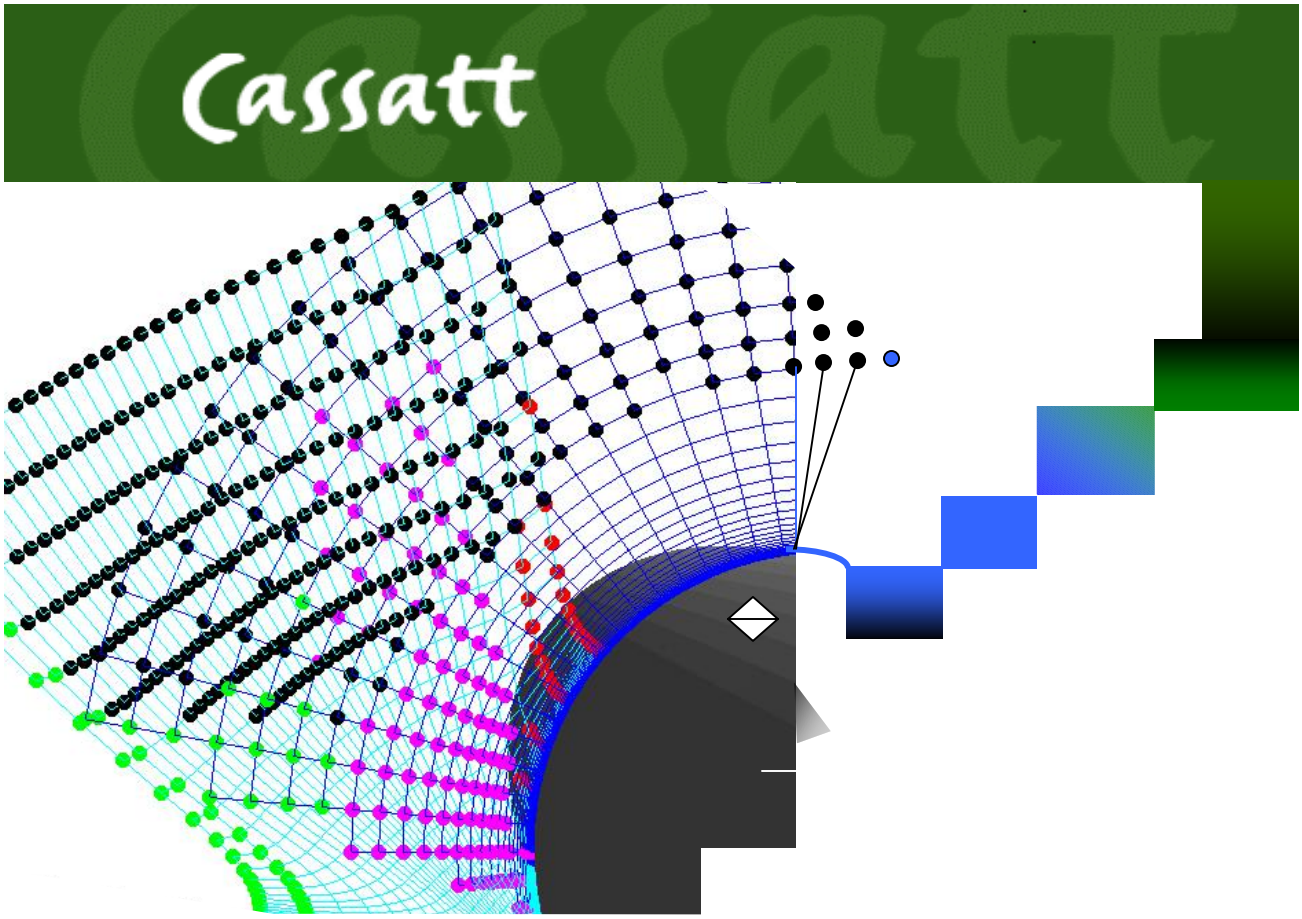

Grid Management Theory:

A Primer for Leading the New IT Organization

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Abstract:

The objective of this paper is to introduce fundamental management practices for grid computing initiatives. It is a guide for executives leading their organization's response to the emergence of Grid Computing, and the principles of autonomic computing environments underlying the Grid.

The basic proposition is that our IT organizations must be transformed to the same degree that we transform our applications and infrastructure.

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Introduction

We have entered a transformational decade in our businesses and our technology, the result of three independent yet inter-related trends: the first is the natural and prolonged economic contraction that began in March 2001, the second is the globalization of a skilled technology workforce, and the third is the advent of service-oriented applications, infrastructure and architecture.

Reinforced by the sharp economic decline during the past three years that forced the dramatic downsizing of IT budgets and staffing, CIOs are currently faced with a paradoxical challenge: they must provide ever-increasing computational capacity while simultaneously reducing cost. For many, this has led them to the new (externalized) architecture to support grid computing and the necessity of utilizing less expensive and increasingly capable offshore talent in the quest to do "more with less."

> IT must fully embrace business-oriented, bottom-line efficiency oriented thinking to reduce costs of how it delivers solutions while continuing to decrease risk and providing order of magnitude improvements in service levels and agility. These imperatives combine to create an *economics of agility* that exerts profound self-reinforcing feedback for improvements across areas of cost, risk and quality.[1]

[1] Credit Suisse First Boston Executive Brief, "Vision" White Paper, June 2003.

