DYNAMIC-AGENTS TO SUPPORT ADAPTABILITY IN P2P WORKFLOW MANAGEMENT SYSTEMS

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Abstract: Peer-to-Peer (P2P) technology is being recognized as a new approach to decentralized workflow management systems to overcome the limitation of the current centralized Client/Server workflow management systems. However, the lack of supporting adaptability and exception handling at instance level of this approach seems to be responsible for the weakness of the P2P workflow management systems. Dynamic agents can be used within P2P workflow management systems architecture to facilitate adaptability and exception handling. This paper presents a novel dynamic-agent P2P workflow management system which integrates three major technologies: software agents, P2P networking and workflow systems. The adoption of dynamic agents within P2P network can help in overcoming the adaptability problem, reducing the need for human involvement in exception handling and improves the effectiveness of the P2P workflow management system.

1 INTRODUCTION

Conventional workflow management systems are based on centralized client/server architecture. This requires a centralized database to store the workflow process definition and a centralized workflow engine to manage activities such as coordination and monitoring process execution (Montagut, 2008; Yan , 2006). The main disadvantages of any such architecture are the potential bottleneck that can arise during process execution, and that the central database can become single point of fault.

In recent years, the integration of workflow and agent technology has attracted the attention of many researchers as a means to support distributed business processes in a dynamic and unpredictable environment (Mo, 2006; Buhler, 2005; Zhang, 2004; Müller, 2004; Wang, 2005; Cao, 2005). Agents are persistent active entities that have the properties of autonomy, reactivity, and pro-activity and can perceive, reason, and communicate with other agents (Singh, 1999). In addition, agents have the capability to dynamically form social structures through which they share commitments to the common goal of workflow enactment by forming a collective entity called Multi-agent systems (Buhler, 2005). Recent research has shown an increased interest in P2P based workflow systems (Aldeeb, 2007; Yan, 2006) to decentralize workflow systems. P2P is a means of developing distributed applications where different nodes, or peers, share resources and have symmetric roles of either server or client. P2P workflow management systems (WFMSs) are proposed to avoid the bottleneck and the central point of fault caused by centralized client/server workflow systems. P2P based workflow can also be used to improve scalability, system openness and support incompletely specified processes (Yan, 2006). In P2P based WFMS peers join “virtual communities” according to their capabilities and discover each other using the services provided by an open P2P network. The coordination between peers is performed by exchange of notification messages.

However, the lack of supporting adaptability and exception handling at instance level of this approach seems to be responsible for the weakness of the P2P WFMS. This paper presents a novel dynamic-agent P2P WFMS system which integrates three major technologies: software agents, P2P networking and workflow systems. The adoption of dynamic agents within P2P network can help in overcoming the adaptability problem, reducing the need for human involvement in exception handling and improves the effectiveness of the P2P WFMS.

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The rest of this paper is organized as follows. Section 2 describes the problem and states the solution adopted. Section 3 describes the proposed dynamic-agents P2P WFMS. Section 4 illustrates the adaptability and exception handling process. Section 5 introduces a case study. Finally in section 6, some concluding remarks are given.

2 PROBLEM STATEMENT

In the centralized Client/Server WFMS the exceptions are handled and managed by the server. However, in a P2P WFMS that is fully distributed, there is no central server and so the exception handling task poses a major challenge. The main shortcoming of the proposed P2P WFMS is that it does not fully support adaptability and exception handling at instance level. The reason for this limitation is that peers are bound to a specific limited set of actions, protocols or messages specified in the protocols defined for workflow application (Willmott, 2004). In addition, rational and cooperative behaviour cannot be guaranteed, because workflow peers are attached to human workflow participants. In (Aldeeb et al., 2007) a mechanism for adaptability and exception handling in P2P WFMS is proposed. This mechanism is based on separating the business logic and exception handling logic using a super-node with exception handling capabilities (Exception Handling Peer - EHP) to make it easy to keep track of both. The EHP captures exceptions, from the workflow peers, characterises the exceptions and applies a recovery policy. However, from the initial findings of this research, extra traffic overhead is generated through the P2P network due to the P2P conversation between the Exception Handling Peer and the other peers which have been affected by an exception. This can lead to an exponential growth of messaging load. As a result, the peer's bandwidth connection may be exceeded which will affect the overall system performance. Chen (2000) and Cao (2005) show that software agents can help in conducting the run-time function of WFMS, monitoring, adaptability and exception handling. In addition, they can move to the appropriate location for high-bandwidth conversation. This was the motivation of this research to superimpose the software agents paradigm on the P2P architecture, where agents can reside in different peers and perform workflow tasks utilizing their decision support capabilities, the collective behaviour, and the interaction protocols of the P2P system. Furthermore, P2P infrastructure supports dynamic service construction, modification and movement, and allows a dynamic agent to participate in exception handling procedures.

