COMBINING BUSINESS ACTIVITY MONITORING WITH THE DATA WAREHOUSE FOR EVENT-CONTEXT CORRELATION
Examing the Practical Applicability of this BAM Approach

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Keywords: Business Activity Monitoring, BAM, Data Warehouse, Real-Time Event, Historical Data, Push-Based, Performance-Indicators

Abstract: Business Activity Monitoring (BAM) the term that Gartner, Inc. introduced to define systems that provide real-time access to critical business performance indicators in order to improve the speed and effectiveness of business operations. Despite the emphasis of BAM on the provision of low-latency views on enterprise performance, the literature on BAM also indicates the technical feasibility of a BAM approach that adds context from historical information stored in a data warehouse to real-time events detected by a BAM system, so as to help enterprises to improve their understanding of current monitoring scenarios. At this point there is a lack of studies that discuss the use of this approach to tackle real-world business problems. To improve our practical understanding of the potential applicability of this BAM approach, the paper will present a synthesis of existing research on BAM and data warehouse (DW) approaches to provide a basis for proposing feasible business scenarios to apply a combination of both technologies (BAM, DW). This study suggests that a contextualized BAM approach allows operational managers to respond better to the occurrence of events by facilitating a better understanding of the nature of the detected event.

1 INTRODUCTION

Enterprises are currently exposed to rapidly changing market conditions and increasingly competitive business environments (Luckham, 2002). To ensure competitiveness, enterprises must maximize revenue generation and cost savings when executing their business processes. Since the occurrence of (exception) business events of interest in transactional systems, such as unusually large orders, delays, unavailability of resources and other situations of high risk have a significant economic impact on the performance of business processes, enterprises need to respond quickly and adequately to such events as they occur. This requires the availability of an infrastructure that provides real-time visibility into the business operations of enterprises.

To enable enterprises to minimize response times to events, software vendors have started developing a new set of capabilities. Gartner, Inc. introduced the term Business Activity Monitoring (BAM) to define this new set of functions (McCoy, 2000). Fundamentally, BAM systems are systems that translate input events into real-time analysis that is “pushed” to recipients for immediate reaction (Govekar et al, 2002). The provision of real-time access to business performance indicators requires gathering and analysing business events from multiple and heterogeneous data sources to detect exception conditions and generate low latency alerts that enable business managers responsible for business processes to quickly make well-informed decisions (DeFee & Harmon, 2004; Chandy & McGoveran, 2004).

Although the concept behind BAM systems emphasizes the provision real-time operational
insights, some studies acknowledge that the combining real-time events with historical data can help enterprises diagnose problems in current monitoring scenarios (McCoy, 2002; Govekar et al, 2002; Gassman, 2004). Nonetheless, at the present time, there is a lack of studies addressing the practical applicability of this contextualized, business monitoring approach. The purpose of this paper is to fill this gap in the literature by presenting a synthesis of existing research on BAM and data warehousing, and provide an objective basis for the application of this approach to real-world business scenarios. This is done by examining both the technical and conventional applications of both technologies and proposing practical combinations of the two.

This paper utilizes the insights obtained by conducting a project that involved collaboration between the faculty of Technology, Policy and Management at Delft University of Technology, Delft, The Netherlands, and the Centre for Process Innovation (CEPRIN), Robinson College of Business at Georgia State University, Atlanta, USA.

2 TECHNICAL CONSIDERATIONS ABOUT BAM

Essentially, BAM systems analyse events to identify problems, diagnose them, and generate alerts to recommend managerial action. BAM systems can be incorporated into the IT infrastructure of enterprises as an event analytics layer at the top of an existing middleware infrastructure. In practice, BAM systems can be viewed as rule-based systems that detect significant events (characterized as state changes) with significant business implications for enterprises. BAM systems serve as a platform upon which event-driven applications can be developed by defining patterns to represent events with significant economic impact. To support the development of event-driven applications, BAM systems are likely to include event modelling functions that define and validate event patterns (Gassman, 2004). This makes BAM systems highly adaptable, as new event-driven applications can be rapidly developed to address new or changing business problems.

In BAM systems, events are likely to come from multiple and heterogeneous data sources (Gassman, 2004). BAM systems are able to gather from internal sources, and also from external sources such as Internet (McCoy et al, 2001). Essentially, BAM performs event analysis by correlating events originating from multiple and independent sources (McCoy, 2004).

To represent BAM systems, Gartner, Inc. has proposed a three-layer model comprised of 1), an event absorption layer, 2), an event processing and filtering layer, 3), an event delivery and display layer (Govekar et al, 2002). Figure 1 provides an illustration of each layer.

In the following sub-sections we briefly describe each layer shown in Figure 1 below.