Our networked applications and our workforce are becoming increasingly diffuse. We are distributing data services and servers, and the teams that manage them, throughout the world, with new strategies and products enabling a "complete, dynamic enterprise system within the framework of a service oriented architecture."[2]

There is extensive literature examining the individual topics of enterprise architecture and human capital, however, in all of this literature, there is a singular absence of clear management theory to lead this complex diffusion. Absent from the dialogue is a management model that incorporates these new technologies and business requirements into a practical set of principles. As Kenneth West notes:

> Given the importance of large business systems in large organizations, one would think the IT industry would provide adequate guidelines and best practices to assist.[3]

This paper offers a review of these new trends and a metaphor that helps to understand the underlying themes. It provides a management primer, a set of basic practices that can be applied to the transformation of your IT organization in the next decade, and it is based upon a concept that, in many ways, is quite simple.

Our information systems are mirrors of the organizations that build and maintain them.

Therefore, in order to transform our information systems, we must transform the systems of relationships that create and manage them.

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[2] John Seely Brown, "Your Next IT Strategy," Harvard Business Review, October 2001.
[3] Kenneth West, "Building a Dynamic eBusiness Enterprise Architecture Strategy," Warburg Pincus Technical Report, December 2003.

Seen from this perspective, we understand why each fundamental economic and technology shift in our history has caused a corresponding societal shift.[4] Canals, steam engines, railways, telecommunications – with each of these developments, economic and political transformations were evoked.[5]

As our world moved from a commodity-based economy to an information-based economy, the rules that governed systems were eventually understood, and by the mid-90's, this shift to an information-based economy was evident in most corporate environments. One example, in the area of IT management, should suffice: during the early adoption of net-based information services (1994-95), many of our initial efforts were managed in a strictly hierarchical manner by single MIS teams. These projects were problematic, and most often, unsuccessful. Alternately, those Internet projects managed horizontally by matrix teams, a cross-functional alliance of business users, corporate marketing staff and technologists throughout the enterprise, were ultimately far more effective.

From a Systems Theory perspective, this was not surprising. Internet applications (hypertext protocols, file search, browsing) are non-hierarchical functions. Eventually,

[4] Systems theorists have long understood that human organizations are also systems, and they function according to the same principles as our information systems. This theory states that our "people systems" must be organized and correlated with the information systems they oversee.

[5] William Janeway calls our current shift the "fifth great wave of transformational technology in the modern history of capitalism." Introduction to the Warburg Pincus Technical Report. December 2003.

we learned that we could not manage net-based projects with standard hierarchical management techniques. The systems were mirrors of the people that built them.[6]

The same principle can be applied to our current dilemma in IT: to support effective services-oriented architecture, we must design and lead the *Services-Oriented Enterprise*. The SOA requires an SOE.

It is not enough to simply instruct IT executives to do all of the right things (enable business users, enhance knowledge management and process tools, coordinate strategy with standards). The constraints upon the CIO in today's business climate are more extreme than ever before – budgets have declined to levels reminiscent of the Reagan recession, yet technologies have become 10x more complicated. The key ingredient is "organizational support" for the high value architectures a company implements, along with changed organizational models.

> …the skills required to organize <underlying technology components> into high value architectures are still in very short supply, and a new generation of skills must be developed with each new generation of architecture. [7]

The goal of this management primer is to provide some basic guidelines for directing the transition to a *Services-Oriented Enterprise*. Using these basic guidelines, IT executives can design their own particular "best practices" so that their IT organizations will continue to successfully enable their institutions in the coming decade.

[6] Robbins, "The System is a Mirror," Association for Computing Machinery, 1995.
[7] Ibid, p. 10.

According to Steve Yatko, who leads the R&D team at Credit Suisse First Boston in New York, this is the very essence of the need for services-oriented applications and infrastructure, because it is the only path to simplifying our complex enterprise environments, and ultimately reducing the total cost of ownership for them.
Yet it is more than simplification. The systems need to be constructed to mend themselves – automatically provisioning, balancing, restoring – toward the path of an autonomic system.[8] In this way, we can continue to reduce the overall cost of technology while increasing our ability to respond quickly to the needs of our business.

"The strategy is to rapidly evolve towards technologies and standards that support an agile network-based computing model."[9] This, in turn, will lead to levels of innovation that could only be supported on a system of this kind.

Credit Suisse has correctly identified the automation of enterprise Business Processes as the key enablers which, when orchestrated, provide the requisite cost savings and flexibility that is required of IT in the coming decade. They further identify three primary types of grids that must be integrated in such orchestration: computational grids, data grids, and infrastructure grids. This paper augments their analysis by proposing a fourth important "grid type": the IT management grid, functioning according to principles of a Grid Management Theory that mirrors the service-orientation being applied to our architecture, applications, and infrastructure.

[8] Interview with the author, January 6, 2004, New York City.
[9] Executive Brief, Credit Suisse First Boston, December 2004 update.

