A conceptual framework for business intelligence based on activities monitoring systems

Dimitris Folinas

Department of Applied Informatics,
University of Macedonia,
156 Egnatia Street,
Thessaloniki 54006, Greece
Fax: +30-231-089-1804
E-mail: folinas@uom.gr

Abstract: Most enterprises have spent an enormous amount of money and time, managing information about their business elements. Such information is often scattered in disparate legacy, operational and enterprise information systems, appointing the aggregation of valuable information and decision-making support quite difficult. Business Intelligence (BI) and their associated processes and tools are helping enterprises to solve this problem. This paper presents the principles and challenges of BI domain and evaluates its current approaches. The limitations of the above approaches will provide the basis for the design and development of a framework that pursues real time insight to business information, as well as, instantaneous awareness and appropriate response to critical business events across the entire enterprise. The proposed framework is based on Business Activity Monitoring (BAM) systems paradigm and attempts to create a unified enterprise-reporting environment. It was applied in a large Northern Greek manufacturing company in the last six months.

Keywords: business activity monitoring systems; BAM; business intelligence; BI; enterprise information systems.

Reference to this paper should be made as follows: Folinas, D. (2007) 'A conceptual framework for business intelligence based on activities monitoring systems', *Int. J. Intelligent Enterprise*, Vol. 1, No. 1, pp.65–80.

Biographical notes: Dimitris Folinas is a Scientific Associate in the Department of Applied Informatics, University of Macedonia, Thessaloniki, Greece. His research interests include: e-logistics, business-to-business integration, supply chain integration, virtual organisation/enterprise and e-commerce models and technologies.

1 Introduction

Today, enterprises generate and process on a daily-basis a tremendously large volume of data deriving from various business activities and processes, such as procurement, manufacturing, retail, marketing, sales and distribution. Such data, is often processed by an extensive array of computer-based applications and has a significant importance to the business entities towards effective and on-time decision making. However, a main drawback of these systems is that they frequently suffer from a lack of contextualised information that is reliable, accurate and delivered 'on time' to have a purposeful meaning to the decision-makers. The value of information grows exponentially with the addition of each domain of data, information or knowledge that is integrated correctly with it. Due to the fact that data alone cannot provide corporate executives and managers with meaningful information on the performance of their companies that they need to stay ahead of the competition, there is a critical need for up-to-date information for decision making and for optimising critical business processes (Sveiby, 1997).

Moreover, from a business perspective, the true value of any enterprise information system (Enterprise Resource Planning (ERP), Customer Relationship Management (CRM) System, etc.) and/or best-of-breed business information systems (Warehouse Management Systems (WMS), Transportation Management System (TMS), etc.), comes from their ability to reveal to end users the inner workings of business activities and to provide useful insight into corporate transactions (Davenport and Prusak, 1998; Davenport et al., 1998; Natarajan and Sheklar, 2001).

These business applications provided static reports and insight to transactional data, which was enough for line-level managers, but decision-makers wanted information in a more summarised fashion in order to perform strategic analyses from huge amounts of data that expanded in a wide time range and from multiple applications. The answer to their requests came from the introduction of Data Warehousing (DW) and the Online Analytical Processing (OLAP) approach. The concept of a DW is to simply extract operational transaction data into a separate repository and reorganising data in a denormalised and aggregated fashion that is more appropriate for analysis and performing queries. OLAP provided the tools to perform interactive analysis against the DW instead of operational files and databases. A DW offered the benefit of integrated source data, which provided better data quality and consistency. It also enabled data to be summarised and kept for historical reporting and analysis. The DW approach also reduced the decision support load on the operational transaction systems. The advantage of the DW is that users can query data from across the enterprise. Using OLAP technique, analysts create complex, multidimensional analyses and deliver to business users meaningful insights that might not be readily apparent (Devlin, 1997; Dobbs et al., 2002; Kaplan and Norton, 1992; Ma et al., 2000; Smith, 2001).

The above software applications, technologies and analytical methodologies, which perform data analysis, constitute the Business Intelligence (BI) domain. BI captures organisational data from disparate sources and presents it to decision-makers through a user-friendly manner (Cooper, 1996; Sawka, 1996). It exploits all the software applications, practices, technologies and analytical methodologies, which perform data analysis and provides real-time visibility and access to pertinent information, wherever its location, for each participant, to support enterprise competitiveness (Corral et al., 2005).

