Towards a Theory of Agile Dashboards for Service Oriented Organizations

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ABSTRACT

Research on the agile and adaptive enterprise promotes real time dashboards as a powerful tool to provide coordination and control. Recent trends in market volatility have led firms to restructure around what organizational theorists term an “adhocracy”. Service oriented architecture represents an emerging architectural mechanism to align an organization’s processes with the flexible structure of such an organizational form. A theory of dashboard creation and implementation that addresses the organizational characteristics of an adhocracy (as exposed through the formalism of a service oriented architecture) is needed in order to develop a grounded methodology for dashboard creation and implementation that targets the coordination and control requirements of this evolving organizational structure. This research seeks to provide such a theoretical foundation grounded in the context of two diverse case studies. Cementing a theory base for dashboard creation and implementation helps to formalize the role of dashboards in service oriented organizations and provides the first step towards developing a methodology for dashboard design and use in an agile environment.

KEYWORDS


INTRODUCTION

In 2004, Paul Gray and Omar El Sawy, along with three executives from Western Digital Corp, published in MISQE an ethnography depicting Western Digital’s implementation of a series of information technology dashboards as an interface to real time operations data (Houghton El Sawy Gray Donegan and Joshi 2004). Their work is in line with a stream of research examining the adaptive and agile enterprise (Campbell 1998; Davenport 1998; Goranson 1999; Haeckel 1999). Western Digital reaped great rewards from the initiative to the tone of a 50% reduction in operations cost. Gray and El Sawy’s account of the Western Digital initiative culminated in a set of “lessons learned” based on the company’s experience in developing the dashboards and their supporting technology.
Gray and El Sawy identify four types of dashboard technologies and organize them across the dimensions of underlying technology infrastructure and origins of their business need as shown in figure 1.

EIS business performance dashboards stem from traditional executive support systems and present top level management with a real-time snapshot of high-level firm performance. Operations control dashboards are local to a specific operational group and give local management greater visibility to the operational performance of their group only. Business process dashboards are geared towards monitoring the performance of transactions as they flow through the enterprise, while collaborative dashboards facilitate joint efforts to execute a transaction by the constituents of the transaction’s workflow.

Gray and El Sawy’s experience with Western Digital took them through the development and implementation of EIS business performance dashboards and operations control dashboards. They conclude their work by suggesting that while Western Digital found success in customizing its legacy architecture into an agile “sense-and-respond” network, new architectural paradigms were soon to be realized that promised to impact both the way that dashboards are implemented and the types of dashboards that must be brought to bear. They make note of the fact that Western Digital, in an effort to increase the agility of its operations, is “moving in the direction” of both business process dashboards and collaborative dashboards. The goal of this movement, combined with the upcoming architectural revolution championing agility, would be to “enable seamless integration of business processes, permitting faster response”.

Concurrent with Gray and El Sawy’s work, service oriented architecture (SOA) has emerged as a platform revolution fostering operational agility. With a transition to SOA, and to an organizational structure suitable for the environmental context which motivates increased agility and flexibility as a key performance characteristic, business process dashboards and collaborative dashboards become not only performance enhancers, but are vital tools in the management of operations in an environment of heightened agility through reengineered technological and organizational architecture. The work presented here looks to champion the efforts of Gray and El Sawy as firms begin to transition to a service oriented architecture and operational structure. We seek to ground the business process dashboard and collaborative dashboard in theory that will serve as a foundation for agile dashboard construction and implementation methodology. A formal methodology for these dashboards can serve to improve the currently ad hoc nature through which dashboards are constructed. A solid theoretical foundation for such a methodology provides a basis for discovering patterns of dashboard construction and implementation, as well as highlighting critical characteristics for dashboards in specific contexts.

