient simplicity to support

qualitative and visual analysis they will help bridge the two worlds. Several examples of approaches to business strategy frameworks are:

- A visual representation of a business factored into well-defined components (not processes) to support strategy formulation discussion and decisions.

- A visual framework to explore implications of various alignment decisions, providing a way to frame discussions.

- A software system comprising a repository of business process models organized as a semantic network linked by verbs.

- A formulaic structure that supports quantitative analysis and, in particular, an evaluation of the economic health of network partnerships by comparing expected value and opportunity costs.

Each of these approaches enables different types of reasoning and analysis and, therefore, supports different kinds of decisions. Herein lies a challenge: just as one set of home blueprints will not suffice for all parties (potential homeowners to carpenters to landscapers), business strategy models can range from highly unstructured (useful for visual reasoning, etc.) to highly structured (useful for quantitative analysis and predictiveness). Most current models fall in

the former category. To envision what a sufficiently structured model with strong visual elements might yield, think of a framework from an unrelated, but familiar field: the periodic table of the elements. It organized known elements in such a fashion that predictions could be made, not just on a visual basis (filling in the missing pieces), but it also allowed for fairly accurate predictions of the properties of the missing elements.

Constructing an analogous periodic table of business elements could be one of the grand challenges for services science. An important first step towards reaching this ambitious goal would be a study of useful models and their supporting tools and the efficacy of various business design and componentization approaches. Even if highly useful frameworks could be constructed, the major challenges of making them usable and convincing business leaders to adopt them would remain. The cultural issues -- teaching technologists to understand the minds of business people; coaching business people on how to reconcile their primarily experiential insight with tool-generated conclusions -- are the first hurdles that would need to be confronted and overcome. In this scenario, services science could help bridge the gap and develop a community of early adopters.

III. BUSINESS PROCESS

A. Continual Business Optimization

Decisions drive businesses, but historically they have been made with either incomplete information, or an inability to process all available data. Evolving technologies have made a flood of "real-time" data available (enterprise resource planning, e-commerce integration, etc.) and will continue to (through pervasive devices, RFID tags, etc.), but only recently has computing capacity reached a point where sophisticated algorithms could be applied to such data to produce solutions that might lead to more informed decisions. Continual business optimization (CBO) applies rigorous mathematical models and algorithms to business data to support decisions in areas such as forecasting, supply planning, scheduling and pricing.

Although dramatic business results have been reported, CBO deployments still remain relatively limited for many reasons:

- Lack of awareness of the capabilities of CBO
- Perceived difficulty of implementation
- Disconnect between academia and business
- Lack of standards for terminology, interfaces and benchmarks
- Lingering history from past deployment failures caused by insufficient computing capacity

Successfully implementing CBO requires a broad range of expertise: modeling, programming with software libraries specializing in appropriate classes of math solvers, understanding the actual business processes involved as well as the underlying I/T infrastructure. Such a range rarely exists in academic-based research teams or industrial consulting or sales teams, but assembling this range of expertise is crucial in both the research and implementation stages of CBO.

Another challenge to the success of continual business optimization may seem simplistic: CBO applications must produce the right answer. But as anyone with business experience knows, the right answer is not always obvious, but the wrong answers often are. So these applications must, at a minimum, not produce wrong solutions that would undermine user acceptance, especially where there is cultural resistance to the idea of a tool-generated decision.

While an extensive body of literature covers the underlying mathematics of CBO, it is skewed toward the theoretical, primarily because existing journals tend to be edited and reviewed by academics. The typical review cycle is difficult for industrial professionals to engage in because as soon as they have completed one project, they must move on to a new one.

Proposals to help close the significant gap that exists between CBO's capability and actual deployments include:

- Increase marketplace awareness of CBO's capability through targeted publicity that highlights advances and specific examples of success.

- Drive a common language, standards and understanding among numerous CBO participants.

- Provide I/T infrastructure, test beds and benchmarking capability for CBO components, especially black-box proprietary solvers.

- Support standards in libraries of solvers, business processes and interfaces to analytic tools.

The fragmentation of continual business optimization expertise across various disciplines and across the theoretical/practical divide could be overcome by a cooperative effort led by services science.

B. Business Standards for the Extended Enterprise

Business issues -- competition, accelerating costs, closer collaboration between partners and suppliers, etc. -- are driving the need for open business standards. In healthcare, for instance, controlling costs while improving quality of care requires integrating patient records across providers, insurance companies and hospitals. In the electronics industry, the growth opportunity in mass-produced customizable products demands integrated supply chains capable of responding to a customer's "configure-to-order" specifications. In the retail industry, burgeoning masses of data (driven by innovative technologies such as RFID) need to be integrated with

business processes and the supply chain for optimization. Other industries face similar challenges, none of which can be solved without agreed upon ways of describing and structuring business processes.

Looking beyond these challenges, we can see more closely integrated relationships among business partners and so-called ecosystem partners that promise a new model for the enterprise: an extended body that is much more resilient, agile and flexible than any one of its component companies. But for such a vision to become reality, business standards must emerge and get adopted. Some standards efforts already underway include:

- RosettaNet in the electronics industry
- Accord in the insurance industry
- Society for Worldwide Interbank Financial Telecommunication (SWIFT) in the banking industry
- Health Level Seven (HL7) in the healthcare industry

Before such standards are widely adopted, many issues remain. Additionally, research into similarities in standards adoptions between vertical industries might be able to hasten their evolution and adoption. Some key issues:

- New economic and governance models implied or made possible by standards
- Relevance and adaptability of standards over time

- Appropriate roles for existing industry bodies, including entrenched players whose participation could slow or help adoption
- Clear metrics and key performance indicators to measure success of standards

Research into two key areas -- best practices in business standards adoption, and the creation of key performance indicators -- could be fruitful in supporting and extending the growth of business standards. Research into the former might answer questions relating to the timing of standardization, generic models for industry standards emergence and adoption, and the preexisting conditions essential to successful adoption. Research into key performance indicators could help measure the value being captured by extended enterprises. Key performance indicators could become de facto standards of a sort -- a common way for businesses in an industry to measure value.

While much of the work being done in this area exists within current disciplines of business and information technology, convergence of the two within a field such as services science might accelerate progress and prevent similar efforts from evolving along parallel but unaligned tracks.

IV. PEOPLE / WORKFORCE

A. Human Capital Management and Optimization

Given that CEOs are focused on growth and the innovation necessary to drive it, companies are trying to become more agile, flexible and adaptive. But they are quickly recognizing that they can only adapt as quickly as their people can. The skills of employees, as well as employees' capacity for leadership and change, determine the outcome of process redesign and business transformation.

At the same time, the nature of work is changing. Boundaries between organizations are blurring as companies strengthen interactions with suppliers, partners and customers, and as they decide which processes to perform and which to outsource. Improvements in connectivity, automation and technology integration have enabled extensible enterprises to dynamically reconfigure business relationships in response to changes in markets, resources and skills. This has profound implications for the people who work for such companies, and the way their work gets structured, which raises important questions:

- As business needs change, how can people quickly develop the new skills needed to meet those needs?
- How can a company with a varied and geographically dispersed workforce effectively educate workers in new skill areas?
- If skills change quickly to meet business demands, how can performance measures keep pace?

- Can we mathematically model and optimize human capital needs across an extended enterprise based on experience, skills, culture and even personalities?
- How can answers to the above also be made to meet the needs of the individual worker in a way that keeps him/her actively engaged and rewarded?

Measuring return on human capital and related metrics such as labor productivity becomes challenging as skills, the types of work and the way work is structured become more fluid. In managing human capital, three important perspectives must be reconciled: those of the organization, the individual and the local government. While the government might not be an obvious companion to the first two, consider what would happen if increased productivity led to massive layoffs in one location with no emergence of an upward job migration path for those who were let go. This scenario could lead to a political and legislative backlash that might detract from any benefits from the gain in productivity.

Ultimately, human capital optimization will not be successful unless it makes sense for businesses and their employees as well as the nations in which they operate. The potential consequences of an imbalance in the intertwined needs of companies, people and governments highlights a grand challenge for human capital management: create sustainable productivity gains while simultaneously improving employee job satisfaction and creating more high-skill, better paying jobs in the overall national/global economy.

Currently, business schools provide courses on human capital management and human resources, drawing heavily on the social sciences when covering human behavior, and economics when covering productivity, labor markets, etc. While there has been a shift from relying on case studies about manufacturing to studying services scenarios, the challenges of human capital optimization in a services economy are still not well understood.

Engineering schools, on the other hand, present human capital optimization as part of industrial engineering and operations research. Computer science programs add computer-supported collaborative work and artificial intelligence to the mix. While it's clear that the business and engineering schools have begun building bridges to address the opportunity inherent in managing and optimizing workforces, services science courses and research could help accelerate those crucial linkages.

V. UNDERLYING TECHNOLOGY

A. Business Performance Management

Where human capital management and optimization aim to enable an organization's people to be flexible and adaptable, business performance management (BPM) concentrates on a company's technical infrastructure to support these same qualities. Its model-based framework allows instant processing and analysis of monitored events to track trends, exceptions and other system information as it relates to defined performance targets. But business performance management solutions go beyond simply delivering timely information and insight -- they can make proactive recommendations and provide the underlying systems to implement them. Finally, business performance management solutions aim to construct a framework to bridge I/T and human resource components, so that decision makers can quickly align all available resources to respond to business opportunities, adjust to changing business climates, and otherwise improve the company's capabilities in the competitive marketplace.

The business performance management approach is a continuous improvement cycle that consists of six core activities:

- Modeling business needs
- Deploying models with appropriate I/T tools
- Running the automated models

- Monitoring subsequent events generated by the business
- Analyzing events and determining their cause
- Adapting models, resources and processes based on the analysis

Business performance management is closely linked to the service-oriented architecture (SOA) of the underlying I/T infrastructure. Service-oriented architectures provide business performance management systems with a set of business-relevant I/T services that can be modified appropriately for changing requirements. They comprise three main components: service requesters to invoke functions, service providers to provide requested functionality, and service brokers to link the two. These architectures are possible because of Web services, an emerging standards-based technology whereby Web-based protocols allow the linking and interaction of software applications and services.

One of the most serious challenges facing the development and adoption of business performance management is the delay between implementation and a measurable return on investment. Unless a company has made considerable progress in implementing BPM tools (passing through the first two phases of a typical BPM road map), it is unlikely it will have realized savings or measurably increased opportunity. In fact, initial investments will probably eclipse any savings. Only in later stages will financial advantages become apparent.

A second major challenge results from the potential volatility of sense-and-respond systems: updates based on real-time information can amplify and thereby overemphasize certain factors or otherwise skew results. Other challenges include

the work involved in aligning business goals with the supporting I/T infrastructure, especially since this involves integrating many disparate applications, data sources and business processes, and the creation of BPM-specific standards.

Business performance management research overlaps many existing disciplines, including supply chain management, operations research, business intelligence, control theory, machine learning and decision science. Additionally, technical areas of research might include BPM models and tools, data visualization, information management, real-time monitoring, rules and events correlation, among others. It is clear that the emergence of a discipline like services science could help coordinate and link such a broad set of efforts, and provide a curriculum for the skill sets that would support them.

B. Information Integration

The information age has not only led to an astronomical increase in the amount of information business leaders can access when making decisions, it has also drastically increased the number of decisions they must make. The cause may also contain its solution, but only new analytical and statistical methods can make sense of the flood of information the Internet has unleashed. Information integration aims to provide a set of services to deliver the right information to decision makers at the right time, with appropriate context, so that decisions can be made more quickly and with more insight.

The nature of the Internet, though, reveals just how challenging this is: an ever-changing global, multilingual source of often unconfirmed information. But because there is the potential for a vast amount of that information to be helpful, we must create new ways of determining authoritativeness, sentiment, patterns, trends and relationships across languages and cultures. This large challenge can be subdivided into three primary goals:

- Information aggregation, especially between so-called structured and unstructured data.
- Integrated analytics, not only the obvious search and analyze functions that must be performed on huge (and increasingly larger) amounts of available data, but also follow-on analysis embedded within core business processes to refine initial analysis and support the decision-making process.
- Democratized information, that is, spreading the results of business intelligence and analytics beyond upper executive and management ranks, so that it can be consumed and acted upon by all appropriate levels in an organization

While much of the technical literature outlines considerable research into extracting meaningful information from unstructured sources and integrating it with structured ones, much of the business literature, while acknowledging its potential value, has not yet clearly articulated examples of its actual business

value. Perhaps the necessary action spurred by regulatory legislation in some countries (Sarbanes-Oxley, Basel II, etc.) may bring both groups closer to narrowing the gap between information integration's promise and its proven value. But beyond regulatory compliance, today's extended enterprises need more than ever the ability to sense the state of their environment and be able to redirect resources in anticipation of competitive threats and opportunities.

