Association for Information Systems
AIS Electronic Library (AISeL)

ICIS 2006 Proceedings

International Conference on Information Systems (ICIS)

December 2006

From Real-Time BI to the Real-Time Enterprise: Organizational Enablers of Latency Reduction

Greta L. Polites
University of Georgia

FROM REAL-TIME BI TO THE REAL-TIME ENTERPRISE: ORGANIZATIONAL ENABLERS OF LATENCY REDUCTION

Social, Behavioral and Organizational Aspects of Information Systems

Greta L. Polites
Department of Management Information Systems
University of Georgia
gpolites@uga.edu

Abstract

Real-time business intelligence (BI) plays an important role in enabling the "real-time enterprise," and as such has received a lot of attention in the practitioner literature in recent years. However, academic research on real-time BI and its role in improving overall organizational agility is scarce today. Most research on the real-time phenomenon has focused on technological, as opposed to organizational, issues. Using practitioner models of information value as a starting point, we draw from theories on individual and organizational decision making to create a model of the components of latency that impact an organization's ability to both sense and respond to business events in real time. Failure to take all the antecedents of these latency components into account when implementing a real-time BI system can have serious consequences on a firm's ability to optimize benefits from conversion to real-time BI systems. We close with suggestions for future IS research on this important emerging topic.

Keywords: Real-time business intelligence, real-time enterprise, agility, latency reduction

Introduction

Real-time enterprises have received much attention in recent practitioner literature (e.g. Hackathorn 2004; McGee 2004b; Reddy 2004; Sawhney 2003; White 2003). A real-time enterprise (or RTE) has been formally defined as an organization that:

> …monitors, captures and analyzes root-cause and overt events that are critical to its success the instant those events occur, to identify new opportunities, avoid mishaps and minimize delays in core business processes. The RTE will then exploit that information to progressively remove delays in the management and execution of its critical business processes. (McGee 2004a, p.1)

The RTE concept has been around for many decades. Its roots can be traced to the principles of time-based competition, just-in-time management, and business process reengineering (Sawhney 2003). However, until recently, technological limitations prevented RTE's potential from truly being realized. Today, such technologies as XML, Web services, data warehousing, middleware, and component-oriented enterprise architectures, as well as the availability of high-speed network connectivity, all work together to enable business processes to become faster and more agile (Reddy 2004; Sawhney 2003).

One of the key components of the RTE is real-time business intelligence. Business intelligence (BI) encompasses "ETL, data warehouses, reporting and analysis tools, and analytic applications. [BI] projects turn data into information, knowledge, and plans that drive profitable business decisions" (White 2003, p.4). Improving the timeliness and quality of this information in order to facilitate better managerial decisions has long been an important goal of organizations, and real-time BI seeks to deliver on both these dimensions. In fact, real-time BI has been referred to as "the most significant development in the past five years," as it allows for the merging of operational and decision support applications (Watson 2005).

Deciding whether to adopt real-time technologies, and to what extent, is an important concern for organizations today. McGee (2004b) estimates that only about 5% of business processes are critical enough to warrant conversion to real or near-real time processing. The issue, however, is in determining the *proper* 5%. Converting to real-time systems can be quite expensive, particularly as the scope increases. In addition, if an organization is not able to reduce *response time* once decision makers have received information in real time, the benefits of technology investments in real-time information *delivery* will be limited.

Despite the obvious value in developing a better understanding of real-time BI and its role in enabling the RTE, academic literature on the topic is sparse. Most attempts at modeling the role of real-time BI in reducing latency and supporting more agile enterprises have originated in the practitioner realm (e.g. Hackathorn 2004; McGee 2004b). This paper seeks to build on these practitioner models, while bringing more theoretical clarity to the discussion of latency reduction and its organizational antecedents. In so doing, we hope to encourage further academic research in this area. In addition, we aim to provide a theoretical foundation for assisting managers in looking beyond the hype regarding real-time BI and determining whether particular aspects of their business might benefit more from conversion to real-time systems than others (and at lower cost), and whether their *technology* solutions for latency reduction will provide the expected benefits given existing *organizational* structures. This is particularly relevant if the company has a goal of becoming a true "real time enterprise." Thus the key research questions guiding our study are as follows:

> *RQ1: Are existing practitioner models of event-to-action latency accurate and complete? If not, how can they be enhanced from a theoretical perspective?*
>
> *RQ2: What types of business decisions are best suited for achieving overall latency reduction in the context of real-time BI?*
>
> *RQ3: What characteristics of organizational structure are best suited for achieving overall latency reduction in the context of real-time BI?*

We begin with a review of the practitioner literature on real-time information processing, and a discussion of two popular practitioner models of the relationship between information value and time. Next, we tie real-time BI and the RTE concept to the literature on organizational agility. We then present a refined model of the components of event-to-action latency that is based on the importance of achieving fit between real-time information needs and organizational response capabilities. We draw from several different theoretical perspectives in presenting propositions related to the organizational factors that impact each of the different types of latency. In so doing, our goal is to shed light on the organizational structures, processes, and other mechanisms that are best suited for acting quickly on information delivered in real or near-real time. These propositions are supplemented where possible with brief examples applying them to real-world settings. We close with suggestions for future academic research in this important emerging area.

Literature Review

Many different acronyms and catchphrases are tossed about in discussing real-time BI applications today. Some of the more significant trends in providing organizations with improved sensing and responding capabilities in relation to their core business processes include active data warehousing, business performance management (BPM), business activity monitoring (BAM), automated business rule processing, and executive dashboards with built-in alerting capabilities (see Table 1 in the Appendix). Real-time knowledge management, customer relationship management, and text mining have also been gaining steam (Malhotra 2005; Watson 2005).

Drivers, Expenses, and Potential Obstacles

Drivers for real-time BI may be direct or indirect in nature, and can be broadly categorized according to a focus on achieving operational improvements, leveraging strategic opportunities, or complying with external reporting requirements (see Anderson-Lehman et al. 2004; Eckerson 2004; Imhoff 2004; Rabin 2003; White 2003). Key expenses associated with the implementation of real-time BI include the costs of data integration and infrastructure changes, hardware and software purchases, new services and IT support personnel, user training, business process reengineering, standardization of metrics, and implementation of technologies to support collaboration (Eckerson 2004). Gartner Group has estimated that 30-60% of a multinational enterprise's IT budget alone would have to be assigned to developing "comprehensive" real-time capabilities. For this reason, many experts have suggested implementing real-time solutions through a planned evolutionary, phased approach (Rabin 2003; Sawhney 2003), keeping in mind that there may be other ways for a firm to gain competitive advantage that are more cost-effective than moving to real-time systems.

Many analysts have been skeptical about the long-term success of conversions to real-time systems. A few analysts even fear that some apparently successful conversions might incur large, hidden expenses down the road, even hinting at a potential huge growth in the IT consulting business, because "some managers are going to botch this, big time" (Stuart in Lindorff 2002, p.4). One concern is that successful implementation of real-time *technologies* cannot prevent *human* failures in planning, forecasting, and selecting appropriate business models (Malhotra 2005). Another concern is the potentially adverse effect that major structural changes from reorganizations, acquisitions, and mergers might have on a firm's ability to continue delivering real-time BI solutions when the data warehouse structures underlying affected business processes have to be changed (Hayler 2004). This implies that a lack of *systems agility*, i.e., the necessary capabilities to redesign infrastructure and information delivery systems quickly in response to changes (Chen and Goodhue 2005), could impact the success of real-time systems over the long run.