2. Management Principles

As observed in the introduction, some of these management principles were first recognized during a similar transformational phase, the mid-90's when net-based applications and hypertext protocols were being initially explored. Since that time, numerous journals have identified specific qualities inherent to "eBusiness" methodology that underscore the multi-disciplinary and interactive nature of systems, data, and the network.[10]

Naturally, the growth of grid computing is rooted in the ubiquity of the Internet and can be seen as the promise of the Next Generation Internet (NGI).

> In fact, the Grid is the natural evolution of the Internet and open standards, coming together…We are now faced with the introduction of disruptive technologies, the need to re-purpose corporate technology resources, and support constantly-changing business processes without the usual 2-3 years required to re-architect enterprise applications."[11]

It is only proper that the key principles in our management primer for the Service-Oriented Enterprise (SOE) are traceable to lessons learned during the past decade. However, they are no longer recommendations. They are no longer intriguing concepts worthy of discussion. They are now requirements. Transforming the enterprise to align with a services-oriented strategy is now critical for any mid-size or large company that

[10] See Donald Tapscott's book Digital Capital, for a description of "business webs" that thrive and are nurtured by inter- and intra-institutional technologies and processes creating value beyond the boundaries of traditional (contained) commercial enterprise.

[11] Mark Forman, former Director of Information Technology for the White House, Office of Management and Budget, in an interview with the author, February 2004.

hopes to survive these complicated economic times. No longer a "should," these principles are a "must" for IT in the coming decade.

Conventional wisdom within the CIO community, confirmed at professional gatherings and conferences every year, states that most problems facing IT organizations are not a result of the technology. Technology is the easy part of a CIO's job. Most IT executives will say, if asked, that 90% of the problems are people issues. And yet, countless IT organizations continue to focus exclusively upon technology, unable or unwilling to confront the more complicated dynamics of trust/learning, and relationship relevance in their institutions.

The advent of grid computing, and the requisite diffusion of human capital and inter-dependent commerce (grid-within-grid or grid-upon-grid) now require that IT executives confront these complicated dynamics. Technology alone will not produce the correct results until those dynamics are managed and interwoven into IT practices. "The CIO will be responsible to prepare business managers to deal with people/process issues."[12]

Those IT organizations capable of transforming themselves into relational business processes, mirrored by technology grids, will continue to be successful and thrive within successful institutions. Those IT organizations and leaders who are unwilling to or incapable of such transformation will not only fail, but they will inevitably become an anchor, dragging their business down with them.

[12] Kenneth West, Ibid, p.86.

3. The Primer

There are many kinds of adjustments we must make, as managers and as employees, in the face of complexity. Adjusting in real-time, which is a pre-requisite for performance in the adaptive enterprise, is even more daunting. We will address the broader implications of Managing Complexity in the concluding sections of this paper; however, there are specific management practices that can be used to nurture the type of organizational shift needed to create the Service Oriented Enterprise.

In this section, we identify 10 elemental techniques, with the hope that these will, in turn, guide the IT community to discover others. In the next section, we specifically focus upon the concept of Process Teams as an integral principle around which many of the individual revolve. Each of the individual techniques, listed below, lead to the optimization of Process Teams as an organizing principle.

- *Insubordination as an Asset* – Corporate behavior, molded from a century of labor-management conditioning, is to dictate ("because I said so") and to comply ("my boss wants me to x…"). The shift to a services-oriented architecture, and the processes requisite to that architecture, means that an employee's obligation is to the enterprise and not to the hierarchical manager (who may only be responsible for administration of regulations and corporate policy). The most illustrative behavior in matrix-managed organizations is for any employee to feel comfortable saying "no" to their boss because they have commitments elsewhere in the enterprise. Not only should they feel comfortable turning down a supervisor's hierarchical request, but the supervisor should also be comfortable with the interaction, and encourage it. IT managers must over-emphasize this adaptation because, as stated previously, it is not reinforced in standard corporate politics, and also because it is not engrained in many third-world cultures where contradicting one's superior is not recognized to be correct. This is also a matter of coaching and cross-management support; employees will not observe the model if they do not see it reinforced at the executive level.

- *Compensation* - During a meeting with the Federal CIO Council's Best Practices Group in Washington DC, Phil Thompson (CIO and SVP of eTransformation, IBM) offered his technique for eliciting cross-functional cooperation from staff throughout the enterprise that have a lot of things to do and do not report directly to the CIO. He suggested that the centralization of IT resources, in order to ensure that the horizontal initiatives were consistently addressed, was not possible in all cases. In such situations where key resources do not report to the CIO and yet need to provide consistent effort, Phil suggested that the CIO negotiate with the other Business Unit general managers to take over the tedious tasks associated with annual reviews and bonus distribution. He found that most senior executives want to retain direct control of the "headcount" yet are willing, in many cases, to transfer administrative burdens associated with performance bonuses to the VP in charge of a cross-functional initiative. In this way, Phil observed, you can gain control of compensation that allows you to regularly reward people for working on cross-functional responsibilities. IBM's eTransformation, in 1999 and 2000 was enabled, in part, by Phil's ability to reward new behaviors well beyond his own IT organization.