Training people to succeed in this type of environment will require a much closer collaboration among engineering departments, business schools and industry. Ultimately, they will need to work in concert to produce a new curriculum that explores specific areas, including:

- Extracting and seamless querying of structured and unstructured sources.
- Reasoning over uncertain data from unstructured sources.
- Certifying data privacy and regulatory compliance.
- Integrating automated reasoning systems with human analysis to create systems that support the decision-making process.
- Creating methods that will scale with the increasing amount of incoming information.

Information integration requires a multi-disciplinary approach, combining aspects of computer science (e.g., artificial intelligence), operations research, operations management, strategy and more. This wide range of disciplines and

influences makes it a natural potential focus area for combining the technical and business approaches inherent in a discipline like services science.

C. Security and Privacy

Security and privacy are two related but distinct topics that have historically been considered solely as technology issues. Recently, however, they have begun moving to the fore of business issues -- primarily dealing with threats, but in some rare instances, creating opportunities. Both existing and pending legislation are helping to force the issue, but security and privacy advocates need to move beyond fear-mongering to recommendations based on business risk analysis and management. To date, there has not been enough work in this vein, with most efforts focusing on how technology, such as firewalls, anti-virus software and spyware monitors, can be added after the fact to prevent attacks or protect personal information.

Chief challenges to this necessary transition include:

- Lack of accepted model for measuring return on investment for an enterprise security/privacy system. Many efforts still focus on the specific technology level, such as determining the return on investment for implementing identity management tools.

- Siloed views of security/privacy make it difficult to incorporate security practices and operational risk inherent in I/T systems into business models. The discussion needs to move beyond I/T to lines-of-business executives across the enterprise so that risk and opportunity can be evaluated at an enterprise level, enabling the enterprise to effectively manage its trust relationship with its key stakeholders.

- Complex nature of shifting security/privacy from being added as an afterthought to building secure systems by design and processes that inherently ensure acceptable levels of privacy protection. Hence, the rise of security engineering as a discipline to focus on problems and the business issues related to them.

- Real possibility of misguided, onerous or corruptible legislation. Because users already view many security/privacy controls as impediments and unduly restrictive, legislation that goes too far could exacerbate this view and cause a backlash. Alternatively, the absence of legislation (and the freedom it would allow companies) would not necessarily lead to better security/privacy products and services.

- Lack of funding for academic research in security/privacy. Corporate investment remains lower than in previous years, while some government agencies (in the United States, for instance: National Science Foundation,

National Institute of Standards and Technology, Department of Homeland Security) have increased support. Corporate entities must continue to be a major supporter of this work if research innovations are to permeate business process and practice

Unfortunately, the academic focus has tended to be at the theoretical level (often small-scale implementations inapplicable to business problems) and solely on technical issues. Though many universities have broadened activity in security/privacy, the number of security/privacy graduates entering the workforce falls far short of demand. This will mean that companies will need to rely more on automation and tool strategies, keeping in mind that security/privacy must be considered as more than a technology issue. Services science, as we are imagining it, could help overcome these challenges and stand firmly against a security/privacy sub-specialization because that would propagate the existing issues.

Training services workers who have a thorough understanding of the underlying security/privacy issues as well as a close link into development organizations could drive greater improvements. In fact, services science should seek to embed security/privacy awareness, engineering methods and skills throughout its entire purview, making it as ubiquitous in business practice as other forms of risk/benefit analysis or opportunity-sizing.

VI. CONCLUSIONS

While the elements covered in the May summit by no means exhausted the possibilities of what a discipline like services science might encompass, they all seemed to support a central premise: because of their increasingly cross-discipline, cross-school nature, a coherent discipline that seeks to coordinate among their fields of study and bridge existing gaps between technical and business efforts might accelerate progress. To begin with, getting participants to develop a *lingua franca* -- covering terms, metrics, standards, methods, etc. -- would be a huge accomplishment. Often groups have found themselves arguing similar sides of a problem once they have mastered the other's jargon.

It is intriguing to think of a discipline such as services science constituting the underpinnings of a significant emerging market like business performance transformation services (BPTS), while underscoring the fact that both monikers cover far more than mundane business processes. Along all axes of BPTS -- strategy, process, people/workforce and technology -- current and emerging services constitute the bulk of where the real work will get done. No aspect of business performance transformation services will be successfully accomplished absent significant technology innovation -- placing the burden entirely on highly skilled, experienced workers simply will not scale to the opportunity, in either its current or future form. Conversely, I/T technology by itself cannot meet the challenge, as its real power is in enabling human judgment and decision making, not replacing it.

That said, it is relatively simple to propose a new discipline to solve such a large challenge, but much more difficult to articulate just how creating something new will actually accomplish the feat. In fact, it is possible that much of the research into BPTS and the services area might be able to sit within the current academic hierarchy, perhaps within existing engineering or business schools. However, there are many reasons to think this may not be the case, many of which were outlined in individual tracks at the summit, and appear here in those sections.

Perhaps the most compelling reason, though, derives from the very cross-disciplinary nature of services in general, and business performance transformation services in particular, and the inherent tension between specialization and generalization that practitioners must exploit to be successful. There are current degree programs evolving that seek to add business school courses to an otherwise highly technical regimen, usually at the graduate level (e.g., professional science master's). This is a good start, particularly because it maintains a degree of necessary specialization -- a smattering of technical knowledge could be more dangerous to a business specialist than helpful (and vice versa for a technologist). In the experience of many summit participants from IBM, solid technical expertise has proven very valuable, albeit when working with colleagues who have a complementary depth of business knowledge and experience.

What is not clear, though, is just what level of schooling will yield an appropriate level of depth -- and what does it mean to be expert enough? Will the

introduction of a few business courses into an otherwise technical master's program provide the right balance? Will giving an MBA student a crash course in computer science truly improve matters? Perhaps. But it is possible that entirely new curricula and skill sets need to emerge that organically combine aspects of both business and technology so that knowledge of both can be obtained at the same time. Or perhaps services science should seek to train generalists so well-versed in both worlds that they can successfully broker or translate between both business and technical camps with more conventional experience.

Whatever the approach, it is doubtful it can all be sketched out over the course of a few months, let alone at a two-day summit. However, its evolution might follow a course like this:

- A few trailblazing courses, programs and centers for research emerge at leading universities, with emphasis on the graduate level.
- Interested graduate students might enroll in independent study programs where they could do research and select thesis topics specifically designed to explore the emerging discipline, and better define or expand it.
- As part of graduate programs (whether independent study or class-oriented), a significant part of the thesis project could be internships with companies with emphasis on studying and implementing theoretical ideas in a business environment.
- Over time, as the body of work in this area grows, its influence could spread to undergraduate level programs as appropriate.

To assist in such an evolution, universities and industry leaders could sponsor a refereed journal specifically skewed to services science research that is not sufficiently supported in current academic writing, helping to build a body of literature in this area. Following the success of such a journal (or in parallel with its development), a cross-academia and cross-industry body could be formed to help coordinate and drive adoption of services science methods and findings.

Moving from the sketchpad to the real world, it will take much more thought and discussion to decide what steps to take in launching such a discipline. To begin, IBM is proposing the following:

- A series of workshops focused on specific aspects of the services science as a discipline question, commencing in late fall 2004.
- Global participation in this discussion via summit-like gatherings in Europe and Asia in early 2005 that build on work already under way.
- Efforts to actively involve government agencies with funding and existing industry/academic institutional stakeholders – Defense Advanced Research Projects Agency (DARPA), National Science Foundation (NSF), Association for Computing Machinery (ACM) and the Institute of Electrical and Electronics Engineers (IEEE), among others.

In any case, the opportunity remains real, as do the challenges. We at IBM look forward to working with our partners to explore the best way to make the most of what we believe to be a perfect time for unprecedented innovation.

SECTION TWO: DETAIL

I. THE CEO GROWTH AGENDA

In early 2004, IBM Business Consulting Services (BCS) conducted a worldwide study of 456 CEOs to create a comprehensive assessment of their current business agenda. The study did not attempt to solve particular business problems; rather, it provided a framework and a context in which future strategies can be considered. It revealed a changed mood: these executives are focusing firmly on revenue growth rather than cost-cutting; they are recognizing the significance of organizational agility and responsiveness; and they are seeking effective solutions to address critical people issues. Major challenges on their agenda include:

Top-line growth: CEOs overwhelmingly view revenue growth as the most important path to boosting financial performance. Consequently, it is their number one priority for the next several years. At the same time, most CEOs also believe that they must maintain their ongoing emphasis on cost containment, a close runner-up to revenue growth as a means of improving the corporate bottom line. As the pendulum swings back toward growth, the CEO agenda is being rewritten by the mix of old and new options, challenges and opportunities involved in delivering differentiated products and services.

Responsiveness as a new key competence: CEOs acknowledge that they need an ability to recognize, analyze and respond more effectively to continuously

changing market conditions and risks. Agility is a high priority across the organization. Yet very few CEOs rated their organization's ability to respond to these changing conditions and external forces as being very good. Reinstituting an organization that is responsive to customers is high on their growth agenda. They also recognize the need to establish effective, real-time response capabilities. And they are clearly aware of the power of I/T and the weaknesses that result from lagging behind.

Challenging the organization within: The other significant challenge for CEOs lies in the issues of people and change. CEOs recognize that growth and differentiation will happen through greater focus and attention on people, yet deficiencies in skills (both inside organizations and in the wider labor force) seriously threaten the growth agenda. Reeducation and retention are urgent needs that increasingly require managerial leadership. CEOs are keen to transform their organizations, but have reached a difficult crossroads where there is a strong desire yet a limited capability.

Services Science?

The challenges raised by the CEOs in the study hint at the emergence of an information services economy where the cycle from discovery of an innovation to selective practice to scale-up to commoditization is shrinking dramatically. We are in an economy where growth requires that talent continuously evolve from areas of routine work to areas of emerging value.

The global nature of competition, the shift in the balance of power between companies and their customers, the unrelenting focus on costs and the emergence of a new growth agenda have created a climate where businesses must look for new ways to strengthen their competitive advantage. This is fostering a shift from thinking in terms of incremental improvements to thinking in terms of innovative breakthroughs, and moving beyond innovation as primarily a requirement for technology to innovation as a continuum requiring both novel technology and business improvements. IBM believes that this continuum will shape the types of knowledge, skills and services required to build a prosperous society.

Technological advances continue to produce faster processors, increased storage capacity, abundant bandwidth and an exponential growth in the number of networked and embedded devices, but those things by themselves are insufficient to meet today's business challenges. Companies must create new and innovative business designs, services and products to differentiate and grow their business and respond to a rapidly changing environment. Universities must examine the need for new programs at the intersection of current disciplines. In this new frontier of computing and information services, neither technology nor business can yield breakthrough innovation for growth without the other. Nor can an after-the-fact assemblage of the two. It is becoming increasingly clear that they must co-evolve as organic partners in the continuum of innovation.

What makes this agenda even more challenging is that it is now taking place within a global ecosystem. There are multiple points of intersection among business, government and academia, and in industries ranging from biotechnology

to transportation, energy to telecommunications and I/T to the public sector. That is why there will not be a single Next Big Thing. Millions of opportunities will be created by the forces of innovation: the question is where and what those opportunities will be.

To begin addressing these challenges, IBM Research and IBM Business Consulting Services (BCS) recently brought together academic participants from the fields of business and technology to examine the changing business environment and explore the case for the development of services science, a new academic discipline that can help create the skills of the 21st century workforce.

Services science will meld together the more established fields of computer science, operations research, industrial engineering, mathematics, management sciences, decision sciences, social sciences and legal sciences to create new skills and markets that offer high-value business performance transformation services (BPTS). The renewed focus on growth leads CEOs to believe that success lies in developing and delivering these new and differentiated services.

Business performance transformation services describe a new opportunity in which I/T infrastructure and expertise will be applied to transform what companies spend on their business processes, such as selling, general and administrative. These services go beyond automating an existing process or outsourcing to a low-cost provider. It's about transforming enterprises to create new business models. It requires expertise in both business process and technology.

IBM believes this opportunity is taking off now for two reasons: the acceptance of standards and the ubiquity and reliability of the Internet. Together, they are making it easier and less costly to conduct transactions within enterprises as well as among enterprises.

In view of the developed world's increasingly intense reliance on information and communication technology, IBM believes that it is at the forefront in the creation of a new field, much like what happened with the formation of computer science in the 1940s. In that example, the computer arena was originally focused on hardware design. Over time, there was a growing recognition of the importance of software. Initially not treated as a serious science, software grew into an area of expertise on its own and the field of computer science was born. In fact, IBM was at the forefront of that effort too, joining Columbia University in teaching the first true computer science class in 1946.

Computer science evolved because there was value to be had -- the development and integration of new software and hardware provided new functionality and new applications that helped businesses grow and evolve. Now, there is tremendous potential for improving the way businesses are structured and the way they operate. This potential will be realized through integrating I/T and business processes to shape the business environment. And that will happen through new services that will take the form of those provided by I/T vendors to businesses, and, in turn, those provided by businesses to their customers. IBM has already embarked on this road. We have teamed our researchers with our Business Consulting Services professionals to work with clients on transforming

their business models and designing new business processes, improving the way they operate and opening up new avenues of opportunity for them. This has proven quite effective and clients have lauded the practice because of the value it brings to them.

