Enhanced Business Intelligence - Supporting Business Processes with Real-Time Business Analytics

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Abstract

In the 21st century, organizations are experiencing environmental changes characterized by indistinct organizational boundaries and fast-paced change. As a result firms need appropriate decision support infrastructures in order to face these challenges. Current Data Warehousing and Business Intelligence approaches are widely accepted as a middleware layer for state-of–the-art decision support. However, they do not provide sufficient support in dealing with the upcoming challenges, such as real-time and closed loop decision making. In this paper, we suggest an architecture for enhanced Business Intelligence that aims to increase the value of Business Intelligence by reducing action time and interlinking business processes into decision making.

1. Introduction

In the 21st century, organizations are evolving into new forms based on knowledge and networks in response to an environment characterized by indistinct organizational boundaries and fast-paced change. Firms are experiencing environmental changes resulting from the new economics of information [10] and the increasingly dynamic and global nature of competition [5] . Therefore organizational survival depends on the construction and integration of knowledge fostering the adaptation to the environment, as well as stimulating environmental changes through the firm's knowledge and practices [8]. As a result especially investments in IT that enable differentiation are of ever increasing importance [19].

An important component of this investment is in Business Intelligence (BI). Coined by *Gartner* in the early 1990s, the term BI denotes on the one hand an analytic process that transforms internal and external data into information about capabilities, market positions, activities, and goals that the company should pursue in order to stay competitive. On the other hand, BI stands for Information System concepts like Online Analytical processing (OLAP), Querying and Reporting, or Data Mining that provide different methods for a flexible goal-driven analysis of business data, provided through a central data pool.

BI may facilitate the connections in the new-form organization, bringing real-time information to centralized repositories and support analytics that can be exploited at every horizontal and vertical level within and outside the firm [20].

This research aims at contributing to the future development of BI. It is grounded in the working assumptions of the information processing theory [29]. As BI is a newer form of decision support systems [9], [28] we build on *Simon's* [27] perspective of decision making and *Weiner's* classic model of an organization as an adaptive system [30]. Therefore, we conceptualize inputs being processed into outputs which feed back to influence inputs and enable adaptation to external uncertainty.

The remainder of this paper is structured as follows: Section 2 reviews related work and describes major future challenges for decision support and Business Intelligence. Section 3 introduces a framework for enhanced Business Intelligence integrating the process-oriented and real-time analytics perspective. In Section 4-5 we describe an architecture for enhancing Business Intelligence and its contribution for advanced decision support.

2. Related Work

Due to the challenges in the competitive environment, two major challenges of the traditional business intelligence (BI) concept can be identified.

Convergence of Business Processes and BI

First, the common thread running through the new-form organization is that the organization's foundation is the value chain – a set of primary and secondary activities that create value for customers [7]. Therefore, BI is targeted to support process-oriented organizations.

Initiated by the works of *Hammer and Champy* [14], *Davenport* [6] and others, companies have redesigned their organizations around business processes. With process orientation gaining importance, the need for effectively managing and controlling business processes is of great importance resulting in new requirements for decision support. Collecting and reconciling all operational data related to business processes, enables the measurement of process performance and helps to identify opportunities for process improvement.

As management decisions require the integration of decision-relevant information, operational data from different applications have to be collected, integrated and prepared for data analysis. Today, this is mainly achieved by using traditional data warehouse systems and traditional business intelligence tools [31]. In most cases, the resulting management information systems are not primarily targeted on measuring the performance of business processes but on fulfilling traditional reporting requirements (e.g. financial reporting) [12].

Convergence of BI and EAI

Second, Business Intelligence aims at providing a closed-loop support that interlinks strategy formulation, process design and execution with business intelligence [11], [22].

In order to increase their competitiveness, companies strive towards reducing the time needed to react to relevant business events. An ideal state would be reached if reactions were possible in real-time, i.e. without any latency between recognizing a relevant business event and taking an appropriate action. Enterprise Application Integration (EAI) suites provide a popular solution for integrating heterogeneous applications in or near real-time because they are able to seamlessly publish any kind of data updates to every subscribing application.

However, this integration usually is achieved between operational systems and involves only little data consolidation. When it comes to extensive data analysis, Business Intelligence will be used to produce the information that is necessary to decide and take appropriate actions. Addressing this field, real-time decision support gained great attention. Concepts such as active warehousing [3], real-time analytics [24], real-time warehousing **Error! Reference source not found.**, or real-time decision support provide suggestions of how to speed up the flow of information in order to achieve competitive advantage.