- *Reinforced Clustering* – A corollary to the previous recommendation is to include, in quarterly and annual objectives (management-based objectives, or MBOs) the expectation that each individual, including management, should be actively involved in 3+ cross-functional teams of certain duration, and that the inter-departmental involvement will be monitored (status reports, performance reviews, hourly tracking in the case of those legally required to record time) and rewarded, for those who consistently engage in more than the expected standard every year. The bonus structure (see Phil Thompson' suggestion, previous page) should reinforce cross-functional and support functions, just as in the case where service monitors log and report the most widely utilized software services and high availability priorities are re-assigned as service usage increases over time.

- *Communities of Practice* – Certain professional affinities can be institutionalized to provide technical and social networking within the enterprise. Job skillsets were previously reinforced by organizational boundary; for example, all of the system administrators were in the same organization, in the same group of offices and attended the same meetings. In a distributed organization where practitioners are service-enabled, assigned by request or circumstance to multiple teams and locations, it is recommended that formal Communities of Practice be budgeted and entitled so that cross training and information sharing within professional domains can continue. These communities of practice can also extend beyond the corporation, for example, where the corporate attorneys for company X and company Y are provisioned (by login and protocol/document access) to work in tandem, regardless of institutional relationship or geographic location.

- *Provisioning and ReProvisioning* – One of the most complicated aspects of the dynamic IT organization, in which working groups are clustered in important but temporary teams to address specific technical issues only to disband when the

issue is resolved, or when another (counter-valent) issue requires a different type of skills clustering to occur. Early stage companies are more familiar with this work style, in which key individuals in the organization may have two or even three primary (and very different) roles, and their supervisors appreciate and sometimes encourage this multiplicity until such a stage when the company can afford to assign distinct duties. This entrepreneurial ability to multi-task, and to be quickly understood in various tasks and teams, should be re-injected into the IT organization. A dynamic (learning) organization that promotes inter-disciplinary and inter-departmental tasking is better suited for services-oriented architectures. Employees must be trained to thrive in an adaptive organization, and tools should be constructed (identity and directory-based software that enhances the ability of individuals to correctly identify subject matter experts in other departments or divisions) or acquired that encourage frequent re-provisioning.

- *Chart of the "Organization"* – Everyone knows their position on the "org chart" and most managers and directors have very coherent perspectives on the visual representation of their department, at any point in time. The responsible director will also know who, by name and role, comprises the sub-category named "Engineering" or "Operations" or "Field Support." The teams' composition may change, but the responsible director keeps steady attentions on the particulars. However, the Director of Engineering may not know or remember who exactly composes the sub-category in Operations, only the proscribed manner for interacting with that team. In similar fashion to this "abstraction" of responsibility distributed throughout the service-enabled organization, agreements between functional groups can be "loosely coupled" allowing for great flexibility when needed. If the technologists are managed in this manner, it is more likely that they will be able to design and support applications that behave in this manner. You wouldn't be passing results of the batch script to Melinda; you would be passing them to the Registered Composer in Quality Assurance, whomever might be handling the responsibility on that day.

- *Councils* – Beyond IT Governance (the Gartner models), decision-making policies must be clearly designated (rules-based protocols with published exception handlers and error messaging) for each strata of the organization. Certain layers can be temporary, assigned to a team or task force and the results absorbed on a permanent council upon conclusion of the concern) however, most Councils are inter- and intra-departmental associations chartered to oversee particular elements of the business that most require multidisciplinary (critical) thinking and (frequently) outside advice or guidance. The Strategy Council is responsible for all long-term policies and decisions, and also responsible to oversee that policies are consistently reinforced (via alliances, vendor selection, prioritization across the enterprise, etc); the Architecture Council specifically oversees the technology matrix supporting the enterprise grid, expected to perform in-depth diligence and investigation, when needed, and respond to any inter-technology conflict that cannot be addressed by a Community of Practice.

- *Manage the Relationships -* The IT industry long ago discovered that it was not simply the data elements (a single bit of information in a table of similar bits) but the composite data in a relational database, utilizing meta-data to uncover relationships between elements. Our data center managers no longer manually configure a single server, but rather, are now coordinating resources for high availability, utilizing blades and automation to coordinate the relationships of individual pieces of hardware. Now it is time to apply that lesson to our individual technologists – it is time to move beyond our "one-on-one" meetings that occupy so much of a manager's time, to supervise two people or more in meetings that focus upon the relationship between their functional roles. Example: do not simply meet with the Engineering manager alone and tell her to improve her interactions with the Quality Assurance manager. Meet with them together and directly discuss why there is conflict between their teams, and what can specifically be done to improve the overall performance. Stop managing individual people and start managing the relationships between them.

- *Presentation Layer* As our infrastructure and our applications become utilities (the inevitable growth of On Demand Computing), our strategic focus must move toward the user interface. As with any globally-applied solution, the generic software product will require a localized presentation layer – this localization will include toolkits that are easy to use and easy to be manipulated, so that "end users" will continue to have control over their desktop, even when the actual functionality of the desktop may be delivered by service providers outside the boundaries of the institution. The ability of each IT organization to manage and deliver exceptional control of the presentation layer (including personalized business intelligence, without denigrating performance) will be able to traverse the coming changes in IT and will still be able to exert technology leadership throughout the institution. Those IT organizations that do not deliver top-notch service at the presentation layer will risk losing control of the technology function entirely to the business units. Identifying and increasing the usability expertise within the IT organization will become increasingly important as this shift to the presentation layer continues.

