ACTIVITY WAREHOUSE: DATA MANAGEMENT FOR BUSINESS ACTIVITY MONITORING

Oscar Mangisengi, Mario Pichler, Dagmar Auer, Dirk Draheim
Software Competence Center Hagenberg(SCCH) GmbH, Softwarepark 21, A-4232 Hagenberg, Austria

Hildegard Rumetshofer
FAW Software Engineering gGmbH, Hauptstrasse 119, A-4232 Hagenberg, Austria

Keywords: Activity Warehouse, Business Process Management, Business Activity Monitoring, Workflow Management Systems.

Abstract: Nowadays collecting checkpoint data of business process activities of transactions becomes important data resource for business analyst and decision-makers to support tactical decisions in general and strategic decisions in particular. In the context of business process-oriented applications, business activity monitoring (BAM) systems, which are predicted to play a major role in the future business-intelligence area is the most visible use of the current business needs. In this paper we address an approach to derive an activity warehouse model based on the BAM requirements. The implementation shows that data stored in activity warehouse is able to efficiently monitor the business process in real-time and provide a better real-time visibility of the business process.

1 INTRODUCTION

Providing high quality services to gain market presence and competitive edge are essential for organizations in the continuously changing business environment. An effective and efficient way for addressing challenges of the current business needs is to optimize business process of the organization, such as monitoring activities of the business process in detail, earlier detecting the unexpected problem of business process activities within a unit transaction to deliver information as fast as possible to make a decision.

Data warehouse (DW) and On-Line Analytical Processing (OLAP) (Codd, E.F., Codd, S.B., Salley, C.T., 1993) tool nowadays are almost identical to Business Intelligence (BI) tools for supporting a high-level business management to take decisions. DWs store historical data that is integrated and collected from different data sources and are organized as multidimensional data (Kimball, R., Ross, M., Merz, R., 2002; Inmon, W., 2002). OLAP tools allow decision-making users to dynamically manipulate the data contained in the DW. Although they have been developed over a decade, however, they are inadequate to meet the current business needs. DWs store end counts, rather than process checkpoints (Creese, G., 2005). For example, total unit shipped in a month, rather than a unit tracked through milestones of assembly, quality assurance, packaging and distribution. In addition, storing internal checkpoint numbers into the data warehouse was usually difficult.

In the context of business process-oriented applications, in fact a unit transaction of business process of the organization is represented as a long running process and may work at intervals. Within the interval, applications apply business process activities, so that process checkpoints occur in the business process.

Workflow management (WfM) systems developed in the last decade is an essential framework for managing and controlling the complex administrative business processes of either an organization or inter-organizational. It allows for the explicit representation and support of business processes and in addition to avoid the need to re-code applications every time a business process

Mangisengi O., Pichler M., Auer D., Draheim D. and Rumetshofer H. (2007).
ACTIVITY WAREHOUSE: DATA MANAGEMENT FOR BUSINESS ACTIVITY MONITORING.
In *Proceedings of the Ninth International Conference on Enterprise Information Systems - DISI*, pages 137-144
DOI: 10.5220/0002377801370144

change (Lawrence, P., 1997; Sheth, A.P., van der Aalst, W.M.P., Arpinar, I.B., 1999).

In the past two years, business process management (BPM) has generated considerable interest in the information technology area to have control and visibility over any type of business process (i.e., short or long-running transaction, system-centric or people-centric) (Chang, J., 2004). In addition, Business Activity Monitoring (BAM) (Dresner, H., 2002), which is predicted to play a major role in the near future for the business-intelligence application, is the most visible use of addressing the current business needs. The notions of BAM systems are to provide real-time event management and visibility of business performance data to enhance operational effectiveness and decision making. The BAM system is a broad concept and a business process-oriented solution, encompassing more than information from BPM systems.

This paper addresses data management for business process monitoring, optimization, and performance. The activity warehouse model is derived based on business activity monitoring requirements.

This work is organized as follows. Section 2 outlines the related works and contributions. In Section 3 we present our research motivation, our solution approach, and a short description of the system architecture overview. Section 4 describes a conceptual structure of the business process, requirements for modelling an activity warehouse, and the model of activity warehouse. Finally, conclusion and further work based on our implementation are presented in Section 5.