Other analysts recognize the ability of real-time BI to provide lasting *operational* improvements, but feel that their ability to provide long-term *strategic* benefits is still unproven. They reason that any competitive advantage gained from real-time technologies will be quickly wiped out as competitors duplicate a firm's moves. Protecting decision makers from the potential for information overload is another concern. According to Reddy (2004), a major difficulty for real-time BI, as with other enterprise systems, is ensuring that managers and executives ask the *right* questions, and also that data from multiple systems is integrated in a manner that *allows* the questions to be answered.

Practitioner Models of Real-Time Information Value

Academic research to date has focused primarily on the more technical aspects of real-time systems development and implementation (e.g. Jeng et al. 2003; Khosla and Pal 2002) and the dynamics of individual real-time decision making processes (e.g. Eisenhardt 1989; Gibson 2000; Gonzalez 2005; Lerch and Harter 2001), with a handful of organizational-level case studies aimed largely at a practitioner audience (e.g. Anderson-Lehman et al. 2004; Houghton et al. 2004). Thus the most commonly cited models addressing real-time BI concepts come from the practitioner literature (e.g. the action distance model of Hackathorn 2004 and "event-impact lag" model of McGee 2004b). We discuss each of these models briefly below.

The action distance model (Figure 1; Hackathorn 2004) identifies three phases of latency (data, analysis, and decision) that are defined primarily in terms of operational real-time BI systems built upon data warehouse technology. *Data latency* represents the time required to capture, transform/cleanse, and store data about a business transaction in a data warehouse such that it is available for further analysis. Data latency can often be reduced through technical means, such as implementation or reconfiguring of middleware and data integration tools (Eckerson 2004). *Analysis latency* encompasses the time it takes to initiate an analysis of the data, package the results, and deliver them to the right people, and can likewise be frequently reduced via technical means, such as rearchitecting the firm's data warehousing and information delivery systems (Eckerson 2004; Hackathorn 2003). Finally, *decision latency* represents the time required for a person to "understand the situation, decide on a course of action and initiate it" (Hackathorn 2004), and is generally considered the least amenable to technological improvements, since it requires the often difficult and expensive reengineering of business processes and policies (Eckerson 2004). Decision latency can occasionally be reduced or eliminated through the implementation of rules-driven systems that automatically enact business processes (Eckerson 2004), and in fact Hackathorn (2003) focuses primarily on the automation aspects in identifying the three requirements for decision latency reduction as 1) providing the decision maker with *alerts* of unusual business events, 2) *informing* them with situational-specific analysis to help gauge priorities, and 3) *guiding* them by suggesting appropriate actions. The key argument of this model, however, is that latency reduction efforts should only be undertaken based on the actual business value that they can provide (Hackathorn 2004). Thus the term "right time" is often preferred to "real time" when discussing individual and organizational information needs, because

> Ultimately, business executives don't care about the degree of latency in a system. They simply want these systems to deliver the *right* information to the *right* people at the *right* time so they can make *optimal* business decisions. *Right time* puts the emphasis on the business value of information, not its latency. (Eckerson 2004, p.31)

McGee's model (Figure 2) takes a higher-level strategic approach. It is based on the view that "there is always warning prior to a business mishap or opportunity," and that if in such cases information had been available in a more timely manner, these mishaps could have been avoided or the opportunities exploited (McGee 2004a, p.3). Therefore, monitoring critical business information in real time not only allows the company more time to respond before the impact of an event is felt, but this extra time also allows a greater array of response options to be considered. McGee argues that reducing the time required to sense changes in the business environment is most important, and that too many companies focus instead on reducing response time based on stale data (McGee 2004b). In McGee's roadmap for becoming an RTE, companies begin by focusing on providing real-time information on their most critical business processes, then gradually integrating these real-time monitoring abilities at the enterprise level, then finally focusing on reducing response time by redesigning key business processes.

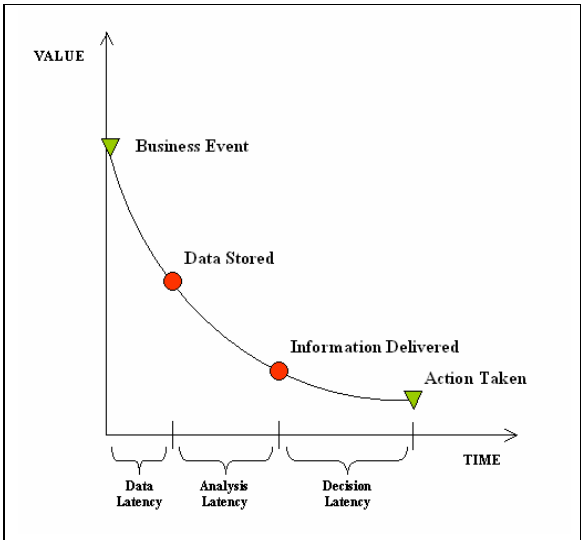

Figure 1. The Action Distance Model (based on Hackathorn 2004)

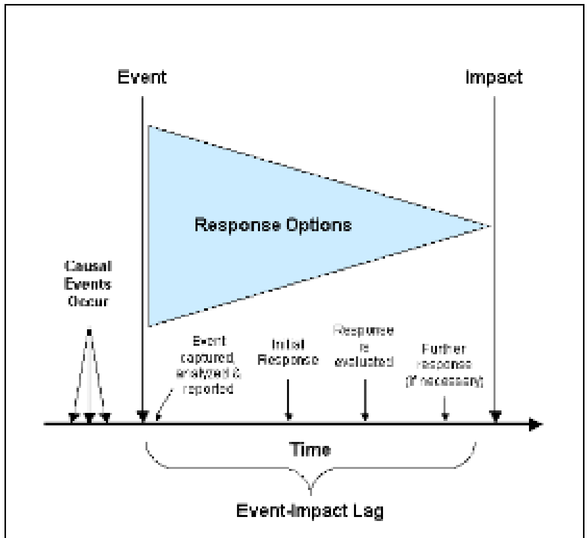

Figure 2. The "Event-Impact Lag" Model (based on McGee 2004b)

While each of these two practitioner models is helpful in understanding particular business phenomena related to the use of real-time BI, each model also presents a somewhat incomplete picture due to its specific focus. While Hackathorn's model is a good approximation of latency in a transactional system where all critical data is captured in an operational data warehouse and responses can often be automated, it does not account for more complex or nonlinear decision-making processes, and excludes the latency associated with actual *implementation* of business decisions. It also does not account for the fact that an important event may occur outside the realm of the company's operational systems, and thus not be captured in the data warehouse. McGee's model, on the other hand, goes beyond transactional systems and also takes the full response time into account, as well as adjustments that may need to be made in the course of responding to an event. However, its focus on reducing data capture and analysis latency over decision making and implementation latency assumes that the impact of an event occurs at a set point in the future (often when a shareholder's report is due) and that no business value is lost as a consequence of slower-than-necessary response times to real-time data. This is perhaps clearest in McGee's suggestion that businesses not focus on streamlining their processes until the final phase of becoming an RTE.

Real-Time BI and Organizational Agility

For all the fancy terminology, "real time enterprises" are simply *agile* enterprises, with agility defined as "an organizational ability to quickly detect strategic opportunities and to assemble requisite resources to make a rapid and effective response" (Chen and Goodhue 2005, p.3). An agile organization is not only *alert* in its use of information networks, both discovering information and interpreting it correctly, but is also *responsive*, in that it can move quickly based on the information obtained, transforming knowledge into action, even in a fast-moving environment (Zaheer and Zaheer 1997). These characteristics are often referred to as *sensing agility* and *responding agility* (Chen and Goodhue 2005).

