AN ACTIVITY WAREHOUSE MODEL BASED ON BUSINESS ACTIVITY MONITORING REQUIREMENTS

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Abstract: Nowadays tracking data from activity checkpoints of unit transactions within an organization’s business processes becomes an important data resource for business analysts and decision-makers to provide essential strategic and tactical business information. In the context of business process-oriented solutions, business-activity monitoring (BAM) architecture has been predicted as a major issue in the near future of the business-intelligence area. In this paper we address an approach to derive an activity warehouse model based on BAM requirements. We analyze different perspectives based on the requirements, such as business process management, key performance indication, process and state based-workflow management, macro and micro level data. The implementation shows that data stored in an activity warehouse is able to efficiently monitor business processes in real-time and provide a better real-time visibility of business processes.

1 INTRODUCTION

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

Data Warehousing (DW) and On-Line Analytical Processing (OLAP) (Codd, E.F., Codd, S.B., Salley, C.T., 1993) tools nowadays are almost identical to Business Intelligence (BI) tools for supporting high-level business management to take decisions. A DW stores historical data that is integrated and collected from different data sources and is 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 a DW. Although DW and OLAP have been developed over a decade, however, their existences are inadequate to meet the current business needs. A data warehouse stores end counts rather than process checkpoints, for example, a 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 a data warehouse was usually difficult.

In the context of business process-oriented applications, a unit transaction of a business process within an organization in fact is represented as a long running process. It may work in time interval time. Process checkpoints applied by applications occur within the time interval of the business process. Workflow management (WFM) systems developed in the last decade are essential frameworks for
managing and controlling the complex administrative business processes of either an organization or inter-organizational. They allow for the explicit representation and support of business processes and in addition to that to avoid the need to re-code applications every time a business process changes (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., long or short-running transaction, system-centric or people-centric) (Chang, J., 2004).

Business Activity Monitoring (BAM) (Dresner, H., 2002) has been predicted as a major issue in the near future for business-intelligence applications. The notions of BAM are to provide real-time event management and visibility of business performance data to enhance operational effectiveness and decision making. BAM is a broad concept and a business process-oriented architecture, encompassing more than information from BPM systems.

This paper addresses an approach to derive an activity warehouse model based on business monitoring requirements. The model is based on the analysis data for optimization and monitoring purpose of BAM requirements.

This work is organized as follows. Section 2 outlines the related works. 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 an activity warehouse model. Finally, conclusion and further work based on our implementation are presented in Section 5.

2 RELATED WORK & CONTRIBUTION


Related to 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. (Pankratius, V., Stuckey, W., 2005) introduce a formal notation for such compositions in form of a workflow algebra based on Petri Nets, which allow for 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 the workflow warehouse.

Concerning data warehouse technology, (Schiefer, J., List, B., Bruckner, R.M.; List, B., et al., 1999) propose an architecture that allows for transforming and integrating workflow events with minimal latency providing the data context against which the event data is used or analyzed. They use an Extraction, Transformation, and Loading (ETL) process to store the workflow events stream in a Process Data Store (PDS).

The existing approaches of process warehouses do not make a distinction between the controlling function and the strategic function. Data from a WFMS system is stored directly to a data warehouse. However, the distinction is essential in the concept of control systems, especially for the BAM architecture. This paper introduces how to derive an activity warehouse model based on essential data in BAM systems used for monitoring and optimizing business processes. Our architecture approach decomposes into three functions, such as operational, tactical, and strategic functions. It satisfies the controlling purpose, which is included in the requirement of BAM system. We distinguish between OLTP, DW, and activity warehouse. Therefore, activity warehouse is able to be coupled directly to OLTP without the ETL process.

3 MOTIVATION

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

3.1 Motivational Issues

Our research partner, the general accident insurance institution, aims at automating the business process using workflow technology. The automation is intended to monitor and optimize the
business process and to support information for tactical and strategic business information. The business process workflow manages customer’s unit transactions in time interval. The organization and its branches are distributed at different locations and provinces shown in Figure 1, such as the locations A, B, C, D. The organization and its branches apply the same business process workflow. A unit transaction, which is identified as a long-running transaction, can be submitted by a customer at a particular location and then can be forwarded to other location to be processed in advance. The institution is organized into the hierarchical structure and that means a decision for a particular activity in the business process is dependent on business hierarchy and roles of the organization.

