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Origins and Directions in Sense & Respond Research

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ORIGINS AND DIRECTIONS IN SENSE & RESPOND RESEARCH

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ABSTRACT

Sense & Respond is a multi-faceted research area – perhaps it is a lens through which one can view a number of intersecting research fields. In this paper we review many of the origins of Sense & Respond research, including Stephan Haeckel's Adaptive Enterprise, Porter's Competitive Advantage, Component Business Model, Model-Driven Business Transformation, Build-To-Order, Continuous Replenishment, Balanced Scorecard, Business Performance Management, and Business Intelligence. We discuss the current status of this research area and identify some future directions.

1 HAECKEL'S ADAPTIVE ENTERPRISE

Stephan Haeckel of IBM is considered by many to be the father of Sense & Respond research. In 1993 he began using the term *Sense & Respond* to describe a new management approach that enables adaptive organizational behavior by moving away from mass production management theories [Haeckel 1999]. He advocated a new form of strategic planning based on reconfigurable roles and responsibilities. In his view, organizational hierarchy is replaced by a dynamically configured network of modular capabilities. He defines a capability as "an organizational subsystem with a potential for producing outcomes that contribute to the organization's purposes." Governance of each capability is performed on the basis of context and coordination by people in roles accountable for outcomes rather than by command and control. The people in roles continually perform a monitoring procedure consisting of the following tasks: Sense, Interpret, Decide and Act.

As an example, a capability called *Client Team* can be formed to fulfill requests from a customer [Kapoor et al 2005]. The Client Team is composed of people in client-facing roles, an event-driven decision support system, an adaptive process and a set of measures and metrics commonly referred to as Key Performance Indicators (KPI's). A KPI is a performance metric that enables the measurement of progress towards organizational goals [About.com 2005]. In Sense & Respond business management, a KPI such as Revenue Growth or On-Time Delivery provides a measurable parameter for event management, visualization and organizational control. Based on the Client Team's perception of the Customer's current and future requirements, outsourcing relationships can be formed with additional capabilities such as *IT Outsourcing Services* and *Consulting Services*. These additional capabilities are free to form their own outsourcing relationships with other capabilities.

In this idealized example, it is important to be able to quickly redesign capabilities or reconfigure the capability network when the business climate undergoes significant change. In some businesses such as consulting, significant change can occur as frequently as every few months. In other businesses, significant change can be much less frequent, but it still needs to be addressed through capability reconfiguration, for example in downsizing or make/buy decisions. Each capability detects changes in its business climate through the monitoring and management of its KPI's.

Haeckel did not define any technological solutions to the issues that he raised. He left the door wide open to a wide variety of research investigations.

2 PORTER'S COMPETITIVE ADVANTAGE AND COMPONENT BUSINESS MODEL

Michael Porter's book on Competitive Advantage [Porter 1985] describes how a firm can gain an advantage over its rivals through *value chain analysis*, in which a company is disaggregated into activities that represent the elemental building blocks of competitive advantage. Each activity is typically designed either for cost leadership or differentiation. Porter's value chain enables managers to isolate the underlying sources of buyer value that will command a premium price, and the reasons why one product or service substitutes for another. He shows how competitive advantage lies not only in activities themselves but in the way activities relate to each other, to supplier activities, and to customer activities.

Porter's Competitive Advantage provides some of the underpinnings for Haeckel's capabilities. More recently, IBM has developed a related approach called *Component Business Model* (CBM), an analytical toolset that helps companies spot overlapping, dependent activities and the resources used to support those activities. By grouping "like" activities -- or business components -- without regard to organizational, geographic or process boundaries, CBM helps companies to optimize the efficiency and cost of their activities [Auto Channel 2004]. It also helps companies to focus more clearly on their differentiating activities.