Real-time BI can improve a company's ability to sense changes in the environment, and this is particularly important when that environment is very dynamic in nature. In some cases, real-time BI may also be able to improve the speed and consistency of responses in the way that a company manages its operations. Referring back to Hackathorn's action distance model, data latency and components of analysis latency (i.e., gathering the information and analyzing it for important changes) are associated with a company's ability to achieve *sensing agility*, whereas other components of analysis and decision latency (i.e., delivering the information to the proper people so that they can then take action) are associated with its ability to achieve *response agility*.

Other forms of agility have been identified in the literature as well, including *customer agility* (capabilities related to a firm's interactions with its customers), *business partnering agility* (capabilities related to a firm's utilization of its ecosystem of external business partners), and *operational agility* (capabilities related to a firm's orchestration of internal operations) (Sambamurthy et al. 2003). More recently, Chen and Goodhue (2005) have segregated two types of agility at the business process level, *business agility* ("the organizational ability to effectively change business processes in response to changing business opportunities") and *systems agility* ("the organizational ability to effectively change information systems to meet business process change needs") (p.8). These latter types of agility, while not discussed in detail here, may each play a key role in enabling lower latency responses to changing business conditions and strategic opportunities discovered through the use of real-time BI.

Development of Research Model

Our proposed research model is shown in Figure 3. Using the previously discussed practitioner models as a starting point, we draw from the literature on dynamic decision making and organizational agility to present a more complete picture of the various types of latency that impact the success of real-time BI systems. We next examine some of the key organizational factors that impact a company's ability to actually *reduce* each type of latency. In presenting propositions for the relationships in our model, we argue that certain types of business decisions and organizational structures are better suited for achieving overall latency reduction than others, and thus should yield greater benefits at a lower cost when implementing real-time BI systems.[1]

The Components of Overall Latency

Redefining Data Latency

For an organization to truly become "real time" or agile, it must be able to process information from a number of different sources, both external and internal. Thus while Hackathorn's (2004) definition of data latency applies well to information processing in *transactional* systems, a broader definition is needed to include information that comes from other sources, particularly those in the external environment. Such information must often be actively sought out, perhaps even manually. This search takes time, and is therefore itself a source of latency. In some circumstances, the company may know what type of information it is looking for, but in others, the exact information needed may be unknown. The bureaucratic organizational model (Cyert and March 1963) argues that

[1] In both our model and the discussions that follow, we use the single generic term "subunit" to represent the various distinct structural entities that may exist within a larger organization. This is done simply for convenience; we acknowledge that in today's business environment, different "subunits" may be located across functional, divisional, or even country boundaries, and in the case of hybrid organizational structures or interorganizational alliances, may even cross *organizational* boundaries.

due to the expense of gathering and processing information, information search in organizations tends to be limited, with firms focusing on *simplistic search* and *satisficing*, which may be quicker but can lead to incomplete or low quality information and decisions that are not always optimal. Once this information is uncovered, it must often be integrated with other information from both internal and external sources, including business partners. All of this must be taken into account in determining true data latency. Thus we redefine data latency as follows:

> Data latency represents the time required to capture and store all the information related to an important business event, including:
>
> 1) the time required to capture, transform/cleanse, and store data about a business transaction in a data warehouse such that it is available for further analysis (per Hackathorn 2004)
>
> 2) the time required to scan the environment and search for information that comes from sources other than a transactional data warehouse.

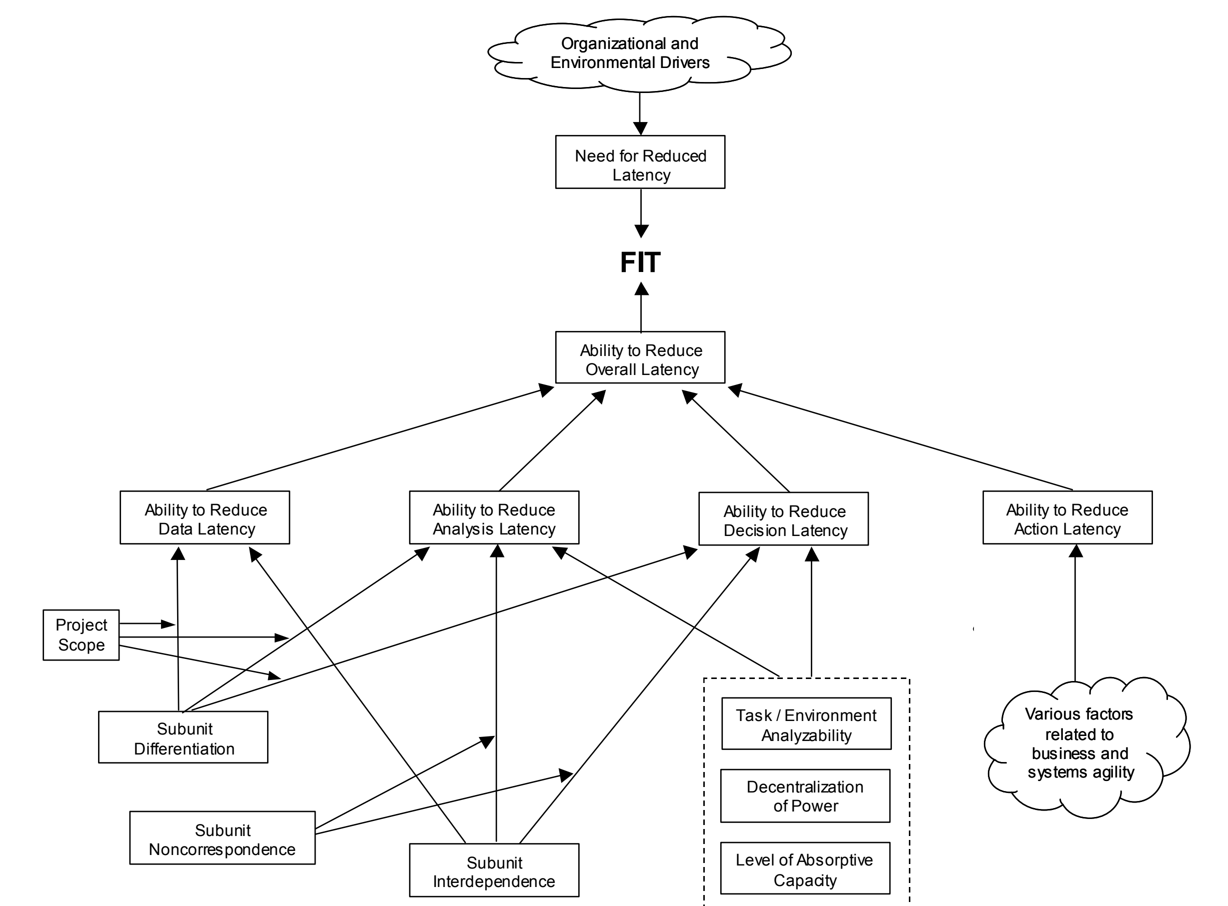

Figure 3. Proposed Research Model

Dynamic Decision Making

A particularly interesting area of research for developing a better understanding of latency issues associated with real-time BI systems is dynamic decision making (DDM) theory (Brehmer 1992). DDM is defined as possessing the following characteristics:

- A *series* of decisions that are required to reach a goal, implying that maintaining control is a "continuous activity requiring many decisions, each of which can only be understood in the context of the other decisions" (Brehmer 1992, p.212),
- *Interdependence* of the decisions (such that earlier decisions may constrain later ones),
- A *changing state* of the decision problem, resulting not only from the consequences of the decision maker's actions, but also from autonomously occurring events, and
- Decisions that are made in *real time.*

DDM theory views decision making as a process of achieving control over a situation, rather than as an isolated, easily identifiable event (Brehmer 1992). The decision maker may depend on a strategy of *feedback*, which involves using only the current information on the system to make inferences on the actual state of the system, a strategy of *feedforward*, which involves using a model of the system to predict its actual state, or a combination of the two strategies. Feedback delays, or *feedback latency*, can negatively impact the decision maker's ability to make proper decisions in a changing environment, whereas this feedback latency may not impact a feedforward strategy if the decision maker is able to assume stability of the environment and use a reliable model to predict what is actually taking place in the absence of feedback. While not all business decisions are dynamic in nature, the key point here as relates to real-time BI is that resolution via a response to a business event is not complete until the decision maker is sure that his or her response was (1) the appropriate one, (2) has had the expected impact, and (3) has not lead to any unexpected (negative) side effects. This fact is not adequately represented in the action distance model, although it is taken into account in the more strategically and competitively oriented "event-impact lag" model.