2 RELATED WORK & CONTRIBUTION

In the context of the BAM architecture, research works have been initialized and introduced by some research institutes and organizations (Dresner, H., 2002; Nesamoney, D., 2004; Hellinger, M, Fingerhut, S., 2002; White, C., 2003; McCoy, D., 2001). In relation to the workflow technology, (Nishiyama, T., 1999) introduces the concept of process warehouse that contains an assortment of various aspects of a target technology compiled into an easy to understand matrix of information. It focuses on a general information source for software process improvement. Moreover, (Pankratius, V., Stucky, W., 2005) introduce a formal notation for such compositions in form of a workflow algebra based on Petri Nets, which allow expressing the creation of a workflow model from other models using an algebraic notation with operators similar to those known from relational algebra in databases. They also propose a repository called as the workflow warehouse. In addition, concerning the data warehouse technology, (Schiefer, J., List, B., Bruckner, R.M., 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. They use the Extraction, Transformation, and Loading (ETL) process to store workflow events stream in Process Data Store (PDS).

The existing approaches of process warehouses have not pay attention to separate tactical data from strategic data yet. However, the separation of tactical and strategic data is essential for monitoring business process to improve business performance and efficiency, since both data semantically differ. Our approach decomposes a system into three functions, such as delivery, regulator, and control functions. Thus, operational, tactical, and strategic data respectively can be separately provided.

3 MOTIVATION

This section presents our motivation to derive an activity warehouse model. First, we discuss the challenges of research issues in related to BPM and BAM, an approach for the solution, and finally an overview of the system architecture.

3.1 Motivational Issues

Our research partner aims at automating the business process using workflow technology to monitor and optimize business process of the organization and to provide tactical and strategic decision. The business process and workflow manage unit transactions at intervals. The organization and its branches are distributed at different locations as well as provinces shown in Figure 1, such as the locations A, B, C, and D. The organization and its branches apply the corporate workflow. A unit transaction is identified as a long-running transaction, can be submitted by a customer at the particular location and then can be forwarded to the other location and it can be processed by other user in a particular role. The institution is organized into a hierarchical structure. That means that the decision of a particular business

process activity is dependent on the business hierarchy and the roles of the organization.

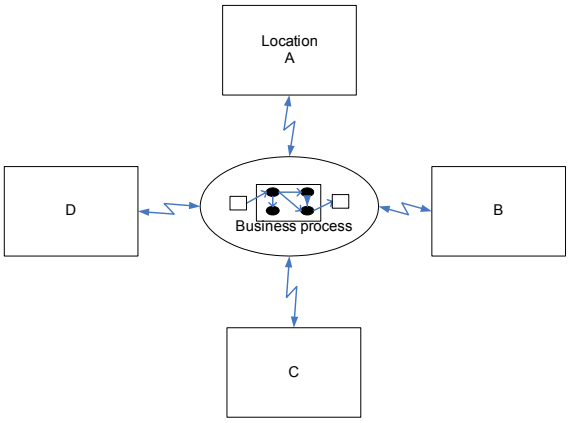

Figure 1: The motivational issues.

3.2 Business Activity Monitoring as the Solution Approach

Monitoring, controlling, and optimizing business process are focused on these challenges. Thus, a solution should be able to as follows:

- Monitor business processes, such as what, how, who, and when an activity has been executed.
- Provide the current state of a business process activity of a unit transaction.
- Track the business process activities of transactions in detail.

Data warehouses (DWs) store end counts data of a transaction and are intended for supporting strategic decision. On the contrary, business activity monitoring applications as well as business process efficiency and performance applications, require tactical data, e.g. the checkpoints of business process activities of transactions, for supporting tactical decisions. DWs cannot be used for monitoring business process and for storing checkpoints of business process activities. To overcome the current challenges, we require an activity repository, called *Activity Warehouse*. Furthermore, our approach deals with three data decompositions, such as operational, tactical, and strategic data.

3.3 An Overview of System Architecture

Figure 2 shows the overall system architecture. An overview of the system architecture is given as follow:

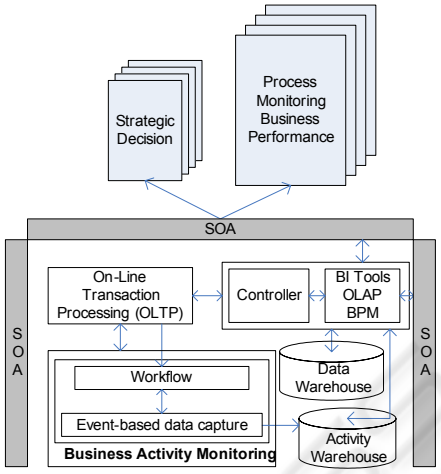

Figure 2: The overall system architecture.

