Architectures for a Temporal Workflow Management System

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Talk Overview

- Introduction;
- Workflow management systems: basic concepts;
- Managing temporal aspects in workflow systems;
- Different architectures for a temporal WfMS;
- Implementation issues;
- Conclusions and further work.
Introduction

• Any business process requires the coordinated execution of single activities to achieve a common goal: a workflow formally describes these activities, including criteria to assign single activities to executing units.

• Workflow management systems, WfMS, are software systems supporting the execution of workflow instances. Most WfMSs use a database management system (DBMS) based on the relational model.

• Considerable advantages may be obtained by the adoption of a temporal architecture for the WfMS. Unfortunately, due to the lack of a high-performance and reliable temporal database systems, no WfMS exists relying on top of a temporal database system.
Goal of the work

- Discuss *different architectures for a temporal WfMS*;
- Deal with some *implementation issues*. 
WfMS: basic concepts

The data models defined in a WfMS are related to:

- the organization where the business process is enacted (organizational model),
- the structure of the managed business process (process model),
- the application specific information (information model).
WfMS data models and temporal information

- **Organizational model.** By suitable tables the organizational model describes the agents and their availability time. Temporal aspects are mainly related to working days and hire time of the agent.

- **Process model.** The process model describes the schema of the managed business process. It is defined by predecessor-successor relationships and may also include routing tasks (*split* and *join*). Temporal aspects are related to changes of a schema of a business process.

- **Information model.** The information model considers both process specific and historical data. The first ones are data collected by the case (i.e., a process instance). The latter ones describe the history of the cases managed by the WfMS.
A concrete situation

The enrollment process of graduated students applying for PhD candidate position: starting from September 1\textsuperscript{st}, 2003, any received application leads to an interview of the applicant. After a few days, the university realizes that interviewing any student is extremely expensive. After September 30\textsuperscript{th}, 2003, the new adopted process model states that applicants’ CVs are analyzed first: applicants whose CV is passed will be interviewed, only.
A concrete situation

The enrollment process: first version

Workflow variables:
StudentName
InterviewResult

StudentEnrollment

ReceiveApplication

Application is received

Interview

Applicant is interviewed

RejectApplication

Applicant is rejected

AcceptApplication

Applicant is accepted

InterviewResult = "no"

InterviewResult = "yes"
A concrete situation

The enrollment process: second version

StudentEnrollment

Workflow variables:
StudentName
CVResult
InterviewResult

ReceiveApplication

Application is received

AnalyzeCV

CV is analyzed

Interview

Applicant is interviewed

InterviewResult = "no"

InterviewResult = "yes"

RejectApplication

Applicant is rejected

AcceptApplication

Applicant is accepted

RejectAndThank

Applicant is rejected
### Temporal tables for the organizational model

<table>
<thead>
<tr>
<th>Agent</th>
<th>AgentId</th>
<th>Role</th>
<th>Availability</th>
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## Temporal tables for the process model

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<td>StudentEnrollment</td>
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<td>[03-09-01 ÷ +∞]</td>
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<tr>
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<td>Interview</td>
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<td>[03-09-01 ÷ +∞]</td>
<td></td>
</tr>
<tr>
<td>StudentEnrollment</td>
<td>RejectApplication</td>
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<td>[03-09-01 ÷ +∞]</td>
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<td>AcceptApplication</td>
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## Temporal tables for the process model

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<tr>
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### Temporal tables for the information model

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<tr>
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<td>[03-09-09 $\div + \infty$]</td>
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<tr>
<td></td>
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<table>
<thead>
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</table>
Workflow Components

Workflow Management Systems (WfMSs) are complex software systems and include many different components, such as:

- the *workflow engine*, made of the interpreter of the process definition language (PDL) and of the workflow scheduler;
- the process model designer unit, which helps the workflow designer to suitably define a process model according to the supported PDL;
- the resource management unit (also known as *resource executive*), to assign tasks to executing agents;
- the database connectivity unit, to access data stored into a DBMS;
- the transaction manager;
- the e-mail feeder, to send agents messages and attached documents;
- the web server and the worklist server.
Workflow Components and Temporalities

- The workflow engine reads the process model and schedules the activities, looking for the successor(s) of a task as soon as it completes.

- In the real practice, the process model of a workflow goes through different refinements over time, e.g. due to corrective and to perfective maintenance, leading to different versions of the same process model.

- The wash-out policy (wait for completion of all running cases of the old schema before any new case can be started according to the latest schema) is not always acceptable.
A reasonable policy is that of completing all running cases according to the schema that was valid at their respective creation time, and to start new cases according to the latest available schema. This policy requires a temporal query which, in turn, can be easily defined if a temporal database system is available.

Additionally the workflow engine manages the history of all the cases run by the WfMS, by suitably updating the CaseHistory and TaskHistory tables.