This leads us to consider several questions. First, should the latency associated with *implementing* a business decision be explicitly included in the latency model, and is there a theoretical rationale for doing so? Second, should *feedback latency* (Brehmer 1992) be added to the model, or can it simply be incorporated into our concept of the decision making process, as a subcomponent of decision (or some other type of) latency? We address each of these questions below.

Accounting for Action Latency

We argue for explicitly including *action latency* as an important component in determining a firm's overall ability to sense and respond to a business event, and therefore as an important factor in determining whether implementation of real-time systems is beneficial in a particular firm. Action latency as defined here includes all the steps necessary to take a decision that has already been made and fully implement that decision in practice. Sometimes the decision and action may be almost simultaneous, and this is often assumed in discussions of real-time BI systems. For example, a firm may want to offer special promotional opportunities to customers who buy a certain quantity of a particular product on its Web site. When a customer visits the site and makes a qualifying purchase, that information is captured almost immediately (low data latency) and sets off a trigger (low analysis latency) that leads the system to automatically serve up a window with the special offer (low decision and action latency). In many situations, however, action is neither as instantaneous or as easy to take.

Formally recognizing the importance of action latency is in line with the concept of organizational agility, since the response to a particular business event or series of events may require redesign of business processes (the speed and success of which depends on business agility) or changes to the company's information systems to match or enable the redesign of these processes (the speed and success of which depends on systems agility) (Chen and Goodhue 2005). Until the response (whatever it may be) is complete, the company will realize few or no benefits from the decision(s) made.

Accounting for Feedback Latency

In the context of DDM, feedback latency may be a function of the decision maker waiting while his/her decision is implemented by others, or a function of waiting until new information arrives on the state of the problem space. In the first case, feedback latency is subsumed by our newly defined action latency; in the second, it is largely part of a subsequent round of data gathering and analysis. Thus it seems inappropriate to explicitly add feedback latency to the model for either of these two situations. It would appear that the primary component of feedback latency that may be unaccounted for in the current model is the time that it takes for an implemented decision to actually have an *impact* on the problem space. Since the organization has no control over this aspect of latency, we exclude it from our model.

Redefining Decision Latency

While we have largely accounted for feedback latency, DDM, with its inherent inability to predict in advance how many stages of feedback and adjustment will be necessary until a particular event response is complete, implies that a refinement of Hackathorn's (2004) definition of decision latency is necessary. Thus we redefine decision latency as follows:

Decision latency represents:

3) The time required for a person (or group) to understand the situation (e.g. an individual or compound business event), decide on a course of action and initiate it, *plus*

4) The time required to initiate all necessary adjustments to that course of action, up to the time that the response to the original business event is deemed adequate or successful.

Recapitulation

DDM theory (Brehmer 1992) highlights the fact that sensing and responding to a business event is not always a linear process. In proposing several modifications to phases of the action distance model, we also acknowledge that iterations between phases in response to a single event may occur. Thus measuring overall latency may prove to be easier in some cases than measuring all the individual components. We now formally offer our first proposition concerning the components of latency that apply to the study of real-time BI system implementations:

Proposition 1. An organization's ability to achieve overall latency reductions in sensing and responding to business events is the sum of its abilities to reduce data latency, analysis latency, decision latency, and action latency.

Achieving Fit in Latency Reduction

Information processing theory's focus on achieving fit between information processing needs and information processing capacity in order to improve organizational or subunit performance (see Daft and Lengel 1986; Goodhue et al. 1992; Tushman and Nadler 1978) is useful in making decisions on how much latency reduction is truly important in a firm. The concept of event-to-action latency implies both a need for a sufficient supply of information to meet company needs, as well as the ability to process and act on this information in a timely manner. The ideal situation occurs when an organization's ability to supply information is matched by its ability to act on it. Too much information (i.e., information provided at unnecessarily close intervals) may imply unnecessary expenses for the firm in supplying this extra information. Likewise, having the appropriate level of timeliness in information supplied without having the proper structures in place to act on it quickly, implies that the firm is missing out on the benefits of this information. Thus in borrowing the "fit" concept from information processing theory, we propose the following:

Proposition 2. When an organization's need for reduced latency is matched by its ability to achieve overall latency reductions, real-time information processing "fit" (i.e., "right-time" information processing) is achieved.

Task Uncertainty versus Equivocality

Rational models of the organization can provide much insight concerning the potential benefits of real-time BI systems. Information processing theory in particular seeks to explain how an organization's (or subunit's) information processing needs are impacted by levels of *uncertainty* (defined as "the absence of answers to explicit questions," or "the difference between the amount of information required to perform the task and the amount of information already possessed by the organization") and *equivocality* (representing ambiguity, "the existence of multiple and conflicting interpretations about an organizational situation," or the idea that people neither know *what* questions to ask or, if they have asked a question, what the proper *answer* is) (Daft and Lengel 1986, pp. 556-557). Uncertainty and equivocality are in turn influenced by many factors, including task characteristics, the task environment, subunit differentiation, and the interdependence of subunits in performing their respective tasks. Information processing capacity can be increased as a result of organizational structure, coordination and control mechanisms, organizational processes, and characteristics of the information technology itself.

There is already a well-developed MIS research stream which has used information processing theory for such purposes as predicting organizational decisions to integrate data (e.g. Goodhue et al. 1992; Wybo and Goodhue 1995), and better understanding the success of enterprise-wide ERP implementations (e.g. Gattiker and Goodhue 2004; Gattiker and Goodhue 2005). Data integration expenses are an important factor to consider in the decision to implement real-time BI systems, particularly those that cross multiple subunits. Subunit differentiation is also an important factor that comes into play when attempting to create standardized key performance indicators (KPIs) for monitoring in real time. The ability of real-time systems to reduce uncertainty versus equivocality is also important to understand in determining how useful such systems will be in a particular firm, since uncertainty may be reduced by increasing the *amount* of information available, whereas equivocality reduction requires increasing the *richness* of information (Daft and Lengel 1986; Goodhue et al. 1992).

It is our premise based on the features common to real-time BI applications today (e.g. emphasizing dashboards designed around KPIs, event-driven delivery of alerts and exceptions, and automated response systems), that real-time BI is *currently* best suited for reducing overall latency when resolving issues of *uncertainty*, i.e., where the questions are known in advance, and the system is capable of delivering information that will allow those questions to be answered and acted upon in a timely fashion. While real-time BI systems can also be used in situations of equivocality, particularly when supported by advanced analytical features that allow for unstructured data exploration and technologies that encourage rich data exchange between decision making parties, many equivocal issues will, by their very nature, be less amenable to immediate action even when discovered via near-zero latency data.