This paper proposes a new advance of BI paradigm, the real-time BI or Business Activity Monitoring (BAM) systems. Many academics and non-academics today consider them as the next generation of BI practices and tools (Gartner Group, 2002). Previous generations of tools present decision-makers with operational reports or analytical tools and expected to find anomalies and examine their root causes based on their analytical abilities. BAM systems on the contrary, combine data collection with process and workflow management capabilities to monitor streaming data from operational systems to detect exceptions or critical business events. BAM requires that an enterprise identify its Key Performance Indicators (KPI's) and put in place a system that allows monitoring and responding to critical changes. These systems are frequently web portal dashboards that display KPI's in near real-time combined with automated system monitoring tools that notify users, via e-mail for example, when a KPI's threshold has been violated. BAM lets companies visualise business events and KPI's in real time and in a format that's actionable (Ibarra, 2004). It gives enterprises insight into their business processes and systems through the use of dashboards and alerts. For example, notifications are sent to managers when certain critical events have occurred, such as inventory stock being under the tolerance limit on a retailer's shelf. These notifications appear on managers' desktop computers or through mobile workers' handheld devices, pagers and cell phones. By enabling users to view, analyse and act on visually represented data, businesses can make rapid, informed decisions and better manage their performance. Based on the above, this paper presents and analyses a conceptual framework, which constitutes a new approach for BI in enterprises.

In the literature, there are many research efforts in terms of proposing conceptual framework architectures about BI domain. Sonnen and Morris (2004), Dresner and Buytendjik (2003) and Golfarelli et al. (2004) proposed Business Performance Management (BPM) solutions that included both traditional tools and practices (such as DW) but they also required a reactive component, capable of monitoring the time-critical operational processes to allow tactical and operational decision-makers to tune their actions according to the company strategy. Shneiderman et al. (1997) proposed a four level framework as a tool to support the enterprise information aggregation process. Reiterer et al. (2000) applied Shneiderman's framework and presented a software solution for finding and analysing business information from the web.

The particular framework proposed by the author, although based on the BI practices is furthermore extended in an effort to provide an added functionality value. Moreover, in order to ensure improved usability and user-acceptance of future systems in terms of accuracy and time constraints, the framework aims to support only data representation that is explicitly related to exceptional conditions. Consequently, such exceptional conditions allow users to backtrack valuable data toward supplementary analysis and examination. By providing relevant information to certain situations, the proposed framework can optimise decision making, improve efficiency and accelerate results.

This paper is organised as follows: Section 1 presents the requirements and challenges being faced today by enterprises that led to the advent of a new approach for BI initiative. These requirements set the foundation for the proposed framework that is based on BAM systems, its architecture and main characteristics are described in the following sections. Implementation issues of the above systems are stated and Section 6 discusses the conclusions of this paper.

2 BI challenges

Business world is changing and the need for accurate and timely BI is ever more pressing. Enterprises are being called upon to integrate many and/or new sources of data, many of them semi-structured or unstructured in format, to create new views of this information often spanning to multiple platforms and to get real time insight into information. Following are issues and challenges that enterprises face today in terms of BI.

Initially, enterprises must store and manage data from multiple different sources such as ERP, CRM, legacy systems, web servers, e-mail repositories, etc. and in a variety of formats such as text, spreadsheet documents, images, voice, video, unstructured data, eXtensible Mark-up Language (XML) documents and more. Although ERP systems promised that information would be held under one common repository, companies today still withhold many of their information assets within departmental systems that work independently from their central information systems (Ramakhrishman and Gehrke, 2000).

Also, most decision-makers do not want to be bothered with data unless there is an exceptional condition they need to examine businesses are required to make more decisions, more frequently and more accurately in shorter time periods. The amount of time between decision making and feedback (requiring a new decision) is becoming shorter and shorter. Thus, there is a need for real-time information visibility in order to support the ability to make intelligent business decisions quickly, which is imperative for an enterprise to remain competitive (Fitzgerald, 1991; Miller, 2001). Today many issues complicate the Information Technology (IT) challenge of real-time information visibility. Multiple diverse audiences want instant access to a personalised view of current information. But this information likewise resides in multiple diverse places. In addition, presenting the required information in different ways and formats, with a uniquely personalised view, all in a constantly changing environment, adds to the complexity of achieving real-time visibility. With the most up-to-date information available, many employees of today and not only line-level managers can get more detailed information and on more devices establishing an 'information democracy' enterprise environment (Gartner Group, 2002; Gold-Bernstein, 2004; Sveiby, 1997).

Finally, the new business environment demands an agreement on the meaning of data amongst people whose perspective is skewed throughout the enterprise to suit their individual needs. This is semantic interoperability, which is the most difficult corner to unlock for most companies and organisations. When semantic interoperability information is organised under a common framework, systems and business users can relate and organise business data under well-defined business processes and activities relevant to the enterprise. Only with semantic interoperability can organisations integrate information and functionality from multiple sources (Gold-Bernstein, 2004; Kernochan, 2003; Roth et al., 2003).

3 Problem*s* with current BI approaches

Line-level managers and information analysts continued to plan and analyse their own areas of the business, in silos, with no connection to each other. They rely only on the historical reporting capabilities, while not giving full weight to the capabilities offered by operational analysis to support demand forecasting, sales and operations planning and the continuous tracking of performance throughout the enterprise. Today, decision-makers wanted information in a more summarised fashion in order to perform strategic analyses from huge amounts of data that expanded in a wide time range and from multiple applications.