![Figure 1: Layers of a BAM system, adapted from (Govekar et al, 2004).](image)

2.1 Event Absorption Layer

Events are fed into the event absorption layer by an event acquisition tool. The source of event messages for BAM will often be business or process-related; however, technical events (such as the unavailability of a router) that occur during the operations of the IT infrastructure may also be collected (Gassman, 2004). BAM systems rely on event gathering mechanisms to gather event information, in real-time, directly from operational systems. A BAM system should have a mechanism in place to gather events occurring in different operational systems by tapping into different information sources. This is enabled by the message-oriented middleware layer that now supports interoperability among disparate transactional systems.
2.2 Event Processing and Filtering Layer

Basically, BAM systems must be able to correlate multiple sources of independent data (McCoy, 2004). To this end, a filtering system must be designed that draws data from a wide range of sources and then against rules that when met generate alerts (DeFee & Harmon, 2001). Therefore, a business rule builder that can handle the exceptions and extract meaning from event information.

2.3 Event Delivery and Display Layer

The alerts issued by a BAM system can be sent to diverse BAM recipients (Govekar et al, 2002). The delivered alerts can populate a display or trigger an action (Gassman, 2004). When alerts are used to populate a display, they are often delivered via graphical displays (“Dashboards”) that are customized for use in different parts of the enterprise and for different audience (McCoy et al, 2001). Alternative mechanisms include: batch office staff, emails, pagers, PDAs, and other systems such that someone or something can react (McCoy, 2003).

The alert can also be used to trigger an action executed by a Business Process Management (BPM) system. In this respect, controlling the reaction cycle will probably be a role of BPM tools (McCoy, 2003). Here, BAM-alerts can be part of a BPM, where they generate an input for the BPM system that triggers a workflow corresponding to a predefined sequence of events (Gassman, 2004). The BPM tool then reacts to the BAM alert by initiating a set of processes that initiate or modify a business process execution (McCoy, 2004).

3 APPLICATIONS OF BAM

BAM systems are applicable to monitoring situations that require very low latency operational insights on the execution of business processes. Essentially, in BAM systems, the emphasis is on responding to events within a short time-frame of opportunity (Chandy & McGoveran, 2004). In fact, BAM systems must generate alerts in real-time, otherwise the value of the system is largely, if not completely lost (McCoy, 2003). DeFee and Harmon (2004) define “good” BAM systems as those that provide managers with sufficient operational insights in near real-time, so that decisions can be taken in time to affect the ongoing performance of the process. A number of examples of the need for real-time operational insights are provided in the literature. Table 1 provides some examples of such needs.

<table>
<thead>
<tr>
<th>Real-Time Operational Insights</th>
<th>Source</th>
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<tbody>
<tr>
<td>A retailer that needs to monitor hourly sales levels</td>
<td>(Hackthorn, 2004)</td>
</tr>
<tr>
<td>A financial system BAM tool issued an alert on a stock volume increase or decrease beyond a threshold level</td>
<td>(McCoy, 2003)</td>
</tr>
<tr>
<td>Provide a real-time view on supply chain metrics</td>
<td>(McCoy et al, 2001)</td>
</tr>
<tr>
<td>Monitor service level agreements (SLAs)</td>
<td>(Luckham, 2002)</td>
</tr>
</tbody>
</table>

4 TECHNICAL CONSIDERATIONS ABOUT THE DATA WAREHOUSE

In practice, the data warehouse can be viewed as a workflow-style process that involves periodically gathering disparate data, then cleansing, transforming, and integrating that data according to business rules stored in a metadata repository. The data is then loaded into a persistent data structure where it can be analyzed (Inmon et al, 2001).

The data stored in a data warehouse represents “historical” data in that it represents events that have now passed (Inmon et al, 2001). The data warehouse is designed to store facts for each time period, thereby creating a historical perspective on performance (Tanler, 1997). It can create a single subject-oriented collection of information by assembling the data from heterogeneous databases (Thuraisingham, 1999). This allows business analysts to query against a single source consisting of a repository drawn from multiple sources. In order to provide a single version of enterprise operational data, the data warehouse needs to integrate data from multiple operational systems of the enterprise. To do this, the data warehouse typically relies on specialized software to carry out the extract, transform, and load (ETL) process. New or changed transactions (fact records) are moved and dimensions are captured as point-in-time snapshots for each load (Kimball & Caserta, 2004). In fact, a new snapshot is created whenever a change needs to be reflected in the data warehouse (Inmon et al, 2001). A fundamental consideration about the ETL process is that it depends on the availability of windows of available downtime (or low-load time) of the associated transactional systems, because it places an additional load on the transactional systems during the loading process. Because of the timing of these windows during low-load periods, the resulting latency associated with the data

Table 1: Examples of the Need for Real-Time
A data mart is a collection of data that is adequate to the DSS processing needs of a specific department or set of users. As such, it is a subset of a data warehouse customized to fit the needs of these users (Inmon, 2001, Brown & Hill, 2000, Sousa, 1999). They provide detailed information focused on a single area, such as marketing, sales, production, or finance (Brown & Hill, 2000). From the data warehouse, atomic data flows to various departments for their customized usage.