Yet, these services have proven to be no small challenge. They require constant iterations in their design, deployment and assessment. There is a lot of expertise required, yet it's obvious that it won't be possible to pair a Ph.D. researcher with every client for every application. It's clear that this innovative approach demands new combinations of skills and a closer partnership between technical and business disciplines, starting at the university level. This is what we mean by the services science concept. There is tremendous computing power out there, but businesses are looking to go beyond just bigger/better/faster versions of the way they are doing things today. Global competition is driving them to re-think the way the operate and there is a great deal of opportunity for improvement in the model -- to reach a point where I/T resources would not only integrate with existing systems, but would also make new business processes possible.

On Demand Business?

IBM's on demand initiative directly targets this fertile intersection of business and technical innovation to help enterprises achieve competitive advantage in the marketplace. IBM defines an on demand business as an enterprise whose business processes are integrated across the company and with key partners, suppliers and

customers, enabling it to quickly respond to any customer demand, market opportunity or external threat.

In 1999, Stephan Haeckel of the IBM Advanced Business Institute wrote a book entitled *Adaptive Enterprise: Creating and Leading Sense-and-Respond Organizations*. Haeckel's book introduced a new management approach called sense-and-respond that promotes adaptive business design and advocates a new form of strategic planning based on reconfigurable roles and responsibilities. In his view, organizational hierarchy would be replaced by a dynamically configured network of modular capabilities. He defined a capability as "an organizational subsystem with a potential for producing outcomes that contribute to the organization's purposes." Governance of each capability is performed on the basis of context and coordination by people in roles accountable for outcomes rather than by command and control.

While adaptability is becoming a major characteristic of today's enterprise, the reality is that the business world is increasingly overwhelmed with information and communication. Information sharing and decision making within the confines of a single corporate structure include managing by span of control, delegation and levels of authority. An extended enterprise, with its web of suppliers, go-to-market partners, and infrastructure providers, can increase complexity to a dysfunctional level, frustrating typical managers who are used to command and control environments.

So what distinguishes an extended enterprise from yesterday's partnerships, alliances and ecosystems? The nature of the extended enterprise is becoming

more strategic rather than transactional as companies seek and measure more than cost advantage. They are looking for partners that help them move from products to developing solutions, reduce costs and make them variable, and increase speed to market. To scout out opportunities to extend their enterprises, companies are organizing their businesses into core and non-core activities, focusing on core components and measuring return, not process, for all pieces. This portfolio management approach allows companies to understand levers of business performance and manage the risks and returns across an extended enterprise.

Further, an extended enterprise is based on relationships that are multi-dimensional; sometimes a partner is both a competitor and a customer. This means understanding all aspects of business potential with the other company: sell to, sell with, sell through and buy from.

The current generation of technology makes it possible for an extended enterprise to outsource its infrastructure, or rely on others for marketing and sales, and still be in control.

The key to governing this sort of a corporation is to create a new set of measures to drive performance across the entire extended enterprise. Services science will focus on these measures, which will consider four characteristics that determine success in the world of the extended enterprise: responsiveness, variability, resiliency and focus. IBM considers these characteristics to be the foundation of an on demand business:

- **Responsiveness** tracks the extended enterprise's ability to manage metrics, such as compound annual growth rates and the latency in aligning a company and its partners' metrics with business objectives as the dynamics change.

- **Variability** reflects the extent to which business models for the extended enterprise allow companies to control costs and manage volatility *within* each quarter. Towards this goal, companies are increasingly moving away from fixed price contracts and favoring pay-for-use or gain-sharing contracts that are aligned to business performance metrics, such as revenue or costs.

- **Resiliency** determines how the partnership chain of an extended enterprise reacts to threats or opportunities -- and whether the extended system can detect problems and correct them before they impact customers. To accomplish this, extended enterprises are increasingly moving to autonomic production systems that are linked by sophisticated technology infrastructures.

- **Focus** signals the contribution each activity makes to the overall business. Consider the extended enterprise as a series of activities that have distinct performance indicators to increase return, revenues or profit to the business. Leaders must manage each of those components as they would

an investment portfolio, looking for maximum contribution to business value.

Successful businesses are no longer created as purely linear entities, each a stand-alone entity that has all of the activities required to design, market, sell, produce, deliver and support products and services. This new business model requires new thinking. Services science will develop the methods, tools and techniques for designing infrastructures, processes and policies for the inter-company models of the extended enterprise.

II. BUSINESS STRATEGY MODELING

A. Definition / Key Elements

Business strategy and frameworks: Business strategy means different things to different people, but this hasn't stopped business executives from formulating and executing them. Over the years, business school scholars have begun to illuminate different aspects of strategy, and discover cause and effect relationships between strategic decisions and their outcomes. Many conceptual frameworks have been postulated that attempt to explain these dynamics and guide strategic decision makers towards maximizing their business' performance and profit. Examples of these business strategy frameworks include Michael Porter's Five Forces, Clay Christianson's Innovation's Solution, and Geoffrey Moore's Crossing the Chasm -- to name only a very few. Several more were presented by their authors during the Business Strategy Modeling track of the recent "Architecture of On Demand Business" summit.

Problem and motivation: Despite the proliferation of business strategy frameworks, business strategy formulation remains much more of an art than a science.[1] Reasons for this are many and include our limited understanding of the

[1] By "science," we mean a repeatable method based on a model that yields predictable results. Observed results through controlled experimentation or empirical analysis may or may not match the expected results, i.e., they will either support or falsify the formulated hypothesis. Culturally for scientists, negative results are as valued as positive results as they help to refine the model towards greater and greater prediction accuracy while applying the principle of Occam's Razor -- i.e., keeping the model as simple as possible, but no simpler.

complexity of business dynamics, the non-deterministic and sociological nature of these systems, the challenge of running controlled experiments in business environments, and the dependency of a business strategy's success on its execution. Nevertheless, there is much incentive to move the formulation of business strategy more towards the realm of science. From a client's perspective, sound and reliable strategic decisions lead to clarity of purpose, focused execution, increased performance and, ultimately, shareholder value. From a business consultant's perspective, employing consistent, proven practices increases the scale and predictability of client engagement outcomes and facilitates value pricing.

Framing a research agenda: How can we get there from here? Business strategy frameworks are a valuable, perhaps even necessary, ingredient but they are not sufficient on their own. They need to be augmented with more structure. Scientific progress is predicated on a paradigm of structure that includes systematic methods, structured models, rational analyses and organized repositories of knowledge where prior results can be located, debated, replicated, built upon and shared within an open community of researchers. To articulate a research agenda for evolving business strategy formulation from an art towards science a reasonable starting point is exploring how conceptual frameworks fit into the paradigm of structure.

Business strategy frameworks are types of models, just as a house's architectural blueprint is. Models are abstracted, simplified representations of reality intended to serve a purpose, and different purposes require different degrees of structure within the model. For example, a home designer may sketch a house's form and style to incite a buyer's investment. A construction crew would use a blueprint of the house to build it to the designer's intent. This blueprint requires more structure than the sketch in terms of notation, precision and semantic relationships of design elements so that details are communicated unambiguously and the resulting physical house has architectural integrity. Figure I shows how the degree of structure in a model enables certain characteristics[2]:

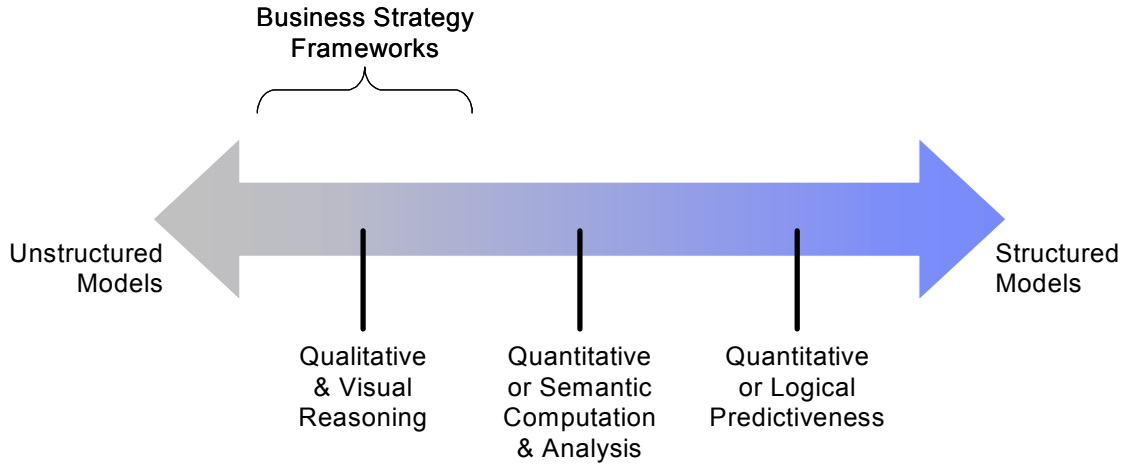


Figure I: Degree of structure in a model determines its capabilities.

[2] This visual image is itself a simplified, abstract model of how structure relates to models. There could be many more dimensions of applying structure to models than the ones shown here. These are visualized as one for purposes of clarity.

Qualitative and visual reasoning: Most business strategy frameworks provide just enough structure to support qualitative and visual reasoning (e.g., pattern identification). For example, IBM's Component Business Model (CBM), presented by George Pohle at the summit, is a visual representation of a business factored into well-defined service centers or "components" (analogous to software components in computer architecture) as shown in Figure II. The columns represent business function; the rows represent activity level.

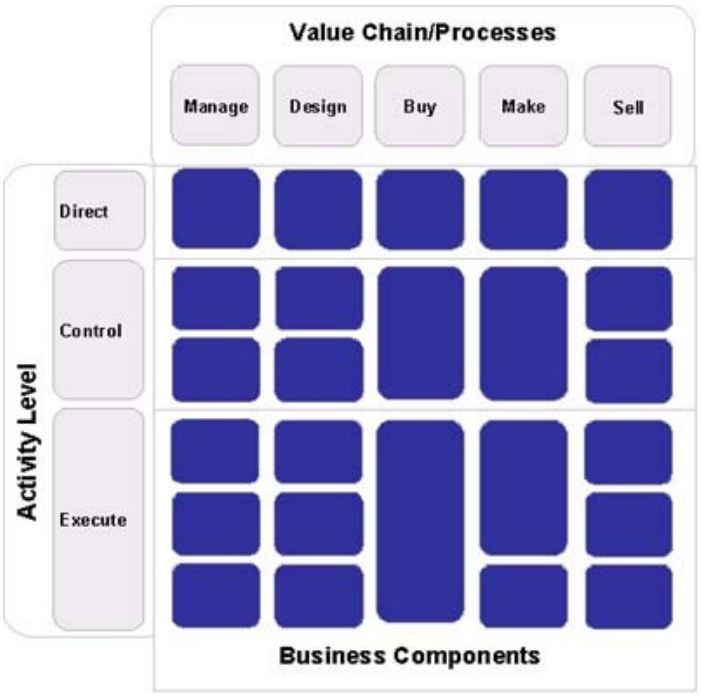


Figure II: Component Business Model (CBM) map

The visual representation provided by a CBM map helps executives view their entire business and facilitates several strategy formulation discussions. For instance, a perceived business performance gap may call into question a business' scope of activities, organizational capabilities and critical tasks. A CBM map can help frame the decisions around these strategic concerns by focusing attention on those business components most closely associated with differentiating the business in the market or most responsible for a performance gap. The resulting analyses and decisions would center on outsourcing alternatives, reorganization or investment in process improvement. Even without quantitative or semantic structure behind them, these are valuable uses of CBM maps. Nevertheless, to go beyond just framing decisions to confidently choosing from various options, more structured models -- e.g., financial models, value network models, process models and data on performance indicators -- are also needed.

Venkat Venkatraman of Boston University School of Management presented a network-centric business strategy framework. This framework poses four network-aware business models as shown in Figure III (on the next page), and helps executives by forcing them to think through the implications of aligning themselves along one of the four options, thus inciting discussions around strategic intent, scope of activities, sustained added value, partner interdependencies, organizational competencies, leadership and more. Like CBM, Venkat's framework is a visual representation, in this case of a business model space, with no quantitative or semantic structure directly supporting it.

And like CBM, this framework is useful for framing strategic decisions, but not for answering them. For that, even more structure is needed.