Additionally, the vendors of BI and data warehousing solutions tend to enhance their products by mechanisms for real-time data integration and real-time analysis: this leads to the convergence of EAI and BI solutions [21].

3. Framework for enhanced BI

BI as Decision Support Middleware Layer

Data warehouse systems are widely accepted as a new middleware layer between transactional applications and decision support applications, thereby decoupling systems tailored to an efficient handling of business transactions from systems tailored to an efficient support of business decisions. The transformation of transaction data into integrated, consistent input for decision support applications by data warehousing consumes a certain amount of time and creates non-volatile, aggregate information. Many operational decisions (e.g. promotion effectiveness, customer retention, key account information [17], need actual yet integrated and subject-oriented data in or near real-time [26].

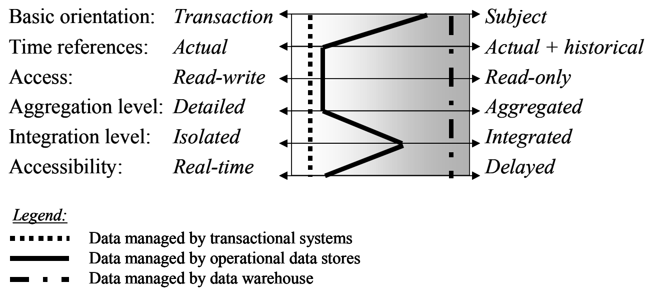

Figure 1: Operational data stores vs. Data Warehouse (adapted from *Winter [32]*)

Therefore, the concept of operational data stores has been introduced for operational decision support [18] and for data-oriented application integration [15]. It becomes evident that operational data stores can be positioned between transactional applications and the data warehouse [17], [18]. Data managed by operational data stores have characteristics that differ from data managed by operational applications, as well as from data managed by the data warehouse (see figure 1).

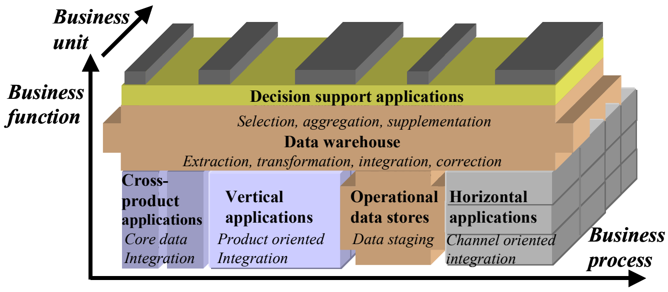

Figure 2: Business Intelligence as Decision Support Middleware Layer (adapted from *Winter [32]*)

Since both the data warehouse and operational data stores can be regarded as data-oriented integration middleware, it was proposed that operational data stores should be implemented as a part of the data warehouse, or that the data warehouse should be directly utilized for transactional services like customer relationship management or e-commerce [23]. Since operational data stores are fundamentally different from the data warehouse due to real-time processing needs and readwrite access to data, these two middleware layers are usually separated in the application architecture. Therefore, *Winter* suggests the application architecture for decision support [32] shown in Figure 2.

Enhancing BI with Real-Time Business Analytics

Data warehousing may contribute to an efficient information supply between transactional applications and decision support applications. However, information 'backflows' take their way indirectly (i.e. by actions of decision makers) into the transactional systems and not directly through the data warehouse (open-loop approach). Operational data stores, in contrast allow an efficient 'local' closed-loop supported between vertical and horizontal transactional applications.

What is decisive is a closed loop approach interlinking operational and strategic decision making. Therefore, BI has to be enhanced towards a closed loop real-time BI, shortening the period of time between the occurrence of a business event that requires an appropriate action by the organization and the time the action is finally carried out. According to *Hackathorn* [13], the additional business value of an action decreases, the more time elapses from the occurrence of the event to taking action.