3.2 Business Activity Monitoring as a Solution Approach

Monitoring, controlling, and optimizing business process are focused on the current business needs. We analyze that to provide those processes, our the systems solution have to deal with three decomposition of functions, namely operational, tactical, and strategic. Furthermore, they involve tracking activities of business processes. Finally, data of the tracking process can be used to provide a feedback-systems. In addition, the system must be able to discriminate between what, how, when, and who of an activity.

This process can not be handled by using the current technologies, such as OLTP and data warehousing. To solve issues of business requirements, we require a repository model in related to an emerging architecture in the business intelligence area for addressing the issues, i.e., business activity monitoring.

3.3 An Overview of System Architecture

In this paper we focus on deriving activity warehouse model. Therefore, we give a short description of the system architecture overview. Figure 2 shows the system architecture as a whole.

![Figure 2: An overview of system architecture.](image)

Each module is discussed as follows:

1. On-Line Transaction Processing (OLTP) manages and stores transactions of customers within the organization. OLTP satisfies the operational function.
2. Data warehouse (DW) store end counts data to support the strategic decision-making. We distinguish between end count data stored in DW and checkpoint data stored in activity warehouse. Each has a repository. However, this paper does not focus on DW as well as the extraction, transformation, and loading (ETL) process.
3. Controller and BI tool, such as BPM software, provide a closed-loop system to BI systems.
4. Service Oriented Architecture (SOA) or web services address problems, such as the distributed accesses, diversity of location and provinces, since a unit transaction can be submitted from different locations and provinces. The SOA wraps the whole architecture.
5. The BAM layer consists of modules as follows:

- Workflow management systems manage and control the business process of unit transactions. It is coupled directly to the OLTP to avoid the time delay between OLTP and BAM systems, since we do not use the ETL process.
Event-based data capture. It is coupled directly to WFM to track events of business activities within the business process. Data captured from the business process is stored in activity warehouse.

An Activity warehouse. It is a BAM repository to store checkpoints of activities in the business process from WFM within a unit transaction. Data in the activity warehouse is intended to support the BPM application (strategic business information) and controller (i.e., tactical business information).

4 AN ACTIVITY WAREHOUSE MODEL

BAM systems in general involve components, such as Business Process Optimization and Key Performance Indicators, and they are intended to optimize the business process. According to (Nesamoney, D., 2004), the requirement of BAM systems must be able to supporting as follows:

- Event-driven decision making.
- Rules-based monitoring and reporting.
- Real-time integration of event and context.
- No latency; comprehensive exception-alert capabilities.

Therefore, the BAM systems must provide a BAM repository – we call an Activity Warehouse (AW) - for storing or tracking data of business events. Depending on the business requirements of an organization, however, the activity warehouse in general is strongly influenced by the business process management requirements. In this section we use a top-down approach to classify requirements for deriving the model.

4.1 A Conceptual Structure of the Business Process

An activity warehouse completely stores activities checkpoints of a unit transaction within the business process. In order to deriving an activity warehouse model, a business process may be decomposed into the lowest level of process or activities. Moreover, to provide a conceptual structure of the business process, we assume as follows:

- A process model is a complete representation of a set of business processes and its associated resources for the purpose of managing process execution.
- A unit transaction within an organization is represented as a long-running transaction within the time interval.
- 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.
- A business process can be decomposed into a set of processes. A process may consist of a set of sub-processes, and a sub-process includes a set of activities.
- An activity is the lowest level process of business process and represents a particular context of a unit transaction in time interval within the business process.

4.2 Business Process Management Requirements

BPM technology enhances the business efficiency and responsiveness and optimizing the business process in order to improve services of an organization (Chang, J., 2004; McDaniel, T., 2001).
Specifically, BPM has closed relationship to the business strategy of an organization. Therefore, BPM strongly influences on deriving an activity repository model in relation to the attributes of measurements for supporting performance. We identify the following BPM requirements namely:

- **Strategic information.** Strategic information is defined as the result of an organization that can be achieved and its hypotheses. The scorecards enable all organization units and employees to understand the strategy and identify how they can contribute by becoming aligned to the strategy. For example:
  - if the organization improves on-time delivery, then customer satisfaction will improve; if customer satisfaction improves, then customers will purchase more.