Each module is discussed as follows:

1. On-Line Transaction Processing (OLTP) system manages and stores the transactions of customers and provides the operational data.
2. DW stores end counts data extracted from the OLTP system used for supporting strategic decision-making. However, this paper does not focus on data warehousing as well as the extraction, transformation, and loading (ETL) process.
3. Controller and BI tool, such as BPM software, provide services for to the business intelligence applications.
4. Service Oriented Architecture (SOA) addresses issues, such as the distributed accesses, the diversity of location and provinces, since transactions can be submitted at different locations and provinces. In addition, the aim of the SOA is to wrap the whole architecture.
5. The BAM layer consists of modules as follows:

    - *Workflow management* (WfM) *system*. Workflow system manages and controls the business process activities of transactions and automates the business process. It is coupled directly to the OLTP system to avoid the time delay between the OLTP and BAM systems.
    - *Activity-based data capture*. The activity-based data capture is coupled directly to the workflow system to track events of business process activities of the organization. Thus, WfM *System* generates the audit trail in the correct format.

- *Activity warehouse*. The activity warehouse stores the data checkpoints of business process activities of transactions in real time.

4 ACTIVITY WAREHOUSE

This section presents our approach to manage data for monitoring business activities. Data management for optimizing and monitoring business process is strongly dependent on business process requirements of the organization. We use a top-down approach to classify requirements for deriving the model.

4.1 A Conceptual Structure of the Business Process

In order to manage completely the checkpoints of business process activities of transactions, the conceptual structure of a business process is required. Assumed that an activity is the lowest level of business process and the business process of a transaction may be decomposed into activities. Thus, a conceptual hierarchical structure of a business process can be given as follows:

- A process model is a complete representation of a set of business processes and its associated resources for managing process execution.
- A unit transaction is identified as a long-running transaction and is valid at intervals.
- A business process can be organized into a hierarchical structure that represents different level of importance from the highest level process to the lowest level process, or vice-versa.
- The 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 represents a particular activity of the business process of a unit transaction.

A conceptual hierarchical structure of business process of the organization is shown in Figure 3. Fig. 3a shows that a unit transaction contains a business process; Fig. 3b presents a hierarchical structure of the business process of the Fig. 3a, and Fig. 3c shows that an activity is represented as three-dimensional workflow.

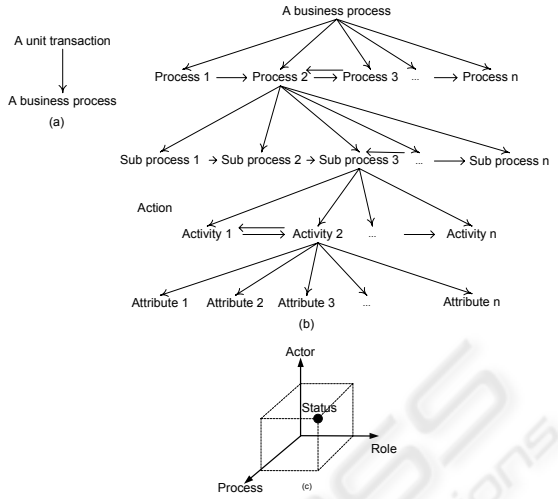

Figure 3: The unit transaction and its business process and the conceptual of a business process.

4.2 Business Activity Monitoring and Business Process Management

Business activity monitoring (BAM) systems consist of components, such as Business Process Optimization (BPO) and Key Performance Indicators (KPI) for supporting the business process optimization and the business metric information. Furthermore, the BAM system architecture must be able to support such as event-driven decision making, rules-based monitoring and reporting, real-time integration of event and context, and no latency; comprehensive exception-alert capabilities (Nesamoney, D., 2004). Meanwhile, the BPM technology enhances the business efficiency and responsiveness and optimizes the business process in order to improve services of an organization (Chang, J., 2004; McDaniel, T., 2001). Specifically, BPM has closed relationship to the BAM system in general and the business strategy of an organization in particular. Thus, the BAM and BPM systems support data as follows:

- *Strategic data*. The strategic data provides the result of an organization that can be achieved and its hypotheses. Also, it can be supported by the scorecards.