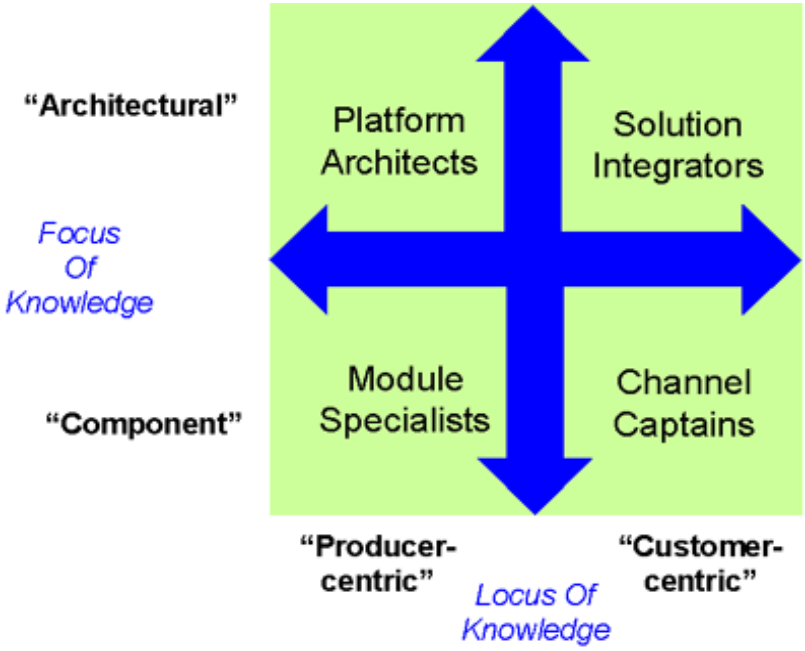


Figure III: Venkat Venkatraman's network-centric framework

Quantitative or semantic computation and analysis: Quantitatively or semantically structured models enable additional levels of computation and analysis. For example, the MIT Process Handbook from Tom Malone at the MIT Sloan School of Management is a software system containing a repository of business process models organized in a verb-inheritance hierarchy (similar to an object hierarchy in object-oriented programming, but for verbs). This structured model of verbs acts

as a semantic network that enables computational capabilities. For instance, the MIT Process Handbook software can generate new process ideas for "hire human resources" by automatically generating a list of similar, but potentially novel, processes. This is done by the software navigating the verb hierarchy structure for "siblings" or "first cousins" as shown in Figure IV (on the next page). Since hiring is a type of buying (i.e., the "hire" verb inherits from "buy") and since there are examples of buying things in an electronic store (i.e., online) within the repository, one of the generated process ideas is "hire human resources in an electronic store." This process ideation capability could incite new business designs and require a re-examination of numerous strategic decisions, including everything from critical tasks and partnerships to organizational talent and culture. There are additional operational purposes and capabilities of the MIT Process Handbook, but those are outside the scope of the business strategy modeling research agenda.

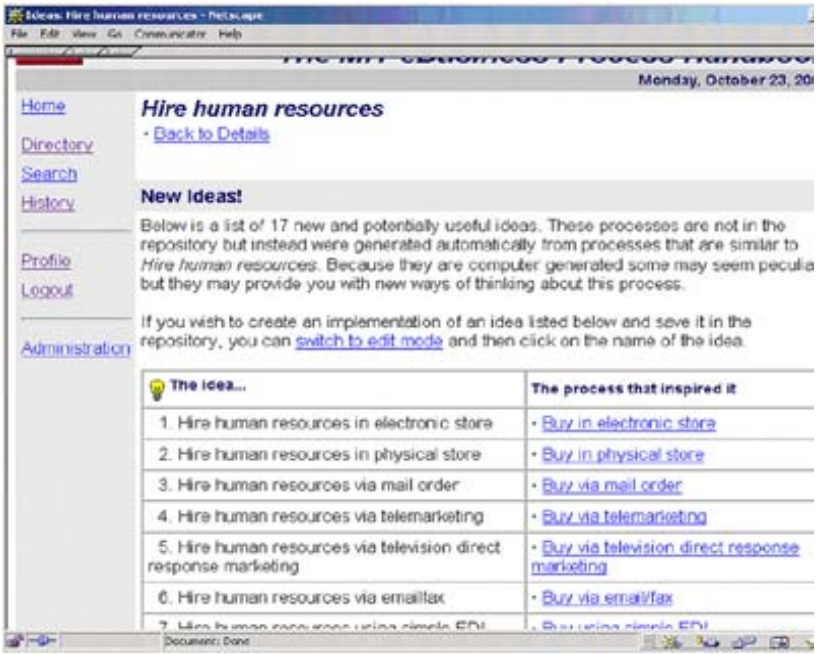


Figure IV: The MIT Process Handbook's semantic nature enables process ideation.

Shyam Sunder of Yale University's Yale School of Management presented a contract-centric business strategy framework. Whereas Malone's repository has semantic structure, Shyam's framework has a formulaic structure that supports quantitative analysis. In particular, Shyam's contract-centric framework concerns the economic health of the value network partnerships by quantitatively capturing expected value and opportunity costs. The health of the network of contracts is based on whether each party expects to receive more value than the opportunity cost for participating. This can be computationally analyzed given quantities for expected value and costs as the example shows in Figure V (on the next page). If

the analysis shows an "infeasible" contract set, then this would require a re-examination of the value net interdependencies with several potential outcomes, including a strategic decision to switch partners or renegotiate one or more partner contracts. More drastic business design decisions could result, depending on the likelihood of resolving an over-constrained set of contracts.

	Opp. Cost (1)	Share (2)	Rent (3)
Shareowner	10	11	1
Manager	10	12	2
Creditor	10	11	1
Employee	10	12	2
Vendor	10	10	0
Subtotal	**50**	**56**	**6**
Customer	60	56	4
Net Surplus	**10**	**0**	

Figure V: Shyam Sunder's contract-centric framework enables quantitative computational analysis.

Quantitative or logical predictiveness: These examples from the "Architecture of On Demand Business" summit are meant to illustrate how differing degrees of structure within a model enable different types of reasoning and analysis capabilities. Yet another degree of structure enables another set of capabilities, namely quantitative or logical predictiveness. Models with predictive powers can be used to forecast the future. For instance, the law (i.e., mathematical model) of gravity can predict with great accuracy and precision where a launched mass will be located at a specific time in the future. A model for forecasting demand of a product at different points within a supply chain is another example. Perhaps the most famous is the periodic table of chemical elements. Organizational principles that Dmitri Mendeleev (1834-1907) used during the initial construction of the periodic table lead to a certain visual representation (Figure VI). The holes in the visual pattern of the then-incomplete periodic table were enough to incite accurate predictions of new element discovery (Figure VII). But it was the quantitatively structured organizational principles (in this case, based on atomic mass, density, etc.) that reinforced the power of the visual representation and its predictiveness.

TABELLE II

REIHEN	GRUPPE I. — R^2O	GRUPPE II. — RO	GRUPPE III. — R^2O^3	GRUPPE IV. RH^4 RO^2	GRUPPE V. RH^3 R^2O^5	GRUPPE VI. RH^2 RO^3	GRUPPE VII. RH R^2O^7	GRUPPE VIII. — RO^4
1	H=1							
2	Li=7	Be=9,4	B=11	C=12	N=14	O=16	F=19	
3	Na=23	Mg=24	Al=27,3	Si=28	P=31	S=32	Cl=35,5	
4	K=39	Ca=40	—=44	Ti=48	V=51	Cr=52	Mn=55	Fe=56, Co=59, Ni=59, Cu=63.
5	(Cu=63)	Zn=65	—=68	—=72	As=75	Se=78	Br=80	
6	Rb=85	Sr=87	?Yt=88	Zr=90	Nb=94	Mo=96	—=100	Ru=104, Rh=104, Pd=106, Ag=108.
7	(Ag=108)	Cd=112	In=113	Sn=118	Sb=122	Te=125	J=127	
8	Cs=133	Ba=137	?Di=138	?Ce=140	—	—	—	— — — —
9	(—)	—	—	—	—	—	—	
10	—	—	?Er=178	?La=180	Ta=182	W=184	—	Os=195, Ir=197, Pt=198, Au=199.
11	(Au=199)	Hg=200	Tl=204	Pb=207	Bi=208	—	—	
12	—	—	—	Th=231	—	U=240	—	— — — —

Figure VI: Mendeleev's early periodic table, published in 1872. Note the spaces left for missing elements with atomic masses 44, 68, 72 and 100. From Annalen der Chemie und Pharmacie, VIII, Supplementary Volume for 1872, page 511.

Properties of Germanium	*Predicted in 1871*	*Observed in 1886*
Atomic weight	72	72.3
Density	5.5 g/cm^3	5.47 g/cm^3
Specific heat	0.31 J/(°C · g)	0.32 J/(°C · g)
Melting point	Very high	960°C
Oxide formula	RO_2	GeO_2
Oxide density	4.7 g/cm^3	4.70 g/cm^3
Chloride formula	RCl_4	$GeCl_4$
bp of chloride	100°C	86°C

Figure VII: Comparison of the properties of germanium as predicted by Mendeleev and as actually observed.

In general, the degree of structure in a model can enable computation and analysis helpful in deciding between options posed by less structured business strategy frameworks. For example, financial models of business design

alternatives can indicate which business design option to choose from several alternatives. Predictive models can forecast outcomes. But the confidence one would have in these results would only be as strong as the confidence one would have in the accuracy and precision of the model (including its simplifying assumptions) and the data it is using.

B. Challenges

Within the scope of this track, there are two categories of challenges for moving the formulation of business strategy from an art towards a science: (1) the development of useful models of business, and (2) their usability and adoption.

Developing and validating models of business strategy is challenging for many reasons, including the ones listed in the above section. The fundamental building blocks of business and how they relate to one another are not yet clear, leading to the proliferation of business frameworks. But, even if we had accurate frameworks and models that were useful in formulating business strategy, there remains the question of using and adopting them. The cultural issues -- teaching technologists to understand the needs of business people to develop tools that are powerful yet technically easy enough, and coaching business people, especially within consulting firms, on how to reconcile their primarily experiential insight with tool-generated conclusions -- being foremost among the challenges to face.

C. Academic Literature / Industry Focus

Business schools have proposed numerous strategy frameworks and models over the years to explain the dynamics of business and provide guidance to executive decision makers. These models come from several disciplines, such as economics (including game theory, market mechanism design and experimental economics), operations research and general business administration. Computer science is a more recent contributor and is generally approaching strategy formulation from a "bottom up" perspective, starting with strategy execution in the form of business process modeling and integration.

In general, the I/T industry is currently battling over business process management from several vantage points, including business performance management.[3] As I/T continues to climb the business-I/T stack seeking refuge and opportunities from ongoing commoditization below, it is expected that the battle will climb into the business strategy layer.

One possible trend and less than obvious opportunity is having structured models play a key role in bridging the "bottom up" I/T world with the "top down" business strategy consulting world in a manner that evolves strategy formulation from an art towards a science and from conceptualization to execution. These new and interconnected models could enable consulting firms to differentiate their services and price with greater confidence while providing their clients with a means to manage their businesses with greater insights, focus and responsiveness.

[3] See http://www.ibm.com/software/bpm

Other scientific principles under the paradigm of structure include systematic methods, rational analyses, and organized repositories of knowledge where prior observed results can be located, debated, replicated, built upon and shared within an open community of researchers.

There are a number of more obvious, nearer-term opportunities, including:

- Augmenting business strategy frameworks with structured ones to provide additional predictive, computational and analytical capabilities. This may be accomplished through structural framework-model linkages or establishing systematic methods. More specifically, linking component business modeling with key performance indicators would help focus performance gaps on the "guilty" components. Additional connections to business process models and components' business services may result in additional insights and value. The MIT Process Handbook may serve as a useful connection vehicle.

- Understanding the verb versus noun dichotomy. Business executives tend to think in terms of business function and activities (e.g., the verb-centricity of the MIT Process Handbook). Years of experience in software development indicates that an effective way to automate and integrate business activities is to build solutions around the lifecycle of business artifacts (i.e., nouns) that get acted upon by people and/or machines and persist in files or databases for sharing, transaction

management, audits, etc. Somewhere between formulating a strategy and implementing an I/T solution to support it, a transformation from verb to noun needs to occur. A single, integrated model that can present verb or noun views is an alternative approach. Whichever the answer, this issue is worth resolving.

- Using value networks as a central consideration for making business design decisions. And yet the frameworks and models described here only touch upon reasoning about value networks. This seems to be a fertile area for additional visualization, structured modeling and tool support.

D. Future Directions

The presentations in the business strategy modeling track portrayed the types of models that encourage further exploration from an integrated business-I/T perspective towards the goals and opportunities suggested in this report. What are the useful models with supporting tools that will yield increasingly predictable business results? A comparative analysis of business design and componentization approaches is in order to make progress on answering this question.[4]

[4] Paul Horn, IBM senior vice president and director of IBM Research, has commissioned such a study instigated by the work presented during this year's "Architecture of On Demand Business" summit.

E. Research Issues

Motivation: Formal modeling -- semantic and mathematical, descriptive and prescriptive -- of business design may have a significant impact on businesses' abilities to focus and adapt to changing needs. Adding computer science constructs to existing prescriptive models from economics and operations research presents many interesting research challenges and potentially lucrative solutions.

Complexity/time frame: This investigation will likely take many forms and be approached from many angles -- from within business schools, computer science departments, and engineering programs as well as from within product and service companies in I/T and other industries. Given the complexity of business dynamics, progress will likely be evolutionary, perhaps with punctuated successes.