- *Productivity vs. Innovation* This final area of "best practices" involves a shift in attention on the part of IT analysts and IT management. The current trend for continued cost savings has delivered exceptional productivity improvement (increased efficiency) within the corporation, and most projections indicate that this emphasis on cost savings will continue. However, as we move to utility-based computing (which also offers percentage improvements in the total cost of IT), there will also need to be increased attention toward the role that technology plays in the evolving culture of innovation that will become even more important. Each "domain of expertise" in IT should include senior staff that are capable not only of demonstrating productivity improvements within the enterprise, but teaching business users how they might adjust or improve their practices in line with the new technology. IT organizations that can only improve the plumbing

will increasingly be relegated to lesser importance in the business. Those that can lead the company, bridging the technology transformation with clear lessons for business transformation through innovation, have an opportunity to become business leaders within and beyond the boundaries of the institution.

- *Refinance in order to Remodel* Analogies from other disciplines are useful to initiate conversations compounded by complexity. While IT organizations consistently struggle with Finance/Operations about the cost of new projects, most of those individual IT managers have already solved a similar problem in their personal lives. Perhaps they needed to reinforce the foundation of their home, yet their salaries were not increasing to afford such an immense cost. By restructuring their current mortgage, they could "pull out" enough money to afford the remodel and perhaps even add a new room or expand the kitchen during the project. The corporate analogy: a critical review of all software and hardware maintenance contracts, combined with a strategic evaluation for end-of-life (EOL) plans, can often provide the budget opportunity to lay the architectural framework necessary for a services-oriented infrastructure.

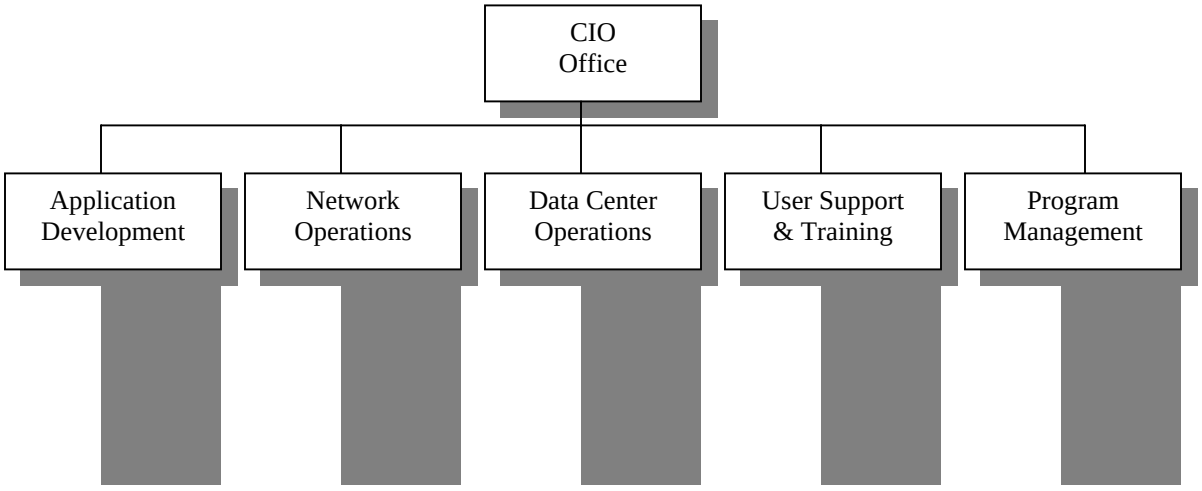
4. Process Teams: Why They Work (and Why They Don't)

Perhaps the most significant shift in workforce methodology will be the dramatic shift toward process team management. For decades, this approach has been relegated to the TQM and Six Sigma initiatives – everyone likes the idea, and who can argue with the benefits of a cross-functional team enabled to be successful? With the increasing significance of grid computing, this approach becomes a mandatory way to address what Stephen Haeckel calls this the "sense and respond" organization.[13]

Standard IT organizations do not become "sense and respond" entities overnight. One intermediary step in the learning curve, toward the goal of creating a services-oriented approach throughout your organization, is to understand and implement process teams for the major initiatives (Introductions of New Technologies, Globalization, Change

[13] Stephen Haeckel, Adaptive Enterprise: Creating and Leading Sense-and-Respond Organizations, Harvard Business School Press, 2003.

Management) as a means of training both your management and your IT staff on the contrary nature of responding to issues by an alignment with key business processes, rather than responding to issues by functional/departmental identity.