Support for the view that real-time BI is best suited for situations of uncertainty as opposed to equivocality also comes from Pfeffer's (1981) model of power and politics. While rational organization models help us to understand how decision making takes place in the presence of a consistent set of goals and a reasonable level of certainty as to cause and effect relationships that may affect outcomes, in the real world this is often not the case. Organizations often have diverse interests and goals that come into play in decision making; in many cases, subunits and subcultures may even come into open conflict. Politics, according to Pfeffer (p.6), involves "activities which attempt to influence decisions over critical issues that are *not readily resolved through the introduction of new data*, and in which there are *differing points of view*." By this definition, organizational politics is an especially important factor in situations of equivocality as opposed to uncertainty, although power struggles may arise for other reasons as well. The presence of political behavior in a firm or subunit implies that response latency cannot be easily reduced in order to provide benefits from real-time availability of information. Thus we formally propose the following:

> *Proposition 3. Real-time (and near-real time) BI systems will be more successful in reducing overall latency when applied to situations of high uncertainty, as opposed to situations of high equivocality.*

Many factors related to organizational tasks may impact overall levels of uncertainty and equivocality. For example, high task *variety* implies a high incidence of unexpected events that require gathering a large amount of information so that they can be discovered and acted on in a timely manner. High levels of *analyzability* in the task or task environment imply low levels of equivocality, and therefore will allow problems to be solved relatively quickly. Thus we can further refine Proposition 3 as follows:

> *Proposition 3a. All else being equal, as task variety, task analyzability, and analyzability of the task environment increase, the ability to reduce both analysis and decision latency will increase, leading to increased benefits from conversion to real-time BI systems for time-sensitive decisions.*

Anderson-Lehman et al.'s (2004) case study on Continental Airlines helps to illustrate the propositions above. One example of critical information that could be acted on quickly (presuming that it was *available* quickly) involved tracking potential gate-connection problems of high-value customers. In this case, the airline knew exactly what needed to be done to improve customer service (i.e., help delayed customers get to their next gate on time), but needed to have the information delivered quickly enough to actually be of use. Stated in terms of our propositions, the task of getting valued customers to their connecting flights on time was an analyzable task, dealing with uncertainty as opposed to equivocality. However, before Continental could accomplish such tasks, it needed to eliminate departmental information silos and create a corporate infrastructure that enabled rapid information access and sharing. This leads us to a discussion of the impact of subunit differentiation and interdependence on the ability to reduce overall latency at a reasonable cost.

Subunit Differentiation and Project Scope

High levels of differentiation between departments lead to increases in equivocality, since each department has its own areas of expertise, goals, frames of reference, and ways of coding information (Daft and Lengel 1986). Thus high subunit differentiation increases the costs in time, effort, and money to both implement and maintain integrated systems that can reduce data latency. Data integration in turn can limit the ability of highly differentiated subunits to respond to their environment quickly (Goodhue et al. 1992).

Subunit differentiation can also impact analysis and decision latency. When high levels of differentiation are present, decisions affecting multiple subunits will take longer and require richer information processing capabilities than what can be provided by current real-time BI technologies alone. Highly differentiated subunits may also use different formulas to calculate the performance metrics used in executive dashboard displays. This might be especially true when subunits cross national, or even organizational, boundaries. Thus we propose the following concerning the level of subunit differentiation, the scope of real-time BI implementations, and their combined impact on data, analysis, and decision latency:

> *Proposition 4. Subunit differentiation will have a differential impact on the success of real-time BI system implementations, depending on the scope of the project.*

> *Proposition 4a. All else being equal, high levels of differentiation between subunits will make it easier to implement <u>intra-departmental</u> real-time BI systems. In this case, subunit differentiation will contribute to an <u>increased</u> ability to reduce data, analysis, and decision latency.*

> *Proposition 4b. All else being equal, high levels of differentiation between subunits will make it more difficult to implement <u>inter-departmental</u> real-time BI systems. In this case, subunit differentiation will contribute to a <u>decreased</u> ability to reduce data, analysis, and decision latency.*

We do not mean to imply here that an organization with several highly differentiated subunits cannot gain benefits from integrating data and implementing real-time BI systems based on standardized KPIs. However, these benefits may come at tremendous expense, making a full cost-benefit analysis critical when determining the appropriate place to start in planning a move toward real-time systems. While KPI standardization is generally presented in a *positive* light by vendors and consultants, there may be circumstances where allowing more subunit flexibility might contribute to greater long-term benefits for the organization as a whole. One such real-world example is an international marketing company structured around relatively autonomous country-specific divisions, that provides data warehousing and analytical services to retailers who lack their own information processing capabilities. In such an organization, the value obtained from a division's ability to flexibly format and provide dashboard information to its clients might outweigh the need to have common data standards and KPIs across all divisions, despite the extra maintenance costs.

Subunit Interdependence

Interdependence has been defined as "the extent to which a unit's outcomes are controlled directly by or are contingent upon the actions of another unit" (Victor and Blackburn 1987, p.490). The role of subunit interdependence in a firm's efforts to reduce latency is complex. Interdependence in and of itself is a *hindrance* to latency reduction. This is true for several reasons. First, as *workflow-related* interdependence increases, uncertainty and interdepartmental coordination/monitoring needs also increase (Thompson 1967). Second, the presence of *competitive* interdependence, or interdependence based on shared yet scarce resources, increases the likelihood of power struggles and political activity (Pfeffer 1981), which can slow down the decision making process.

Interdependence theory (Victor and Blackburn 1987) seeks to combine the various forms of interdependence into a single construct based on interactions between interdependence and correspondence (i.e., commonality). It is based on the view that interdependence in and of itself is only a necessary, but not sufficient, condition for conflict to form. Using the matrix of potential interactions (see Figure 4), one can determine the proper coordination strategy for simultaneously managing both interdependence and conflict.

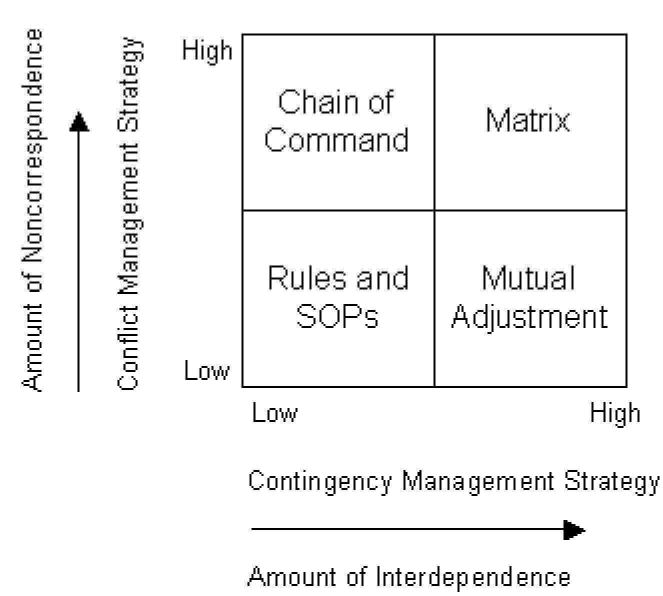

Figure 4. Coordination Strategy Selection and Effectiveness (from Victor and Blackburn 1987)

We will refer to this matrix in forming propositions regarding the impact of interdependence and correspondence on the various types of latency, and regarding the appropriate strategies for counteracting these impacts when implementing real-time systems. First we posit the following:

> *Proposition 5. Subunit interdependence and correspondence will interact with each other in impacting a firm's ability to achieve latency reductions as a consequence of implementing real-time BI systems.*

Put differently, in the absence of any technological improvements, increases in subunit interdependence will increase data, analysis, and decision latency, and this effect will grow stronger as levels of noncorrespondence between subunits increase.