Suggested focus item: Component business modeling is currently being developed as a conceptual framework. It is worthwhile to explore augmenting it with more structured models, such as Tom Malone's MIT Process Handbook, to provide additional levels of insights, computation and analysis, and to help make strategy decisions actionable through transitions to their execution.

Potential sponsor: IBM

Potential communities: Business strategy consultants and computer scientists need to come together in a community where they can earnestly explore needs and possibilities. The increasing relationship between IBM Research and business schools should also be nurtured. More broadly, the relationship between computer science programs and business schools should likewise evolve, such as through an extension of the Association of Computing Machinery's special interest group for e-commerce and similar academic communities.

F. Dependencies on Other Issues

Perhaps the most daunting obstacle towards progress is the two-way cultural issue. With business consulting firms under great pressure to achieve near-term revenue targets, there are natural difficulties in securing their attention, patience and investment in long-term research, even with some degree of incremental value being extracted from the research. This makes it too convenient for researchers to postulate theories from the proverbial ivory tower completely removed from business people's needs.

G. Relevance to Services Science

Paul Horn has suggested that a periodic table of business elements (i.e., models of business) may be the grand challenge for services science. Whether this challenge is adopted or not, the goal of evolving business strategy formulation

from an art towards a science is likely to have some important relationship to services science.

Defining models and tools to help formulate business strategy requires an interdisciplinary approach across business schools, computer science departments and other disciplines. This could be a significant augmentation of management science.[5]

[5] For example, see http://www.stanford.edu/dept/MSandE/

III. CONTINUAL BUSINESS OPTIMIZATION

A. Definition / Key Elements

Continual business optimization means applying robust, rigorous mathematical models and algorithms to business data to support real-time decisions on how to allocate and deploy resources as well as for business functions, such as demand forecasting, supply planning and pricing. There are a number of well established mathematical models and algorithms that can, at least in theory, address a broad range of business problems. However, there have been several obstacles to the wide-scale deployment of business optimization, particularly in support of operational decision making. These obstacles include a lack of computing capacity, data availability and skilled application developers as well as a legacy of local decision making that has become institutionalized in business designs and in the supporting business software solutions.

Only in the past few years have we had adequate computing capacity to apply these algorithms to realistic business problems and produce solutions at a rate that can support operational decisions. Continued increases in computing capacity in pervasive devices, on the individual's desktop, in the enterprise infrastructure and in accessible grids indicate that computing capability, although still an issue for some classes of mathematics, will no longer be an insurmountable obstacle for wide-scale deployment of business optimization. Robust commercial and open source libraries that provide well tested, well documented implementations of

these algorithms became available in the 1990s. However, using these libraries to develop continual business optimization solutions requires significant technical expertise coupled with industry-specific business knowledge, and the number of subject matter experts working on business applications remains small. Information availability has dramatically improved in the past decade with the deployment of enterprise resource planning, e-commerce and business integration systems, and it is expected to continue to improve with the widespread use of pervasive devices, including RFID. Information is now more readily available to enterprises, including, in some cases, up-to-the-second status information on internal and external events.

B. Challenges

Numerous businesses have realized dramatic benefits from business optimization, but deployment remains limited. The reasons for this are not clear, but possibilities include a lack of awareness, the perceived difficulty of developing or deploying, past failures of deployment resulting from lack of computational capability and data, the disconnect between business and academia, and a lack of standard terminology, interfaces and benchmarks. The Institute for Operations Research and the Management Sciences (INFORMS), the operations research and management sciences professional society in the United States, has undertaken a publicity campaign to increase awareness of the impact and capabilities of mathematical programming and related technologies. This campaign may succeed

in increasing the demand for business optimization, but not in increasing the supply or rigorous industrial strength application software.

Successfully developing and deploying applications in this space requires modeling expertise (selecting an appropriate abstraction to fit the business process and mapping the business data to the model elements), computational and programming experience with existing software libraries that implement solvers for common classes of mathematical formulations abstractions, and an understanding of the specific business process being optimized and the supporting I/T infrastructure. Few academic-based research teams have the necessary breadth, few industrial teams (I/T consultants, software product vendors) have the necessary depth and each specialized skill group tends to underestimate the need for complementary resources. Building prototypes to support a pilot study or research exercise is relatively fast and easy. Building a robust implementation that can be customized for rapid deployment in many enterprises, and can be maintained and enhanced to deal with new situations is much more difficult.

There are examples of layered implementations in which the solver layer is isolated from the domain layer though application programming interfaces and industry templates. These layered implementations allow software developers with process domain expertise to perform customized deployments and computational mathematicians to develop solver enhancements. However, this type of architected implementation stack seems to be the exception rather than the norm.

In rare cases, the optimization capability is embedded in a fully automated process that has no human oversight. In most cases, the solution created by the mathematics is used, or at least reviewed, by a person who has significant business and environmental knowledge. For broad acceptance, it is crucial that the optimization application produce the right answer, or at least not produce obviously wrong answers. This aspect is very often overlooked by all of the participating parties, except the user, and may play a significant role in lack of user acceptance. However, the requirement can be addressed in a variety of ways: more extensive up-front analysis to understand how the optimization capability will be used, designing the solution to allow user interaction and override; and including additional computational steps to examine, evaluate and correct the solution before it is presented to the user. Finally, an additional layer of data collection and analysis to track the data, the proposed solution, and the actual decisions and actions taken can be put in place, and used for refining and maintaining the model and tool.

C. Academic Literature / Industry Focus

There is an extensive body of literature covering the underlying mathematics of continual business optimization. The journals published by INFORMS and its international counterparts, as well as the journal *Mathematical Programming, the Journal on Discrete Applied Mathematics,* and others from the Society for Industrial and Applied Mathematics (SIAM) contain the bulk of the relevant

literature. Many of the articles address stylized problems, which are mathematically elegant and (often) tractable, but are not directly applicable in complex business situations. An amazing number of articles have been written about every possible variation of single machine scheduling, parallel machine scheduling, economic order quantity and lot sizing. Articles dealing with specific industrial applications of operations research or management sciences are most often found in *Interfaces,* particularly in the issues dedicated to the finalists in the annual Edelman competition for excellence in the application of either area. Most of these articles have academic authors or co-authors, including academics who have small consulting or software companies. With the exception of *Interfaces*, articles written from an industrial perspective, detailing the business problem, the impact, and the integration and deployment process appear only occasionally in these journals. As most of the journals are edited and reviewed by academics, the acceptance criterion seems to favor mathematical rigor over business reality. Further, the long review cycle and the extensive revisions, including additional computational experiments requested by many of the referees, make publication difficult for industrial practitioners who move on to other work after completing a project.

Harvard Business Review articles focus more on the business impact, but omit much of the modeling and computational details.

Airlines and petroleum refineries were the first to extensively apply business optimization techniques, so much of the early application literature is from these industries. Financial institutions also make extensive use of analytic methods, but

have generally been less apt to publish details of techniques or applications. Telecommunications companies have used mathematical models for network planning, routing and, more recently, in pricing. In the past decade, there has been significant activity in the broad area of supply chain, specifically in transportation logistics.

D. Future Directions

There is a significant gap between the capabilities of mathematical models for business optimization and their rate of deployment or effective usage. The most significant opportunities for impact are in the area of continual business optimization, as it interlocks well with business integration and automation. Relatively small-scale projects can have significant impact in a relatively short time. To increase the rate of deployment we must:

- Increase marketplace knowledge of the capability of business optimization through targeted publicity highlighting advances and specific examples of success.
- Drive the numerous participants (mathematicians, business schools, I/T providers, business users) toward a common understanding of categories of capability.
- Drive toward standardized business processes and interfaces to analytic tools.

- Provide I/T infrastructure, test beds, and benchmarking capability, particularly for black-box solvers based on proprietary methods.
- Support standards libraries for underlying solvers.

E. Research Issues

The challenge of communicating value and increasing user acceptance should be addressed. Esoteric technology is used in the design and operation of many consumer products without causing buyer/user angst -- users trust that it will work, and don't ask how. But math is somehow regarded as different and much harder. It would be worthwhile to investigate the reasons for this, so that we could develop possible solutions. The Institute for Operations Research and the Management Sciences (INFORMS) and the Society for Industrial and Applied Mathematics (SIAM) could possibly play a role in this study.

As long as the various disciplines within applied mathematics, operations research, management science and computer science compete with one another, the business community will remain confused and hesitant to invest. The structure of university departments contributes to the fragmentation of research effort, which manifests in a fragmented market. The National Science Foundation (NSF) is focused on advancing science, but with only limited focus on the transfer of that science to business impact.

IBM can provide some leadership, especially if we decide to invest broadly in business optimization. The National Science Foundation, in particular the cyber-infrastructure initiative, can provide a linkage between university research teams and business applications. The Institute for Operations Research and the Management Sciences could provide some leadership, but probably only in cooperation with other professional societies that it may regard as competition.

F. Relevance to Services Science

Applying operations research and management sciences to consumer service businesses (financial, retail, healthcare and call centers) has been ongoing, and is the focus of several centers associated with business schools and/or industrial engineering departments. This community's attention to business services (I/T outsourcing, business process outsourcing, contracts and service level agreements) has been minimal. IBM has several activities underway that apply OR/MS, statistics and data mining to business problems in IBM Global Services, ranging from revenue forecasting to contract pricing to workforce allocation. Work is underway, following an INFORMS workshop, to assess the current activity and organize an NSF-sponsored workshop to define a research agenda.

IV. BUSINESS STANDARDS FOR THE EXTENDED ENTERPRISE

A. Definition / Key Elements

Industry business pressures are driving the need for I/T to focus on open industry standards:

- In the automotive industry, quality issues are of primary concern, with warranty costs averaging $700 per vehicle in the United States, and the increasing need to integrate systems and software from multiple vendors in the vehicle itself.

- The healthcare industry is faced with accelerating costs, slow responsiveness and problems with the quality of patient records, which is leading to increased pressure to integrate payers, providers and hospitals.

- The electronics industry lacks the ability to mass produce with last-minute customization and is moving from manufacturing/product orientation to customer/configure-to-order integrated supply chains.

- The banking industry has multiple silos, tremendous redundancy and under-utilization of data, and requires a standardized approach to develop new products and services faster to build customer loyalty.

- In the retail industry, the available information is increasing exponentially, from RFID and other technologies, and is not yet used effectively. Retail lacks the seamless integration to deliver information as needed and optimize its supply chains.

- The telecommunications industry's infrastructures are islands with multiple legacy and heterogeneous entities, and telecom companies lack a consolidated view of a customer's activation information, self-services, billing and other customer care records.

In addition, building relationships with business partners in the extended enterprise is becoming more and more essential for an enterprise's survival and growth. Individual companies need to both provide services to others and consume services provided by third parties. As this trend escalates, it will ultimately lead to industry ecosystems where data is intensive, enterprises sense-and-respond instantly and plug-and-play supply chains are ubiquitous.

But to realize this vision and start to resolve the business pressures listed above, a new breed of vertical, industry and domain-specific standards must emerge. These standards will build on existing horizontal technical standards and will standardize the data and business processes across organizational boundaries in a context that is meaningful for a particular domain. The result will be a shift from *vertically* integrated structures to *virtually* integrated structures that extend the enterprise through collaboration, improving agility, flexibility and resilience.

Examples of industry standards already exist in many industries:

- RosettaNet for the electronics industry
- Accord for the insurance industry
- Society for Worldwide Interbank Financial Telecommunication (SWIFT) for the banking industry
- Health Level Seven (HL7) for the healthcare industry

Within the last several years, we have seen a huge increase in the number of organizations producing vertical standards across a wide range of industries and domains. Although the content of these standards are particular to the domain, the business drivers, methodologies employed, types of standard artifacts produced and usage patterns for these standards are very similar.

Work is underway to identify the global patterns that are emerging in standardization across vertical industries, and the impact these standards are likely to have. This will have a profound effect on both the industry in which these standards are produced and for the I/T industry at large.

B. Challenges

Many fundamental issues need to be resolved before these vertical standards are widely adopted and their true value realized:

1. What are the market drivers and new economic models for these standards?
2. What governance models are appropriate?
3. What role should industry forums, leading institutions, government bodies and vendors play in the formation and maintenance of these standards?
4. How do we accelerate the definition of standards so that they are relevant for a period of time? Standards need to become more adaptive over time -- how will this happen?
5. Will entrenched players slow the adoption of these standards, or see new opportunities?
6. Will established players be able to explore the benefits of codifying and formalizing standards in new, and still forming, domains by working vertically as well as horizontally?
7. How will software architectures and products evolve to exploit these vertical standards? And will these standards provide an evolutionary path for industries or do they portend major revolutionary transformations?
8. To make business standards work in supply chains, there should be clear metrics and key performance indicators. How will this rollout in the marketplace?
9. Does the widespread adoption of eXtensible Markup Language (XML) and industry standards truly herald a new era in cross-enterprise communication or is it just a new phase in long-existing trends like electronic data interchange?

10. Will standards portend major upheavals or just substitute a new technology in re-implementing existing business processes?
11. What industries are most likely to move to this new paradigm -- ones that already have established standards or those that don't?