Consider for example the Supply Chain paradigm where there are many enterprises operating many software applications in heterogeneous platforms. Significant complexity exists since no system was originally designed to share information with other systems.

Historically there has been no ubiquitous, common network platform over which to share information until the emergence of the internet. Furthermore, many existing organisations run legacy systems that are not designed with the thought of directly connecting to corresponding systems in other organisations.

Based on the literature (Gunasekaran et al., 1999; Lau and Yen, 2001; Sakaguchi and Frolick, 1997; Widom, 1995; Wixom and Watson, 2001), there are some disadvantages with the current BI approaches (mainly DW approach):

- The cost and complexity of establishing a DW environment is substantial. Deployment and management costs are very high and these environments require well-trained, dedicated staff.
- Because information is drawn from various repositories across the enterprise, there is a need to extract, transform and load the data into the central repository. This process takes time, so users will not receive the freshest, up-to-date operational data. Additionally, requests for additional information can take weeks or months to complete.
- The tools used to analyse data residing are designed for the power user or analyst. They are not well suited for end-users, managers or executives. Thus, these individuals must request the services of a developer or database analyst to acquire the reports they need. Again, this causes delay and users do not receive the freshest operational data available.
- The DW approach implies that the data schema of the centralised database has to be predefined. Any changes in the source database or changes in the user requirements may require complex redesign procedures, the data uploading procedures and the related analysis modules.
- Another disadvantage is due to the database systems used. Currently, most DW approaches use a relational database system to maintain data. However, data sources other than relational databases cannot be uploaded to the relational database system easily. For example data in company annual reports, documents, memos, policies and technical papers are important data sources but are in a non-relational table format. Therefore, it is very difficult to place such information into a relational database system.

To conclude, enterprises deploying DW trade-off data freshness and real-time availability for the ability to perform complex, multidimensional analysis on data pulled from across the organisation. In today's demanding environment for most enterprises, this is not an acceptable trade (Mathie, 1998).

4 Conceptual framework for BI based on activities monitoring systems

As described above the DW architecture is founded on the premise that all data required for a particular end user inquiry or report should be brought together in a single environment. This is done to provide stability, consistency of data and guaranteed access to data. But how can the new requirements for lower data latency, access to remote data sources and incorporation of structured and unstructured data formats be supported? The answer is the adoption of decentralised architectural approach, which enables distributed queries to take place. This distributed architectural approach provides the possibility of maintaining the logical appearance of a single DW (a semantic representation of the warehouse), without the prior physical movement of all the data.

By using a metadata repository to describe the various associations amongst distributed data repositories, users can submit queries or request reports that combine data from both data warehouses and operational systems and view the information as if it resided in a single source. Mostly all users, can view real-time specific information (from operational systems) in combination with traditional, historical data already resident in the DW. The proposed architecture is not an attempt to replace the existing approaches (DW architecture and BPM approach). Rather, it should be seen as an extension, in order to promote an insight into real-time transactional data that resides within operational systems or to unstructured data formats that cannot easily be incorporated within a DW and presents only the required information at the right time.

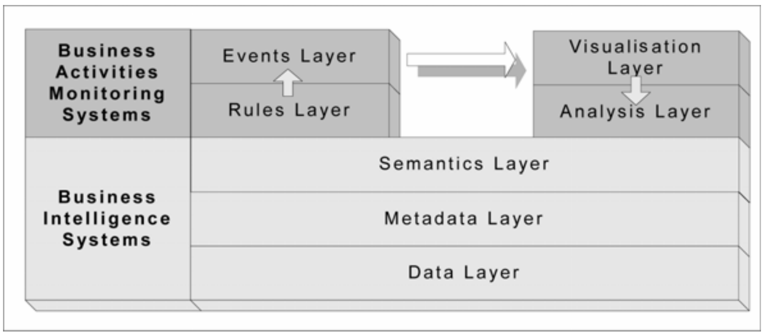
4.1 Characteristics of framework

The proposed framework attempts to create a unified event-handling and enterprise-reporting environment that has the following characteristics:

- information is gathered in real time from the native data sources without any attempts to duplicate data in a secondary repository (such as DW approach)
- associations, transformations and metadata elements are implemented in real time to further describe and enrich existing data in the underlying data sources
- both structured and unstructured are incorporated under a common framework with reference data being established from one format to the other
- business requirements are easily represented within the architecture according to business semantics, without technical interpretation and the heavy need of IT to cope with the data sources
- vital information is monitored and real-time events and intelligence are delivered directly in totally visual manner to decision-makers who need to take action
- only exceptional conditions are delivered to decision-makers, in order to be further analysed and examined in detail.

The suggested architecture consists of two main packages of layers: BI Systems layers, (which are Data, Metadata and Semantics layers) that aim to integrate information from many sources and Business Activities Monitoring Systems layers (which are Rules, Events, Visualisation and Analysis layers), that aim to detect and analyse in real-time critical business events (Figure 1).