3 MODEL-DRIVEN BUSINESS TRANSFORMATION

In order to achieve the Sense & Respond objective that capabilities can be rapidly redesigned and reconfigured, significant advances in business process management are required. One approach from IBM is called Model-Driven Business Transformation [Kumaran 2004]. The goal of this initiative is to avoid the paradigm in which minor changes in business requirements explode into complex transformation projects. To make capability implementation more homogeneous, the Service Oriented Architecture (SOA) concept [IBM SOA 2005], where standardized web services are provided and used on demand, is rapidly gaining traction. However, SOA only drives homogeneity at the implementation level. To ensure that implementation is driven by business requirements, IBM is developing a top-down approach in which implementation models are derived from higher-level business models. IBM believes that this approach will revolutionize application development.

4 BUILD-TO-ORDER, CONTINUOUS REPLENISHMENT, KANBAN SYSTEMS

Haeckel describes an organization that is driven by its customers' needs. Such an organization does not "make-and-sell", it makes what its customers need. This same concept has been embodied in many supply chain designs ranging from Build-To-Order to Continuous Replenishment to Kanban Systems.

Build-To-Order is best exemplified by Dell's practice of manufacturing personal computers only after a customer order has been received [Dell and Fredmen 1999]. This practice significantly reduces inventory risk. IBM has also made progress in this area [Feigin et al 1996].

Continuous replenishment refers to the practice of partnering between distribution channel members that changes the traditional replenishment process from distributor-generated purchase orders, based on economic order quantities, to the replenishment of products based on actual and forecasted product demand [Prime Logistics 2005]. The mathematical foundations of continuous replenishment lie in a family of inventory policies where inventory is replenished only when the inventory level reaches a specified *reorder point* [Zipkin 2000]. Continuous replenishment can be seen as an outgrowth of the Japanese theory of production based on kanban systems [Japanese Management Association 1989].

While many industrial supply chains have already transformed from Make-and-Sell to Build-To-Order or Continuous Replenishment, military supply chains are just starting to plan the transformation. The traditional long-term supply contracts in the military-industrial complex have delayed the transformation. Interestingly, some people in the military-industrial complex refer to this transformation goal as Sense & Respond.

5 BALANCED SCORECARD

In Haeckel's influential article "Managing By Wire: Using I/T to Transform a Business From Make-and-Sell to Sense-and-Respond" [Haeckel and Nolan 1996], Haeckel comments:

"Imagine an enterprise design model that defines the behavior of an entire business. Imagine making this model a part of the corporate informational infrastructure, implementing it on technology that connects all relevant sources and users of information and affords maximum sharing among all parts of the firm. Managers could respond to the read-outs appearing on the console, modifying the flight plan en route based on changes in external conditions, monitoring the performance of delegated responsibilities, sending coordinated directions to subsidiary functions, and experiencing exhilaration upon their execution. It constitutes institutional memory and intelligence, which augment management's ability to run the business."

In this vision, Haeckel builds upon the Balanced Scorecard concept [Kaplan and Norton 1992]. The metrics in a Balanced Scorecard are grouped into four perspectives: *learning and growth, internal business process, customer, and financial*. Kaplan and Norton found that traditional metrics resulted in leaders managing their organizations by "looking in the rear-view mirror", so they developed a technique that included metrics to drive future performance. Performance drivers provide early indications about whether the strategy is being implemented successfully. This corresponds to Haeckel's core compe-

tency of "knowing earlier" which enables timely responses to customer needs and proactive redesign and reconfiguration of capability networks.

A Balanced Scorecard is not just a collection of performance metrics; it must also model the relationships among organizational objectives and metrics. The four perspectives represent a causal chain in which improvements in employee skills (learning and growth) cause improvements in internal business processes which cause improvements in customer satisfaction which cause financial improvements.

6 SCEM, BAM, BPM

In order to implement the analytics and decision support implied by the Sense & Respond and Balanced Scorecard visions, a reusable infrastructure is needed to supply the necessary information and communicate the decisions that are made. In 2000 AMR Research began publishing a series of reports describing an emerging layer of Supply Chain Management software that they referred to as *Supply Chain Event Management* (SCEM) [Bittner 2000]. SCEM software was said to perform the following functions:

- *Monitor*: Provides ongoing information about supply chain objects and events
- *Notify*: Alert messaging for real-time exception management
- *Simulate*: Decision support by assessing what will happen if specific actions are taken
- *Control*: Operational execution of decisions
- *Measure*: KPI calculation

AMR indicated that between 25 and 50 software vendors were active in this space at that time.

