Workflow Management Based on Mobile Agent Technology

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INTRODUCTION

Nowadays Information Systems (IS) are designed for individual task execution control allowing coordinating, monitoring, and supporting the logistical aspects of a *business process*, in other words, the IS has to manage the flow of work through the organization.

The WorkFlow Management represents a critical issue for achieving enterprise competitiveness among organizations. Many companies have realized that the *business processes* (*BP*) within their organizations, and between the companies and their partners have not been clearly described and there are not enough techniques and methods to automate the processes.

The *Workflow Management Coalition* (*WFMC*) states that *workflow* (WF) is concerned with the automation of procedures where documents, information, or tasks are passed to the participants according to a defined set of rules to achieve, or contribute to, an overall business goal (WfMC, 1999). Another definition of WF can be found in (Rusinkiewicz & Seth, 1994) where *workflows* are *activities* involving the coordinated execution of multiple tasks performed by different processing entities (persons or machines). A *task* or process involves a piece of work and a process entity which executes the work.

Workflow Management (WFM) is a fast evolving technology which is increasingly being exploited by businesses in a variety of industries. Its primary characteristic is the automation of processes involving combinations of human and machine-based activities (Aalst & Hee, 2002), (Aalst, 1998).

A *Workflow Management System* (WFMS) provides procedural automation of a *business process* by management of the sequence of work activities and the invocation of appropriate human and/or IT resources associated with the various activity steps. Although the most prevalent use of *WFMS* is within the office environment in staff intensive operations such as insurance, banking, legal and general administrations, etc, it is also applicable to some classes of industrial and manufacturing applications (WfMC, 1995). *WFMS* needs to integrate other technologies such that *agent* technology, which provides flexible, distributed, and intelligent solutions for business process management.

This work presents a methodology for mobile agent-based WFMS development. The proposed methodology consists of a modular and gradual specification of the system where a mobile agent guides the process through organizational units and executes different tasks. Several mobile agents evolve through the system executing concurrently their assigned task.

BACKGROUND

Workflow Management

The notion of *agent* in (Yuhong, Zakaria & Weiming, 2001) is used as "a computer system situated in some environment, which is capable of autonomous action in this environment in order to meet its design objectives" (different notions can be found in (Wooldridge, 2002) and (Nwana, 1996)). These works also highlight the benefits of applying agent technology to *business process* management; some of these benefits are: distributed system architecture, the inherent autonomy of software agents because agents can start a WF based on event trigger, the agent reactivity because it have the ability to generate alternative execution paths, etc. An intelligent agent is capable of autonomous operation and flexible behavior in order to meet its design goals and also has the properties of reactivity, pro-activity, and social ability (Wooldridge, 2001).

In other works both concepts are integrated. In (Repetto, Paolucci & Boccalette, 2003), a methodol-

ogy for the design of agent based WF was presented; it consisted in three steps. In the first step the authors model the *BP* with UML Activity diagrams by identifying all the necessary resources and activities. In the second step, all the activities identifying roles in parallel paths are grouped. Finally, they define an agent for each group.

Several researchers took the *agent* technology for the improvement of WF applications. In (Marin & Brena, 2005), an architecture for high-level agent-based WF is proposed. On this architecture they break down the WF execution and the process flow control in small execution units handled by intelligent agents and a WF processes is controlled in a decentralized way.

A collaborative approach for workflow systems is presented in (Savarimuthu & Purvis, 2004) where agents collaborate by forming social network (societies), in (Savarimuthu, Purvis & Fleurke, 2004) agents are embedded in a system that can monitor and control the overall functioning of a workflow process in an agent based WF system.

In (Minhong, Huaiquing & Dongming, 2005), agent technology is used for the WF monitoring where various intelligent agents working together to perform flexible monitoring tasks in an autonomous and collaborative way.

Multi-Agent Systems

Mobile agents are autonomous programs that can travel from one computer to another under its own control. They offer a robust and efficient framework to develop distributed applications including mobile applications.

A stationary agent is executed only on the system where it began its execution. If it requires information from a different system or needs to interact with another agent, it uses a standard client-server communication (RMI, RPC, CORBA).

A mobile agent (MA) is not always attached within the systems where it starts the execution, rather it is capable of moving itself through the network nodes where it is allowed, modifying eventually its execution environment; the MA carries with itself its current state and its code (strong mobility). Furthermore, MAs may exhibit several advantageous features due to mobility, for example a) interaction with the resource during its migration to the needed resource location, keeping the bandwidth and reducing the latency of the network (Cabri, Leonardi & Zambonelli, 1998), b) interaction with the users during the migration to the user location, answering faster user requests. In both cases the agent continues the interaction with the resource or the user even with temporary network connections failures.

Most of distributed applications fit naturally on the model of MAs because the agents can migrate sequentially through a computer network, they send other agents to visit computers in a parallel way, they remain stationary and interact with remote resources, etc.

There exist several organizations with the aim of establishing standards for agent software development and agent interoperability. One of them is FIPA (FIPA, 1997).

JADE Development Tool

JADE (Java Agent Development Framework) is a software framework completely implemented in Java language which simplifies MA system implementations by using a middleware which fulfill FIPA (FIPA, 1997) specifications. The agent platform can be distributed through machines (which not necessary share the same OS) and the configuration can be managed by a remote GUI (Bellifemine, Caire, Trucco & Rimassa, 2006).

The communication architecture offers flexible and efficient message passing where JADE creates and manage the incoming private ACL message queue for each agent. The complete FIPA communication model has been implemented and its components have been clearly distinguished. JADE integrates completely interaction protocols, ACL, ontology's, transport protocols, etc. Most of the FIPA defined protocols are available in JADE.

MOBILE AGENT-BASED WFMS DEFINITION

This work presents a methodology for the development of Mobile Agent-based *WFMS*. The basic idea for conceiving such a system is that a MA guides the workflow process through the different organizational units in which several *tasks* are executed according to the handled *case*.

During the design phase the components are described in a clear and compact way. The system is described as a set of interconnected organizational units that have a specific resource allocation. The agent