Figure 1 A conceptual framework for business activities monitoring systems



4.2 BI systems layers

The BI systems consists of the following layers.

4.2.1 Data layer

This compromises the native data sources where the data actually lies. The data layer consists of data that resides inside relational data base systems (Oracle, AS/400, SQL Server) or in other semi-structured files such as excel documents, text documents, etc. Non-structured formats include various files whose content is not organised in any format, such as: customer contracts that are implied in word documents, image files, such as pictures, scanned documents, etc. and multimedia files. These documents provide a vital information source for companies and once tagged with the appropriate metadata elements, they can prove to be an important information source (Kernochan, 2003).

4.2.2 Metadata layer

The metadata layer provides the actual mappings and relations in the underlying data sources between the semantic layer and the actual physical data. Mappings can be simple such as one to one representations of an entity element to a field element in a database table or can be more complex, such as various elements within a specific entity can be mapped and transformed from disparate data sources (e.g. a customers order entity may consist of a 'CustomerID' element that is mapped to a field element in a CRM application and also a 'Totals Invoice' element that is preserved within an ERP system). Associations amongst entities from the semantic layer allow the representation of relationships existing within elements. For example, customer sales orders are preserved with an ERP application while production planning information needed to fulfil the production of customer sales orders is preserved within a customised application that is home built to fulfil the company's specific requirements. Individual settings of association attributes allow the definition of complex rules associated with the actual representation of entities within the semantic model. Transformations are also defined within the metadata layer that applies specific business rules and policies amongst entities and elements. For example, a CustomerID is preserved in both the company's ERP and CRM system, each system though, holds a different ID for this data element. From the semantic perspective the enterprise only understands one version of a customer, regardless of the actual physical representation of the data within two disparate systems. Transformation classes allow the organisation to actually apply a single version of a customer by defining the rules that exist to map and relate the CustomerID from one system to the CustomerID in a different system. Transformation can be simple as one to one (1-1), one-to-many representations or can imply conditional logic or mathematical and statistical expressions according to specific business needs and the diversity of the underlying data within the data sources.

Business wrapper classes have a big effect on allowing unstructured forms of data to be correlated with structured information (Gandon et al., 2000). The true value of business wrapper classes lies in its ability for a business analyst to define specific metadata that apply to an unstructured form of business data, for example a word document or an e-mail message. Consider the case of a company's customer contracts that all reside in word documents and are organised in hierarchical folders within the operating system. How can one manager simultaneously view the customers invoice information (which is represented as structured data within an ERP system) with specific word documents scattered on physical disks? Naturally a physical word document lying on a hard drive has a restrictive set of elements defined by the operating system (such as file path, date modified, file size, etc.). These elements have no potential business meaning for the company, nor provide any information that this document is a customer contract. By defining a business class wrapper named ‘Contracts’ with a specific set of elements (e.g. Date of Expiration, Contact Person, Contract Amount, etc.) and ‘capturing’ the physical file within the business wrapper class, businesses can enrich unstructured information and provide associations with other structured forms of information, that are presented to end users.

The use of the metadata layer provides the actual framework that promotes true real-time insight into business information because: information is manipulated from the native data sources and not from copies of the data like the DW approach, all data systems (structured, unstructured) once modelled can be consumed from end users and finally, during information retrieval, inner workings of the metadata layer (transformations, associations, etc.) are transparent to the presentation layer accessing the information.

4.2.3 Semantic layer

The purpose of the semantic layer is to abstract the information content into a business model that is easily apprehended from a business perspective and that describes the enterprise information resources. The model captures the true business nature and aspects of the information the enterprise has within its systems and the way the enterprise uses data in its daily operations. This information is captured under an entity instance which is a grouped set of various data elements and provides a common conceptualisation of a business domain as seen by the enterprise. Entities provide abstraction at a high level and comprise of attributes and associations between them to form a business domain vocabulary with all entities connected in a semantic manner. Entities also encapsulate specific metadata elements to provide a more useful meaning of content within existing data assets. The data model contains standard constructs that show the business entities and operations according to specific business practices. Once the semantic layer captures the enterprise information resources into a model, then it can easily integrate this information with the assistance of the metadata layer.

4.3 Business activities monitoring systems layers

This section presents the four-layers that comprise BAM systems.

4.3.1 Rules layer

The rules layer allows business users to dynamically model complex analytic scenarios/business activities and track how they change their business state over time. Such models allow them to quickly perform real-time trend analysis on up-to-date information. Furthermore, this layer monitors the operation of business activities by looking for metrics or information that meets specific conditions. When a rule finds an exceptional condition in an activity, it triggers an event and sends the appropriate contextual information to the upper event layer notifying them of the fact. Thus, the event layer ensures that critical issues are processed without delay. If an exceptional condition continues to exist after some time, the rules layer can then escalate the alert to another set of users to ensure that critical problems are not ignored.