In 2002 Gartner generalized this concept to cover event monitoring of any business activity, coining the term *Business Activity Management* (BAM) [April 2002]. By expanding the scope, Gartner doubled the revenue projections that had been issued by AMR Research.

SCEM and BAM didn't achieve the business traction and sales projections predicted by the analysts, partly due to the economic slowdown of that period. In 2004, a new term emerged in this space, Business Performance Management (BPM) [IBM BPM 2004]. BPM, in addition to embracing many of the BAM concepts, includes a process modeling aspect that is derived from Model-Driven Business Transformation. BPM is supported by an architectural framework of loosely coupled components which give a BPM designer the freedom to select from a variety of physical components. One version of IBM's BPM framework is shown in Figure 1. The components communicate with each other through an event bus. Each component has well-defined interfaces for receiving and publishing events on the event bus.

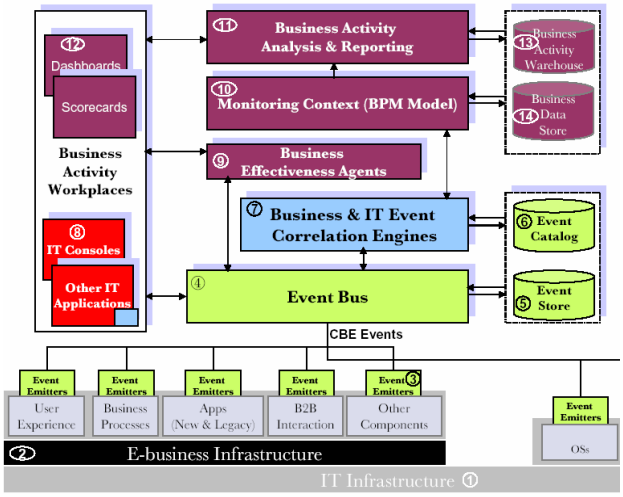

Figure 1. Example BPM architectural framework

The logical components of IBM's framework include:

- *Monitoring Context*: A model that configures and drives a BPM implementation.
- *Event Emitters*: Placed at appropriate points in the business process and responsible for sending signals and information to and from the BPM system. This is done by taking a snapshot of key business artifacts and placing a corresponding event on the Event Bus to be consumed by other components in the BPM system.
- *Event Bus*: The central component of the architecture. Other components publish events on the bus and consume events placed on the bus. Raw events published on the bus by Event Emitters are consumed by Business & IT Event Correlation Engines, which calculate KPI's and check for situations, which are either exceptions or noteworthy trends. Situations are published on the bus and consumed by Business Effectiveness Agents. Decisions made by Business Effectiveness Agents are published on the bus and communicated to users in Business Activity Workplaces.
- *Business & IT Event Correlation Engines*: Receive raw events published by Event Emitters. Correlation Engines parse each event, correlate multiple events, perform complex aggregations and recalculate KPI's from the data contained in events. KPI's are stored in the Business Data Store while

events are stored in the Event Store. Correlation Engines evaluate new KPI values against predefined commitments (e.g. KPI thresholds) and publish situations if any commitments have been violated. Correlation Engines also try to detect important trends that could lead to violated commitments in the future.

- *Business Effectiveness Agents*: Receive situations published on the Event Bus and propose one or more actions. Actions can fall into a number of categories, including notifications to key business managers, changes to operational parameters or business rules, reallocation of resources, invocation of exception processes, improvement of ineffective processes and improvement of ineffective strategies.
- *Business Activity Analysis and Reporting*: Utilizes data in the Business Activity Warehouse to support trend analysis and root cause analysis. Standard OLAP (On Line Analytic Processing) tools are provided for analysis, as well as data mining tools and advanced visualization graphics.
- *Business Activity Workplaces*: Receive information from the Event Bus and present it to business users in various formats. Provide visibility to current and historical KPI values as well as trend information. Support root cause analysis, in concert with Business Activity Analysis and Reporting. When situations arise, support decision making in concert with Business Effectiveness Agents.