- **Tactical information.** Tactical information provides controlling the business process and monitoring activities and its progress in detail. The tactical information must be able to provide data in detail. Since the tactical information provides data for a particular transaction in detail, then the tactical information must provide contextual information. In addition, the tactical information provides information for a closed-loop system. For example:
  - Give the unit transaction has been completely processed today?
  - Give a particular unit transaction has been accepted and can be processed in advanced?

- **Business metrics information.** The business metrics information aims at supporting the strategic improvements of higher level goals. They support departments and teams to define what activities must be performed and to contribute the higher level goal. It is identical to Key Performance Indicator (KPI). In this way, the diverse indicators enable individuals and teams to define what they must do well to contribute to higher level goal. The following queries are as follows:
  - Give a particular unit transaction has been processed for a particular department for a particular time?

4.3 Workflow Management Requirement

Principally, WF aims at supporting the BPM requirement presented in Section 4.2. In the context of the business process-oriented applications, 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 model we apply the process and state workflow management (References) for the activity warehouse model. Depending on the business requirements, which WF will be used for managing a business process, however, in general there exist two characteristics of workflow that must be included in an activity warehouse to store data in a particular context.

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 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. Therefore, we include at least information for this requirement as follows:

- **Tracking Activity.** The tracking activity deals with activities checkpoints of a unit transaction within the business process. It represents the history of a unit transaction and its progress. The following queries are typically provided as follows:
  - Give a progress of a particular unit transaction?

- **Status Activity.** The status activity provides the activity status of a unit transaction within the business process. In addition, the use of status activity is to inform the current status to an actor to decide the next execution. In addition, it arranges the executions of workflow in order. Typically the queries is given as follows:
  - Give the current status of a particular unit transaction?
  - Find activities with the current status “submitted” in October 2006.

4.3.2 Three Dimensional Workflow

An activity is the lowest level of business process shown in Fig. 2c. It can be represented as the three dimensional workflow. The three dimension workflow at least is as follows:
• **Action.** An action is represented by a method of a particular activity. Within the business process, an action is corresponded with an actor. Activities may be assigned to actors, applications, or system queues based on rules.

• **Process.** A process defines the business activities and the sequence in which they are to be performed. 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.

• **Actor.** An actor is defined as the person who executes a particular action. An actor must have a particular role to execute an action. An action is dependent on the role of an actor in WF.

Furthermore, in our model we provide a set of dimension tables to support the three dimensional workflow, such as the dimension **process**, the dimension **actor**. Additional dimensions for supporting three dimensional workflow requirements are as follow:

• **Role.** An action in WF must be executed by an actor and its particular role. Role is the important requirements in workflow management systems. A role has close relation to a specific department within the organization or intra-organization.

• **Organization.** Organization is intended to support the role of an actor, because of the close relationship between role and organization. An organization is structured into a hierarchy model, where it consists of some departments.

Moreover, we provide dimensions, such as the dimension **role** and the dimension **organization** to support the three dimensional workflow.

### 4.3.3 Additional Requirement

This specific requirement of workflow is dependent on the business requirement or application. In our model we need the following additional attribute:

• **Next Actor.** In this model, workflow can be used to forward a unit transaction to other actor with a particular role to be processed in advance. This model supports an additional attribute, namely next actor. The next actor with a particular role required to find out who is responsible to the next action, for example. We distinguish two actors for an action (i.e., parent and child actors). The parent actor is an actor who executes an action or the owner of action, whereas the child actor or next actor responsible to the next action is descendant of the parent actor.

