An Agent-Enhanced Workflow Management System

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Abstract. The overall goal of the research is to address the problems in traditional workflow management systems by developing a distributed and adaptable workflow management system. This paper discusses the research objectives and the work that has been carried out in the development of a workflow management system, JBees, which uses agent-based infrastructure as the building block. We also outline the work under progress and our future plans on enhancing our workflow system.

1 Introduction

Traditional workflow management systems [9-11] suffer from disadvantages such as the lack of dynamic incorporation/modification of process models, lack of adaptability of process models during run time and the lack of support for the integration of distributed process models. The overall goal of the research is to address these problems by developing a distributed and adaptable workflow management system. Employing a distributed network of autonomous software agents [21] that can adapt to changing circumstances is our solution to address this problem. These changes would be triggered by market changes and the process improvements due to continuous process re-engineering. The agent-based system, JBees [3] would facilitate the distribution of process models and the dynamic changing of process models during run time.

In the context of WfMSs, agent technology has been used in different ways [25]. In some cases the agents fulfil particular roles that are required by different tasks in the workflow. In these cases the existing workflow is used to structure the coordination of these agents [26, 27]. An example of this approach is the work by Nissen in designing a set of agents to perform activities associated with the supply chain process in the area of e-commerce [27]. In other cases, the agents have been used as part of the infrastructure associated with the WfMS itself in order to create an agent-enhanced WfMS [28, 29]. These agents provide an open system with loosely coupled components, which provides more flexibility than the traditional systems. Some researchers

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have combined both of these approaches [30], where an agent-based WfMS is used in conjunction with specialized agents that provide appropriate application-related services. In our framework, JBees [3], the WfMS is partitioned among various interacting agents following the interaction protocols. The model associated with a business process is represented using the Coloured Petri net formalism and is executed by a specially designed agent. This agent-based environment facilitates the dynamic incorporation of changed models into the system and thereby assists process re-engineering. Advantages of employing agents include the facilitation of inter and intra organizational co-operation and flexibility in choosing processes on the fly and controlling process parameters.

The paper is organized as follows. The research objectives of our work are given in Section 2. Section 3 provides a summary of the work that has been carried out, the work under progress and our future plans. The concluding remarks are presented in Section 4.

2 Research Objectives

We propose to achieve our final goal by refining the work into three objectives. Our first objective is to enhance the agent-based architecture by providing support for the creation and execution of process models and the changing of process models during runtime. The architecture will include a simulation engine to model, study and evaluate executions prior to run time. The architecture will also include components for monitoring and controlling the system. Rapid growth and availability of services in the Internet can be well made use of, by the workflow systems. Modern workflow systems should provide appropriate mechanisms to connect and use these freely available web services as well as web services that are proprietary to businesses. The architecture of our system will be extended to support the service-oriented architecture of web services.

The second objective is to build a society of agents that can work in a collaborative fashion to solve problems. This social network of agents would provide mechanisms for negotiation to perform tasks and also for sharing workload. Each society will comprise of its own norms and rules. There would be a repository for ontologies specific to the workflow system as well as repositories for domain specific application. We would also be developing a mechanism for intelligent resource allocation.

The final objective is to develop practical examples of workflow systems (with many workflow societies) from different domains, which will be used to validate our system and also demonstrate the capabilities of the system.

3 Summary of the Work

Our research is focused on developing an agent-enhanced WfMS, where the work associated with running a WfMS has been partitioned among various collaborating agents that are interacting with each other by following a standard agent communication protocol, FIPA [23]. JBees is based on Opal [4] and uses the CPN execution tool JFern [5]. A first description of JBees can be found in the previously published papers [1] and [2].

3.1 Architecture of the Agent Based Workflow System

Our first research objective is to build an agent based infrastructure for the workflow management system. According to Sycara [21], there are several benefits for using multi-agent systems for building complex software. For example, multi-agent systems can offer a high level of encapsulation and abstraction. Because agents are independent, every agent can decide, which is the best strategy for solving a particular problem. Different developers can build the agents simultaneously as long as they understand the communication between the agents that they develop. A second important benefit is that multi-agent systems offer distributed and open platform architecture. Agents can support a dynamically changing system without the necessity of knowing each part in advance.