7 BUSINESS INTELLIGENCE

Until recently, Business Intelligence meant that a business manager would ask the IT department to run some batch queries on the firm's data warehouse. According to a recent industry analyst [Business Intelligence Pipeline 2005], BPM and BI are converging, and Business Intelligence is becoming part of online management dashboards. According to the analyst, "BPM systems have the same need for dashboard-like monitors, analysis functions and control functions that BI and BAM systems use, but with a broader view of dataflows".

BPM systems with BI-based predictive analytics play a key role in the Sense & Respond and Balanced Scorecard visions. IBM has been very active in prototyping and piloting this type of technology within its own processes [Kapoor et al 2005]. The prototypes and pilots include:

- *Demand Conditioning*: This pilot has been used in IBM's supply chain operations since 2004. It helps IBM to steer customer orders toward warehouse and pipeline inventory to avoid stockouts. This is accomplished by proactively detecting potential shortages and overages using new order trending analytic developed at IBM Research.
- *Transportation Management*: This prototype was developed to monitor freight transportation and integrate that information with other supply chain information. The prototype features an OLAP system for historical analysis as well as advanced visualization techniques [Kapoor et al 2004].
- *Customer Segmentation*: This prototype uses data mining to detect customer movement across segments as well as inefficiencies in customer segment definitions.
- *Portfolio Management*: This new prototype will correlate the effect of operational metrics on enterprise metrics. The goal of the system is to allow business transformation investments, which are typically focused on operational improvements, to be prioritized by their potential impact on enterprise performance.

8 FUTURE DIRECTIONS

In this section we will identify a number of future directions for Sense & Respond research. These subjects have been investigated independently for some time but have not been convincingly demonstrated in a Sense & Respond environment yet.

8.1 Decision Support

Most Sense & Respond research has been focused on the Sense part, which is natural since responding is not possible without proper information. One exception is Lookahead Decisions Inc., who build simulation systems for real-time decision making [Dalal et al 2003]. IBM has also begun to do work in this area [Huang et al 2004].

One direction that would be very helpful for Sense & Respond decision support is the standardization of interfaces to simulation, optimization and other decision support services. This standardization could be based on SOA and grid computing principles. It would greatly simplify the design and interconnection of sensing and decision support systems. The inherent difficulty in establishing standard interfaces is the amount of customization in most simulation and optimization applications.

8.2 Metric Causality

The concept of metric causality described by the Balanced Scorecard vision has not achieved full traction yet in implemented systems. Business managers are increasingly interested in this concept as a way of drilling down into enterprise-level pain points to identify operational drivers. Metric causality can also be used as a predictive analytic to understand the potential effects of operational changes.

8.3 Distributed Agents

Although there has been a lot of research on distributed agents, there are few examples of agents helping to make decisions based on real-time information. Conversely, a significant number of agent-based simulations have helped in making strategic decisions.

One issue in this area is widespread disagreement over the definition and purpose of an agent. Another issue is that distributed agent decision making borders on artificial intelligence, which is difficult to formulate and computationally intractable.

8.4 Stability

Sense & Respond systems enable the use of real-time information to update strategic and operational policies, managing execution based on context, not according to a preset plan. Managing execution based on context can be beneficial, but need not always be. The Bullwhip Effect [Lee et al 1997] is a classic example where frequent demand forecast updates based on uncertain information can cause undesirable effects. As information updates become more frequent due to Sense & Respond, a key challenge is to understand the uncertainty in the information and to make stability-preserving decisions based on stochastic and dynamic analysis. IBM has begin to do some work in this area [Chen et al 2003].

8.5 Risk Management

Compliance legislation such as Sarbanes-Oxley has made it more urgent for companies to be aware of exceptions to their financial plans. Independent of legislative issues, companies need to monitor their strategic plans to ensure that the assumptions of their strategy continue to hold. They also need to be aware of operational business risks and monitor their operations accordingly.

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