The dynamic agent can be defined as the software agent that supports dynamic behaviour modification and does not have fixed set of predefined functions, however, it carries application-specific actions, which can be loaded and modified on the fly (Chen, 2000). Dynamic agents can, therefore, be used to mediate between the workflow peers and the exception handling peer to automate the exception handling process in P2P WFMS. Thus using dynamic agents within a P2P WFMS can facilitate system optimization; reducing the communication overhead, reducing the human involvement in exception handling and improving the effectiveness of the P2P workflow management system.

3 DYNAMIC-AGENT P2P WFMS

A high level architecture of the dynamic-agents based P2P WFMS is shown in Figure 1. This system is upgraded from previously designed P2P WFMS (Aldeeb, 2007). The detailed mechanism and the functionalities of the peer-to-peer workflow system can be found in (Yan, 2006; Aldeeb, 2007).

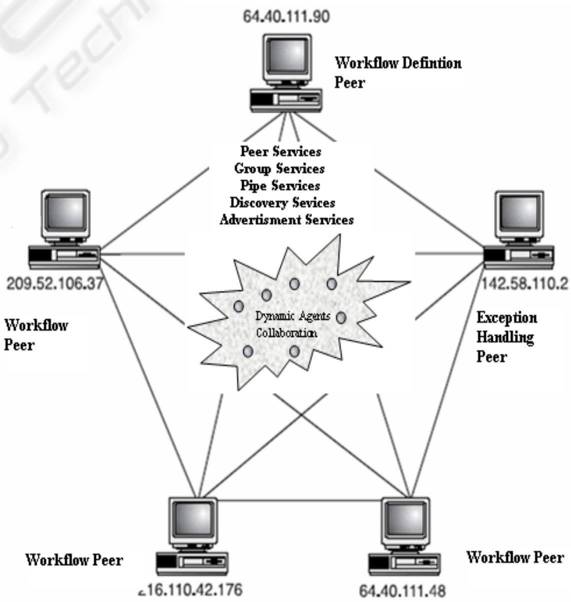

Figure 1: Dynamic-Agent based P2P WFMS.

The new dynamic-agent version of the system is proposed to take the exception handling function out of the P2P system level to a dynamic-agent level. The exception handling function includes: exception monitoring, exception detection and exception handling. The build-time function is conducted at P2P level which includes workflow process modelling, storing process definitions and distributing the process to workflow peers. At run-time, one of the workflow peers will be responsible for Instantiating a workflow instance which includes several tasks. The coordination of tasks will be achieved by message exchange between peers. Dynamic agents reside at workflow peers to conduct exception handling function of the system. As shown in figure 1, the P2P network provides services that include advertisement services, group services, peer services, pipe services, and discovery services. In addition, it facilitates a user interface with human workflow participant. The workflow peers can be classified into three types based on their capabilities: two super-nodes: Workflow Definition Peer (WFDP) and Exception Handling Peer (EHP). The third type is an ordinary Workflow Peer (WFP).

The WFDP facilitates the design and the storage of the whole workflow schema at build-time. The workflow process is partitioned to separate tasks according to the roles of the workflow participants and the organizational structure. These tasks are distributed to associated peers.

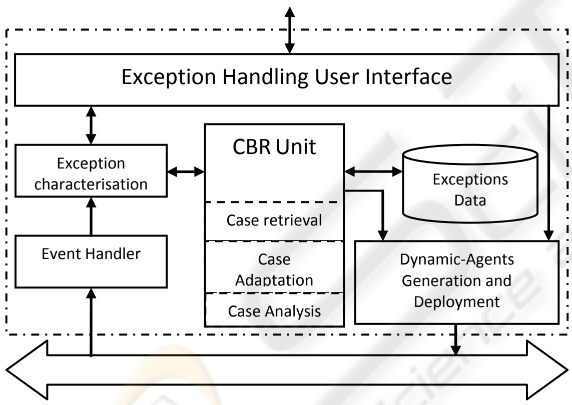

Figure 2: The workflow exception handling peer.