We choose to focus our research through organizational theory for its contributions in explaining the contemporary motivation of many firms to restructure to a more agile form, supply networks as an analog to agile organizational structure, and coordination theory to examine the critical aspects of coordination and control in the context of an agile organization. In order to formalize the structure of an agile organization and therefore begin to decompose it into analyzable elements, SOA is presented as an architectural mechanism for closely aligning a firm’s processes to an agile organizational form. The formality of SOA definition can then be translated to an agile organizational structure itself.
The rest of this paper is organized as follows: section 2 leverages organizational theory to explain what is driving the need for firms to adapt their architecture and organizational structure towards increased agility as well as how the agile-structured firm behaves. Section 3 lays out the vision of Service Oriented Architecture (SOA), or more generally a service orientation, as a critical enabler for firms to be able to fully adapt to an agile style of organization known as an “adhocracy”. Section 4 maps interactions in an SOA-enabled adhocracy to those of a supply network and details the characteristics of these types of interactions. It will be shown that business process dashboards and collaborative dashboards expose critical interfaces to coordination and control points for the operations of the agile firm. Coordination theory is leveraged to derive mechanisms that target the predicted requirements for control and coordination of instantiated processes. These mechanisms inform the design of business process and collaborative dashboards and predict characteristics of dashboard implementation in this context in order to preserve the agility of the organization. Lastly, in section 5 reports from the early stages of case studies with both a major international computer chip manufacturer and a major international financial institution are presented as evidence to support the emerging theory base of a methodology for agile dashboarding.

ORGANIZATIONAL STRUCTURE IN TODAY’S VOLATILE ENVIRONMENT

Mintzberg argues that a firm’s choice of organizational structure is dictated by both the complexity of the firm’s processes and the volatility of the firm’s environment (Beshears 2005; Mintzberg 1983). Table 1 demonstrates organizational structure under Mintzberg’s intersection of complexity and volatility.

<table>
<thead>
<tr>
<th>Simple</th>
<th>Complex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stable</td>
<td>Machine Bureaucracy</td>
</tr>
<tr>
<td>Dynamic</td>
<td>Entrepreneurial Startup</td>
</tr>
</tbody>
</table>

Table 1: Organizational Structure Matrix

Historically, business strategy has been oriented towards maintaining stability in the business environment in order to support the organization as either a machine bureaucracy or a professional organization. A machine bureaucracy is characterized by routine and predictable activities that can be automated and executed at high volume. Professional organizations are characterized by a stable set of expertise that can be leveraged to support demand for similar types of problem solving. Within the confines of these stable environments, organizational theory posits that standardized processes and standardized skills or norms represent the appropriate coordination mechanism. Efforts to maintain stability in the business environment have lead to a wealth of business process standardization and enterprise norms which help to coordinate operations through a shared and standard vision across the firm.

It has been predicted from forward thinkers the likes of Peter Keen (Keen 2004) and noted in the work of Gray and El Sawy that increasing complexity of market demand and accelerated pace of change will necessarily drive firms to an adhocracy structure. Under this scenario, the pace of change in a given firm’s environment becomes so rapid that efforts to maintain environmental stability prove ineffective.

By Mintzberg’s definition, an adhocracy represents the environment where traditional organizational structure and management philosophy break down. He characterizes adhocracies as composed of dynamic, market-based teams built on the advancement of preserved knowledge and led primarily by project management of ad hoc project groups or teams. We posit that these market-based teams take on a service orientation in the way that they specialize on fulfilling specific aspects of a firm’s demand.

Fulfillment of business requirements, then, occurs through the choreography, or stringing together, of resources into a team structure to meet a specific and potentially unique need. Resources represent the full spectrum from human capital to equipment to information processing and data services. A resource for a project team may even take the form of another project team. This is similar to the “project office” management approach for IT services (Demirkan and Nichols 2008).

Under this structure, a new management focus arises in terms of the requirements for handling engagement and coordination across resources as they are choreographed together to suit the needs of a business process. This calls for mechanisms to both schedule and monitor the execution of a process as it transitions across a choreography of teams, and to facilitate the transition of a work product from team to team.
The emergence of Service Oriented Architecture (SOA) as the new business service platform provides an architecture to formalize interfaces for low level resources composing the Service Oriented Infrastructure (SOI). SOI can then be choreographed into compositions of resources suited to a business processes needs which stem from market-driven demand and therefore map to the market-based team concept of the adhocracy. SOA therefore represents an architectural mechanism to closely align a business’s structure with the characteristics of adhocracy as predicted by Keen to be mandated by the current business climate. The next section details the concepts and capabilities of SOA that can be leveraged to provide architecture/structure alignment as outlined above. Current research on SOA is beginning to consider the enterprise-wide and cross-enterprise conceptualization of service orientation known as the Service Oriented Enterprise (Brown and Carpenter 2004; Goul Demirkan Nichols and Keith Working Paper). Under this conceptualization, where all of a firm’s resources can be mapped to services and exposed for service invocation, SOA provides the necessary alignment of technical architecture and organizational structure for formalizing execution interfaces in an adhocracy.

