AN AGENT ARCHITECTURE FOR STEEL PRODUCT BUSINESS NETWORKS

Heli Helaakoski
VTT Electronics, Rantakatu 5 A, FIN-92101 Raahe, Finland

Janne Kipinä
Oulu Polytechnic, Raahe Institute of Technology and Business, Rantakatu 5 A, FIN-92101 Raahe, Finland

Harri Haapasalo
Department of Industrial Engineering, University of Oulu, P.O. Box 4610, FIN-90014 University of Oulu, Finland

Keywords: Software agents, B2B application, distributed manufacturing systems, supply chain management

Abstract: Networked manufacturing enterprises are now moving towards more open information exchange for integrating their activities with those of their suppliers, customers and partners within wide supply chain networks. Therefore there has been increasing need for software systems to support business networks. This paper introduces SteelNet agent architecture, which facilitates a real collaboration of companies by enabling a seamless information and material flow in a business network. Different operations of order-delivery process in the network have been modelled as agents that are able to collaborate with each other. The SteeNet agent architecture is a basis for a prototype that handles the operations of manufacturing steel products in a supply chain.

1 INTRODUCTION

The development of business and industry has led to a situation where companies cannot compete alone anymore and this has created a need for the companies to network with each other. These business networks are rather complex coalitions of business relationships where different counterparts of individual relationships and networks actively communicate with each other (Gummesson, 2000).

Traditional Electronic Data Interchange (EDI) and legacy systems no longer respond to today's needs, because they are very inflexible and expensive to use and maintain, especially for small and medium-size companies. Current Internet technologies are expected to ease these restrictions by being more efficient and economical. With the development of Internet technologies, the traditional B2B systems have extended to business networks where several companies are collaborating via electronic messages.

Recently, agent technology has been considered an important approach for developing industrial distributed systems (Jennings et al., 1995, Jennings and Woolridge, 1998). Agents can be used to encapsulate existing software systems to solve legacy problems and integrate the activities of manufacturing enterprises, such as design, planning, scheduling, simulation execution and product distribution, with those of their suppliers, customers and partners into an open, distributed intelligent environment via networks (Fox et al., 1993, Barbuceanu and Fox, 1997).

The SteelNet project presents an agent architecture for networked medium and small size manufacturing companies. The SteelNet architecture takes into account the fact that the networked companies use different types of information technology and various data security solutions,

Helaakoski H., Kipinä J. and Haapasalo H. (2004).
AN AGENT ARCHITECTURE FOR STEEL PRODUCT BUSINESS NETWORKS.
In *Proceedings of the Sixth International Conference on Enterprise Information Systems*, pages 467-470
DOI: 10.5220/0002605904670470

which must be able to collaborate with the SteelNet system. The purpose of this paper is to present how a community of agents can make decisions and carry out tasks within a manufacturing network. By digitising the information flow between the collaborative companies they have a possibility to increase their competitive position and profitability.

This paper is organised as follows: section 2 describes the business case of the SteelNet project. Section 3 describes a technical architecture for network manufacturing enterprises. Section 4 describes a prototype application for distributed manufacturing. Section 5 concludes and outlines our future plans and work.

2 STEELNET BUSINESS CASE

Business-to-business transactions consist of several typically repeated chains of events like the requisition of resources, a request for quotes from candidate business entities, vendor selection, order enactment and delivery, relationship management among businesses, and product life cycle management. These events are relevant to the functions of several business networks, such as a strategic sourcing network, an electronic procurement network, a network for virtual enterprise, a network for product design, manufacturing, inventory, and delivery management, a network of electronic marketplaces, a network for workflow/supply-chain management, and a network for supplier relationship management (Blake and Gini, 2002). Autonomous and intelligent software agents are capable of easing this complex environment of business networks in electronic commerce.

The SteelNet business network consists of several collaborating companies in the steel product industry. Within the business network, companies work together as a supply chain, while each of the companies has their own field of expertise like bending, flame cutting and welding. Besides this business network each company has its own customers and partners, therefore each company must have equal rights in the SteelNet system (Haapasalo et al., 2002, Iskanius and Haapasalo, 2003).