4.3.2 Events layer

The event layer captures key events produced by the rules layer and collects contextual information that enhances these events. Then it presents the combined information in business views to the visualisation layer and provides appropriate action to take, according to predefined rules or settings. An event is just a signal that the internal data of a system has changed – a contact name has been updated, a new order has arrived, a pending request has been cancelled. Most applications already generate events, if only for their own internal use.

Events can come from various sources, including enterprise applications, data flowing over a messaging bus, database updates and messages from trading partners or web services. The role of event layer is to capture the event that occurs in these sources and provide appropriate action to take according to predefined rules or settings (Mills, 2003). It adds a common middleware framework for detecting events, communicating them to an integration hub, converting them to a common format and linking them to triggered actions in a modelled business process (Morgenthal, 2004). The key advantage of the events layer architecture is that it is integration-friendly and supports loose coupling. One process component, say a packaged application, does not need to issue an API call to another one in point-to-point fashion in order to integrate with it. It simply has to generate an event, which often requires no code at all. The rest is modelled and managed within the BAM system. It does not matter if the components being integrated are on different system platforms or are written in incompatible programming languages. In fact, the component generating the event (e.g. a Siebel application) does not even have to know anything about the component taking the action (e.g. an SAP application) or what the action is. It just has to generate the event.

4.3.3 Visualisation layer

Once the events have been clarified and formed, information needs to be delivered to the appropriate person or system for review and action. The visualisation layer is simply a visual exception report. Visualisation involves multidelivery mechanisms such as alerts via e-mail, dashboards, instant messaging, wireless devices, cellular phones, etc. Furthermore, it lets users place half-a-dozen metrics on the screen for easy viewing and sometimes reports or other documents. The metrics are represented as visual icons (such as stoplights, gauges or thermometers), charts or tables and are updated as needed to meet user requirements (e.g. minutes to hours to days). The metrics give users a quick overview of the performance of the processes or people they manage.

Moreover, the use of portal initiatives allows content to be delivered within a personalised view often in the form of graphs, gauges or charts. This content in some cases can become interactive with the recipient and integrate with other BI or reporting tools to allow instant drill down or investigation into information. The purpose of the visualisation layer is not to overwhelm users with a dizzying array of reports or analytical options. It is to provide only the information users need and when they need it. Thus, it must keep things simple by highlighting anomalies that users need to investigate and providing additional information only as needed.

4.3.4 Analysis layer

Once the events have been captured and presented in the visualisation layer, the next step is to provide context to these events so that they can be analysed. For example, it may be needed to add customer information to an event that represents order exception, sending information about related orders of the same product, inventory levels, etc. Context may come from historical or real time sources, so, there is a need to understand and pass critical information without delay. Sometimes events need to be analysed and business rules applied to derive KPI's and alert content. Access to trend data stored in operational systems and data warehouses is needed to provide critical and relevant information that will be formed and delivered to the information recipient. This layer is an analytical system that users access by clicking on a metric or performance icon. OLAP technology enables users to quickly see when performance is above or below expectations. Then, if desired, they can 'click on' a metric and get more information about what is driving the exceptional condition.

5 Case study: BAM system supports traceability in diary sector in Northern Greece

The traceability of products is becoming a subject of primary importance within the various production chains. In the food chain, traceability means the ability to trace and follow a food feed, food producing animal or substance through all stages of production and distribution (Wilson and Clarke, 1998). In the last decade, the credibility of the food industry safety schemes was heavily challenged after a number of food crises, such as BSE and food-and-mouth disease and prevented a new type of system, the traceability system. The role of such a system is to assure consumers' health and safety by enabling rapid recall and withdrawal of hazardous products in case of food crises.

The efficiency of a traceability system depends on the ability to gather/collect safety and quality related information, in a way that enables continuous monitoring from primary production (harvesting, catch and retirement) until final disposal to consumer. The means and technique for identifying the uniqueness of product may differ in each stage of the supply chain (bar-code, papers, RFID tag, computer produced labels, etc.) (Karkkainen, 2003; Salin, 1998). An efficient traceability system shall be able to link all these different techniques to an integrated product monitoring system.

BAM systems were considered as the appropriate solution for traceability systems in food sector. In the following table, the food sector traceability requirements are presented against the characteristics of BAM approach (Table 1).

Based on the above, the proposed conceptual framework has been applied in a large Northern Greek dairy manufacturing company for the last six months, in order to monitor the whole production and traceability process.

The examined company operated two autonomous software applications in two different locations:

1 An application that covers the milk collection processes, starting from the designing of collection processes from the suppliers (collection rooting, tracks, collection points, cooling tanks, etc.) to the shipment to the industry (such as delivery notes, invoices, etc.).

2 Another application that covers all processes concerning cooling tanks, such as cost and property status of ice cooling tanks and information for quality and quantity about cooling tanks.

Table 1 Food sector traceability requirements and BAM approach characteristics

Food sector traceability requirements	*BAM approach characteristics*
In the food sector there is a huge gap in terms of economic size, structure and access on ICT applications. In addition, a problem exists regarding the increased heterogeneity of the technology platforms used.	BAM systems exploit business data, which are produced from many sources and are maintained in many formats. Both structured and unstructured data are incorporated under a common framework with reference data being established from one format to the other.
In case of food product crisis business information regarding logistics operations such as quantity, origin, destination, dispatch date, allowing the rapid tracking of product's current location, origin and destination, is a necessity.	BAM systems watch for predefined circumstances to occur and then send out an alert that the condition has been detected. Once events have been captured and presented, the next step is to provide context to these events so they can be analysed. Only exceptional conditions are delivered to decision-makers, in order to be further analysed and examined in detail.
Decision-makers in the food sector, have mainly business than technical background. Business requirements must be easily represented, without technical interpretation and the heavy need of IT to cope with the data sources.	BAM systems are targeted mainly at management and operational tasks that fall below the executive level.
In the food supply chain, vital information needs to be monitored and real-time events and intelligence must be delivered directly in totally visual manner to decision-makers that need to take action.	BAM systems may use dashboard technology to provide business managers with a visual picture of business activity as it occurs.

The operation of the above applications has produced many problems especially in two critical functional areas: traceability process in case of food crisis and the printout creation process. It was not possible to ensure backwards product tracing from management of milk distribution. Also, it was very difficult to create reports at different levels of information in order to make effective milk analysis per sample origin, commodity or at any level (collection point, silo level, factory level, etc.).

An application module has been developed based on the proposed conceptual framework. This module collected data from both the existing systems in a real-time manner. During its operation, the proposed BAM platform:

- Provided information to the senior management for timely decision-making process with the establishment of an integrated information environment.
- Provided the capability of monitoring the qualitative and quantitative information and financial situation as Greek Law imposes or the administrative practices of the company on an assessment and/or reporting basis.
- Offered an easy and accurate auditing process. Headquarters can easily and in real time have an access into the system and track all the information needed.
- Improved the quality of the services provided.

6 Lessons learnt from the case study

The case study revealed significant insights, regarding the way the framework was perceived by the dairy manufacturing company. Regarding the BI system layers the examined company had no difficulty in selecting the right traceability and logistics data that were maintained resides inside relational database systems in the software applications. In the metadata layer a number of mappings and transformations were required. Company agreed upon the usage of Physical Markup Language (PML) – an XML-based technology – to be the common 'language' for describing physical objects/products in the examined supply chain. PML is intended to be a general, standard means for describing the physical world, by describing physical objects for use in remote monitoring and control of the physical environment (Brock, 2001). PML is proposed to model the traceability data that were identified and classified in the previous phase of the framework and to provide information about various parameters/elements such as: product properties, process properties, tracing properties, business entities properties, properties of means of production used on the product and data measurement properties. In order to provide this information, PML provides a number of XML elements and data types. These include a root element, which captures a 'snapshot' of the whole physical environment and subelements in a product decomposition tree that hold the above mentioned properties. The above process had a great effect in the implementation of the third layer (Semantic Layer). The required data were modelled using PML approach capturing the business nature and aspects of the information the enterprise has within its systems and the way the enterprise uses data in its daily operations.

Business activities monitoring system consists initially the rules and events layers. Company has a great experience to define the traceability business rules. Company has recently adopted ISO 22000:2005 – Food Safety Management Systems – Requirements and ISO 22519 – Traceability System in the Agriculture Food Chain – General Principles for Design and Development Quality Standards that define the requirements for a traceability system within a food safety management system and the data that needs to be retained. A large programming effort was required not only to retrieve the right information when an event occurred but also to provide the context to these events so they can be analysed. Production and Logistics Managers agreed upon the fact that further research is a necessity so as to support effectively decision-making process. Also, there is a need to implement various add-ons as well as, API's modules. In the last layer (Visualisation Layer), two mechanisms have been applied, dashboard and instant messaging to operation's managers cellular phones.

Furthermore, a number of issues arose from the implementation of the proposed framework in the examined environment. The issues in question are.

6.1 Project requirements definition

An effective implementation plan is required to ensure the viability of the proposed conceptual framework. This plan needs to emphasise the incremental approach, in which the plan breaks into manageable pieces/steps. Furthermore, a BAM project must be defined/documented clearly in terms of: goals and objectives, scope (the expected project deliverable), risks, constraints, assumptions, change-control procedures, issues management procedures, as well as, the source of the events and the nature of the rules.

6.2 Source data preparation and analysis

In general, one of the biggest challenges to all BI decision-support projects is the quality of the source data. Possible errors in the above process may result in a very expensive, time consuming and tedious auditing procedure. In addition, data analysis in the past was confined to the view of one line of business and was never consolidated or reconciled with other views in the organisation. This step takes a significant percentage of the time allotted to the entire project schedule.

6.3 Metadata analysis

Metadata describes an organisation in terms of its business activities and the business objects on which the business activities are performed. Consider, for example, a sale of a product to a customer by an employee. The sale is a business activity and the product, customer and employee are the business objects on which the sale activity is performed. Business activities and business objects, whether manual or automated, behave according to a set of relationships and rules, which are defined by the business. These activities and objects and the relationships and rules that govern them provide the context within the business people using the business data every day. Metadata is so important for the proposed framework because it helps transform business data into information. The difference between data and information is that information is raw data within a business context. Metadata provides that business context; that is, metadata ensures the correct interpretation (based on activities, objects, relationships and rules) of what the business data actually means.

6.4 Requirements for new tools

A new generation of BI tools, which blend reporting and analysis capabilities inside a web-based performance dashboard or portal, promises to finally empower all knowledge workers. When combined with a robust DW and OLAP mechanisms, the new tools provide the right data to the right person at the right time to optimise decision making, improve efficiency and accelerate results. The new tools must be customisable and personalised according to the decision-maker role and business level, proactive so that decision-makers should be notified about an exceptional condition and whether to trigger an automated action or series of actions, timely, self-defining, flexible, scalable and also to support a collaborative and portable environment.

6.5 Requirement for an enterprise infrastructure

Since BI applications are cross-organisational initiatives, an enterprise infrastructure must be created to support the proposed framework. Technical (hardware, software, middleware, database management systems, operating systems, network components, meta data repositories, etc.) and non-technical (e.g. meta data standards, data-naming standards, enterprise logical data model, methodologies, guidelines, testing procedures, change-control processes, procedures for issues management and dispute resolution) infrastructure components may already be in place before the first BI project is launched. Other infrastructure components may have to be developed over time as part of the BI projects.

7 Conclusion

The rapid pace of today's business environment has made BI systems indispensable to an organisation's success. These systems turn a company's raw data into usable information that can help management identify important trends, analyse customer behaviour and make intelligent business decisions quickly.

BI was the first major attempt to convert enterprise data into useful information. But it has focused mainly on analysing previous behaviour. This approach has proved valuable for strategic analysis and offered the benefit of integrated data source, which provided better data quality and analysis. While the benefits of the above approach remain valuable, new business needs have given birth to new requirements. These new requirements concern timeliness and extensibility of information. Timeliness refers to driving out information latency and closing the time gap existing from the occurrence of a business event and the actual delivery of information to end users. Extensibility refers to the need to incorporate structured and unstructured forms of data within an organisation's BI framework, either residing within an enterprise information system or outside.

BAM can confront the above requirements and also provide significant business benefits to enterprises. By alerting managers and the operations staff to business events in real time, BAM allows them to focus more on their work and spend less time worrying about repetitive problems or opportunities cropping up unnoticed. BAM is a way to automate part of the responsibilities that workers have. According to Gartner Group by 2008, at least 60% of BAM solutions will be supplied as functionality built into enterprise infrastructure and applications.

The proposed conceptual architectural framework of this paper attempts to address new requirements by providing a combination of BI and BAM practices and methods, in order to integrate and deliver information without requiring all data to be stored in the DW first. This is not an attempt to diminish the value of the DW or other BI practices but rather builds on their success and provides an extended framework for accessing operational or legacy data and combining all the information assets of organisations under a common framework. The goal of this architectural framework is to deliver a semantically rich information platform and make data location and format transparent to end users, so as to enable them to see all the data they need, as if it resided in a single source. It provides an information infrastructure with standardised reference points so that all decision-makers may look at one true picture when evaluating a company's performance.

References

Brock, L. (2001) 'The physical markup language – a universal language for physical objects', Auto-ID White Paper, WH-003, February, Available at: http://auto-id.mit.edu/pdf/MIT-AUTOID-WH-003.pdf.

Cooper, H. (1996) *Business Intelligence, A Primary Executive Protection Inst.*, Berryville, VA.

Corral, K., Griffin, J. and Jennex, M. (2005) 'Experts' perspective', *Business Intelligence Journal*, Vol. 10, No. 1, pp.36–40.

Davenport, H. and Prusak, L. (1998) *Working Knowledge: Managing What Your Organisation Knows*, Boston, MA: Harvard Business School Press.

Davenport, H., DeLong, W. and Beers, C. (1998) 'Successful knowledge management projects', *Sloan Management Review*, Vol. 39, No. 2, pp.43–57.

Devlin, B. (1997) *Data Warehouse: From Architecture to Implementation*, Reading, MA: Addison-Wesley.

Dobbs, T., Stone, M. and Abbott, J. (2002) 'UK data warehousing and business intelligence implementation', *Qualitative Market Research: An International Journal*, Vol. 5, No. 4, pp.235–238.

Dresner, H. and Buytendjik, F. (2003) *Business Intelligence and Data Warehousing Scenario: Key Trends and Evolving Markets*, Cannes, France: Gartner Symposium ITXPO.

Fitzgerald, A. (1991) 'Relational database technology: its use for real-time management information', *Integrated Manufacturing Systems*, Vol. 2, No. 3.