**SOA: A PLATFORM FOR ADHOCRACY**

Service Oriented Architecture is rooted in a movement to modularize the components of software applications, standardize the invocation of software components, and therefore transform the software development process from the creation of inflexible applications to the stringing together of specialized components with standardized interfaces resulting in adaptable software that can conform to the changing needs of the business processes it is built to support (Nichols and Chen (Forthcoming); Papazoglou and Georgakopoulos 2003).

![Diagram of SOA Architecture](image)

The power of the SOA paradigm materializes when the standardized invocation interfaces for components (made possible by web service technologies) are mapped to organizational resources beyond computational services (Demirkan Kauffman Vayghan Fill Karagiannis and Maglio 2009). Under this paradigm, components represent human capital, computational services, machinery, project teams, etc.

Figure 2 depicts the generic SOA architecture as rooted in the foundational technologies detailed in Erl (Erl 2004) and conceptualized more generically in Demirkan and Goul (2006). Business processes at the SOA level are mapped to services at the SOI level which are, in turn, mapped to specific resources required to perform the
specific service. This architecture leaves open the possibility for multiple different compositions of services providing the required capabilities to support a given business process. Further, the mapping of resources to a specific service is itself not considered static. There may be multiple resources capable of performing the required functions to bring about a specific service offering.

Under this conceptualization, resources are no longer constrained to operate within the boundaries of a static organizational structure. The demands of a volatile and evolving market are represented by the business processes that they invoke within the firm. These business processes are supported by choreographies (or groups or teams) of services that can be combined to tailor to the unique requirements of the process that invokes them.

Each service leverages the capabilities of resources which may themselves consist of services, in which case the mapping of a business process (market demand) to a choreography (group or team) of services is recursive in nature with the mapping of a given service’s process for execution mirroring the mapping of a business process to a set of services. A required capability for a component’s execution process is either assigned to a resource local to that component, or is sourced through other components. The pattern continues for each component’s execution process until each execution process requirement is mapped to a resource. This recursive process is depicted in figure 3.

In order to support this style of recursive mapping, we identify the characteristics of an adhocracy’s market-based teams following the lead of traditional SOA in terms of defining standard interfaces through a minimal set of capabilities required for each team. As shown for each team (hereafter referred to as component) in figure 3, a component must be able to reveal its capabilities and become engaged or committed to a workflow (advertise/market and bid/expose capabilities), to receive a work object (the supplier facing aspect of the component), transform a work object to the desired output (through internal capabilities and by possibly recursively sourcing aspects of its internal processes), and to pass the results of work object transformation along to the next stage in the service choreography (the customer facing aspect of the component). Figure 3 therefore depicts the recursive nature of the resource mapping process where the component at the top is selected as part of a service choreography and begins the task of mapping aspects of its internal processes requirements to further components in its own choreography.

Without loss of generality, the sourcing process described here is represented in figure 3 through a market mechanism of requests for proposals and bids. This process could also be conceptualized as a centralized one in
which control is given to the sourcing component and candidate components share information such as availability of resources. In either case, and as depicted in figure 3, any given service type required for a specific process may be achieved through the invocation of one of a set of components. Regardless of the mechanism leveraged, sourcing a choreography for a process requires selecting which of these alternative components to invoke. Once a choreography is defined, execution occurs along the sequence as depicted in figure 4. Each selected component performs their function and passes the result along to the next until the requirements of the process are met.

Figure 4: Choreography Execution Flow

In this fashion, the organizational SOA vision, as laid out in Goul et al. (Goul et al. Working Paper), provides an architecture closely aligned with the characteristics of an adhocracy: dynamic teams (component choreographies) responding to volatile market demand (evolving business processes) by leveraging specialized resources (people, equipment, other services, etc) in a manner tailored to unique market requirements.