C. Research Issues

We identified two areas of research we think would be extremely fruitful to pursue. The first focuses on discovering best practices in adopting vertical standards, including developing a business value model for the process. The second deals with developing standard vertical industry key performance indicators.

Best practices and business models: Little is really known about what determines the success (in terms of widespread adoption) of vertical standards. When is it appropriate to standardize? Can a generic business value model be formulated for standards adoption by an industry? Such a model would identify the key stakeholders and roles, and develop the reasons why these stakeholders should be involved. It would identify key events and participation that need to occur across the standards diffusion lifecycle and the tipping points that can determine success or failure of standards adoption.

Related to this effort would be gaining a better understanding of the sorts of standards to be developed, the right level of abstraction for these standards, and a better mapping between business objectives and standards. What are the trade-offs that need to be made in standards, and how do these trade-offs affect the wide adoption needed to instigate industry transformation and productivity enhancements? Some of the parameters that may conflict with one another are: flexibility, ease-of-use, generalization (applicability across multiple business processes and geographies), time-to-value (speed of standard setting and adoption), and ability to integrate into legacy infrastructures.

We also conjecture that different industry topologies and marketplace dynamics will require different sorts of standards (e.g., serial supply chains versus hub-and-spoke marketplaces).

Some of the issues outlined here are already beginning to be addressed in academic literature. A recent conference ("Standard Making, A Critical Research Frontier for Information Systems," Management Information Systems Quarterly Special Issue Workshop, Seattle, December 13-14, 2003), for instance, investigated several important issues relevant to this topic: the difficulty in standardizing data definitions that are applicable across a broad set of enterprises, the economics of standardization, a conceptual model for vertical industry standardization, a vertical standards diffusion model and case studies of specific industry standards.

Key performance indicators: The emergence of a critical mass of business standards will drive the need for key performance indicators to measure the value that the extended enterprise is delivering. To be effective, these metrics themselves will need to become standardized. A start in this direction is already underway.[6]

Developing key performance indicators is a good opportunity for those in industry and those in academia to collaborate. Some service integrator companies have developed a perspective on key performance indicators for business performance, while academics have developed theories on business performance. An important and valuable research project would be the two groups collaborating on a set of case studies. Areas to explore include:

- How do we develop a key performance index from key performance indicators?
- How do we use a retrospective look?
- How can we map from I/T metrics to business metrics?
- Can metrics seen in practice be validated by academic theory? What is the impact of what did not happen?
- We know a lot about the supplier side. What's the customer adoption process?

[6] See http://www.APOC.org

D. Dependencies on Other Issues

Vertical standards are both a motivation for, and will benefit from, the emergence of service-oriented architectures.

E. Relevance to Services Science

Research in business standards for the extended enterprise can be handled effectively within the current disciplines of business and I/T research.

V. HUMAN CAPITAL MANAGEMENT AND OPTIMIZATION

A. Definition / Key Elements

Human capital is a way of defining and categorizing peoples' skills and abilities as used in employment and otherwise to contribute to the economy. Simply put, human capital attempts to be an aggregate measure of the value of the people in an organization for performing existing work and their capacity to do new types of work in a flexible and adaptive fashion that meets changing demands.

This challenge is leading CEOs to search for ways in which all parts of their organization can become more flexible and agile. Defining the concept of agility and responsiveness is easy compared to making it happen, but CEOs have set their sights on bringing these qualities -- and ultimately growth -- to their companies, and they recognize the importance of their employees' skills.

Given the CEO growth agenda, the drive to introduce new and better-quality products and services and build more agile organizations, executives' renewed interest in people-related issues is hardly surprising. But while their people agenda starts with skill levels, it actually goes deeper and wider. Strong leaders recognize that leading successful change management and business transformation programs requires them to call upon the commitment and drive of their people -- as well as their talent.

The agenda for growth mirrors overall themes from the study: it's not purely about costs, but about striking the right balance between productivity and skills.

Companies that have been through the fire of restructuring recognize that their way forward is through people and are now placing their focus on developing their capabilities. Companies that are shifting their business models acknowledge that it is the cultural and change issues that will determine success. For global leaders, having the right workforce is the key to running the business. If the workforce cannot be responsive to customers, then the business will falter and disappear.

If there is one insight that is shared as universally as the recognition that only people can deliver on the growth agenda, then it is that people are the principal obstacle to achieving the organization's goals. More precisely, it is the deficiency of leadership and managerial skills that encumbers organizations. It is a mark of just how crucial the issue of human capital has become that CEOs cited "workforce issues" as an external barrier to change and "limited internal capabilities and leadership resources to manage change-related projects" as a major internal barrier.

No matter which sector -- from retail to pharmaceuticals, the public sector to financial services -- the story remains the same: the skills of current staff frequently do not meet expectations or needs. Top executives believe that education -- or often re-education -- and the lack of qualified candidates are the people issues that will have the greatest impact upon their businesses over the next three years. Even in a world where unemployment is rising and companies are seeking out overseas labor, demand for highly skilled workers continues to outpace the capability of societies to provide it.

Some CEOs are looking for technical skills, especially as products are becoming ever more complex. Others want more business skills. Still others need to develop relationship skills as the heads of well-established, family-run enterprises hand over the reins to their successors. The principal issue, in many cases, is figuring out a way to convert and develop mono-talented individuals into multi-talented ones. This is causing age-old tensions to re-emerge: in a talent search that is increasingly global, how can companies obtain a return on their training investment?

CEOs are also expressing renewed interest in transforming their businesses -- and fast -- but they feel ill-prepared to do so. They are at a critical juncture, and keenly aware that their people can be their most valuable asset -- or their biggest roadblock.

Many CEOs are worried about social attitudes and the limitations imposed by governments and unions, especially as so many societies are moving away from a physical labor base to a knowledge base. In a world of nanotechnology, biotechnology and software, new skills and attitudes are essential. And CEOs recognize that they must take into account a new generation of employees who have new attitudes about their careers and employers.

The responsibility for nurturing and finding new generations of talent is not the responsibility of corporations alone. The pool of apprentices, university graduates and those who join the workforce directly from school has to be both wide and deep. CEOs believe that business is not always well-served in this process.

Teaching people how to take responsible levels of risk and changing corporate culture from entitlement to performance are two of the principal challenges for today's environment.

A key aggregate measure related to human capital is "labor productivity" or the revenue per hour of labor. Labor productivity gains are at a 31-year high.[7] Six Sigma and Lean Manufacturing have been transforming the industrial sector. As we move into a services economy, the challenge for services science is to create new methods to reliably and predictably improve productivity in the services sector.

From an organizational perspective, IBM defines seven human capital management functions:

- work design and labor cost management
- competency development and knowledge management
- workforce planning and management
- performance and behavioral reinforcement
- talent sourcing and selection
- leadership
- culture and community management

In addition to revenue growth, profit growth and margin growth, businesses are also increasingly aiming to achieve productivity growth, as labor costs

[7] See http://www.usatoday.com/money/economy/productivity/2004-06-13-productivity_x.htm

become the dominant costs in business. There is strong demand for human capital management services that can deliver sustainable, predictable productivity gains.

From an individual's perspective, people move in and out of jobs (the half-life of job assignments is decreasing, average now under two years in the United States), move in and out of roles (multi-tasking between multiple project teams is increasing, average of over twelve projects per person), move in and out of activities (multi-tasking as part of communication, reporting and other work activities is increasing, average daily of fifty conversations with co-workers or clients, twenty e-mails, ten telephone calls, five Web sites visited, five meetings, etc.). Recent studies of workers indicate that "challenge" and "flexibility" are rated more highly than "pay" in the choice of a job. Balancing rewards, risks, relationships, identity enhancement and many other factors go into job and role choices. The ability of people to work effectively depends on four types of factors: (1) their own abilities, attitudes, values and perceptions; (2) their ability to use tools and technological capabilities; (3) their ability to align with organizational capabilities, including other people; and (4) their ability to gain capabilities directly from their environment.

It is also important to take a global/national economic perspective. If increased productivity results in massive layoffs, with no upward job migration path, then there will likely be a political and legislative backlash against achieving productivity gains with those techniques.

B. Challenges

As companies focus on agility and flexibility, they are recognizing that they can only adapt as quickly as their people can. It is the skills of employees, as well as their capacity for leadership and change, that will determine the outcome of process redesign and business transformation. At the same time, the nature of work is changing. Boundaries between organizations are blurring as companies strengthen interactions with suppliers, partners and customers, and as they outsource more processes. Improvements in connectivity, automation and technology integration are enabling extensible enterprises whose business relationships are dynamically reconfigured in response to changes in markets, resources and skills.

To compete in this dynamic business environment, companies must be able to transform their workforces, processes and organizations as quickly as needed. But what do these sorts of business transformations mean for workers? How will jobs be transformed? How will new skills be developed quickly and precisely in response to changing business needs? How will learning programs be delivered to a far-flung and varied workforce? How will organizations themselves adapt to enable the changing and flexible workforce? How will companies measure performance if skills vary and must be adapted more quickly than ever before? Will we ever be able to mathematically model optimal teaming of workers based on experience, skills or even personalities? Human capital optimization -- having

the right human resources and skills in the right place at the right time -- is one big challenge now being faced by companies.

C. Academic Literature / Industry Focus

Most business schools provide courses on human capital management and human resources, which draw heavily on social science areas in discussing behavior, the role of incentives, learning and many related topics. They also draw on economics in discussing productivity, labor markets and, recently, off-shoring. Other topics include labor legislation and, increasingly, the use of information technology to improve productivity. Case studies have shifted from using manufacturing jobs as examples to studying services jobs. There is also an increasing emphasis on models (e.g., design of a model for return on human capital investment, design of a model for expatriate management, etc.). Specialization exists for specific industries, including government, healthcare, education, legal services, business services, retail services, hotel and restaurant services.

A quick Google search will prove the prevalence of this topic. Productivity is referred to 10 million times, human capital about one million times, human capital management about 100,000 times, human capital management plus optimization about 10,000 times, and human capital management plus curriculum about 2,700 times.

Moving from business schools to engineering schools, you'll see human capital optimization presented as part of industrial engineering and operations research courses. Computer science departments sometimes have programs in computer support collaborative work and often in artificial intelligence that present many models of human-technology systems that are optimized around specific work functions. Also emerging out of artificial intelligence programs is the area of computational organization theory and agent-based computational economics. The models in these areas are still relatively simple compared to optimization problems for real businesses in the area of labor force optimization or project team optimization. Nevertheless, they are rapidly becoming more sophisticated and gaining more related analytic techniques. Computational organization theory and agent-based computational economics are clearly on a convergence path with human capital optimization as it approaches being developed in industrial engineering and operations research areas.

Business schools, social science programs and engineering schools often form joint programs to focus on the redesign of work, which typically seeks to generate more business value and more satisfying work for individuals. Aligning organizational goals (productivity) and the goals of individuals (satisfaction) is a key theme in the literature on designing work, but there is a great deal of cynicism as to whether or not both goals can be achieved. One human capital management course claims the object is to "transform the person into a competitive resource."[8]

[8] See http://cc.ysu.edu/~mnwebb/staffing/SyllabusSpring2004_staffing.pdf

Erik Brynjolfsson, Lorin Hitt and T. Breshnahan of MIT provide comprehensive surveys of the literature from business schools that explores issues of measuring productivity gains from I/T investments. Their key findings are easily summarized and very relevant to the notion of services science. For instance, productivity increases when I/T investments are linked to complementary investments in organizational practices (business practices and intangibles associated with organizational culture). A second key finding of this team is that I/T investments result in the need for more highly skilled workers in organizations.

Forbes magazine recently ranked[9] IBM number one in human capital management, so the obvious opportunity is to view human capital and worker productivity as the most important "adjacent space" for growth by IBM. The company is well positioned and can gain a moral high ground if it approaches improving worker productivity from both an individual job satisfaction and an organizational productivity standpoint.

The less obvious opportunity is to own the evolution of work and evolution of services offerings (total lifecycle) from the human-intensive, creative/collaborative phase to the final automation phase. To achieve this will require a mechanism that changes the relationship between service provider and client into a win-win collaboration. A possible key is to realize that as communication and computation get cheaper, the really hard thing is to align people coherently around a goal. Services engagements are often one-offs, since

[9] See http://www.forbes.com/forbes/2004/0419/059tab_print.html

the people in the client organization are new, and oftentimes the people in the provider organization are also new. A possible solution is to create a rehearsal infrastructure that allows the provider and client to try each other out to make sure they are on the same page and able to align and coherently work together. Many human activities require doing it right the first time -- from landing on the moon to conducting military engagements to performing surgeries to performing on stage -- the first time had better be good or you may not get a second chance. In all these human endeavors, rehearsals have played a key role. Our services business does not have a rehearsal infrastructure that allows IBM and its clients to realistically rehearse doing a services engagement together.