The resource executive assigns tasks to agents: criteria for agent selection are statical (e.g. the role the agent must own, the agent’s availability in terms of working time during weekdays), and dynamical (e.g. workload balancing among agents over the last two weeks).
Architectures for a WfMS Managing Time

Some options:

- flat DBMSs vs fully-fledged temporal DBMSs (T-DBMSs);
- standard DBMSs vs active DBMSs.
1) A Temporal Architecture

- Agent's Client
- Web Server
- Worklist server
- Engine Interface
- WfEngine
- Temporal Layer
- Resource Executive
- DBMS
2) A Temporal Active Architecture
Temporal active features for workflows

Assuming that there is a straight connection between the completed task and its successor (i.e., there is no fork or join connector in between), the trigger FindSuccessor can be expressed in the extended Chimera-Exception language as:

```plaintext
define trigger FindSuccessor
    event insert into TaskHistory
    conditions TaskHistory TH, ToAssign TA,
                 WorkTask WT, CaseHistory CH, Next N,
                 occurred(insert(TH)),
                 TH.FinalState='Completed',
                 CH.CaseID=TH.CaseId,
                 N.SchemaName=WT.SchemaName,
                 N.TaskName=TH.TaskName,
                 VALID(WT) CONTAINS BEGIN(VALID(CH)),
                 VALID(N) CONTAINS BEGIN(VALID(CH))
    action insert into ToAssign(CaseId,TaskName,
                                 Role,AgentId)
               values TA.CaseId=TH.CaseId,
               TA.TaskName=N.NextTask,
               TA.Role=WT.Role,
               TA.AgentId=NULL,
               VALID PERIOD(current_time(), +∞)
end trigger
```
3) an Active Architecture with a Temporal Layer

- Agent's Client
  - Web Server
  - Worklist server
  - DB Interface
  - Choose Successor
  - Resource Executive
  - Temporal Layer
  - A-DBMS
Active features for workflows

The trigger `ActivateChooseSuccessor` is fired when an `insert` is performed over the `TaskHistory` table, and that simply activates a stored procedure, namely `ChooseSuccessor`.

```sql
define trigger ActivateChooseSuccessor
  event insert into TaskHistory
  condition NULL
  action activate(ChooseSuccessor)
end trigger
```
Implementation Issues

Agent's Client

Worklist server

DB Interface

Choose Successor

Resource Executive

TimeDB

Oracle Server

Java Stored Procedure
Implementation issues

Let us consider the functionality of choosing a successor as performed by the workflow engine.

- The agent sends back to the worklist server the completed task: the DB interface module automatically updates the workflow history tables via the TimeDB layer.

- The Oracle trigger ActivateChooseSuccessor has to invoke the Java stored procedure LaunchChooseSuccessor, which in turn invokes the ChooseSuccessor procedure, also written in Java, via a remote method invocation (RMI).

- The stored procedure is executed by the internal Java virtual machine of Oracle, while the ChooseSuccessor procedure needs for being executed outside Oracle, so that the procedure can access the database via the TimeDB layer.
Implementation issues

- In this way, the ChooseSuccessor procedure can perform temporal queries that could not be performed if inside the Oracle environment.

- We define a public Java class, we register it inside the database of the procedures, and define the Oracle trigger, obtaining thus the following:

```java
public class LaunchChooseSuccessor{...};
create procedure LaunchChooseSuccessor
    as language Java ...;
create trigger ActivateChooseSuccessor
    after insert TaskHistory
    for each row LaunchChooseSuccessor
```
Discussions and Conclusions

• In this paper we analyzed some architectures for a temporal workflow engine, featuring the management of temporalities for the process, organization, and information models, and an active engine for task scheduling.

• The best architectural solution is based on the adoption of a T-A-DBMS (temporal active DBMS), providing temporal active rules. Unfortunately no available DBMS provides those features all together: we thus adopted an active DBMS on top of which we interfaced a temporal layer.

• The proposed architecture simulates temporal active rules by atemporal (timeless) active rules which, in turn, activate stored procedures and external procedures managing the temporalities via the temporal layer.
Discussions and Conclusions

- This work around, however, deepens the portability problems that feature the definition of a trigger over a DBMS:
  - (a) no SQL-like standard is available yet for the trigger definition language, and the adoption of a new DBMS requires a new set of triggers;
  - (b) very often the language used for the stored procedures is strictly DBMS-dependent, and again a change in the adopted DBMS requires rewriting the stored procedures.
Future work

- Extending the engine to adopt many different schema migration policies: concurrent to completion which is the only one currently implemented, conditional or unconditional migration to final workflow, and migration to ad-hoc workflow.
- Defining a temporal interpreter for active rules.
- Extending obtained results to an open source WfMS.