- *Tactical data*. The tactical data controls and monitors the business process activities and its progress in detail and supports a contextual data. The queries are given as follows:

- *Give transactions has been completely processed today?*
- *Give transactions has been accepted and can be processed in advanced today?*

- *Business metrics data*. The business metrics data supports the strategic improvements for the higher level goals. It supports departments and teams to define what activities must be performed. The example of query is as follows:
  - *Give transactions have been processed for a particular department for a particular time today?*

4.3 Workflow Management

Workflow aims at supporting the BAM and BPM requirements presented in Section 4.2. A workflow process definition specifies which tasks need to be executed and in what order (i.e., the routing or control flow). There are some workflow perspectives (i.e. control flow or process, resources or organization, data or information, task or function, operation or application). In our approach, the process and state workflow management is used for the activity warehouse. Depending on the business requirements, which workflow will be used for managing a business process, however, in general there exist two characteristics of workflow that are be included in the activity warehouse to store data in the particular context of business process activities.

4.3.1 Common Workflow

The common characteristics of all workflow applications are that they are concerned with the registration of information and with tracking that information in a simulated environment; it is possible to determine the status of information while it is in the environment and which stakeholders are responsible for performing activities pertaining to that information. For the common workflow requirement, the following data in the activity warehouse are 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. The queries are typically provided as follows:
  - *Give the progress of a particular unit transaction?*
  - *Give the progress of transactions on October 24, 2006.*

- *Status Activity*. The status activity provides the status of a unit transaction after the execution of a business process activity. The current status also is be used by an actor to decide for executing the next activity of the business process and in addition to arrange the executions of workflow in order. Typically the queries is given as follows:
  - *Give the current status of a particular unit transaction?*
  - *Get transactions with the current status "submitted" in October 2006.*

4.3.2 Three Dimensional Workflow

An activity that is the lowest level process of business process shown in Fig. 3c can be represented as the three dimensional workflow. The three dimension workflow at least is 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 for the start and exit conditions for each activity and for the control and 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 the person who will execute a particular action.

In the activity warehouse, the three dimensional workflow is provided by a set of dimension tables, such as the dimension *process*, the dimension *actor*. Additional dimensions for supporting three dimensional workflow requirements are as follow:

- *Role*. An actor must have a particular role. A role has close relation to the specific department of an organization or intra-organization.
- *Organization*. Organization supports the organization of an actor as well as the actor role. An organization is usually structured into a hierarchy model.

Moreover, to support the three dimensional workflow of activity warehouse, the dimension *role*

and the dimension *organization* are essential for the activity warehouse.

4.3.3 Additional Requirement

This specific requirement of workflow is dependent on the business process requirements. The activity warehouse requires the following additional attribute:

- *Next Actor*. A next actor with the particular role is required to be recorded. For example, forwarding an activity that is processed by the other actor in advance. Who is responsible for the next activity in the business process? Thus, the activity warehouse provides the attribute *NextActor*.

4.4 Time Dimension

Time aims at recording when activities are executed. The activity warehouse has to deal with the entry date of an activity, and furthermore it uses the dimension *time* like in the multidimensional model. In our approach for the activity warehouse, we separate between the execution time and the measurement times for an activity. The dimension *time* manages when an activity is executed. Thus, the dimension *time* is limited up to the day basis. Also, the dimension *time* can be used for aggregating the business process, such as rolling-up, drilling-down. Examples of queries are as follows:

- *Get activities have been accepted by the particular actor, role, and department on the October 24, 2006*.
- *Get activities have been finished by the particular actor, role, and department on the October 24, 2006*.
- *Get all activities that have been accepted by the particular actor, role, and department by rolling-up from* ***date*** *to* ***month*** *of the time dimension, i.e., October 24, 2006 to October 2006*.

In order to optimize the business process performance and its efficiency, the activity warehouse must be able to capture the execution time of an activity up to second, millisecond, or microsecond. Therefore, the activity warehouse uses additional attributes for the time efficiency for the purpose given in Section 4.5.2.

4.5 Measurement Data

To reach the business performance optimization, the activity warehouse supports a set of attributes for measurement data (e.g., the efficiency of cost) and a set of attributes for time efficiencies. The measurement data and the time efficiencies must be to be tracked in detail for the checkpoints of business process activities of transactions. Furthermore, like OLAP tools, measurement data can be aggregated against the dimension tables. In the context of BAM, data stored in the activity warehouse must be able to provide an event-driven decision-making that means the lowest data level or an activity can be used to make decision for the business process efficiency. For example, the lowest business process data can be used for finding unexpected problem in the business process. To support the measurement data for the activity warehouse, we classify measurement data into as follows:

4.5.1 Macro Level Data

The macro level data represents end count of a unit transaction that is stored in the operational data management and it will be stored in data warehouse in advance.