D. Future Directions

IBM is probably better positioned than any company on the planet to collect data and build models of complex services engagements that require human capital management and optimization methods to improve productivity. Academic institutions know this and are eager to gain access to data and help to develop improved models. This creates a short-term and long-term opportunity to create new academic relationships relevant to IBM's business growth and success in services.

Optimizing human capital management to achieve further productivity gains in the services sector is the opportunity that clients would like IBM to help them realize. To do this in a way that continues to create an upward spiral of high skill,

high pay jobs for the global economy will be critically important. If human capital optimization is performed in a way that results in massive layoffs with no upward path for people to move onto, then political pressures will mount to slow or halt that type of human capital optimization work.

The grand challenge in human capital optimization is to: (1) sustainably and predictably create productivity gains for the client organization; (2) improve employee job satisfaction; and (3) create more high-skill, high pay jobs in the overall national/global economy. To be successful, human capital optimization has to make sense for businesses (productivity), for individual workers (satisfaction), and for nations (high-value job growth).

E. Research Issues

Motivation: Improve productivity in the services sector in a way that creates more high skill, high pay jobs.

Complexity/time frame: Services engagements are complex for many reasons. Even as communication and computation costs drop, aligning people across multiple organizations (provider, client) will require new tools, methods and skills. Optimizing human capital cannot be done without modeling the client organization as well as the service provider organization. Ultimately, modeling what happens to displaced workers needs to be included in the optimization too.

Suggested focus items: Define a solid curriculum for services science that addresses the opportunity to improve productivity in the services sector via human capital optimization.

Potential sponsors: The National Science Foundation faculty awards and funding should be aligned to help move this forward. We must gather better labor and economic statistics. The MIT work on I/T productivity makes some strong recommendations and lobbying for those changes will help accelerate progress.

Potential communities: Business schools and social science programs (especially those with strong technology, organizational and work design courses) are already bridging to engineering schools in the area of human capital management. Perhaps services science courses can help accelerate those linkages.

F. Dependencies on Other Issues

As mentioned, if human capital optimization is performed in a way that results in massive layoffs with no upward path for people to move onto, then political pressures will mount to slow or halt that type of human capital optimization work. The industrial sector can improve productivity through layoffs because the growth in services sector is perceived by many as an upward path. However, service sector productivity that results in layoffs will not be so well received. The potential for political backlash is enormous if this is not properly addressed.

G. Relevance to Services Science

All of this connects very well with the work going on for the Global Technology Outlook on services science. We should look for additional connections with that work.

VI. BUSINESS PERFORMANCE MANAGEMENT

A. Definition / Key Elements

Business performance management (BPM) is a real-time, model-based technical framework that supports the sense-and-respond paradigm of on demand business. It enables business operations and I/T infrastructures to adapt in response to dynamic performance targets. The BPM framework can proactively monitor internal and external events, detect trends and business exceptions, and devise concrete actions to rectify business situations using combinations of human and automated activities.

Solutions based on business performance management have the potential to deliver timely information, promote proactive recommendations and provide a dynamic interface to enable the underlying systems to respond. BPM allows a business to closely monitor and manage business and I/T activities across and beyond the enterprise as they occur, to recognize areas for improvement, and to implement quickly actions that optimize and bridge business and I/T performance.

By coordinating business and I/T events within an integrated framework, decision makers can quickly and efficiently align I/T and human resources based on the current business climate and overall market conditions. Business executives can leverage the results of core business process execution to speed business transformation, and I/T executives can rely on business views of the I/T infrastructure to recommend I/T-specific actions that can drive competitive advantage.

The BPM methodology is based on a continuous performance improvement cycle that consists of six core activities: modeling the business needs; deploying the models with the appropriate instrumentation; running the automated models; monitoring the events generated by the business operations and supporting I/T infrastructure; analyzing the events and causality; and adapting (e.g., redeploying resources, altering business rules or revising business processes). This model-based approach provides several advantages: practical reuse of the BPM assets, flexibility to adapt to dynamic changes and efficiency in capturing business intent to ensure solution fidelity (how well the solution implementation reflects the needs of the business).

Model: Business models help capture what matters to businesses, such as business policies, key performance indicators, business events and situations, and the actions to respond to events and optimize performance. Once automated, these models can be monitored in order to optimize business operations and their supporting I/T infrastructure.

I/T models help capture the topology of an infrastructure and the properties and relationships between its managed I/T resources and services. I/T models can offer significant benefits to activities such as service level management, resource provisioning, transaction performance monitoring, and problem determination. They can help with causal analysis by correlating events back to the resources that directly or indirectly caused them to occur.

Deploy: Deployment includes transforming the above platform-independent business and I/T models to technology-specific implementations that are packaged and deployed to the underlying infrastructure in support of the business operations. Deployment capabilities should include the handling of virtualized resources (e.g., virtual teams for human resources, workload management for infrastructure resources), the addition of new components to a running solution (hot deploy) or the modification of already deployed components (dynamic redeploy).

Run: The business performance management run-time is a model-driven execution environment, instrumented to monitor business metrics, key performance indicators and critical business situations in real time. The run-time also provides a feedback loop from monitoring and analysis back to model improvement and redeployment, and enables the insertion of executable business rules in order to allow for dynamic changes in business behavior.

Monitor: Monitoring allows users to access performance data in real time by tracking the status of artifacts, resources and business processes. It can also aggregate historic data, invoke actions when particular business patterns occur, and report on business metrics and alerts for one or more areas of responsibility. Workplaces are used to enable role-based data reporting and industry-oriented dashboards.

Analyze: Analysis of real-time event data and other business data, including historical data on business operations, is necessary for computing the key performance indicators and diagnosing business performance problems. Both predictive analysis to uncover potential violations of business and I/T policies, and reactive analysis in support of adapting to business conditions are supported by the framework.

Adapt: Adapting can be either tactical or strategic in nature. The tactical approach usually involves a user reacting, in real-time, to exceptions triggered by business conditions. Such a reaction can, over time, be automated. The more strategic approach is based on a deep analysis of the operational systems of an enterprise and may result in modifying the process structure, policies and rules, and trigger conditions of the business components of this enterprise.

The business performance management methodology is enabled by a service-oriented architecture that supports the overarching business needs to reduce costs while increasing I/T flexibility, speed to market, reuse and customer responsiveness.

A service-oriented architecture exposes a set of I/T services whose implementation can be modified to meet changing functional and non-functional requirements. Business functions in this model are choreographies of services. A service is generally implemented as a coarse-grained, discoverable software entity that exists as a single instance and interacts with applications and other services.

At a very high level, a service-oriented architecture is composed of service requesters and service providers, and a service broker to register services. Service requesters can optionally discover (via a service broker) and invoke the functions of service providers.

A service-oriented architecture can be realized through Web services, a standards-based technology that represents both a business process and I/T capability that can enable a more flexible and responsive enterprise regardless of underlying technologies, platform or programming language. The nature of Web services allows it to be gradually introduced into I/T infrastructures and integrated with existing systems, and does not require total replacement of existing functions. Its inherent abstraction also makes it easy to replace Web services that have already been deployed.

B. Challenges

Like any major business transformation, adopting the sense-and-respond paradigm of on demand business requires a strategy and a road map. For most companies, a sense-and-respond road map involves a progression through four levels of maturity:

Automated: Developing a better understanding of transactional data that represents customer needs while also monitoring environmental factors.

Visible: Integrating data and applications throughout the extended enterprise to increase visibility and operational efficiency.

Controlled: Creating flexible control mechanisms and reacting with agility to a changing environment.

Adaptive: Developing competitive advantage through adaptive, proactive optimization of complex objectives supported by dynamic trade-off analysis and cross-functional collaboration.

This four-level maturity model imposes a serious challenge because it is difficult to predict and measure return on investment in the first few phases. The expense of transforming a business to the automated and visible stages may at times outweigh short-term savings. The business may have to reach the controlled stage before seeing a clear financial benefit.

A second challenge is related to volatility. Sense-and-respond systems enable the use of real-time information to update operational policies and manage execution accordingly, but this isn't always beneficial. The phenomenon of demand amplification in a multi-echelon supply chain (also known as the Bullwhip Effect) is a classic example of too many updates in the supply chain causing undesirable effects. This leads to higher inventories accompanied by increasing volatility as one moves up the supply chain.

Business performance management, the technical framework that supports the sense-and-respond paradigm, also has its challenges. One challenge is the need to align business goals and objectives with the I/T infrastructure that executes the business operations. Businesses face significant challenges in integrating a diverse set of applications, data sources and business processes to support operations, which consist of a collaborative network of decision makers within and between enterprises. Business performance management capabilities are expected to provide the information visibility required to detect performance situations and the flexibility to adapt operations to correct problems and optimize overall business performance.

Further, there is an industry focus on the creation of BPM standards. Although there are many industry specific solution standards (e.g., Supply Chain Operations Reference Model[10] or Telecom Operations Model[11]), there are no standards specific to business performance management itself. Two standards organizations have recently emerged to help advance these practices, technologies and processes: BPM Standards Group[12] and BPM Forum.[13]

[10] See http://www.supply-chain.org
[11] See http://www.tmforum.org
[12] See http://www.bpmstandardsgroup.org
[13] See http://www.bpmforum.org

C. Research Issues

Sense-and-respond overlaps many disciplines, including business performance management, supply chain management, operations research, business intelligence, control theory, machine learning and decision science. Related publications can be found in journals and conference proceedings from all of these fields. As sense-and-respond infrastructures mature, there will be more opportunities to plug in analytics and optimization, as well as opportunities to deliver business transformation, collaboration, supply chain management, business intelligence, control theory, machine learning, decision support and action planning.

Over the next couple of years, many topics that are currently considered sense-and-respond research will become standard practices. Generally, these topics lie in the automated and visible maturity levels described above. Example topics include the design of dashboards, data warehouses, analysis and standardization of metrics in various industries, and data bridging.

Many issues in the controlled and adaptive maturity levels will remain research topics for many years. As mentioned above, these issues are related to business transformation, collaboration, supply chain management, business intelligence, control theory, machine learning, decision support and action planning. Specific examples include:

- Representing and learning the complex relationships between metrics for planning and analysis purposes.

- Creating frameworks for decision making. Business people make critical decisions every day. How can a computer system represent decisions in a reusable framework, to support these users? How are such frameworks customized for each application? How are analytics and optimization plugged into these frameworks? In particular, using service-oriented architecture, is there a way to standardize the interface to analytics and optimization?

- Discovering if it is possible to apply techniques from optimal control theory when generating responses.

- Improving decision making through machine learning.

- Reducing the risk associated with the automated and visible maturity levels of sense-and-respond. Is it possible to identify event-driven processes in existence today and target these processes for the first round of deployment? Is it possible to build small prototypes that quickly tunnel into the controlled and adaptive maturity levels so that benefits can be quickly realized?

- Identifying and controlling volatility related to sense-and-respond systems.

In addition, technical areas of research around the business performance management framework will include:

- Business performance management models and tools: Simulation models that are used at design time to assess and evaluate improvements in business processes. These same models use real-time business information at run time to analyze and develop actions that help adapt business operations.

- Business value models for creating activity-based costing and analyzing the risk of value realization strategies.

- Business data visualization: Models and graphics for visualizing business performance and related business information for continuous analysis and decision making. How should business performance be displayed for specific role players (chief executives, business operations managers and business users in an enterprise)? How should information be garnered from a variety of back-end business services and systems, aggregated, and analyzed to support the business needs of specific role players?

- Business information management: Data models for representing key performance indicators and the network of relationships between them at multiple levels. Data architectures, data management approaches and extract-transform-

load techniques for handling large volumes of real-time event data to provide a holistic view of business performance information.

- Real-time monitoring: Models for continuous monitoring and tracking of business processes and I/T resources that provide visibility to business operations. Policy-driven autonomic monitoring systems that can dynamically adjust the observation models based on changes in performance targets, allocated resources and other environmental changes.

- Business rules and event correlation: Business rules for detecting situations that require an immediate response. Correlation patterns and mechanisms for instantly processing complex events.

- Business performance optimization: Decision models and optimization techniques that determine the actions necessary to adapt business operations and realize performance targets. Planning, scheduling and learning algorithms for adaptive and pro-active business performance management.

- Complex event processing: Correlation of events generated from process and data flows, and physical sensors and actuators to create an impact on business operations. Autonomic and messaging models for event mediation, routing and distribution between event producers and consumers as needed.

VII. INFORMATION INTEGRATION

A. Definition / Key Elements

Over the past ten years, the number of decisions required by businesses to compete in the marketplace has increased dramatically. Many of the decisions are critical to businesses because they must understand their changing markets, shifting customer segments and evolving customer preferences. Traditional analytic and statistical methods may not support marketplace requirements in the near future. If the Internet is to become the new source of consumer, product and marketplace insights, then traditional search and portal approaches will face one of the most interesting set of I/T challenges of our time. New approaches will need to be developed to determine authoritative measurements, sentiment measurements, pattern, trends and relationship measurements in an environment where the amount of content on the Internet will increase by four orders of magnitude in the next five years. The changing demographics of the Web will add even more pressure to this environment. To reach markets around the world, Internet tools will have to be capable of both trans-lingual processing as well as detecting sentiment expressed in different cultures.

