Software Agent Architecture for Managing Inter-Organizational Collaborations

E. Tello-Leal*[1], O. Chiotti[2] and P.D. Villarreal[3]

[1] Facultad de Ingeniería y Ciencias
Universidad Autónoma de Tamaulipas
Victoria, Tamaulipas, México
*etello@uat.edu.mx
[2] INGAR – Instituto de Desarrollo y Diseño
CONICET-UTN, Consejo Nacional de Investigaciones Científicas y Técnicas
Santa Fe, Argentina
[3] Centro de Investigación y Desarrollo de Ingeniería en Sistemas de Información (CIDISI)
Facultad Regional Santa Fe, Universidad Tecnológica Nacional
Santa Fe, Argentina

ABSTRACT
The growing importance of cooperation among organizations, as a result of globalization, current market opportunities and technological advances, encourages organizations to dynamically establish inter-organizational collaborations. These collaborations are carried out by executing collaborative business processes among the organizations. In this work we propose an agent-based software architecture for managing inter-organizational collaborations. Two types of agents are provided: the Collaboration Administrator Agent and the Process Administrator Agent. The former allows organizations setting up collaborations. The latter allows organizations executing collaborative business processes. A Colored Petri Net model specifying the role, which an organization fulfills in a collaborative process, is used to carry out the behavior of the Process Administrator Agent that represents the organization. Planning and execution of the actions of the Process Administrator Agents are driven by a Colored Petri Net machine embedded to them. Thus, Process Administrator Agents do not require to have defined at design-time the protocols they can support. In addition, we propose a model-driven development method for generating Colored Petri Net models from a collaborative process model defined as interaction protocol. Finally, an implementation of the agent-based software architecture and methods based on model-driven development are presented.

Keywords: Software agent, inter-organizational collaboration, Model-Driven Development, collaborative business process, BPMN.

RESUMEN
La creciente importancia de la cooperación entre las organizaciones, como consecuencia de la globalización, las oportunidades actuales de mercado y los avances tecnológicos, alienta a las organizaciones a establecer en forma dinámica colaboraciones inter-organizacionales. Estas colaboraciones se llevan a cabo mediante la ejecución de procesos de negocio colaborativos entre las organizaciones. En este trabajo de investigación se propone una arquitectura basada en agentes de software para la gestión de colaboraciones inter-organizacionales. La arquitectura provee dos tipos de agentes: el Agente Administrador de Colaboraciones y el Agente Administrador de Proceso. El primer agente permite a las organizaciones a establecer colaboraciones. El segundo agente habilita a las organizaciones ejecutar procesos de negocio colaborativos. El rol que una organización desempeña en un proceso colaborativo es especificado mediante un modelo de redes de Petri coloreadas. Este modelo es usado para dirigir el comportamiento del Agente Administrador de Proceso, el cual representa a una organización. La ejecución de los planes y las acciones del Agente Administrador de Proceso son dirigidas mediante una máquina de redes de Petri coloreadas embebida en el agente. Entonces, los Agentes Administrador de Proceso no requieren tener definido en tiempo de diseño los protocolos que dan soporte a su comportamiento. Adicionalmente, se propone un método basado en el desarrollo dirigido por modelos para la generación en forma automática de modelos de redes de Petri coloreadas a partir de un modelo de procesos de negocio colaborativo definido como protocolo de interacción. Finalmente, la implementación de la arquitectura y los métodos basados en el desarrollo dirigido por modelos son presentados.

1. Introduction

The growing importance of cooperation among organizations, as a result of globalization, current market opportunities and technological advances, encourages organizations to dynamically establish inter-organizational collaborations. An inter-organizational collaboration entails a process-oriented integration between heterogeneous and autonomous organizations which must be achieved at a business level and at a technological level [1]. Inter-organizational collaborations are carried out through the execution of collaborative business processes. A collaborative business process (CBP) defines the global view of the behavior of the interactions among enterprises to achieve common business goals [1, 2]. The design and implementation of CBPs implies new challenges, such as participants' autonomy, decentralized management, peer-to-peer interactions, negotiation, and alignment between the business solution and the technological solution [1, 3]. In order to maintain the organizations' autonomy, it is required a decentralized management of the CBPs, which can be achieved through distributed and synchronized implementation of the integration business processes of each involved organizations. An integration process specifies the public and private behavior that supports the role an organization performs in a CBP. It contains, from the viewpoint of an organization, the public and private logics required to process or generate the information exchanged with its partners.

Therefore, the software applications must be developed in a manner they can interoperate effectively in this new distributed, heterogeneous, and sometimes, unreliable environment. Software agent technology is seen as a potentially robust and scalable approach to meet this challenge. Since the features of software agents such as autonomy, heterogeneity, decentralization, coordination and social interactions are also desirable for organizations involved in inter-organizational collaborations [1], the use of this technology can be considered as appropriate to be used within this domain [4, 5]. Software agents that execute CBPs can help to improve process integration, interoperability, reusability and adaptability [6, 7, 8].

In this work we propose an agent-based software architecture for managing inter-organizational collaborations. This architecture consists of two types of agents that represent organizations. Collaboration administrator agents provide the functionality to establish a collaboration agreement among organizations. Process administrator agents support the execution of collaborative business processes that organizations agreed to carry out in a collaboration agreement. The role an organization fulfills in a collaborative process is defined in a Colored Petri Net (CP-Net) model, which is used to drive the behavior of the process administrator agent representing the organization. The planning and execution of the actions of process administrator agents are driven by a CP-Net machine embedded in them. Thus, the behavior of the process administrator agents is derived in run-time. In addition, we propose a Model-Driven Development (MDD) [9] method for the automatic generation of CP-Net models from collaborative process models. CP-Net models of the process administrator agents are derived from collaborative process models, which are described as business interaction protocols defined with the UML Profile for Collaborative Business Processes based on Interaction Protocols (UP-ColBPIP) language solution [1, 10]. Hence, interaction protocols representing collaborative processes are executed by process administrator agents without the need for protocols defined at design-time in these agents. Finally, as a proof of concept, we also present an implementation of the agent-based architecture for inter-organizational collaborations.

The paper is organized as follows. Section 2 describes the agents that compose agent-based architecture for inter-organizational collaborations. Section 3 describes the MDD-based method for generating CP-Net models. Section 4 describes an implementation of the proposed agent-based architecture. Section 5 shows an application example of the architecture and its implementation. Section 6 includes related work and, finally, Section 7 presents conclusions and future work.

2. Agent-based architecture for inter-organizational collaborations

In this section we present an agent-based architecture for inter-organizational collaboration.