4.5.2 Micro Level Data

The micro level data provides activities of the business process data and represents the lowest level data. Therefore, the micro level data is defined as a checkpoint data of a business process activity of a unit transaction. The micro level data is distinguished into time efficiency data and measurement data. Micro level data includes data as follow:

- *Time efficiency*. The existence of the time requirement is very important in the activity warehouse. The time efficiency is intended to answer how long an activity has been done. The activity warehouse provides the time efficiency attributes to measure the performance and efficiency of business process. Attributes for the time efficiency are dependent on the business optimization performance requirements. A set of time efficiency attributes could be as follows:
    - *Cycle time*. The cycle time is the total elapsed time, measured from the moment when a request enters the systems to when

it leaves it. This is the time measure that is most obvious to the customer.

- *Work time*. The worked time that the activities that execute the request are worked on. Practically, activities are sometimes idle or waiting for other activities to finish and for this reason cycle time and work time are not the same.
- *Time worked*. It concerned with the actual hour of work expanded on the request. Sometimes more than one person is working on a request at one time. Thus, time worked is not the same as work time.
- *Idle time*. The idle time refers to when an activity or process is not doing anything.
- *Transit time*. The time spent in transit between activities or steps.
- *Queue time*. The time that a request is waiting on a critical resource; the request is ready for processing, however it waiting for resources from another activity to reach it.
- *Setup time*. The time required for a resource to switch from one type of task to another.

- *Cost efficiency*. The cost efficiency attributes are dependent on the value of the attributes *time efficiencies*. The cost measurement data is essential to optimize the business process and to calculate the cost of business process.

The macro and micro data levels enable the business process management tools to monitor and drill down data from the macro data level to the micro data level as well as horizontal and vertical rolling-down to each individual transaction or business process. Using these functionalities, an organization can improve the visibility of the overall performance of the organization at both the macro and micro data levels. The macro and micro data level are shown in Figure 4.

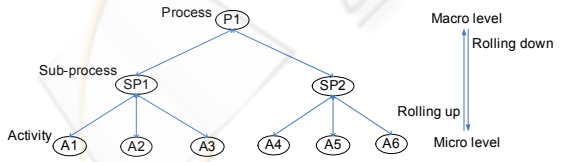

Figure 4: The macro and micro level data.

4.6 An Activity Warehouse Model

An activity warehouse model can be shown in Figure 5. Fig 5.a shows the relationship between the OLTP system and the activity warehouse (AW), whereas Fig 5.b shows the activity warehouse in detail.

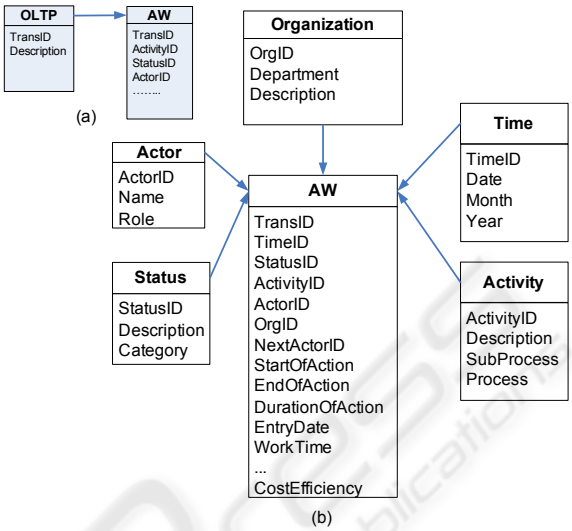

Figure 5: The activity warehouse model.

The model consists of the table *Activity Warehouse* and a set of dimension tables. The table *activity warehouse* consists of unit transaction identity, a set of dimension identities, the status identity, and a set of measurement and optimization attributes, such as cost and time efficiencies. The table *activity warehouse* is represented as follows:

```
AW(TransID, StatusID, ActivityID,
ActorID, OrgID, NextActorID, TimeID,
StartOfAction, EndOfAction,
DurationOfAction, EntryDate,
TimeEfficiency, CostEfficiency)
```

A set of dimension table consists of the dimensions, such as the dimensions *Activity*, *Organization*, *Actor*, *Status*, *Time*, and *Activity*.

```
Actor(ActorID, Name, Role)
Organization(OrgID, Department,
Description)
Activity(ActivityID, Description,
SubProcess, Process)
Status(StatusID, Description,
Category)
Time(TimeID, Date, Month, Year)
```

5 CONCLUSION & FURTHER WORKS

In this paper we have presented an approach for deriving an activity warehouse model based on the

Business Activity Monitoring (BAM) requirements to provide strategic and tactical decisions. Experiments shows that the benefits of data stored in activity warehouse are able to monitor detail activities that occur in the business process and provide a good visibility for monitoring the overall business process as a whole. Other challenge is that the volume of data in the activity warehouse rapidly grows because of storing business process activities in very detail.