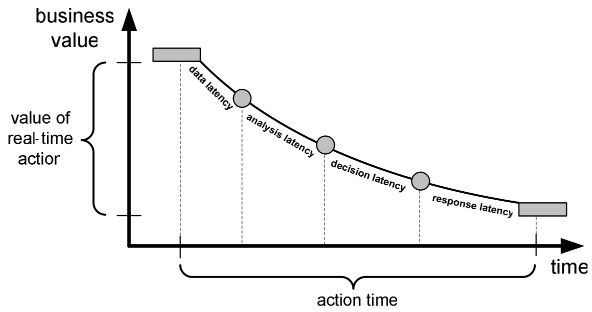

Figure 3: Business value and reduced action time (adapted from *Hackathorn* [13])

The elapsed time is called action time and can be seen as the latency of an action. Action time comprises four components:

1. **Data latency** is the time from the occurrence of the business event until the data is stored and ready for analysis.
2. The time from the point when data is available for analysis to the time when information is generated out of it is called **analysis latency**; it includes the time to determine root causes of business situations.
3. **Decision latency** is the time it takes from the delivery of the information to selecting a strategy in order to change the business environment. This type of latency mostly depends on the time the decision makers need to decide on the most appropriate actions for a response to the business environment.
4. **Response latency** is the time needed to take an action based on the decision made and to monitor its outcome. This includes communicating the decision made as a command or suggestion, or executing a business action in a target system.

4. Architecture for Enhancing BI

In this section, we propose an architecture for real-time analytics with the aim of reducing the action time and thereby increasing the value of Business Intelligence.

Figure 4 shows an architectural diagram for real-time analytics with two infrastructure types: 1) information integration infrastructure and 2) business integration infrastructure. The main objective of this architecture is to seamlessly integrate the two infrastructure types in order to minimize the aforementioned latencies. In the diagram we extended the components and modules of traditional BI in order to enable real-time analytics for business environments.

The information integration infrastructure is responsible for managing the data for business intelligence purposes and offers data analysis to decision makers and to IT systems. Traditional Business Intelligence aims to support strategic decision makers and therefore uses analytical applications that are periodically fed with data from the data warehouse. These analytical applications are generally completely disconnected from operational IT systems. Decisions are executed by communicating them as a command or suggestion to humans. On the other hand, the enhanced Business Intelligence includes analytical services which are continuously fed with data from the operational environment (e.g. via the ODS) and can be directly invoked by other systems. The object of analytical services is to provide continuous data analysis that is able to also cope with current changes in the business environment.

The central piece of the Business Integration infrastructure is a Sense & Respond (S&R) system that communicates events via hubs with the internal and external business environment. Table 1 provides an overview of the modules of the S&R system. The internal business environment comprises vertical and horizontal applications which are shown on the left side of the diagram. From the external business environment on the right side, events are captured during the collaboration with business partners, or when the contents of websites changes (e.g. a competitor updates the product prices).