Achieving Latency Reductions in the Presence of Workflow Interdependence

When subunit interdependence and noncorrespondence are both low (Cell 3 of Figure 4), it should be relatively easy for individual subunits to make decisions, since there is no need for coordination, and no need to obtain the approval of other subunits before making decisions. There will be no pressing need for data integration (thus data latency should be short within subunits), and analysis of the data, as well as decision making based on that information, does not depend on anyone from outside the department. In such an atmosphere, Victor and Blackburn's model posits that coordination between subunits will be based on rules and standard operating procedures (SOPs). Per Cyert and March (1963), these SOPs increase the speed of decision making.

As workflow interdependence increases, all forms of latency have the potential to increase. However, if the workflow process is well-known, well-codified SOPs (including task performance and information processing rules) can easily be converted into automated rules processing systems, which not only reduce analysis and decision latency but also reduce errors from mishandled or misdirected information. Such process automation also frees up human resources to perform other tasks. On the other hand, these procedures may be outdated due to organizational inertia, meaning that decision making processes may be easy to follow but are not necessarily optimal.

When subunits are highly interdependent with low levels of noncorrespondence, Victor and Blackburn (1987) posit that coordination of workflow will be based on mutual adjustment. Previous IS research indicates that increased monitoring and coordination needs will make data integration (including implementation of common data definitions) more likely (Goodhue et al. 1992). This improved integration will directly impact data latency, and paves the way for further reductions in analysis latency as pertinent information can be served up to all concerned parties simultaneously. Thus we conditionally offer the following refinements to Proposition 5:

> *Proposition 5a. All else being equal, the ability to base mutual adjustments in coordinating workflow on integrated data will lead to reductions in both data and analysis latency.*

> *Proposition 5b. All else being equal, the ability to automate business rules and SOPs will lead to reductions in both analysis and decision latency.*

For Continental Airlines, the company's potential to improve customer service by sensing gate-connection problems and implementing appropriate responses could not be achieved without an infrastructure that enabled data integration and information sharing across departments (Anderson-Lehman et al. 2004). Although this scenario required a *human* response to opportunities discovered through near-real time data, even greater latency reductions may be possible when responses can be *automated*. For example, General Electric's consumer appliance division improved customer service by installing online kiosks inside Home Depot stores, allowing customers to self-order appliances, select their desired delivery date and time, and receive (dis)confirmation of their request immediately (Lindorff 2005). Taken together, these two cases imply that, in situations where subunit interdependence is workflow-based, the maximum benefits in overall latency reduction will occur when data integration is feasible (both technically and financially) and further, when business rules and SOPs are clear or can be easily automated.

Resource Interdependence and the Distribution of Power

Pfeffer (1981) argued that when power is dispersed, political activity and bargaining are more likely to occur, which would imply an increase in decision latency. However, while centralizing power (Cell 1 of Figure 4) may reduce the problems inherent with many "warring factions" within the organization, having a single decision point may also lead to bottlenecks which increase decision latency (Cyert and March 1963; Pfeffer 1981). In a dynamic environment dependent on real-time information, this delay is particularly critical. Recent research (e.g. Andersen 2005; Eisenhardt and Bourgeois 1988) supports the view that in dynamic environments, decentralized power can actually *decrease* political activity and improve the speed of strategic decision making, particularly in the presence of computer-mediated communication tools. We would expect the same thing to hold true for *operational* decisions impacted by real-time information. DDM theory has likewise argued that delegating subsequent decision-making tasks to subordinates who are "closer to the action" in dynamic environments can help mitigate the impact of feedback latency to the initial decision maker (Brehmer 1992). However, other characteristics of the environment (e.g. its simplicity or complexity) may play a role in the actual *appropriateness* and *success* of such rapid decisions for the firm as a whole (Siggelkow and Rivkin 2005). In other words, in a complex environment, actions may be taken by one subunit that later prove to be detrimental to another, due to more complex, unrecognized interdependencies that have not yet been accounted for theoretically (Siggelkow and Rivkin 2005). In addition, this decentralization, which often delegates information searching and sharing responsibilities to individual subunits, can increase the risk of bias, of information being inappropriately screened out, or of information not being passed on to all affected parties. Thus in regard to the data analysis process, the firm's success at getting information to all the proper people may be just as important as the actual latency involved. Therefore we conditionally propose:

> *Proposition 5c. All else being equal, as decentralization of power increases, the ability to reduce both analysis and decision latency will increase, which in turn will lead to greater benefits from implementing real-time BI systems for time-sensitive decisions.*

Absorptive Capacity: Increasing Benefits over Time from Real-Time BI

Earlier, we argued that real-time BI would provide more *immediate* benefits in latency reduction in situations of uncertainty rather than equivocality. However, this argument may not always hold when looking longer term. Several studies (e.g. Eisenhardt 1989; Gibson 2000) have looked at the ability of individuals to make quick, and appropriate, decisions in a dynamic environment using real-time data. In particular, Eisenhardt (1989) found that the use of real-time information was one of several factors (including examination of multiple simultaneous alternatives, input from experienced counselors, active conflict resolution, and decision integration) that led to faster strategic decisions by executives and as a consequence, improved performance. One of the reasons offered for this finding was that executives who immerse themselves in real-time information are able to develop a "deep personal knowledge of the enterprise that allows them to access and interpret information rapidly when major decisions arise" (Eisenhardt 1989, p.570).

The literature on absorptive capacity also indicates that real-time information can "build intuition about the marketplace" at the organizational level, particularly in high-velocity, information-intensive markets where situation-specific knowledge is important (Eisenhardt and Martin 2000; Zaheer and Zaheer 1997). Organizational learning, via "learning loops" (Houghton et al. 2004), may also lessen the need over time to focus on simple search and satisficing, although improvements in organizational learning are most likely when there is an infrastructure in place for sharing knowledge and information. In fact, processes related to "obtaining, processing, and utilizing information" have been referred to as "invisible assets," resources that can provide sustained benefits to the firm (Zaheer and Zaheer 1997). Therefore we propose the following:

> *Proposition 6. All else being equal, as a firm's absorptive capacity increases, its ability to reduce both analysis and decision latency will increase, leading to greater benefits over time from the implementation of real-time BI systems for time-sensitive decisions.*

The implications of this proposition may be far-reaching for organizations aspiring to become true RTEs. Much of the current real-time BI technology is built on the premise of delivering the "right information to the right people at the right time" through automation of routinized processes. Malhotra (2000, p.6) argues that this notion is based on an outdated business model of incremental change in a relatively stable market, where "executives can foresee change by examining the past." Today, fundamental change may be more important, particularly in dynamic, rapidly changing environments. This implies a more flexible "anticipation-of-surprise" model, in which the "right information" is harder to determine, and the "right person" and "right time" perhaps unknown. Thus while real-time automated processes may work well in stable environments, more flexible structures and richer information exchange technologies, combined with the active development of absorptive capacity and organizational learning capabilities, may take precedence in dynamic environments.

Discussion and Conclusions

Most of the literature on the organizational aspects of real-time BI systems, and their relationship to agility, has originated within the practitioner community. However, evidence of real-time BI failures, or simply implementations that have been less successful than expected (see Malhotra 2005), suggests an opportunity to improve practitioner models through a better *theoretical* understanding of the real-time BI phenomenon. Real-time BI is just one of the tools that organizations can use in their quest to improve sensing and responding capabilities. While past research has looked at how *individuals* can improve decision-making in real time, there has been limited attention to how decision-making based on real-time information takes place at the *organizational* level. We have argued that the organizational level theories of information processing, bureaucracy, power/politics, and absorptive capacity can all provide leverage in understanding factors affecting the success of real-time BI systems, by introducing their constructs as antecedents to the individual components of the event-to-action latency cycle.