Information integration refers to the set of services required to deliver the right information to the right decision makers with the right context and content powered by rich analytics at the right time, enabling them to act in an insightful manner that adds value when implementing the business strategy.

The right information: Delivering focused, relevant, actionable information. Eliminating information overload. Supplying relevant metrics to manage to short-term and longer-term objectives.

To the right decision makers: Enabling decision makers at all levels of the organization -- from executives, business managers and operational associates, to external associates (suppliers, partners, regulatory agencies, etc.).

With the right context and content: Delivering within the context of the individual's workplace environment (i.e., enterprise portal setting). Supporting with relevant metrics. Surrounding it with relevant content to support the initial request as well as supporting the follow-on question scenarios. Basing feedback upon past action.

Powered by rich analytics: Enabling with embedded analytical capabilities. Guiding analyses and decision making based upon common scenarios. Using advanced algorithms and mathematical modeling, and making them useful to a broad range of decision makers.

At the right time: Providing based upon push or pull scenarios. Alerting to negative trends or exceeding predetermined thresholds. Calling attention to a problem with predictive analytics before it is too late.

B. Challenges

Business leaders want to know what they can do to take advantage of the information on the Internet and other data sources to gain better insight on their businesses, customers and competition. What can they do to analyze such information for areas such as corporate reputation management, competitive analysis and product customization? What other activities might prove valuable? What is the impact to core business processes like marketing, competitive intelligence and product development if the Internet emerges as a rich and constantly changing representation of customers' requirements? What will be the new models for competitive advantage? What technologies will enable the integration and analysis of data? What can they do to take further advantage of this information, use it for multiple purposes, and create new sources of competitive advantage?

Companies must face three primary challenges when confronting these questions:

Information aggregation: Aggregating consistent, timely data across the entire extended enterprise; aggregating unstructured and structured information.

Integrated analytics: Applying advanced search engines and analytical techniques and methods to increasing volumes of data for enhanced decision

making; embedding analytics within core processes and systems to support decision making throughout the enterprise.

Information to the masses: Expanding the use of business intelligence and analytics beyond the typical executive and management ranks; making information focused, relevant and accessible to a broad set of internal and external information consumers at all levels of the organization.

C. Academic Literature / Industry Focus

While the technical literature reflects considerable activity around the issues of extracting information from unstructured text and integrating it with structured data, typically found in a database, business schools have yet to fully understand the current state of technical capabilities, which they need to so they can guide their development in addressing vital business issues. Much of the business literature addresses, acknowledges and promotes seeking the value in information integration, yet there is a gap between the technology view and the articulation of business value.

This gap needs to be addressed by both constituencies in the immediate future. There are a number of compelling business needs that center on the ability to provide integrated information and analytics in a well architected manner. Perhaps the single most urgent need is in the arena of monitoring regulatory compliance. Sarbanes-Oxley, Basel II, Patriot Act, Health Insurance Portability

and Accountability Act (HIPAA), and Tread Act legislation have now brought about a growing awareness within industries that the ability to sense the state of the business, even to the extent of monitoring millions of e-mails between employees and customers, is looming as both a business necessity and a huge technical challenge. Many financial firms today have between 10 and 20 terabytes of e-mail. The ability to constantly not only monitor the flow of correspondence, but also to analyze, index and retrieve correspondence when a suspected compliance breach is detected is one of business' most daunting challenges. Yet the ongoing revelations with Enron make it clear that this is not an academic or speculative issue.

In addition to the needs imposed upon enterprises from regulatory practice, there exists the more systemic need to improve a firm's ability to sense the state of its environment and its ability to redirect resources to respond to competitive threats and opportunities.

Key to this strategic need is the ability to provide integrated information and powerful analytics that transform data into information, then into actionable knowledge. The evolutions that started with shop floor automation and extended to supply chain management and integrated customer relationship management are now evolving into the integrated sense-and-respond system. Information integration and analytics are at the heart of such capabilities.

D. Future Directions

Emerging and converging themes in business intelligence:

- industry-focused solutions
- sense-and-respond
- real-time analytics
- management dashboards and analytics
- integration of external data
- content management/unstructured data
- advanced search engines
- portals and collaboration
- compliance and risk
- enterprise data management/data quality
- global sourcing and outsourcing

Sentiment analysis challenges: We must keep in mind that Internet sources differ in form, tenor, language and grammar, and that sentiment analysis is difficult even in restricted domains.

E. Research Issues

Motivation: We must make advances in the ability to extract basic information, create an architecture for integration and design business models before we can deal with information integration and analytics on a vast scale to meet regulatory compliance as well as to implement a new generation of enterprise sense-and-respond capabilities.

Complexity/time frame: The complexity of these applications is enormous and will require a concerted effort over many years to address. While much can be done to provide near-term benefits, the larger problems will require much closer collaboration between engineering departments, business schools and industry to realize the full benefits. Ultimately, we will need to evolve new curricula and train a new generation of practitioners to deal with the ongoing challenges of information integration.

Suggested focus items: Though far from complete, this list will suffice to convey a sense of the focus areas:

- Extracting information from unstructured sources and populating ontologies and knowledge bases
- Querying structured and unstructured sources seamlessly
- Reasoning over uncertain data from unstructured sources
- Certifying privacy of data and compliance with regulatory practice

- Developing decision support systems that mix automated reasoning systems with human analysis
- Dealing with the scale of information necessary to support future business requirements

Potential sponsors:

- The National Science Foundation (NSF) Computer and Information Sciences Engineering Directorate
- The Defense Advanced Research Projects Agency (DARPA) Information and Processing Technology Office

Potential communities: Academics, vendors, companies and coalitions.

F. Dependencies on Other Issues

Bridging the cultural gap between information integration, historically a highly technical field, and the business school faculty that has concentrated on the uses of information in the enterprise is of primary importance. We must establish a common ground regarding what expectations are appropriate for the technology capabilities and the rate at which they can evolve.

G. Relevance to Services Science

This area will require a multi-disciplinary approach, and bridges between computer science (artificial intelligence and systems), operations research, operations management and strategy.

VIII. SECURITY AND PRIVACY

A. Definition / Key Elements

The growing number of vulnerabilities and security patches with only small improvements from industry and academia are maintaining our society and economy in a survivable but highly uncomfortable situation. Consequently, security and privacy lead the list of customer concerns across all industries.

Security and privacy have moved from being solely technology issues to board of directors' issues. With the enactment or proposal of legislation, such as Basel II and Sarbanes-Oxley, which deal with information security and privacy on a global, federal, state, and local level, many enterprises and industries are being forced to address these issues. To effectively communicate with lines of business, chief executives and boards of directors, security and privacy advocates and practitioners must move from using arguments based on fear, uncertainty and doubt to others based on business risk analysis and management.

B. Challenges

There has been little practical work done to describe security and privacy in traditional risk management and avoidance terms at the business level. Work thus far focuses upon security risk avoidance through technology (e.g., use of firewalls to block inappropriate behavior or anti-virus software). While there is a

continued focus on security technology, those products and services are being commoditized and interest is shifting towards studying how to build systems that are secure by design rather than by the addition of retrofitted extensions or simple external protection.

The lack of a broadly accepted and applicable model for the return on investment for an enterprise security program continues to distract chief executives and boards of directors. Current work has focused on point products or solutions and, again, often at the specific technology level (i.e., return on investment for implementing identity management). Effective security practices as well as the operational risks that I/T systems introduce must be explored and incorporated into business models, just as other, more traditional, forms of risk are addressed today. In the current business climate, expenditures for security are evaluated not only by the I/T organization, but also by the lines of business. The cost of security, whether enterprise-wide or within a line of business application, is measured in terms of return on investment to the enterprise. Fear, uncertainty and doubt are no longer viable arguments for the purchase of security programs, software, hardware or programming. Security solutions must enable the enterprise to more effectively manage the trust relationship with its stakeholders.

The increasing emphasis on regulatory compliance, and the monitoring and remediation that it implies, is indirectly driving the industry towards improving security. This is not a recent development, as the Basel II, Sarbanes-Oxley and HIPAA have been in place for some time. Yet, many of the tools and services that are being employed in an attempt to meet these requirements are sorely lacking in

capability, coverage and usability, and are poorly integrated into I/T practice, if at all.

With the emphasis on business transformation and the effective use of all enterprise resources comes the need to be able to link business process modeling, I/T infrastructure and security. Changes in a business process can have multiple effects on the infrastructure, security policy, compliance and audit. Providing models of the enterprise is an effective way to be proactive in determining the effects of changes at the business process, security policy or I/T infrastructure levels.

C. Academic Literature / Industry Focus

The I/T industry and the governments of various high-tech countries have called for the revitalization of security and privacy curricula at our universities over the last few years. Many of those governments (e.g., United States, European Union and Japan) have increased their financial support of research in security and privacy. This call has become even stronger due to the broad impact of the patch-of-the-week problem and the increased focus on risk management, regulatory and compliance issues. But that focus is no longer limited to specific security and privacy technologies. It has grown to include the broader themes of security engineering and risk management.

Security engineering is a natural component of software and hardware engineering that has not had the focus that is needed. This is primarily due to two

major factors: (1) the booming 90s, where security-skilled programmers were in short supply and the development schedule was in Web-months, leading systems-builders to think less often about security; and (2) because consumers (public or private, enterprise or small and medium businesses) didn't place a premium on security. The cost-benefit ratio for security engineering was simply too high. In a post-9/11 and post-Enron world, this is no longer the case.

Another aspect of security engineering is getting it right. Too often, academic institutions focus on theoretical or small-scale implementation challenges that have little relevance to business problems or to business concerns about security and privacy. There have been a large number of security vulnerabilities caused by incorrect specifications, implementation, or testing of security subsystems. Academia must address challenges that are realistically scaled for businesses.

Incorporating security and privacy into a business process is often omitted or is left as an add-on at the end. This has never worked well, often resulting in missing or misclassified security risks. A challenge facing the industry today is working out a way to move security into a mainline effort, making it a part of the complete product or service lifecycle, rather like quality. As is often the case in a true engineering discipline, an appropriate means of measurement is essential. On the technical side, such a measurement can be the certification of systems (e.g., Federal Information Processing or common criteria), which is driving research into tools and procedures to make the building of such systems more economical. On the business side, another kind of measurement is needed: we need a way to determine a return on investment for security and privacy protection investments.

Security needs to be a part of the vernacular of the corporate lines of business. Security programs will be assessed in the same manner as any other corporate investment. Finally, a related need that is voiced by companies of all sizes is the ability to answer the question of how secure their organization is. Here, research in assessment, risk and compliance analysis and management, and automation strategies for the remediation process will be the key focus areas.

D. Future Directions

Business and technology modeling is for the entire enterprise. Combining business process and technology infrastructure modeling to solve security issues at a business level is a strong future directions.

A final challenge is funding these efforts. Corporate investment in academic research is still down from past years. Fortunately, government grants supporting research in these areas are increasing in the United States (National Science Foundation, National Institute of Standards and Technology, and the Department of Homeland Security) and abroad (European Union members). While they are highly competitive, good work is getting funded.

E. Dependencies on Other Issues

Legislatures in the United States and in some other countries are actively considering enacting controls on security and privacy, which would have a broad

impact on this area. If the legislation is particularly onerous, misguided and corruptible (e.g., Digital Millennium Copyright Act), the situation could worsen because computer users already see security and privacy controls as impediments. And, while the lack of legislative action would allow more freedom for companies to act and compete, it is unclear whether better security and privacy products and services would necessarily follow.

While academic institutions are increasing their focus on security and privacy, the number of graduates entering the workforce with this expertise is still predicted to fall quite short of the demand. This is perhaps the toughest challenge because part of the reason the industry is in such a security mess now is because too many under-skilled people were pushed to take care of security in the products we currently use. While the means for attracting and keeping the right kinds of students in such programs is beyond the scope of this paper, it appears that the demand will likely outpace the supply even if we are successful in increasing enrollment. Thus, the depending on automation and tool strategies becomes even more important.

F. Relevance to Services Science

As we said before, security engineering is a new discipline that would have great impact on the security and privacy problems facing the industry in the future. But security engineering is not focused only upon the development lifecycle; it also extends into enabling the effective usage of systems in secure ways. Security has

always been notoriously difficult to administer -- just try to configure a highly secure system using Windows XP or Linux. The challenge here is that without researching how to make security easier to deploy and manage, most of the other efforts we described earlier will have less impact.

Services science can play a key role in this effort because it is through the provision of services that many of the security and privacy challenges emerge. Close two-way communication between services and development organizations can lead to larger improvements more quickly than traditional market analyses and field tests.

However, the aforementioned shortage of available deeply skilled personnel also impacts our services organization. Thus, the On Demand Innovation Services approach of selectively enhancing consulting engagements with researchers serves two purposes: adding skills where they are lacking, and bringing back business issues and situations to feed into research projects.

To view complete presentations and papers from the "Architecture of On Demand Business" summit, see www.research.ibm.com/facultysummit