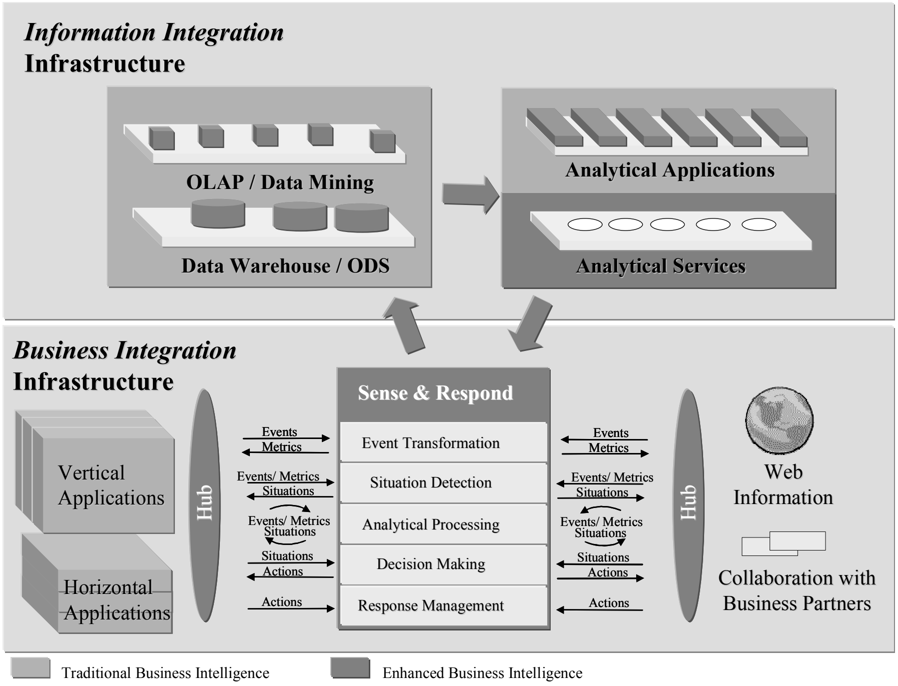

Figure 4: Architecture with enhanced Business Intelligence

Module	Description
Event Transformation	Transformation of the captured events from the business environment into meaningful business information, such as key performance indicators.
Situation Discovery	Detection of business situations and exceptions in the event data and business information. For instance, an organization wants to detect suspicious customer behavior (e.g. fraud behavior) which should be countered with a proactive response.
Analytical Processing	Invocation of analytical services in order to determine the root causes for business situations and exceptions. Also, prediction of the performance and assessment of the risks for changing the business environment. Please note, that the S&R system delegates the analytical processing to the analytical services of the information integration infrastructure. The S&R system correlates and collects event data for the data analysis, invokes the analytical services and processes the results.
Decision Making	Based on the analytical results, selection of the best option for improving the current business situations and determining the most appropriate action for a response to the business environment. This step can be automated with rules, or done by involving humans.
Response Management	Response to business environment by communicating the decision made as a command or suggestion (e.g. by e-mail), or by directly adapting and reconfiguring business processes and IT systems.

Table 1. Modules of the S&R System

During the event processing in the S&R system, business information is continuously generated and decisions are made to which a response follows. The response has an effect on the source systems (from which the S&R system originally received the events) and consequently also on the performance and the success of the organization. In order to reduce action time, latency has to be reduced in all four stages of the action time. In the following we discuss how our extensions to traditional Business Intelligence help to minimize the various types of latencies.

Minimizing Data Latency

Data Latency is usually mainly influenced by the refresh cycle of the data warehouse system in which the data is stored for analysis purposes. A main drawback of the data warehouse concept is the time-consuming and resource-intensive process of extracting data from operational systems, transforming it and loading it into the data warehouse database. Due to this fact, the so-called ETL processing is often executed in batch mode at non-peak times (e.g. overnight), causing time-lags between the recognition of a business event and its delivery for analysis purposes.

In contrast to the data warehouse system that requires extensive data cleansing, data consolidation and data quality management, an ODS stores a limited scope of data with only basic (or even none) consolidation and data quality management, thereby allowing real-time or near real-time updates and faster data distribution [16].

Another way of reducing data latency is to change from a periodic batch-oriented to an event-driven update of the data warehouse by using EAI technology. By doing this, data representing a certain business event will be populated into the data warehouse as soon as the event is recognized in an operational system [25].

We extend the approach from *Schiefer and Bruckner* [25] by integrating event streams from the business environment with integration hubs. The integration hubs unify the raw event data and feed them continuously into the S&R system. The S&R system generates business metrics that are stored in a real-time data store (e.g. an ODS) and used as input for the invocation of analytical services.

Minimizing Analysis Latency

Analysis latency is mainly determined by the time it takes to inform the person in charge of data analysis that new data has to be analyzed, the time needed to choose appropriate analysis models and the time to process the data and present the results. Current approaches that deal with the reduction of analysis latency are provided by BI software. A prominent BI concept is Online Analytical processing (OLAP), which concentrates on reducing the time needed for analyzing the data by providing powerful user-interfaces that let the analyst explore the data along previously defined analysis dimensions [4].

In contrast to the fixed dimensional structures necessary for doing OLAP, Data Mining is a more flexible BI approach which allows the application of different data exploration techniques to a large amount of data in order to discover unknown relationships between variables or single data items [1]. While pure data mining is mainly focused on reducing the time for data processing by applying efficient data exploration algorithms, data mining software tools like SPSS or IBM intelligent miner also facilitate the process of selecting and adapting a data mining technique that is suitable for a given problem. In order to reduce the time for notifying the analyst of business events, the approach of automated exception reporting can be used.

In order to reduce the analysis latency, we use in our architecture analytical services in the information integration infrastructure which enable an invocation of analytical function without manual intervention. A service-oriented architecture for analysis provides standardization for using various types of analysis techniques within a BI process. Unlike traditional BI tools, analysis services are permanently available, which is a prerequisite for a continuous and automated BI process.

Minimizing Decision Latency

The least IT support can be identified in the area of decision latency. In most cases, the interpretation of analysis results and the derivation of appropriate actions are seen as manual processes that have to be carried out by knowledge workers and are therefore time consuming. Newest advances especially in the area of Business Activity Monitoring (BAM) try to improve this situation by automating certain decision processes with the help of rule-based decision engines. Based on the real-time analysis of data from an EAI platform, the decision engine checks for predefined business rules and notifies responsible people, or triggers other tools for conducting further actions.