We began this paper with three guiding research questions. First we asked, "Are existing practitioner models of event-to-action latency accurate and complete? If not, how can they be enhanced from a theoretical perspective?" This question has been answered by using DDM theory to redefine data, analysis, and decision latency to incorporate a broader range of organizational phenomena and decision types, and by drawing from the literature on organizational agility to explicitly include action latency as an important component of an organization's response to opportunities and threats revealed through real-time data.

Our second research question was, "What types of business decisions are best suited for achieving overall latency reduction in the context of real-time BI?" Our analysis indicates that in the short run, overall latency is easier to reduce for decisions involving uncertainty as opposed to equivocality. In this case, technology can be used to improve information sharing across departments, and to automate or streamline well-established routines and SOPs. However, in following Malhotra (2000), the task environment must also be taken into account. In a stable task environment, an organization can leverage real-time opportunities through efficiency gains based on programmable logic. However, in a very dynamic task environment, such routinization may not be adequate or even appropriate. In such situations, real-time information may not be as useful unless it enhances individual and organizational learning capabilities. This is especially true as the task environment increases in complexity.

Our final research question was "What characteristics of organizational structure are best suited for achieving overall latency reduction in the context of real-time BI?" Drawing from several organizational theory bases, we have argued that wide scale implementations will be more difficult, and not necessarily desirable, in the presence of high subunit differentiation. While real-time BI applications become more valuable as workflow-based interdependence increases and associated coordination and control needs rise, competitive interdependence and its resulting political activity may make it more difficult to reduce latency, even when information is available in real time. Decentralization of decision-making and delegation of authority are critical for avoiding information bottlenecks that can increase both decision and action latency. Finally, an organizational infrastructure (and culture) that facilitates learning and information sharing may lead to increased absorptive capacity from real-time information over time.

Limitations and Future Research Directions

Recent research suggests that there may be additional types of organizational interdependencies that have not been explicated in extant theory (Siggelkow and Rivkin 2005). Particularly when decision making is decentralized, actions taken at one level of the organization may have unintended and unanticipated consequences on other parts of the organization, if not the organization as a whole. While some of the mitigating factors have been accounted for in our model, others doubtless exist. Thus Victor and Blackburn's (1987) framework for operationalizing interdependence and correspondence may not be appropriate for all situations.

While we explicitly included action latency in our model, we did not address its antecedents. For timely responses to business events requiring major strategic shifts, a firm may need to possess business, systems, customer, partnering, or operational agility. The key factors influencing these various types of agility are good candidates to consider in attempts to better understand action latency.

Future academic research on real-time BI and the RTE could also investigate:

- The critical success factors and challenges to successful implementation of real-time BI systems (using follow-up studies to examine both long-term implementation successes *and* failures). This is particularly relevant given a 2004 ITtoolbox study indicating that 37.1% of surveyed companies considered their real-time BI project to be only "somewhat successful," another 14.3% found it to be "adequate," while 12.9% more felt their project "needed improvements." Case studies on Cisco and Enron have also pointed out that early RTE technology successes do not necessarily prevent longer-term, human-related failures in other areas, such as through poor planning or forecasting; according to Malhotra (2005), it is not so much the RTE *technologies* that lead to successes as the RTE *business model* in place that these technologies support.
- The blending of real-time BI and knowledge management technologies (see Malhotra 2005), as well as the impact of real-time BI on organizational learning (see Bhatt and Zaveri 2002).
- Individual resistance to the adoption of real-time systems, due to increased "information democracy" and its resulting power shifts (see Fuchs 2005; McGee 2005), or concerns regarding continuous performance monitoring (see Lindorff 2002; Malhotra 2005).
- Other social and individual impacts of the implementation of real-time systems. For example, might an overreliance on dashboard systems and automated alerts lead to routine-based mindlessness that degrades performance, by encouraging individuals to trust in the *system* to provide the necessary data, rather than seeking out new insights on their *own* (per Butler and Gray 2006)? How does the need to respond to alerts delivered in real time impact employees who are very mobile, or not monitoring the system as they should? What technological and managerial interventions are possible to deal with each of these circumstances? Such issues, while beyond the scope of this paper, could have a substantial impact on the ability of firms to reduce analysis and decision latency, as well as on the ability of individuals to make timely, appropriate, and high-quality decisions.

This paper has been intended as a first step toward improving our theoretical understanding of the organizational factors impacting latency reduction in the context of real-time BI. It is based on the premise that "there is nothing so practical as a good theory" (Lewin 1951, p.169). We strongly encourage researchers to further investigate (empirically) the many issues we have raised here, with the ultimate goal of helping organizations to achieve more successful real-time BI implementations in the future.

References

Andersen, T.J. "The Performance Effect of Computer-Mediated Communication and Decentralized Strategic Decision Making," *Journal of Business Research* (58), August 2005, pp. 1059-1067.

Anderson-Lehman, R., Watson, H.J., Wixom, B.H., and Hoffer, J.A. "Continental Airlines Flies High with Real-Time Business Intelligence," *MIS Quarterly Executive* (3:4), December 2004, pp. 163-176.

Bhatt, G.D. and Zaveri, J. "The Enabling Role of Decision Support Systems in Organizational Learning," *Decision Support Systems* (32), January 2002, pp. 297-309.

Brehmer, B. "Dynamic Decision Making: Human Control of Complex Systems," *Acta Psychologica* (81), December 1992, pp. 211-241.

Butler, B.S. and Gray, P.H. "Reliability, Mindfulness, and Information Systems," *MIS Quarterly* (30:2), June 2006, pp. 211-224.

Buytendijk, F., Wood, B., and Geishecker, L. "Drivers and Challenges of Corporate Performance Management," *Gartner Strategic Analysis Report R-22-0730*, January 2004.

Chen, D.Q. and Goodhue, D.L. "Understanding the Agility Impact of Enterprise Resource Planning Systems," Working paper, 2005.

Cyert, R.M. and March, J.G. *A Behavioral Theory of the Firm*, Blackwell Publishing, Malden, MA, 1963.

Daft, R.L. and Lengel, R.H. "Organizational Information Requirements, Media Richness and Structural Design," *Management Science* (32:5), May 1986, pp. 554-571.

Eckerson, W. "The 'Soft Side' of Real-Time BI," *DM Review*, August 2004, pp. 30-32, 67.

Eisenhardt, K.M. "Making Fast Decisions in High-Velocity Environments," *Academy of Management Journal* (32:3), September 1989, pp. 543-576.

Eisenhardt, K.M. and Bourgeois, L.J. III. "Politics of Strategic Decision Making in High-Velocity Environments: Toward a Midrange Theory," *Academy of Management Journal* (31:4), December 1988, pp. 737-770.

Eisenhardt, K.M. and Martin, J.A. "Dynamic Capabilities: What Are They?," *Strategic Management Journal* (21), October-November 2000, pp. 1105-1121.

Fuchs, G. "BI and Political Resistance," *DM Review*, April 2005.

Gattiker, T.F., and Goodhue, D.L. "Understanding the Local Level Costs and Benefits of ERP Through Organizational Information Processing Theory," *Information and Management* (41:4), March 2004, pp. 431-443.

Gattiker, T.F. and Goodhue, D.L. "What Happens After ERP Implementation: Understanding the Impact of Interdependence and Differentiation on Plant-Level Outcomes," *MIS Quarterly* (29:3), September 2005, pp. 559-585.