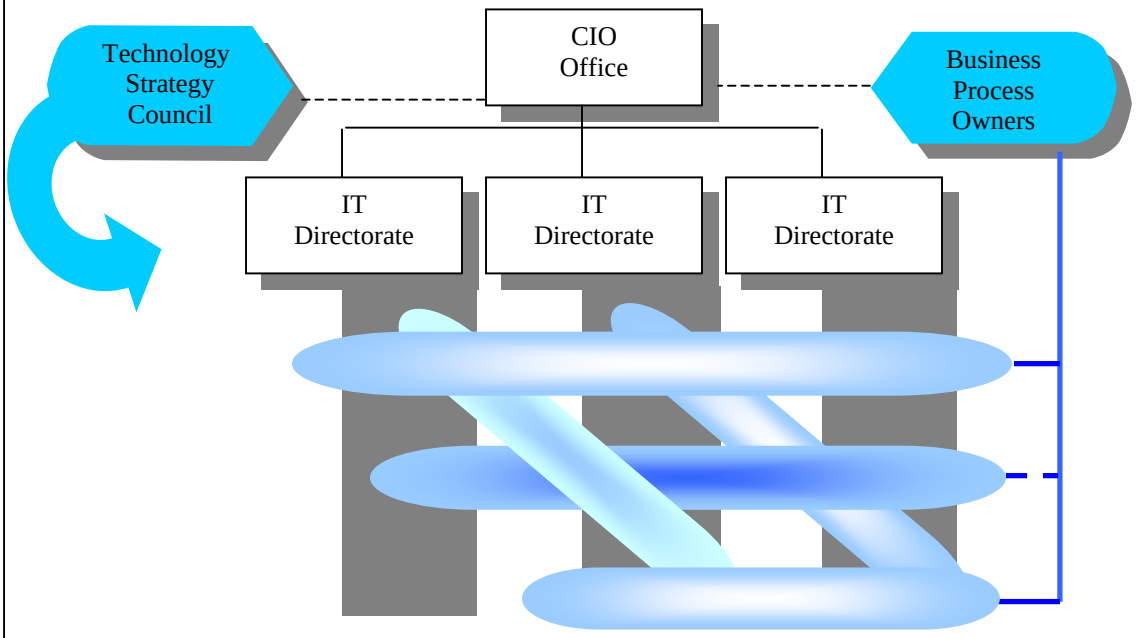


Example 1: Standard IT Organization managed by Functional Area

In an organization such as that diagrammed in Example 1 (above), communication flows hierarchically and projects are managed by formalized teams aligned by functional domain. In even the most successful companies, IT organizations can still be understood best by means of this traditional framework. Rank, determined by hierarchical position, reflects the capacity to make decisions, etc.

Among the "customers" in such companies, IT has the reputation for lengthy and expensive project cycles, promising a lot and delivering a little, and in the worst cases, not delivering anything at all.

In an organization such as that diagrammed in Example 2 (below), communication flows horizontally and vertically and projects are managed by cross-functional teams directed by business process owners, in coordination with the Executive Team.



Example 2: IT Organization driven by Process Teams

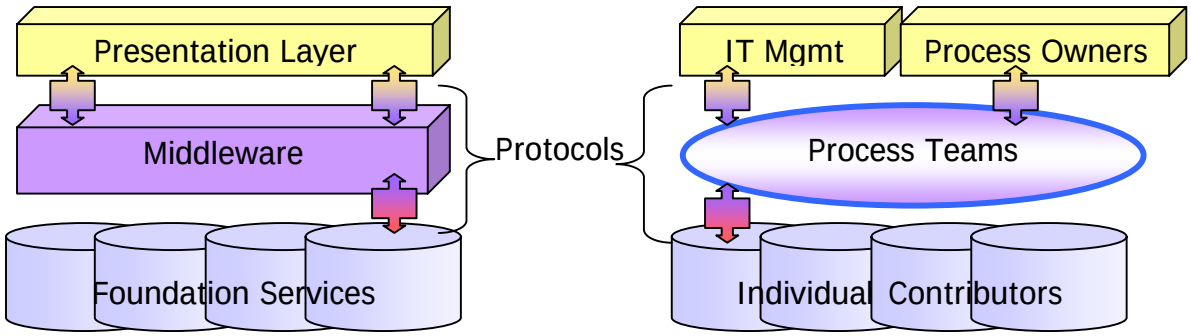
There are entire books written about process team management. It is not in the scope of this paper to outline every necessary feature, however, there is a quintessential element of process team management that has clear and compelling application in the area of grid management, which is the importance of open/standard protocols and interfaces.

This metaphor, the role of the API in organizational development, is a useful tool because it is based upon principles that all technologists understand and accept.

In traditional software development methodology, application programming interfaces (APIs) are the defined intra-layer protocols utilized to pass data in regulated manners between different types of software. While the role of the API in software development,

integration, and testing is well known, its mirror analogy is less familiar but equally important in the services-based organization.

As with the software, each organization has different functional layers (individual contributors at the foundation level, middle managers at the middleware level, executives at the presentation layer) and there is a similar need for APIs between the organizations: initially, the API can be a program manager or team lead responsible for creating the published standard for communication, decision-making, or escalation between the layers, however, eventually it should be a business process, accessible by anyone in the appropriate role (appropriately provisioned to pass information or receive information). *Failure within organizations is almost always traceable to the absence of or inadequacy of an API between the relevant departments or teams.*



Success factors for Process Teams reflect basic API design principles:

- The management team, like a well-designed presentation layer, must be easily understood, usable, and responsive.
- The Process Team, like middleware, must manage the information/task flow reliably and clearly communicate errors in a manner that can be addressed and resolved
- The ability for individual contributors (foundation services) to be successful is directly related to the capacity of the entire system to utilize communication protocols (API's) to interact, ensuring optimal performance and predictability.