In our architecture we follow the approach from BAM and use rule-based decision making for automating many operational and tactical decisions. Please note, that the rules for these decisions are in many cases derived from strategic decisions that are made by humans. The decision rules help to intelligently respond very quickly to the current business situation.

Minimizing Response Latency

The final outcomes of a Business Intelligence process are actions based on the decisions made (manually or automated). There are two kinds of response latencies: 1) the time it takes to initiate an action and 2) the time it takes to execute and monitor the action. *Hackathorn* considers in [13] the response latency as part of the decision latency which is reasonable for strategic decision making. When it comes to real-time analytics, it is also crucial to communicate and carry out a decision very quickly. We consider separately in our model the time it takes to initiate and execute an action in the business environment. For this reason, a S&R system includes a response management module which is responsible for triggering business operations and monitoring their outcome.

The business value of our architecture with enhanced Business Intelligence can be summarized as follows:

- **Real-time business information**: Minimal latency for preparing and analyzing data and hence improved visibility and accuracy of business performance indicators. The indicators are also available for operational and tactical decisions.
- **Optimized business processes**: By integrating real-time analytics, the internal and external business environment can be optimized by more efficient and intelligent control mechanisms. The S&R system operates as an "external advisor" for the business environment.
- **Automatic discovery of situations and exceptions**: A S&R system supports a continuous discovery of business opportunities and exceptions based on the current state of the business environment. For instance, companies are able to detect suspicious customer

behavior (e.g. fraud behavior) which can be countered with a proactive response.

- **Proactive responses**: By continuously observing and analyzing customers, business partners and the competition, the business environment can be proactively adapted and optimized.
- **Generating more accurate forecasts** in near real-time under consideration of current and historic data (e.g. continuous update and optimization of production plans based on the current orders).
- **Integrating internal and external source systems:** The S&R system is able to correlate and merge event streams from the internal and external business environment.
- **Less integration effort**: The S&R system has a significantly lower integration effort than traditional data warehouse solutions since only events from the source system have to be integrated. For the event processing the S&R system does not have to know internal details of operational systems, such as the data model.

5. Real-Time Business Analytics in Action

Let's assume that the company Meyer AG offers transportation services for various goods. In order to better monitor, synchronize and optimize the processing flows, the company uses mobile devices (e.g. mobile bar code scanners) to store information for every article about the current location and the status of the current method of transportation. The S&R system continuously processes and analyses this data and calculates indicators which provide instant and concise interpretation of essential business information, such as the current transportation time for a shipment, the current transportation costs, or the utilization of the transportation vehicle.

Additionally, the S&R system detects situations early which are relevant for the planning and coordination of the logistics, such as delays of a freight or loading the freight into a wrong container. In the case of such problem situations, the S&R system commences arrangements in order to deliver the goods in time, such as changing the transportation route (e.g. choosing a more direct transportation route to the customer) or changing the method of transportation (e.g. express transportation services). In case that it is not possible to deliver the goods on time, the Sense and Respond system automatically sends notification to the customers with an estimate of the shipment delay.

In this example, the S&R system reacts in near real-time to changes in the business environment. Events from various sources (vehicles, distribution centers, contractors, customers) are received and unified (→ Event Transformation) in order to assess the current state of the business environment. Certain event patterns describe a business situation (e.g. a truck is stuck in a traffic jam) that is automatically discovered by the S&R system (→ Situation Discovery). A business situation triggers the invocation of analytical services in order to forecast whether a shipment is going to be late (→ Analytical Processing). Based on the analytical results a rule decides (→ Decision Making) whether the transportation route should be adjusted, or whether the customers should be notified about the shipment delay. The S&R system instantaneously initiates and executes the appropriate actions (→ Response Management) based on the outcome of the decision rule.

6. Conclusion and Future Work

Traditional BI architectures lack in the support of real-time BI and closed-loop decision making. In this paper we extended a traditional BI architecture with S&R system and analytical services to transform business events into performance indicators and intelligent business actions. We discussed the latencies during the analytical processing and showed how our extensions enable real-time analytics for a business environment. The work presented in this paper is part of a larger, long-term research effort aiming to develop a service-oriented Business Intelligence platform.

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