### 4.4 Time Dimension

An activity has to deal with the activity entry date. In the context of BAM, time for the activity warehouse aims at supporting to addressing monitoring purpose, especially when an activity is executed. On the other hand, a unit transaction can be summarized based on the time dimension. Time also can be used for supporting the aggregation purposes, such as rolling-up, drilling-down, drilling-through process like in OLAP applications. Therefore, the time dimension, like in the multidimensional model, can be used for this purpose. The aims of the time dimension as the activity entry date is to know when an activity is executed. Examples of queries are as follows:

- Get all activities have been accepted by a particular actor, role, and department on the October 24, 2006.
- Get an activity have been finished by a particular actor, role, and department on the October 24, 2006.
- Rolling-up all activities that have been accepted by a particular actor, role, and department in October 2006.

In the context of BAM, an execution of an action requires a particular amount of time, normally second, millisecond, or may be microsecond. Therefore, the time dimension must be able to measure an activity until those levels. Because of the access performance reason, we do not use the time level until up millisecond or microsecond. We limit the time up until date. Instead of the level millisecond of time dimension, we use the time efficiency for the purpose.

### 4.5 Measurement Data Requirements

To reach the aim of measurement purposes, such as business performance optimization, business metrics, tactical and strategic information, an activity warehouse must support following attributes, such as a set of attributes for measurement and a set of time efficiency. The measurements and time efficiencies must be to be tracked in very detail.
for each checkpoint activity of a unit transaction. On the other hand, like OLAP tools, measurement data can be aggregated against the dimension tables. In the context of BAM, data stored in activity warehouse must be able to provide event-driven decision-making that means the lowest level of data can be used to make decision. Therefore, data can be drilled down until the lowest process level. We classify the following level data for supporting measurement data requirements: We categorized measurement data into as follows:

4.5.1 Macro Level Data

Macro level data represents the operational level data and is stored in the operational data management and is defined as end count of a unit transaction.

4.5.2 Micro Level Data

Micro level data represents activities of the business process data. Micro level data must satisfy the business and workflow requirements. As the lowest level process, an activity represents a checkpoint of a unit in a process. A micro level data is defined as a checkpoint data of an activity in a process. We distinguish micro level data into time efficiency data and measurement data. Micro level data includes data as follow:

- **Time efficiency.** On the other hand to optimizes business performance and efficiency. Therefore, 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 must provide the time efficiency attributes to measure the performance and efficiency of business process. Many attributes for the time efficiency dependent of the business optimization performance requirements can be available in activity warehouse. The time efficiency attributes provides data for succeeding the business performance optimization. These attributes are equal to measure an activity or an action for a particular actor as the function time. We identify a set of time efficiencies 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 time efficiency attributes. Cost measurement data is essential to provide optimization information.

![Figure 4: Macro and micro data level](image)

The use of macro and micro level data is to enable the business process management tool to monitor or drill down data from macro level to micro level as well as horizontal and vertical drill down to each individual transaction or business process. Therefore, an organization can improve the visibility of the overall performance of the organization at both a macro and micro level.

4.5 An Activity Warehouse Model

An activity warehouse model can be shown in Figure 5. The model consists of a table activity and a set of dimension tables. The table activity consists of the attribute of unit transaction identity, a set of attributes for measurement and optimization purposes, such as cost, time efficiencies, a set of dimensions identities, and status identity. The activity table is represented as follows:

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Activity(UnitID, RoleID, ProcessID, ActorID, RoleID, DepartmentID).
```

A set of dimension table consists of the dimensions, such as the dimensions process, organization, actor, role, and time.
5 CONCLUSION & FURTHER WORKS

In this paper we have presented an approach for deriving an activity warehouse model based on the BAM requirements for supporting strategic and tactical business information. Based on our implementation and experiment, the benefits of data stored in activity warehouse is able to monitor detail activities occurred in the business process and provides a good visibility for process monitoring applications.

In the context of business-process oriented, where organizations focus on monitoring and optimizing their business processes, we believe that the Business Activity Monitoring is an important business requirement. Other challenges appear from our experiment that the BAM repository collects the process or subprocess with different intervals. Increasing data in the activity warehouse is very fast, so we need to research to improve the performance.

Merge data warehouse and activity warehouse capabilities to monitor streaming data from operational systems to detect business events, such as production-line problems, spikes in customer complaints, and diminishing stock on a retailer's shelf.

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