SOA-ENABLED ADHOCRACY AS A SUPPLY NETWORK

Nassimbeni (Nassimbeni 1998) points out that those organizations taking the form of an adhocracy evolve to resemble a supply network. A supply network for this purpose is defined as a market enhanced by additional coordination and communication capabilities. Entities in a supply network, referred to as “nodes” of the network, are given autonomy in order to support product and process flexibility. This is to say that nodes in a supply network organize themselves to fill a specific aspect of demand so that they can contribute in concert with other nodes to meet volatile demand patterns in a manner flexible through both product and process. We believe this depiction of nodes and node interaction in a supply network to be analogous to Mintzberg’s notion of market-based teams in an adhocracy.

The critical difference between traditional markets and supply networks is the infusion of a higher degree of communication and coordination (i.e. enhanced collaboration). The incentive to participate in collaborative fashion is derived from the interdependencies in a supply network that prove greater than those in a traditional market. Nodes are both vertically interdependent through their reliance on the nodes from which they source, and horizontally interdependent through their reliance on nodes with which they are connected to execute a given business process.

These interdependencies which incent and therefore make possible higher degrees of coordination, communication, and control, give rise to a critical tradeoff in the design of any supply network (and therefore any adhocracy): Coordination and control mechanisms must be leveraged to the highest degree possible in order to synchronize node activity and create efficiencies in node engagements while preserving the autonomy of the nodes themselves in order to ensure the flexibility of the network structure. The tradeoff between coordination and control to improve firm performance and autonomy to maintain competitiveness in the market ads a dimension of complexity to the coordination and control paradox (Gittell 2000). Handling the complexities of this paradox involves an exploration of the coordination and control mechanisms that theory suggests will most adequately address this need for node synchronization and efficiency without sacrificing autonomy.

Supply network integration has examined two types of network interactions analogous to the recursive SOA process mapping and the SOA choreography execution outlined in section 3. These are the contractor/subcontractor interaction and the production chain interaction. A brief description of each interaction is followed by an application of theories of coordination in order to position the business process dashboard and the collaboration dashboard as key enablers in the context of supply networks. Since the interactions described below are analogous to two key SOA interactions, and since organizational SOA has been presented as a formalism closely linked to adhocracy structure, the role of the dashboards in a supply network map directly to the role they might play in an adhocracy. The theoretical exposition of how these dashboards may be oriented in a supply
network, then, is analogous to grounding them through theory to their appropriate role in and the beginnings of their needed characteristics for the agile organization.

**Contractor/subcontractor interactions**

![Figure 5: Contractor/Subcontractor interaction (adapted from Nassimbeni (Nassimbeni 1998))](image)

The contractor/subcontractor interaction is analogous to the recursive SOA process mapping interaction. A node selects other nodes from which to source components of a larger good and is then responsible for monitoring execution across each subcontractor node, viewing the execution as a workflow or a choreography. The primary coordination mechanism as suggested by Mintzberg is “direct supervision”. Direct supervision is described as scheduling and tracking the progress of flow along the supply line or choreography (Nassimbeni 1998). This is analogous to the purpose laid out by Gray and El Sawy of the business process dashboard:

“...most commonly used for transactional processes. It monitors business processes across an enterprise while they are executing…” (Houghton et al. 2004)

Coordination theory suggests that the dashboard developed for this interaction go beyond scheduling and tracking to facilitate examination of choreography alternatives in a planning phase prior to flow execution. The extent to which effort is spent upfront designing the choreography is related to the rate at which the execution stabilizes (Mookerjee and Chiang 2002). This is to say that extra effort and therefore increased planning capability for business process dashboards in this context is inversely proportional to the ability of choreographed nodes to coordinate amongst each other independently during execution.

Coordination theory further prescribes that monitoring at this level focus on additional measures such as volatility of requirements during execution, duration and difficulty for nodes to adjust to changes in requirements, and rework time possibly as relates to requirements misspecification or inability to adapt to changes successfully (Hayashi and Herman 2002; Koushik 1995). It is likely that dashboards designed to monitor such items will need to rely on historical performance of nodes across these dimensions.