Our work builds on the work done by Ehrler, Fleurke and Purvis [1, 2] on multi-agent based workflow system. Figure 1 shows the enhanced architecture of our agent based system, JBees [6, 7]. The manager agent provides all functionality the workflow manager needs such as creation and deletion of tasks, roles and process definitions, instantiation of new process instances and creation of resource agents. The process agent executes a process instance. Each resource in the system has its own resource agent. These resource agents may be interfaces to the human agents as well as devices such as scanners and printers. Every resource in the system gets registered to one of the broker agents that allocate the resources to the process. The storage agent manages the persistent data that is needed. The monitor agent collects all the process specific data and sends them to the storage agent. The control agent continuously looks for anomalies to the criteria specified by the human manager and reports the violations to these criteria to the manager agent. The manager agent provides information to the human manager, which can be used for the feedback mechanism.

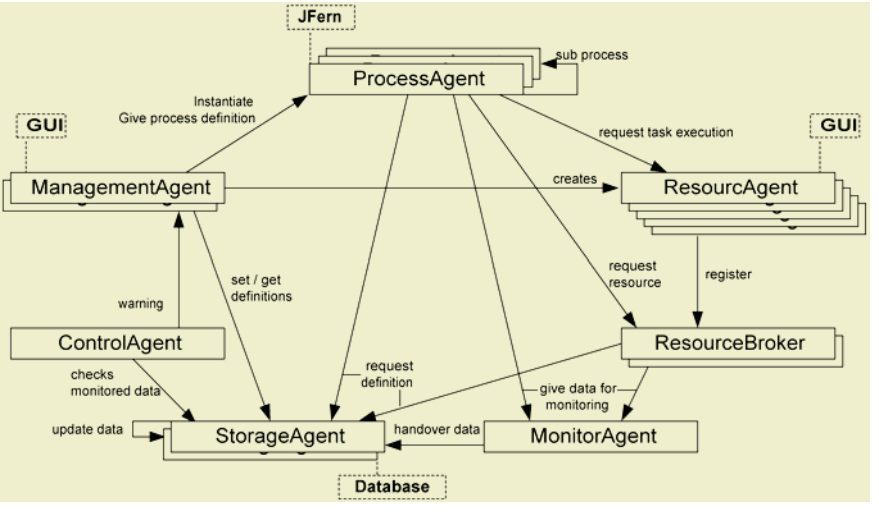

Fig. 1. The current architecture of JBees

To the enhanced architecture shown in figure 1, we intend to integrate the Web Services. Web Services are software components available on the Internet, which

provide certain services that may be of general interest, such as weather monitoring services, currency converters, etc. A large fraction of the web services are used within companies protected within their own firewalls. These web services can be accessed for day-to-day business transactions. Examples of these web services include banking services and air ticket booking. The workflow process modeller can integrate web services with the existing workflow system. For example, a process model associated with the travel plan of a tourist may depend upon environmental factors, such as the weather conditions. The task associated with finding the weather condition can be provided using a web service. We have implemented the basic infrastructure that helps in incorporating the web services by wrapping a web service as an agent. Our work on integration of web services to the framework can be found in our works [19, 20, 24].

We are currently modifying the architecture of the system to incorporate composition of web services. The Coloured Petri Net (CPN) [12] formalism that we use for modelling processes will be used for the composition of web services as well. With the incorporation of the web service agents the resource agents provide the interfaces to human agents, devices as well as web services.

3.2 Conceptualisation and Implementation of Workflow Institutions/Societies

In order to achieve the goals of a collaborative environment in a workflow system, the agents in the system form societies. The inspiration for this work has been drawn from the previous research in the area of agent institutions/societies [13-17]. The new architecture would include the libraries that specify the norms of the society. Each society will comprise of its own norms and rules. There would be a repository for ontologies specific to the workflow system as well as repositories for domain specific application (software development, medical information system etc). The resource agents possess similar capabilities within a given society. The resource brokers allocate resources depending upon the manager's request. The resource brokers negotiate with the resources to identify and allocate the best possible resource that suits the task to be performed. The resource broker will also consider the reputation of resource agents during the allocation of a task. We are currently implementing the architecture that we proposed in our previous work [18].

3.3 Creation of Practical Examples to Validate the Functionalities System

Finally, to validate the overall working of the workflow management system we intend to develop several practical examples of workflow systems with all the features described in the previous sub-sections. So far, we have used examples from different domains such as auctions, online book purchasing, car insurance and diamond processing industry in our previous works. These examples would be enhanced with the new features that will be developed, validated and demonstrated.

4 Conclusions

In this paper we have described our research objectives in the development of agent-enhanced workflow management system, JBees. We have discussed the work that has

been undertaken and the work under progress. We have also explained the future work that would be carried out.

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