The EHP has the capability to deal with various types of exceptions. Figure 2 shows the internal structure of the exception handling peer. The presence of this peer is essential for the P2P workflow management system and if this peer became unavailable, the system must wait for another peer with exception handling capabilities to join the group. The EHP generates and deploys dynamic agents corresponding to workflow peers. When an agent is deployed, it registers its symbolic name and address at its destination node and keeps an address book for other agents. The dynamic agents delegate the exception handling functions of correspondent workflow peers. The exception handling procedure is discussed in the next section.

The WFP can reside on any machine on the P2P network enabling direct communication with other workflow peers to enact the workflow process. Each WFP performs one task or more of the whole workflow process. The WFP is associated with a human workflow participant involved in the workflow process enactment. Process co-ordination is achieved by the exchange of messages between peers.

4 THE ADAPTABILITY SUPPORT

Workflow adaptability is the ability of the workflow processes to react to exceptional circumstances (Sadiq, 2005). Exceptions that occur during workflow execution have been divided into: basic failures, application failures, expected exceptions and unexpected exceptions (Casati, 1998). Basic failure is related to failures at system level (e.g., DBMS, operating systems, or network failure). Application failure corresponds to failures of any applications invoked by the WFMS. In the proposed Dynamic-agent based P2P WFMS, two workflow exceptions can be identified according to their location: local workflow exception and global workflow exception. Local workflow exception affects the task of one workflow peer. The workflow peer can handle this exception using its local dynamic-agent and by applying one of two possible self-recovery policies; forward recovery or backward recovery. If the local workflow exception can not be handled within the affected workflow peer, its effect may propagate to the other peers leading to a global workflow exception. These types of exceptions will, of course, affect more than one node and a coordinating node is required to deal with this exception. The coordinating node which has the capability to deal with the exceptions is the exception handling peer. This peer generates and deploys dynamic agents loaded with updated exception handlers based on prior knowledge. Once these dynamic agents are deployed to the workflow peers, they communicate with each other to capture exceptions, characterize the exceptions and apply a recovery policy. In addition, these dynamic agents can be mobile agents which have the capability to move between the EHP and the exception raising peers. This can lead to the reduction of the amount of the communication between nodes as the interaction will take place locally at the exception raising node (Cao, 2005). In addition, The EHP will acquire knowledge from previous exceptions and updates its exception handling knowledge base to deal with similar exceptions in future. The EHP is provided with a Case Based Reasoning (CBR) unit to handle exceptions which need to be managed in similar way, but may occur in different instances. The EHP reloads the dynamic agents with the acquired exception handling logic in order for these agents to react to similar exceptions.

5 A CASE STUDY

To better illustrate how the proposed Dynamic-agent based P2P WFMS works, an example of a motor insurance claim process is used. The workflow tasks are distributed over the workflow peers, based on the roles of the workflow participants and structure of the organization. After the tasks are distributed, each workflow peer is aware of its own tasks and the input and output workflow attributes. The Workflow tasks in this case study are modelled in Petri Net. Java has been chosen as the programming language for this prototype. The P2P network environment is based on the Java coded Sun Microsystems JXTA. The workflow peers engines are based on Bossa workflow engine. Bossa is an open source and lightweight workflow engine written in Java. In addition it does not require a RDBMS and is very simple to use and to integrate with java applications. For these reasons Bossa is chosen for the prototype implementation and four Java classes; Place, Transition, Edge and PetriNet can be adapted for the P2P environment. To examine the system, build-time, run-time and exception handling functions are being implemented.

6 CONCLUSIONS

This paper has proposed a Dynamic-agent based P2P Workflow Management System. This builds on our previous work on P2P WFMS. P2P systems and software agents can fit together for workflow application. We believe that these two technologies will play a key role in the future of workflow systems design and implementation. Dynamic agents can be used to mediate the workflow peers and the exception handling peer to automate the exception handling process. Future work includes: completion of the different components of prototype and evaluation of the effectiveness of the system.

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