**Production Chain Interactions**

![Figure 6: Production chain interaction (adapted from Nassimbeni (Nassimbeni 1998))](image)

The production chain interaction is analogous to the SOA choreography execution flow interaction. Nodes that have been selected for a given choreography are now responsible for handling the work object transition between each other. Mintzberg’s primary coordination mechanism for this interaction type is “input/output standardization”. This mechanism is described as synchronizing the transition between two nodes both through formal interface definition and support for actual work object hand-off. This is analogous to the purpose put forth by Gray and El Sawy of the collaborative dashboard:
“...Shared by multiple partners in a ... supply chain and provides ... synchronization across enterprises.” (Houghton et al. 2004)

Coordination theory suggests that the collaborative dashboard support the capability to predefine the work object through formal interfaces (Terwiesch and Loch 1999). The greater the extent to which outputs from each node can be formally defined for a given choreography, the greater the opportunity for parallel development to reduce cycle time. It is also suggested that collaborative dashboards represent a mechanism through which disruptions in internal execution can be propagated to nodes waiting for output in order to initiate a rescheduling or other activities geared towards maintaining efficiency of the network as a whole.

Mutual Adjustment: Agile Dashboards in an SOA Adhocracy

Organizational theory refers to mutual adjustment in a supply network as the continuous exercise of solidifying procedures, mediating issues, and resolving problems. In an SOA adhocracy sense, mutual adjustment represents shared efforts and resources for improved control and coordination over the life of the organization. The SOA platform is enhanced as depicted in figure 7 by the mutual adjustment efforts that make possible the mapping of metrics and operational data to dashboards geared towards each unique interaction while the adhocracy operates.

![Figure 7: Dashboard roles and relationships](image-url)

Each type of dashboard is agile in the sense that the key performance indicators may vary across each dynamic implementation as suits the autonomous nature of the components. In an environment where autonomy is a precursor to agility and therefore viability as an organization in the face of volatile demand, this type of flexibility in supporting technologies is critical to provide the requisite variety for the unique characteristics of components and choreographies (Ashby 1969).

The dashboards from Gray and El Sawy have been organized in figure 7 as a stack where metrics from each dashboard can be composed of more granular metrics that suit the class below. This is an extension of their work in which they noted that the strategic EIS business performance metrics were derived from transformations of operations control metrics across the enterprise. In this environment, operations control dashboards local to components leverage metrics which can be transformed to support monitoring and control of input/output transitions through collaborative dashboards. Business process dashboards, for which the task of monitoring choreography execution is assigned, can benefit from transformations of metrics used in the collaborative stage for each input/output transition in the choreography. Finally, strategic performance metrics to monitor the performance of the organization as a whole can be formulated as, Gray and El Sawy show, from transformations of lower level dashboard metrics.

In a supply network, mutual adjustment results in a kind of “shared overhead” supported by all network participants so that the overall network performance improves to the benefit of each node. In an organizational SOA, the “shared overhead” of
maintaining performance history and metric definition categorized by component characteristics, input/output transition characteristics, and choreography characteristics becomes the analog to mutual adjustment efforts in a network environment.

The collaboration and business process dashboards find their place in this environment as tools to preserve the required autonomy and flexibility of the organization and its components, and coordination and organizational theory begin to create a foundation for the characteristics of these tools that will create the greatest advantage through increased control and process management.

SUPPORT FROM TWO CASE STUDIES

The research team is in the early stages of case research with two major international firms. The first, an international computer chip manufacturer, has engaged the team as it works through the process of defining dashboards to support coordination of their supply network in a Service Oriented Enterprise context. The second, an international financial institution, has recently restructured their business intelligence organization into component teams as a response to the increasing volatility of demand for their products and services. They are working with the research team to better understand the costs associated with their processes and how to coordinate component team interaction through agile tools as they adapt to their new service orientation. They have noted the significance of engagement overhead as a result of their shift in structure and are targeting efforts to combat this new cost driver while preserving the agility gained from restructuring. Brief accounts of the current state of these two firms are presented below. Both are exemplars for the need of an agile dashboard methodology targeted at addressing coordination and control issues in a service oriented context.