In the SteelNet system, agents represent major functionalities of a company. Figure 1 shows the usual operations in manufacturing companies, which are substituted by agents in the SteelNet system. They are able to communicate and collaborate within the company and likewise with other companies' agents via the Internet. This enables a seamless information flow though all the operations in a company and also through the whole business network. Practical operations in a business network have been analysed through some business cases, in order to reflect the reality. Delivery processes for products in project deliveries (modules of oil drilling rigs) and in volume production (hardened plate products) have been modelled in the SteelNet project.

3 TECHNICAL ARCHITECTURE FOR NETWORKING MANUFACTURING ENTERPRISES

The SteelNet environment consists of several manufacturing companies that have different network structures. However some generalisations can be made, in particular that companies have a private LAN (Local Area Network) which is connected to the Internet through a firewall. Legacy systems and workstations are located in the LAN. The selected architecture must enable workstations and legacy systems to interact with the SteelNet system as well as enable the companies to share information with each other without any modifications to the company firewall (Helaakoski et al., 2003).

Figure 2 shows the SteelNet architecture. The

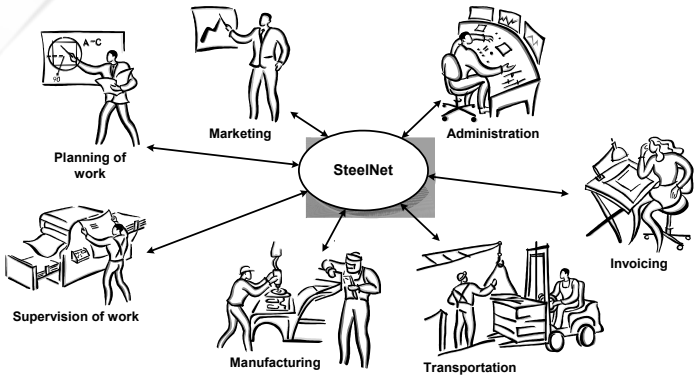

Figure 1: Usual operations in a manufacturing company.

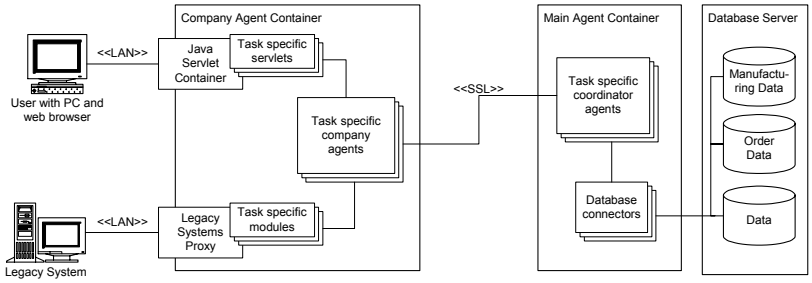

Figure 2: The SteelNet architecture.

architecture consists of one service provider and one or more companies. Each company has their own agent container server and a set of task specific agents. Each of these agents handles one of the roles presented earlier in Figure 1. The service provider has corresponding co-ordinator agents, that act as mediators between agents of the same role in different companies. Furthermore, the co-ordinator agents provide a data storage for the company agents. The communication between agents is secured by using a Secure Sockets Layer (SSL) connection.

The SteelNet architecture defines a set of basic services that are available for all agent containers in the system. The services include a web application server to provide user interfaces, a user administration service, a file distribution service and an alarm service and an information service for companies' to register their manufacturing and transportation services to the network.

The use of co-ordinator agents makes the system centralised, but it has some very considerable advantages. All data is easily available and in obscure situations it is easier to inspect if the data has been changed and by whom. Furthermore, security issues can be addressed more easily in a centralised environment that in a decentralised one.

One drawback in this centralised approach is scalability. When the number of companies and active agents grows significantly, co-ordinator agents won't be able to handle the vast amounts of incoming and outgoing data in reasonable time. Thus, in the future the architecture should be enhanced in order to make it more affordable and decentralised.