5. What is the Service Oriented *Enterprise*?

In a Service Oriented Enterprise, there is an ecosystem of managers, employees, alliance partners and vendors organized in a loosely-coupled framework specifically designed to provide support for and respond to the ongoing requirements of a grid computing environment, in order for the systems and for the business of the enterprise to be optimized in an ongoing manner.

> Web Services will eliminate barriers between systems and organizations and thus can enable an entirely new class of organization, the seamless enterprise…"[14]

Zapthink's "seamless enterprise", for our purposes, can be defined as the business organization's ability to rapidly and easily implement multi-party interactions. It is an entire business operating efficiently along the protocols and principles described in a services oriented architecture. With the barriers eliminated, both in our technology and in our processes, and with an organization that is aligned to encourage rather than thwart this service orientation, new levels of IT efficiency and innovation will emerge.

One aspect of the "economics of agility" noted by the teams at Credit Suisse First Boston is that the network-based computing model and autonomic computing platforms allow us to undergo (or rather, accelerate our own insistence upon) rapid change. The old "federal versus state" metaphors become stale, because the boundaries between states and the relationship between federal and state entities in large enterprises will become

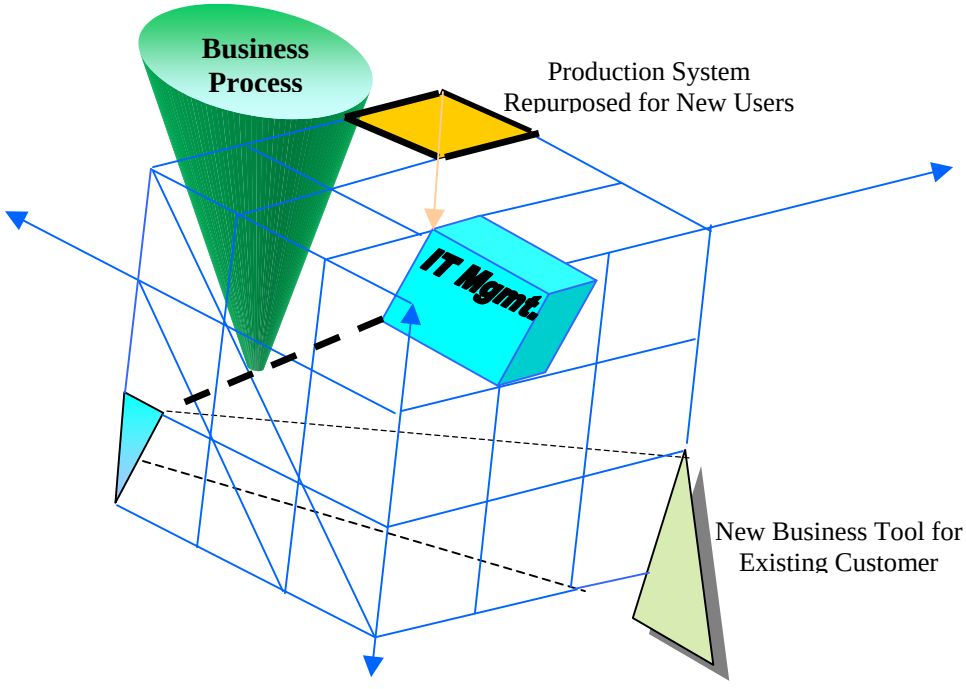
[14] http://www.zapthink.com/wspractice.html

increasingly dynamic, requiring a more agile way to respond to the needs of the enterprise.

It is this relationship between components of any system which makes the system unique, allowing it to grow or change or, impacted by change, to become unbalanced and ultimately dysfunctional.[15]

Our organizations are information systems, and our enterprises are systems, embedded in a system of relationships beyond the borders of the corporation that outline the exchange of core products or services that has value in our economy.

We Must Transform Ourselves



Example 3. Conceptual response/action sequence in Grid-oriented organization

[15] Robbins, ACM, 1998.

6. Managing Complexity in Real-Time

What is Complexity?

There are as many different definitions of "complexity" as there are species in our universe, and this metaphor offers the most basic definition, because complexity theory was once the domain of the physical sciences. Complex, adaptive systems are very similar to flocks of birds in flight, wherein the individual bird (autonomous agent) needs only to follow the basic rules: don't bump into anything, keep up with everyone, and stay in close proximity to the formation.[16]

[16] Megan Santosus, "Simple Yet Complex," CIO Magazine, April 15, 1998.

An excellent analogy can be found in the world of environmental art, specifically in the sculptures of Andy Goldsworthy. (See a picture of his sculpture, Stick Dome, p.19.)

The natural assumption is that the illustration portrays the end result of the sculptor's efforts, however, it is only the interim phase of the project.

As the sea approaches the beach, the oncoming tide slowly lifts the entire stick dome and it floats independently out to sea, where the swirling tides slowly uncurl the arrangement to create an immense, dynamic spiral that is entirely in sync with the complex water currents that support it.