Coordination of the Service Oriented Enterprise: The Case of a Leading Chip Manufacturer

The firm in this case has embraced and is actively involved in research on the concept of the Service Oriented Enterprise. The scope of the research being performed with this firm spans the firm’s supply network. They are advocates of the conceptualization of components in an SOE as spanning organizational boundaries, which extends the scope of the adhocracy to the level of the value chain and adds validity to the analogy drawn between an adhocracy and a supply network.

While the research team initially worked with the firm to examine the SOI layer mappings of services to resources, this was quickly depreciated in favor of focusing on the higher level mapping of business processes to services. The firm is interested in exploring coordination mechanisms for defining, preserving, and invoking patterns of service use that can be propagated along the value chain. These patterns can represent characteristics of both production chain interaction and sourcing (contractor/subcontractor) interaction. They can be examined upfront as choreography alternatives, and the metrics preserved for pattern comparison can be taken directly from the dashboards used at multiple levels in prior choreography executions. The dashboards themselves can be preserved and mapped to a pattern in order to maintain the appropriate linkages from local component dashboards to collaboration and process dashboards and to dashboard metrics included in the monitoring of global network performance. A methodology for agile dashboard construction is needed by this organization in order to formalize how dashboards at the appropriate levels of their service oriented enterprise can be invoked from preserved choreography patterns and adjusted to suit the particulars of the specific choreography execution.

Due to the inter-organizational nature of the firm’s interest, the team is in the process of garnering international support for the initiative from research organizations and corporations in order to complete the formal proposal process of a well known international research and development program.

Component Teams and Engagement Overhead: The Case of an International Financial Institution

The second firm the team is working with has recently restructured its business intelligence organization into component teams (Keith Goul Demirkan Nichols and Mitchell 2006). Their notion of component teams is analogous to the service oriented approach towards organizational resources laid out in section three. Prior to restructuring, the firm had in place a monitoring and reporting mechanism similar to the EIS business performance dashboard as detailed by Gray and El Sawy. This mechanism served as their primary control point for performance across the organization. After the organization was restructured into component teams, executives noted two critical issues: First, the monolithic performance dashboard implemented prior to restructuring no longer provided adequate visibility into the performance of the organization as evidenced by increasing difficulty planning and forecasting project costs and timelines as well as reduced ability to access the characteristics of projects being executed in order to make adjustments in their planning cycles. Second, the cost in terms of
engagement overhead involved with coordinating component team interaction across a production choreography was substantial.

The firm has recognized the need for support tools both to reconnect the high level performance indicators to the lower level process activities and to smooth the interactions of component teams in order to reduce cycle time and lower the cost of engagement between teams. Initiatives are underway to reconsider the orientation of their current monitoring and reporting system and the (lack of) fit of this system with their current architecture and organizational structure. The goal of one initiative is specifically to explore the appropriate role and positioning of dashboards across the organization. This initiative, and others targeting coordination and control across the organization, can benefit from the theoretical foundations presented here as a basis for formalizing a methodology for agile dashboard construction and implementation.

The team is in the process of finalizing a generic recursive sourcing and execution pattern that represents the activity of the organization. In an activity-based costing fashion, the team will then decompose the pattern to constituent activities, identify cost centers, and map the sourcing and execution process to a cost model which can be used to define performance metrics at a detailed level. The theoretical foundations presented here will support the prioritization of performance indicators and the positioning of those indicators within their appropriate location across the execution environment. The results of this can feed into the current organizational initiative to define dashboards as a response to guard against high engagement costs and low process visibility.

The firms being examined are significantly different in terms of the scope of their domain and their maturity in a service oriented context. However, the theoretical underpinnings and resulting operational framework presented here maps cleanly to both scenarios. Each firm is looking to enhance their coordination and control in a service oriented context, and therefore both firms stand to benefit from continued efforts to formalize a methodology for agile dashboard construction and implementation derived from the theoretical foundations shown here to encapsulate the context of a service oriented enterprise. Continued research with both firms as they work to discover methods and processes for agile dashboards will help to guide the research team down the path from grounded theory to formal methods.

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