The architecture enables the physical location of the company agent container to be in the service provider's premises. This arrangement will be especially useful for small companies that do not have such legacy systems that need to be connected to the SteelNet system, or if they don't have enough resources to maintain an agent container server.

In the SteelNet project, business models are being developed to enable the use of information systems in an open manner between independent companies. After a suitable business model is found the technical solution must be further refined to facilitate the use of the business model.

4 PROTOTYPE APPLICATION FOR DISTRIBUTED MANUFACTURING IN THE STEEL PRODUCT INDUSTRY

The SteelNet architecture forms a base, on top of which the functionality of an electronic distributed supply chain is built by implementing agents for different roles. In the SteelNet project a prototype application is being developed to demonstrate the use of the architecture in a real-world supply chain. The first phase of the prototype implementation has been completed and it includes the basic services described earlier, except the file distribution service, and an application for a real-time tracking of heavy steel product manufacturing in a business network.

The manufacturing tracking functionality has been implemented by developing company and co-ordinator agents to share manufacturing-related data with each other using well-defined ontology. The co-ordinator agent provides facilities to store the data securely. The co-ordinator agent notifies the company agents about events that they might be interested in, for example a new manufacturing order in which the company is involved in or a change of a schedule. This enables the company agents to raise alarms when there seems to be delays in the manufacturing process, so that the companies can re-arrange their internal schedules, thus helping to reduce any undesired bull-whip effect, especially for companies that are at the end of the process chain.

In the first phase, the company agents provide a web application that is used to update information in the system. The user interfaces are delivered by using standard Java Servlet and JSP technology-

based web applications that can be used with any modern web browser.

The second phase of the prototype implementation will be completed during the spring of 2004. The main focus is to integrate company agents with legacy systems. The integration work will start with two companies participating in the SteelNet project. The described prototype addresses the issues related to information flow and transparency in a distributed manufacturing process. By using electronic distribution of information with the help of agents, the information flow can be improved significantly, which can be considered essential for optimising throughput times of manufacturing processes.

For the implementation, JADE (Java Agent Development Framework) has been selected as the used agent platform. JADE's main features are compliance to FIPA standards for software agents and the use of the platform-independent Java programming language (Bellifemine et al., 1999).

5 CONCLUSIONS

This paper describes the information technology problems in networking companies to form a supply chain. An agent technology-based technical architecture is presented to address the problems. A prototype application using the architecture in the context of distributed manufacturing in steel product industry is described.

The presented architecture intends to distinguish itself from similar ones by being designed and implemented for real-world use by companies of various sizes and in different industries. At the current state the architecture has limitations in scalability, which need to be addressed in the future.

The described prototype implements an application for efficient distribution of information in distributed manufacturing, but later the system can be easily extended to cover other areas of a supply chain network. The companies participating in the SteelNet project have tested the prototype in laboratory conditions and the results are promising. The prototype will be field-tested during the spring of 2004, thus creating more valuable information for future development of the architecture and prototype.

The agent technology has proven to be an applicable and affordable solution for electronic business networks. However, the technology needs to be developed further to provide a significant benefit when compared to traditional methods.

ACKNOWLEDGEMENTS

We gratefully acknowledge the funding and support by the Technology Development Centre of Finland (TEKES) and the companies associated with this project.

REFERENCES

Barbuceanu, M. and Fox, M., 1997. Integrating Communicative Action, Conversations and Decision Theory to Coordinate Agents. *In Proceedings of Autonomous Agents'97*, Marina del Rey, CA.

Bellifemine, F., Rimassa, G. and Poggi, A., 1999. JADE - A FIPA-Compliant Agent Framework. *In Proceedings of the 4th International Conference and Exhibition on the Practical Application of Intelligent Agents and Multi-Agents*, UK, 1999.

Blake, M.B. and Gini, M., 2002. Guest Editors, Introduction to the Special Section: Agent-Based Approaches to B2B Electronic Commerce, *International Journal of Electronic Commerce*, Volume 7, Number 1, Fall 2002, pp. 7.

Fox, M.S., Chionglo, J.F., and Barbuceanu, M., 1993. *The Integrated Supply Chain Management System. Internal Report,* Dept. of Industrial Engineering, