TOWARDS A CLOSED-LOOP BUSINESS INTELLIGENCE FRAMEWORK

Oscar Mangisengi
BWIN Interactive Entertainment AG, Marxergasse 1B, A-1030 Vienna, Austria
SMS Data Systems, GmbH, Lilienbrunnen 18, A-1020 Vienna, Austria

Ngoc Thanh Huynh
Mayr-MeInhof Karton Gesellschaft m.b.H, Brahmsplatz 6, A-1041 Vienna, Austria

Keywords: Activity Warehouse, Business Activity Monitoring, Workflow Management Systems, On-line Analytical Processing (OLAP), and Business Intelligence.

Abstract: An existing challenge is that organizations need to make business processes as the centrepiece of their strategy to enable the processes performing at higher level and to efficiently improve these processes in the global competition. Traditional Data Warehouse and OLAP tools, which have been used for data analysis in the Business Intelligence (BI) systems, are inadequate for delivering information faster to make decisions and to earlier identify failures of a business process. In this paper we propose a closed-loop BI framework that can be used for monitoring and analyzing a business process of an organization, optimizing the business process, and reporting cost based on activities. Business Activity Monitoring (BAM) as data resource of a control system is as the heart of this framework. Furthermore, to support such a BI system, we integrate an extracting, transforming, and loading tool that works based on rules and state of business process activities. We show that some functionalities of our prototype are working well. The tool can automatically transfer data into a data warehouse when conditions of rule and state have been satisfied.

1 INTRODUCTION

In today's fast-paced business environment and due to regulatory compliance, organizations encounter new challenges to increase an ability to make adjustments quickly, to monitor and optimize business activities and to early identify process defects. The optimization of activities within a business process aims at analyzing cost of activities, so that an organization is able to improve competitiveness, and to provide high quality services to gain market. Furthermore, organizations need to make business processes as the centrepiece of their strategy to enable the process to perform a higher level (Lopez-Claros 2006).

Information technology provides a highly significant role for making better decision and controlling business processes. A traditional Business Intelligence system has been developed a decade ago and is built on data warehouses (DWs) as a data resource for On-Line Analytical Processing (OLAP) (Codd et al., 1993) tools to make decisions for high-level management. DWs store historical data and data in a DW is organized as multidimensional data (Kimball et al., 2002, Inmon 2002). DWs and OLAP tools offer strong data analysis functionalities based on multidimensional data and its hierarchies, such as rolling-up, drilling-down, or drill-through. The concept of data warehouse concentrates on data, however, in fact, business processes of an enterprise or an organization are processed from department to department and run as a long–running transaction. Such a process can be divided into discrete activities. Activities, checkpoints, and events occur within the process. As the result, granulated data is created inside the process. Unfortunately, the granulated data is not preferred to store in a data warehouse. DWs are modelled to store transaction end counts, and are not designed to capture events of a business process. DWs store end counts, rather than process checkpoints (Creese 2005). Therefore,

Mangisengi O. and Thanh Huynh N. (2008).
TOWARDS A CLOSED-LOOP BUSINESS INTELLIGENCE FRAMEWORK.
In *Proceedings of the Tenth International Conference on Enterprise Information Systems - DISI*, pages 210-217
DOI: 10.5220/0001693602100217

data stored in DW lacks process contexts and does not represent events of the business process. Furthermore, data warehouse as a part of BI system is insufficient data resource to deal with the emerging new challenges of business environment above.

In this paper, we identify two challenges for rebuilding BI applications in our work. They are given as follows:

- A further development of BI applications attempts to integrate workflow technology (Sheth et al., 1999) and Business Activity Monitoring (BAM) (Dresner 2002) into data warehousing. A workflow of a transaction of a business process is a long-running transaction and in addition activities of the workflow have to be monitored in detail. Therefore, a data repository that is used to store event, activity, or process data or event-oriented data within the transaction of the business process is necessary, and such a repository can be used as data source for monitoring and detecting the events, activities, and processes of the workflow. In (Mangisengi et al., 2007) an activity warehouse has been successfully implemented and the event-oriented data stored in activity warehouse can be used for efficiently monitoring business processes in real-time and providing a better real-time visibility of the business process.
- The needs of establishing BI framework that can integrate data resources and new applications into a BI system are essential to address business requirements and to improve business processes, e.g., a solution must be responsive to the demand of issue. Shorter decision cycles require more flexibility. Decision-making flexibility requires the ability to perform continuous 'what-if' analytics and ongoing scenario planning. It is inadequate to deliver information faster to decision makers in the form of reports, dashboards, or alerts only. Moreover, it is essential for supporting for evaluating decision alternatives. Building a sense-and-respond capability in a process context is critical to realizing continued improvement in business performance (Morris et al., 2007).

This paper proposes a closed-loop Business Intelligence framework addressing the emerging challenges to provide adaptive information and to enhance decision-making cycles. The notions of a closed-loop BI framework are able to early identify and detect failures of activities in a business process, to provide a closed-loop decision based on tactical and control data and strategic data on the operational data, to integrate data centric and process centric into a unified system in order to work together to provide an adaptive information, and to report activities based costing.

In our approach we divide data resources for establishing a closed-loop BI framework into three different classes of data (i.e., operational, tactical and control, and strategic data). Using a rules and state-based ETL tool, they work together to provide adaptive information.

This work is organized as follows. Section 2 outlines related work and contribution. Furthermore, we present our motivation in Section 3. Then, section 4 presents briefly an overview to derive an activity warehouse based on the BAM requirements. A closed-loop BI framework is presented in Section 5. Finally, conclusion and further work are presented in Section 6.

2 RELATED WORK

Recently there exist research works in the literature for the architecture of Business Activity Monitoring, workflow management systems, and real time data warehousing. The architecture of BAM is initialized and introduced in (Dresner (2002), Nesamoney (2004), Hellinger & Fingerhut (2002), White (2003), McCoy 2001). The concept of process warehouse has been introduced for different purposes, such as in (Nishiyama 1999) a process warehouse focuses on a general information source for software process improvement, (Tjoa et al., 2003) introduces a data warehouse approach for business process management, called a process warehouse, and in (Pankratius & Stucky 2005) Pankratius and Stucky introduce a process warehouse repository. Furthermore, in relation to data warehousing, (Schiefer et al., 2003) proposes architecture allows transforming and integrating workflow events with minimal latency providing the data context against which the event data is used or analyzed. An extraction, transformation, and loading (ETL) tool is used for storing workflow events stream in Process Data Store (PDS).

3 MOTIVATION

Based on the successfully implementing Business Activity Monitoring for integrating enterprise applications (Mangisengi et al., 2007), in this paper we continue our work to face the second challenge to reach a future, powerful business intelligence system.

We argue that a traditional BI system, which includes DWs, OLAP applications and some Data Mining/Reporting tools, is insufficient to meet the emerging challenges, e.g. to increase an ability to make adjustments quickly, to monitor and optimize business activities, and to identify process defects earlier. Although in the last few years there are many powerful tools developed for specific tasks in these areas, however, there is still need a controllable and monitorable BI framework. It cannot only adapt to the now-a-day quickly changes in business requirements and processes, but also provide a way to assess and optimize business processes. Within our BI framework we integrate the traditional BI system with BAM and other technologies (i.e., workflows and business activity monitoring). Furthermore, the adoption of new technologies for BI system changes the way of business management, assessment, and optimization, e.g., shorter life cycle of a business assessment, accelerating the information flows within the system. The intention of such a change is on the one hand to provide better decisions at the right time (i.e., strategic and tactical decision in the operational), on the other hand to measure performance and optimize business processes so that the cost of business processes can be analyzed (i.e., activity based-costing).

4 BUSINESS ACTIVITY MONITORING SYSTEM

On the whole, a BAM system is the heart of the control system. In this section we briefly present an overview of a BAM system. The detail of this system is given in (Mangisengi et al., 2007). To monitor and control business activities, a BAM system must be able to capture events and activities of a business process. Additionally, this paper also address a system, called activity warehouse which depends on various requirements, discreteness of a business process, business process management, workflow, and the repository of BAM. We respectively present the requirements in the following sub sections

4.1 Discreteness of a Business Process

In order to monitor and control activities within a business process, we divide a business process into discrete processes. The discrete processes are intended to obtain granulated data that represents activities of a business process, so that a business process can be analyzed and reported in very detail. To discrete a business process, we need a conceptual hierarchical structure of a business process given in Figure 1 (Mangisengi et al., 2007).

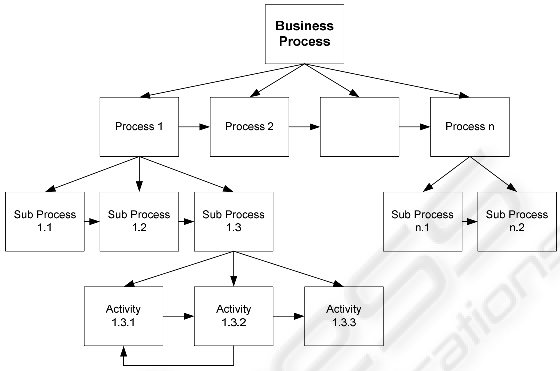

Figure 1: The conceptual hierarchy structure of a business process.

Figure 1 shows a business process with a set of activities represented from the highest level to the lowest one. In this example the activity 1.3.2 cannot go further to the next activity 1.3.3 activity if a failure exists, it then goes back to the previous activity 1.3.1. The conceptual hierarchy structure of a business process given in Figure 1 can be represented as follows:

- A business process can be organized into a hierarchical structure that represents different level of importance from the highest level to the lowest one, or vice- versa.
- A business process may be decomposed into a set of processes. A process may consist of a set of sub-processes, and a sub-process includes of a set of activities.
- An activity is the lowest level process of a unit transaction. It can be represented as three-dimensional workflow given in Section 4.3.

4.2 Business Process Management

BPM aims at enhancing the business efficiency and responsiveness of an organization and, at optimizing the business process of the organization. BPM has closed relationship to the business strategy of an organization. BPM requires essential data and its intention for enhancement and optimization as follows:

- Strategic data is to provide the result of an organization that can be achieved and its

hypotheses. Also, it can be supported by the scorecards.
- Tactical data aims at controlling and monitoring business process activities and its progress in detail and supports a contextual data.
- Business metrics data is to support the strategic improvements for the higher level goals. In addition, it supports departments and teams to define what activities must be performed.

4.3 Workflow Management

To derive the repository of a BAM system, called activity warehouse, we approach a process and state workflow management. Depending on the business requirements, a specific workflow will be used for managing a business process, however, in general there exist two characteristics of workflow that are included in the activity warehouse to store data in the particular context of business process activities as follows:

- *Tracking Activity*. The tracking activity deals with the checkpoints of business process activities of a unit transaction. It provides the history of activities of a unit transaction.
- *Status Activity*. The status activity represents the status of a unit transaction after the execution of a business process activity. The current status is also used by an actor to address and execute the next activity of the business process and in addition to arrange the executions of workflow in its correct order.

In our point of view an activity of a business process can be represented as three-dimensional workflow as follows:

- *Action*. An action is represented by the method of a particular activity and is corresponded with an actor. Activities may be assigned to actors, applications, or system queues based on rules.
- *Process*. A process is a network of activities, with rules to control the start and exit conditions for each activity and the data flow between the activities. It defines the business process activities and the sequence in which they are to be performed.
- *Actor*. An actor is defined as a person or an intelligent agent who or which respectively executes a particular action. Furthermore, the actor has a role and an organization.

Other requirements used for optimizing business process are measurement data. The measurement data consists of two levels of data, namely macro and micro. In the macro level data represents end count of a unit transaction within a business process, whereas in the micro level data represents activities within a business process. Analysing/mining the data in the micro level we can detect failures in a business process and/or to provide different tactical decisions. It supports time and cost efficiencies. The time efficiencies aim at optimizing business processes and consist of cycle time, work time, idle time, transit time, queue time, and set up time, whereas the cost efficiencies are intended for calculating costs based on these activities in relation to the business process.

4.4 BAM Repository

A BAM repository (activity warehouse) is given in Figure 2. An activity warehouse provides data resources that are rich in process context and event-oriented data. Figure 2 shows the relationship between the OLTP system (i.e., the unit transaction table) and the activity warehouse table.

The model consists of the Activity Warehouse table and a set of dimension tables (i.e., Actor, Activity, and Status). The activity warehouse table consists of unit transaction identity, a set of dimension tables, and a set of attributes for measurement and optimization purposes, such as cost and time efficiencies. The table *activity warehouse* is represented as follows:

```
ActivityWarehouse(Unit_ID,
   Status_ID, Activity_ID,
   Actor_ID, StartOfAction,
   EndOfAction, Duration, EntryDate,
   CycleTime, WorkTime, IdleTime,
   TransitTime, QueueTime,
   SetupTime, Cost)
```

A set of dimension table consists of the Activity, Actor, and Status dimensions.

```
Actor(Actor_ID, FirstName, LastName,
   Role)
Activity(Activity_ID,   Description,
   SubProcess, Process)
Status(Status_ID,       Description,
   Category)
```

The activity dimension categorizes a business process until the lowest level. The Process attribute represents the highest level of the business process and the Activity_ID and its description attributes represent the lowest level of the business process.

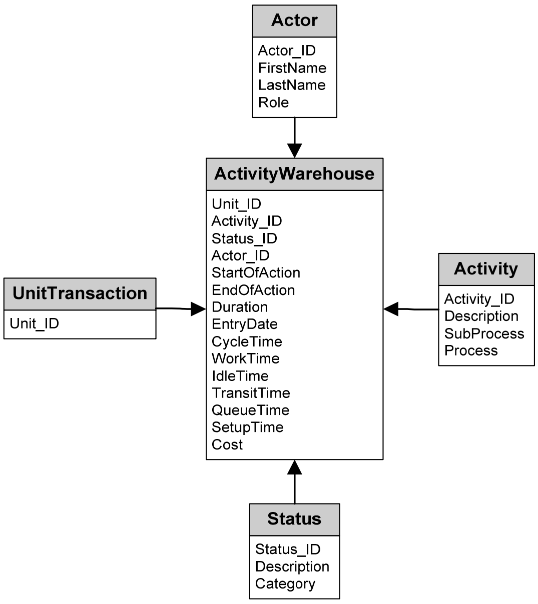

Figure 2: Activity warehouse and unit transaction.

5 A CLOSED-LOOP BI FRAMEWORK

This section focuses on discussing a closed- loop Business Intelligence framework in detail and how its components can interact to each other's so that they can provide adaptive information. In relation to our previous work, the BAM system can be used for efficiently monitoring business processes in real-time and provide a better real-time visibility of the business process. We integrate a BAM system into a traditional BI system, combine all traditional BI component and BAM into a new framework that has a robust controlling characteristic and a closed-loop BI framework is obtained. The notion of the new framework enables enhancing decisions, such as:

- Monitoring, identifying and detecting defects of activities earlier in a business process.
- Providing decisions created from control and tactical, strategic, and operational data that are given by a closed-loop system.
- Integrating data centric and process centric into a unified system in order to work together to provide an adaptive information.
- Reporting activities based costing.

This framework consists of three main components, named operational, BAM, and data warehouse subsystems. They provide three different data resources, namely operational data, control and tactical data, and strategic data respectively. All data of the system represents data centric and process-oriented data. With the supporting of BAM, the event-oriented data now will be used for controlling the ETL tool to extract, transform, and load data from operational system to DW. On a whole a closed-loop BI framework is shown in Figure 3.

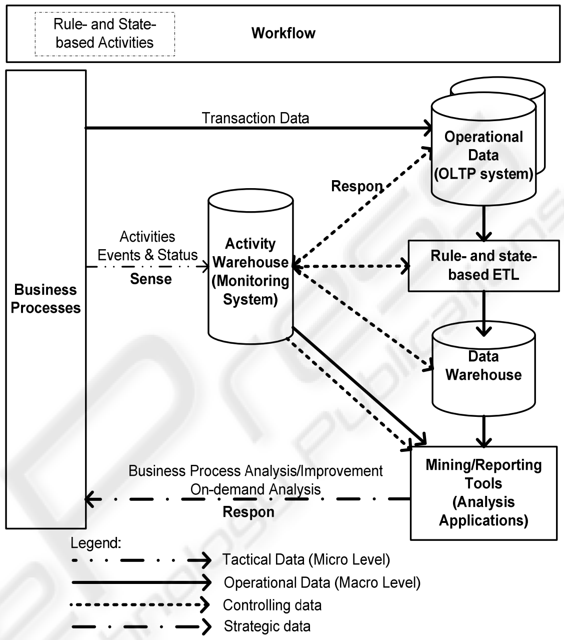

Figure 3: A closed-loop BI framework.

Figure 3 shows that a closed-loop BI framework consists of an application layer, strategy decision layer, and operational and tactical decision layer and its workflow. The application layer consists of different applications for different management levels, such as activity monitoring, OLAP tools, and OLTP applications. The strategic decision layer comprises data warehouse and an ETL tool, whereas the operational and tactical decision layer includes OLTP system data and BAM system.

In the following sub-sections we demonstrate to addressing the notions.

5.1 System Interaction and Data Flow

Dependent on information or decisions that will be generated, system interaction and data flow can be categorized into three classes:

- *Strategic Decisions*. To generate strategic decisions, operational system interacts with data warehouse, where the interaction moves data from operational system to data warehouse using an ETL tool. This mechanism is similar to in a traditional data warehousing. However, the

ETL tool of this framework uses different approach that is given in Section 5.3.

- *Tactical Decisions*. Tactical decisions are generated by monitoring applications, where data is taken from the activity warehouse. These decisions monitor failures of business processes. Monitoring applications interact with BAM system.
- *Operational Decisions*. To generate decisions, the framework apply two approaches, namely from operational applications and from closed-loop approach. The second uses tactical decision and strategic decision for improving processes in the operational application.

A system interaction and data flow in our closed-loop BI framework is shown in Figure 4.

Figure 4: System interaction and data flow in a closed-loop BI framework.

To support the system interaction and data flow in the framework, we have implemented a prototype that is divided into some modules and its basic functionalities:

1. *Business Process Module*. It contains a business process scenario namely:
   - What-if
2. *Monitoring and BAM Module*. This module consists of the following functionalities:
   - Refreshing
   - Browsing
   - Throwing events
   - Auto-detecting
3. *Rule-based ETL Module*. It consists of functionalities as follows:
   - Trigger
   - Procedures

5.2 Business Process Improvement

To quickly and correctly improve or optimize a business process organization needs not only flowchart tools or methodologies, but also a costly time and men-power analysis process. The both aspects are available in this closed-loop BI framework. Analysing data of all states and activities of a business process organization can identify the weak points or undesired properties of this process. Additionally this framework supports on-demand activities analysis, which allows organization making a correct decision in a short period of time.

5.3 Rules and State-based Extraction, Transformation, and Loading

Rules and state-based extraction, transformation, and loading tool are an important approach of this system. The ETL tool works dependent on rules and states of activities within a business process. Thus, a regular time is not required to move data from operational system to data warehouse. The ETL automatically works when a specific state of an activity within a business process is achieved. The characteristics of the ETL tool are flexible and more dynamic.

5.4 An Extension of On-Line Analytical Processing

Traditionally OLAP tools aggregate data in DW for rolling-up or drilling-down functionalities. To monitor activities and detect failures within a business process, we extend OLAP functionalities, so that they can be used for accessing data micro level in an activity warehouse and for summarizing and calculating costs and performances based on activities for a unit transaction. Additionally, new functionalities to calculate and to report costs- and performances-based on activities or processes are needed. To navigate data stored in activity warehouse, we provide metadata given in Figure 5. It applies the multidimensional graphical notation as it is developed by (Bulos 1996) using the ADAPT modelling tool developed by (Totok & Jaworski 1998).

Figure 5 shows that each dimension contains the All hierarchy level. For example, to obtain micro level data based on dimensions, such as process, state, and activity, we navigate the hierarchy level of the Process dimension *All* → *Process* → *Sub-process* → *Activity*, the State dimension (i.e., *All* → *Category* → *State*) and the Actor dimension (i.e., *All* → *Role* → *Actor*) respectively. On the contrary, to obtain macro level data, we navigate the hierarchies on the opposite direction. In addition, using this metadata navigation, *On-Line Activity-based Costing* and *Performance* can be monitored and summarized in real-time for one or more unit transactions.

New functionalities of OLAP applications have a strong relation to different level managements. For example, applications, such as activity monitoring, costing, and performance, can be categorized into some high-level management applications. They are executed by different decision-makers dependent on their roles and securities, however, in this paper we do not discuss on the security issues in any detail.

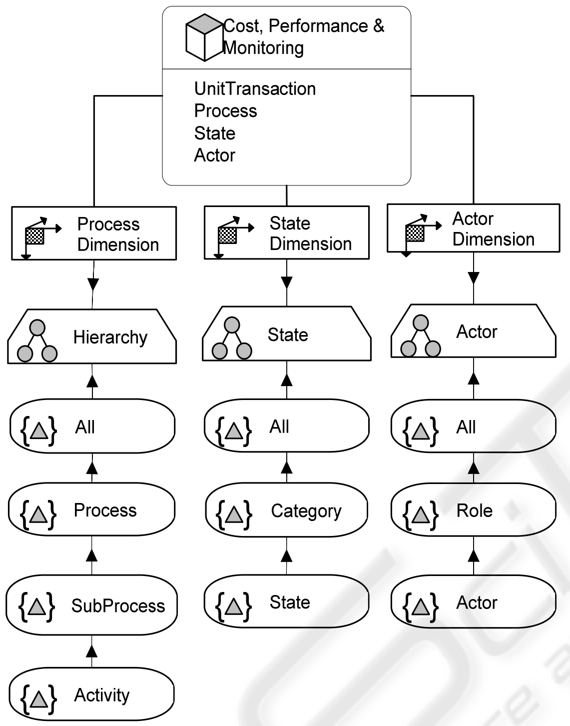

Figure 5: An extended of OLAP for navigating micro level data.

5.5 Comparison between a Traditional and a Closed-Loop Business Intelligences Frameworks

We summarize a comparison between the traditional BI and a closed-loop BI framework. The comparison is given in Table 1.

Table 1 shows that the closed-loop BI framework provides some extending functionalities as well as provides a better environment for decision-making compared to the traditional BI framework. An important feature of the closed-loop BI is that an ETL tool works based on rules and states of a business process.

Table 1: A comparison between traditional Data Warehousing and the proposed a closed-loop OLAP system.

Feature	Traditional BI	A closed-loop BI
Data source	Operational and strategic data	Operational, strategic, and tactical and control data
ETL	Working based on regular basis	Working based on rules and states
OLAP	Summarization, aggregation	Summarization, aggregation, monitoring, failure detection, cost
Data access	Aggregated data, macro level data	Aggregated data macro, and micro level data
Decision	Strategic decisions	Tactical and strategic decisions
The aim of data	Business	Business, Performance, Optimization

6 CONCLUSIONS & FURTHER WORKS

In this paper we have proposed a closed-loop On-Line Analytical Processing system to bring adaptive information to a Business Intelligence framework. Our approach is based on three data resources (i.e., operational, tactical and control, and strategic) to provide the framework given by operational system, Business Activity Monitoring (BAM) system, and Data Warehouse respectively.

The advantages of the closed-loop OLAP BI framework are to earlier enable detecting failures within a business process, to monitor and optimize the business process in detail, and to improve a quality of the business process.

Integrating the closed-loop framework into current traditional BI framework in real-world business applications becomes a challenge for enterprises and organizations because of a different life cycle of the development process. Based on our experiences, since BAM system is the centrepiece of the closed-loop BI framework, first a robust BAM requirement analysis and business processes of an organization are completely necessary and second BAM system must be well coupled to an operational system.

Our implementation is based on the Java technology and it's Service-Oriented Architecture. Currently we are integrating BAM system and DW into unified information to bring sense-and-response information as well as rules and state- based extraction, transformation, and loading system and incrementally implementing the framework.

We believe that a closed-loop Business Intelligence framework plays a major role in the area of enterprise application integration in the near future. Furthermore, we continuously investigate on security issues of the new framework in real-world applications.

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