Table 2: Examples of Data Warehouse analyses

<table>
<thead>
<tr>
<th>Example of Analyzes Based on a Data Warehouse</th>
<th>Source</th>
</tr>
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<tbody>
<tr>
<td>Managers need to view sales by product and region and make correlations with advertising campaigns and marketing promotion.</td>
<td>(Brown &amp; Hill, 2000)</td>
</tr>
<tr>
<td>Answering questions such as,</td>
<td></td>
</tr>
<tr>
<td>• What type of customer is the most profitable for our business?</td>
<td></td>
</tr>
<tr>
<td>• Over the years, how has transaction activity changed?</td>
<td></td>
</tr>
<tr>
<td>• Where has sales activity been highest in the springtime for the past three years?</td>
<td></td>
</tr>
<tr>
<td>• When we change prices, how much elasticity is there in the marketplace?</td>
<td></td>
</tr>
<tr>
<td>The most frequent use of a data warehouse is to analyze historical data, discover trends and correlations and project events forward into the future.</td>
<td>(Meltzer, 1999)</td>
</tr>
<tr>
<td>Use data warehouse to analyze business data historically by focusing on planning such as trends in daily sales levels as compared with previous months.</td>
<td>(Hackathorn, 2004)</td>
</tr>
</tbody>
</table>

6 LINKING BAM AND THE DATA WAREHOUSE: EVENT-CONTEXT CORRELATION

Besides analyzing real-time operational information, BAM systems can also support event-context correlation. This is an important aspect of BAM systems because the addition of contextual

Table 3: Monitoring situations that can be addressed by the proposed BAM approach
information to an event provides additional information about the nature of the situation that is being monitored. For example, the definition of a certain filtering criteria to detect exceptional events can be seen as a basic form of adding context to BAM alerts; defined by Gassman (2004) as “events with context.” Specifying a threshold for a certain performance-indicator, represented by an event property, the value of the threshold can be regarded as contextual information. However, more sophisticated ways of adding context to events are usually required. For example, the decision support need of the BAM recipient may require the diagnosis of problems to respond to events with high accuracy, or event forecast data to guide anticipated response to future problems. Just raising alerts indicating the occurrence of exceptional situations might be insufficient to ensure a proper response in many monitoring situations.

Data warehouses can be employed to add context from a historical store for business activity to a real-time alert. This can be done by building models that correlate patterns of events with previous occurrences of problems and opportunities. For example, an hourly trend of expected order volume may be updated nightly by a BI system and used as a reference against real-time orders to detect exceptional variations in order volumes (Gassman, 2004). Additionally, BAM systems can improve long-term analyses by adding the context of real-time feeds into an Operational Data Store (ODS) (Hackathorn, 2004). This enables a more complete understanding of trends, because it supports an analysis of trends by providing understanding of current states.

7 APPLICATION OF THE PROPOSED BAM APPROACH

After understanding differences and similarities between BAM systems and data warehouses, we highlight a set of generic monitoring situations that can be addressed through the combination of real-time events with historical data. These monitoring situations were identified in the course of a graduation project. Table 3 illustrates the problems and analyses of historical data and real-time event information.

<table>
<thead>
<tr>
<th>Brief Problem Description</th>
<th>Data Warehouse</th>
<th>BAM</th>
</tr>
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<tbody>
<tr>
<td>Benefit from opportunities in Customer Relationship Management (CRM) systems by selecting customers for preferred treatment based on purchase records of customers and provide a higher level of service to the type of customer that is most profitable for the business.</td>
<td>Identify what type of customer is the most profitable for the business.</td>
<td>Generate alert to notify the need to provide service privileges to the selected type of customer.</td>
</tr>
<tr>
<td>Health surveillance and disease control can be empowered to detect early signs of emerging epidemics. In this way, patient care decisions can be adjusted when patterns of previous epidemics are detected.</td>
<td>Identify patterns of patient admissions in previous epidemics</td>
<td>Integrate patient admission data from several hospitals and searching for pattern that matches a historical pattern of previous epidemics.</td>
</tr>
<tr>
<td>Refine sales forecast models by adjusting forecasts taking exception events into account.</td>
<td>Extrapolate sales levels from historical data.</td>
<td>Produce new forecast when an exceptional high order is placed that affects the forecast.</td>
</tr>
<tr>
<td>Support investor’s trade decisions to buy and sell shares in companies.</td>
<td>Calculate historical prices of shares.</td>
<td>Generate alerts when prices are above or below historical levels to indicate the need to buy or sell. Include news and forecast in analysis.</td>
</tr>
<tr>
<td>Optimize purchase of products in a supply chain.</td>
<td>Calculate historical market prices of products.</td>
<td>Generate alerts when current prices approximate historical</td>
</tr>
</tbody>
</table>
Support retailer’s inventory management. | Calculate historical averages for demand for products and services | Identify peaks in demand for products or sales from historical data.

8 CONCLUSIONS AND FUTURE WORK

We have presented an assessment of the practical applicability of a BAM systems and data warehouse. The paper provides evidence that the combining real-time events with historical data can help to improve a users’ understanding of the nature of the current problems, resulting in better support for rapid and adequate user responses. Regarding future research, we believe that an important direction is the need for a thorough search for industry-specific problems that are likely to require a contextualized-BAM approach. Another area concerns the quantitative measurement of the benefits generated by this BAM approach. Although the benefits that might accrue through this BAM approach may seem evident to a user, an improved basis is needed if the additional costs and efforts necessary are to be justified.

REFERENCES