Gibson, F.P. "Feedback Delays: How Can Decision Makers Learn Not to Buy a New Car Every Time the Garage is Empty?," *Organizational Behavior and Human Decision Processes* (83:1), September 2000, pp. 141-166.

Gonzalez, C. "Decision Support for Real-Time, Dynamic Decision-Making Tasks," *Organizational Behavior and Human Decision Processes* (96), 2005, pp. 142-154.

Goodhue, D.L., Wybo, M.D., and Kirsch, L.J. "The Impact of Data Integration on the Costs and Benefits of Information Systems," *MIS Quarterly* (16:3), September 1992, pp. 293-311.

Hackathorn, R. "Current Practices in Active Data Warehousing," *DM Review* white paper, November 2002, pp. 1-38.

Hackathorn, R. "Minimizing Action Distance," *The Data Administration Newsletter*, September 2003.

Hackathorn, R. "The BI Watch: Real-Time to Real-Value," *DM Review*, January 2004.

Hayler, A. "Real-Time Business Intelligence? Get Real," *DM Direct Newsletter*, June 2004.

Houghton, R., El Sawy, O.A., Gray, P., Donegan, C., and Joshi, A. "Vigilant Information Systems for Managing Enterprises in Dynamic Supply Chains: Real-Time Dashboards at Western Digital," *MIS Quarterly Executive* (3:1), March 2004, pp. 19-35.

Imhoff, C. "Intelligent Solutions: The Year of Compliance, Part 1," *DM Review*, January 2004.

Information Technology Toolbox, Inc. "2004 ITtoolbox Data Warehousing / Business Intelligence Survey," 2004, http://emergingtech.ittoolbox.com/research/survey.asp?survey=BI_Survey&p=1. Accessed May 1, 2005.

Jeng, J-J, Schiefer, J., and Change, H. "An Agent-Based Architecture for Analyzing Business Processes of Real-Time Enterprises," *Proceedings of the Seventh IEEE International Enterprise Distributed Object Computing Conference*, 2003, pp. 86-97.

Khosla, V. and Pal, M. "Real Time Enterprises: A Continuous Migration Approach," *Information Knowledge Systems Management* (3), 2002, pp. 53-79.

Langseth, J. and Vivatrat, N. "Outward Bound," *Intelligent Enterprise*, November 2002.

Lerch, F.J. and Harter, D.E. "Cognitive Support for Real-Time Dynamic Decision Making," *Information Systems Research* (12:1), March 2001, pp. 63-82.

Lewin, K. *Field Theory in Social Science: Selected Theoretical Papers*, Cartwright, D. (Ed.), Harper & Row, New York, 1951.

Lindorff, D. "Case Study: General Electric and Real Time," *CIO Insight*, November 2002, http://www.cioinsight.com/print_article2/0,2533,a=33483,00.asp. Accessed January 7, 2005.

Malhotra, Y. "Integrating Knowledge Management Technologies in Organizational Business Processes: Getting Real Time Enterprises to Deliver Real Business Performance," *Journal of Knowledge Management* (9:1), February 2005, pp. 7-28.

Malhotra, Y. "Knowledge Management for [E-]Business Performance," *Information Strategy: The Executives Journal* (16:4), Summer 2000, pp. 5-16.

McGee, K. "Gartner Updates Its Definition of Real-Time Enterprise," *Gartner, Inc. Research Note DF-22-2973*, 2004.

McGee, K. Heads Up: How to Anticipate Business Surprises and Seize Opportunities First. Boston, MA: Harvard Business School Press, 2004.

McGee, K. "Identify Your Real-Time Enterprise 'Fear Factor'," *Gartner, Inc. Research Note G00124225*, 2005.

Nesamoney, D. "BAM: Event-Driven Business Intelligence for the Real-Time Enterprise," *DM Review*, March 2004, pp. 38-40.

Pfeffer, J. *Power in Organizations*, Ballinger Publishing Company, Cambridge, MA, 1981.

Rabin, S. "The Real-Time Enterprise, the Real-Time Supply Chain," *Information Systems Management*, Spring 2003, pp. 58-62.

Reddy, R. "The Reality of Real Time," *Intelligent Enterprise*, June 2004.

Sambamurthy, V., Bharadwaj, A., and Grover, V. "Shaping Agility Through Digital Options: Reconceptualizing the Role of Information Technology in Contemporary Firms," *MIS Quarterly* (27:2), June 2003, pp. 237-263.

Sawhney, M. "Real-Time Reality Check," *CIO Magazine*, March 2003. http://www.cio.com/archive/030103/netgains.html. Accessed January 15, 2005.

Siggelkow, N. and Rivkin, J.W. "Speed and Search: Designing Organizations for Turbulence and Complexity," *Organization Science* (16:2), March-April 2005, pp. 101-122.

Thompson, J. *Organizations in Action*, McGraw-Hill, New York, 1967.

Tushman, M.L. and Nadler, D.A. "Information Processing as an Integrating Concept in Organization Design," *Academy of Management Review* (3), July 1978, pp. 613-624.

Victor, B. and Blackburn, R.S. "Interdependence: An Alternative Conceptualization," *Academy of Management Review* (12:3), July 1987, pp. 486-498.

Watson, H.J. "Sorting Out What's New in Decision Support," *Business Intelligence Journal*, May 2005.

White, C. "Building the Real-Time Enterprise," *TDWI Report Series*, November 2003.

Wybo, M.D., and Goodhue, D.L. "Using Interdependence as a Predictor of Data Standards: Theoretical and Measurement Issues," *Information and Management* (29), December 1995, pp. 317-328.

Zaheer, A. and Zaheer, S. "Catching the Wave: Alertness, Responsiveness, and Market Influence in Global Electronic Networks," *Management Science* (43:11), November 1997, pp. 1493-1509.

Appendix

Table 1. Common Terms Associated with Real-Time BI Systems

Term	Definition / Description
Active Data Warehousing / Active Business Intelligence	Views an organization's BI systems as an active (rather than passive) tool in conducting business. Active data warehousing and active BI both support the "intelligent enterprise," which is responsive, pervasive, globalized, and integrated (Hackathorn 2002).
Business Activity Monitoring (BAM) Also known as: Operational Performance Management "Operational BPM"	"A process by which key operational business events are monitored for changes or trends indicating opportunities or problems, and enabling business managers to take corrective action" (Nesamoney 2004, p.38). BAM uses an event-driven architecture based on key indicators of operating performance rather than a "pull" approach to getting information (Buytendijk et al. 2004).
Business Performance Management (BPM) Also known as: Corporate Performance Management (CPM) Enterprise Performance Management (EPM)	Includes all the "processes, methodologies, metrics, and technologies that enterprises use to measure, monitor and manage business performance;" it is a "convergence of enterprise applications, business intelligence technology and process support" (Buytendijk et al. 2004, pp.4,10). Planning, budgeting, and KPI reports are "pulled together…using a common strategic and technological framework to drive all parts of the organization toward a common set of goals and objectives" (Eckerson 2004, p.1).

Term	Definition / Description
Proactive Business Intelligence	Involves "real-time, mission-critical, actionable insight being automatically mined from the data warehouse and proactively communicated (potentially wirelessly) to the appropriate individuals for immediate attention and follow-through" (Langseth and Vivatrat 2002, pp.1-2).
Vigilant Information System (VIS)	A system that "integrates and distills information and business intelligence from various sources to detect changes, initiate alerts, assist with diagnosing and analyzing problems, and support communication for quick action" (Houghton et al. 2004, p.19). A VIS includes both sensing and responding capabilities. Sensing is accomplished through real-time dashboards with automated alerts. Responding is accomplished through capabilities that aid decision making and action (Houghton et al. 2004).