Our analogy to the current service-oriented architecture and the broader field of autonomic computing is easily explained: current rigid system architectures are akin to the stick dome on the beach, which required very specific manual intervention to be constructed and to be maintained over time. The stick dome, once afloat in the sea, is our architecture that exists dynamically with the surrounding environment, responding to complex change without human intervention.

Clearly, IT management techniques for one type of architecture (rigid, manual, costly) are the practices seen in most current IT organizations: high degrees of attention and effort being given by very senior staff to maintain the structure on its changeless foundation. IT management techniques for the dynamic architecture, in which the spiraling architecture is self-governing, aligned with natural forces of change and requiring little human intervention, are quite different.

Therefore, it is useful to gauge how much change our organizations must undergo, to move to the next level of computing. Consider this, from an article about Managing Complexity in CIO Magazine:

> A few simple rules guide the interaction between the components of a system. First, in a business context, managers should attend to relationships at all levels of their organizations. The second rule is that small changes can have large effects. And third, interesting and unpredictable properties can be expected to emerge from a system. As a result, it is hard, if not impossible, to implement a strategic plan for anything but the short term.[17]

Subsequently, one of the first and most important objectives for IT leaders that hope to move their organizations from the rigid and expensive paradigm of their current architectures to the more adaptive, autonomic systems in the network-based computing model is to begin the education (of their employees, of their executives) that a dynamic technology framework requires a dynamic organizational framework, one in which teams can form spontaneously (without formal approval structures or barriers) to solve problems in their context.

In an institution where relationships thrive and trust is an enabled commodity of exchange between management and the employees, those employees are capable of responding to even the most extreme problems. Their solutions will be innovative and cost-effective, and will be implemented quickly. Once a single institution (single system) begins to behave in this fashion, the overall enterprise (network of networks) can begin to interact in this manner.

Such is the promise of a network-based computing model.

[17] Roger Lewin, CIO Magazine, April 1998.

Some Concluding Observations

We have demonstrated the relationship between our information systems and the systems of relationships required to manage them. The correlation can be extended one level further, to the individual employee – not only at the CIO level, where the changes will be the most obvious, but for each IT employee who may become a distributed service, a function that is available and accessible to those who have been provisioned to access the service. In this way, it could be said that a truly enabled services-oriented enterprise will be composed of *services-oriented employees*, each capable of rapid response to changing business needs through an orchestration of loosely-coupled functions and clearly-delineated standards and processes.

The industry needs a new vocabulary. When Quantum Physicists transformed the mechanical view of the universe by declaring that a wave could also be a particle, they triggered not only a new way of looking at the physical world, but a change in vocabulary to address the transformed perspective. We are at such a stage in the computing industry, where old notions of servers (hardware or software) and objects (in databases) are replaced by virtual computing environments composed of an infinite number of potential resources, where people can be nodes and objects and users simultaneously.

> "…one has divided the world not into different groups of objects but into different groups of connections…The world thus appears as a complicated tissue of events in which connections of different kinds alternate or overlap or combine…"[18]

[18] W. Heisenberg, Physics and Philosophy, as quoted by Fritjof Capra in The Tao of Physics, p. 252.

This distribution of resources, the natural outgrowth of diffusion in the workplace, suggests that the hierarchical relationships (who reports to whom) become far less important than the actual skill set of the employee. Systems will ultimately include data about the employees of the corporation, and applications will be created that allow for and support the engagement of IT functionality (whether it is from the computing grid or the "Employee Grid") throughout the enterprise. Exceptionally talented IT practitioners will take assignments on a prioritized basis from a wide variety of users distributed around the world.

The task of IT management (utilizing Grid Management Theory) is to capably and efficiently create an environment wherein the talent that is available to the enterprise is well utilized, well managed, and productively distributed. Every senior manager, responsible for their particular (functional) section of the grid, will also be responsible for efficient utilization of IT resources (personnel) in their functional section. To do so, they must understand the necessary correlations between skills sets, prioritize business needs in real-time, and be able to manage change (at the systems and business level) so that new work does not impede the overall stability of the architecture.

One of the barriers in the IT industry that has prevented a clear definition of the term "web services" can be traced to the inclination, within the industry to obscure or entirely overlook the very human aspect of information technology. By limiting our understanding of services oriented architectures to the technology – by once again omitting the human-centric element – we have unintentionally excluded the primary

element that bridges the disciplines of complexity theory, autonomic computing, and a network-based computing model.

In order to properly manage our networked systems, we must properly manage the people that build and support them. To do so, we must manage the relationships between people and organizations in addition to the relationships between objects and file systems.

This is Grid Management Theory for the IT executive.

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Revision History and Acknowledgements

Version	Author	Publication Date	Changes
Revision 1.0	Stuart Robbins	February 20, 2004	Circulated for Internal Review: Forman, Dowell, McAllister
Revision 2.0	Stuart Robbins	March 31, 2004	Cassatt feedback incorporated; new diagrams drafted
Revision 2.2	Stuart Robbins	April 8, 2004	Circulated for Internal Review: Dowell, Forman
Revision 2.2a	Stuart Robbins	May 15, 2004	External Review*

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