Gandon, F., Dieng, R., Corby, O. and Giboin, A. (2000) 'A multi-agent system to support exploiting XML-based corporate memory', in U. Reimer (Ed). *Proceedings of PAKM2000 – Practical Aspects of Knowledge Management, PAKM 2000*, 30–31 October, Basel, Switzerland.

Gartner Group (2002) *The BPA Market Catches Another Major Updraft*.

Gold-Bernstein, B. (2004) 'Enterprise information integration: what was old is new again', Available at: http://www.ebizq.net/topics/eii/features/4371.html.

Golfarelli, M., Rizzi, S. and Cella, I. (2004) *Beyond Data Warehousing: What's Next in Business Intelligence? DOLAP'04*, 12–13 November, Washington, DC.

Gunasekaran, A., Marri, H. and Menci, F. (1999) 'Improving the effectiveness of warehousing operations: a case study', *Industrial Management and Data Systems*, Vol. 99, No. 8, pp.328–339.

Ibarra, F. (2004) 'Evolution of BAM', *Business Integration Journal*, Available at: www.bijonline.com.

Kaplan, S. and Norton, P. (1992) 'The balanced scorecard – measures that drive performance', *Harvard Business Review*, Vol. 70, No. 1.

Karkkainen, M. (2003) 'Increasing efficiency in the supply chain for short shelf life goods using RFID tagging', *International Journal of Retail and Distribution Management*, No. 31, pp.529–553.

Kernochan, W. (2003) *Enterprise Information Integration: The New Way to Leverage E-information*, Available at: www.aberdeen.com/ab_company/hottopics/eii2/default.htm.

Lau, A. and Yen, J. (2001) 'How XML supports financial information integration', *Proceedings of International Conference on Supply Chain Management and Information Systems in the Internet Age (SCMIS 2001)*, pp.347–357.

Ma, C., Chou, D. and Yen, D. (2000) 'Data warehousing, technology assessment and management', *Industrial Management and Data Systems*, Vol. 100, No. 3, pp.125–135.

Mathie, S. (1998) 'Re-engineering in practice', *Work Study*, Vol. 47, No. 7, pp.251–256.

Miller, J. (2001) 'Millennium intelligence: understanding and conducting competitive intelligence in the digital age', *Online Information Review*, Vol. 25, No. 2, pp.131–141.

Mills, W. (2003) 'The event driven enterprise', *Business Integration Journal*, November, Available at: www.bijonline.com.

Morgenthal, J. (2004) *Transforming Business Data into Business Events*, Available at: www.bijonline.com.

Natarajan, G. and Sheklar, S. (2001) *Knowledge Management: Enabling Business Growth*, McGraw-Hill International Edition.

Ramakhrishman, R. and Gehrke, J. (2000) *Database Management Systems*, McGraw-Hill International Edition.

Reiterer, H., Mussler, G., Mann, T. and Handschuh, S. (2000) 'Insyder - an information assistant for business intelligence', *In Proceedings of the 23 Annual International ACM SIGIR 2000 Conference on Research and Development in Information Retrieval*, ACM pres, pp.112–119.

Roth, A., Wolfson, D., Kleewein, C. and Nelin, J. (2003) *Information Integration: A New Generation of Information Technology*, Available at: www.research.ibm.com/journal/sj41-4.html.

Sakaguchi, T. and Frolick, N. (1997) 'A review of the data warehouse literature', *Journal of Data Warehousing*, Vol. 2, No. 1, pp.34–54.

Salin, V. (1998) 'Information technology in agri-food supply chains', *International Food and Agribusiness Review*, No. 1, pp.329–334.

Sawka, K. (1996) 'Demystifying business intelligence', *Management Review*, Vol. 85, No. 10, pp.47–51.

Shneiderman, B., Byrd, D. and Croft, W. (1997) *Clarifying Search: A User-Interface Framework for Text Searches. D-Lib Magazine*, Available at: http://www.dlib.org/dlib/january97/retrieval/01 shneiderman.htnd. Accessed on 17 August 1999.

Smith, M. (2001) *Companies using BI Tools to Look within, Business Intelligence*, June, Available at: www.advisor.com/Articles.nsf/aid/SMITT286.

Sonnen, D. and Morris, H. (2004) 'Business factor: event-driven business performance manager', *TIBCO White Paper*.

Sveiby, E. (1997) *The New Organizational Wealth: Managing and Measuring Knowledge based Assets*, San Francisco, CA: Berret Koehler Publishers.

Widom, J. (1995) 'Research problems in data warehousing', *Proceedings of the 1995 International Conference on Information and Knowledge Management*, pp.25–30.

Wilson, T.P. and Clarke, W.R. (1998) 'Food safety and traceability in the agricultural supply chain: using the internet to deliver traceability', *Supply Chain Management*, No. 3, pp.127–133.

Wixom, H. and Watson, J. (2001) 'Perspectives on data warehousing', *Journal of Data Warehousing*, Vol. 6, No. 1, pp.2–8.