Based on our implementation, in the context of business-process oriented applications, we believe that the BAM is an important business requirement in the near future to improve business process efficiency of the organization and moreover improving the performance is in the near future will be essential.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge by the Austrian Government, the state of Upper Austria, and the Johannes Kepler University Linz in the framework of the ***Kplus*** Competence Center Program. Furthermore we would like to thank the General Accident Insurance Institution (Allgemeine Unfallversicherungsanstalt - AUVA) for sponsoring the project.

REFERENCES

Nesamoney, D., 2004. *BAM: Event-Driven Business Intelligence for the Real-Time Enterprise.* DM Review, Vol. 14, Number 3.

Hellinger, M, Fingerhut, S., 2002. *Business Activitity Monitoring: EAI Meets Data Warehousing.* EAI Journal.

White, C., 2003. *Building the Real-Time Enterprise,* TDWI Report Series, A101 communications Publication. The Data Warehousing Institute.

McCoy, D., 2001. *Business Activity Monitoring: The Promise and the Reality,* Gartner Group, July.

Lawrence, P., 1997. *Workflow Handbook 1997*, Workflow Management Coalition. John Wiley and Sons, New York.

Sheth, A.P., van der Aalst, W.M.P., Arpinar, I.B., 1999. Processes Driving the Networked Economy: Process Portals, Process Vortex, and Dynamically Trading Processes. *IEEE Concurrency*, 7(3): 18-31.

Codd, E.F., Codd, S.B., Salley, C.T., 1993. *Providing OLAP (On-Line Analytical Processing) To User-Analysts: An IT Mandate*, E.F. Codd & Associates, White Paper.

Chang, J., 2004. The Current State of BPM Technology, *Business Integration Journal*, March.

Hollingsworth, D., 1995. *The Workflow Reference Model*, Workflow Management Coalition, Document Number TC00-1003, UK.

Kimball, R., Ross, M., Merz. R., 2002. *The Data Warehouse Toolkit: The Complete Guide to Dimensional Modeling*, John Wiley & Sons.

Inmon, W., 2002. *Building the Data Warehouse*, John Wiley & Sons.

Nishiyama, T., 1999. Using a Process Warehouse Concept A Practical Method for Successful Technology Transfer. *In Proc. 2nd. International Symposium on Object-Oriented Real Time Distributed Computing*, IEEE Computer Society, Saint Malo, France.

Georgakopoulos, D., Hornick, M., Sheth, A., 1995. An Overview of Workflow Management: From Process Modeling to Workflow Automation Infrastructure. *Distributed and Parallel Databases*, Kluwer Academic Publishers, Boston, 3, 119-153.

Schiefer, J., List, B., & Bruckner, R.M., 2003. Process Data Store: A Real-Time Data Store for Monitoring Business Processes, *Lecture Notes in Computer Science*, Database and Expert Systems Applications (DEXA).

Tjoa, A.M., List, B., Schiefer, J., Quirchmayr, G., 2003. *The Process Warehouse – A Data Warehouse Approach for Business Process Management*. Intelligent Management in the Knowledge Economy, Edward Elgar Publishing, p. 112-126.

Dresner, H., 2002. *Business Activity Monitoring: New Age BI?,* Gartner Research LE-15-8377, April.

Pankratius, V., Stucky, W., 2005. A Formal Foundation for Workflow Composition, Workflow View Definition, and Workflow Normalization based on Petri Nets. *The 2nd. Asia-Pacific Conference on Conceptual Modeling* (APCCM 2005).

McDaniel, T., 2001. *Ten Pillars Of Business Process Management*. Enterprise Application Integration (EAI) Journal.

Creese, G., 2005. *Volume Analytics: Get Ready for the Process Warehouse.* DMReview, April 15, 2005. http://www.dmreview.com.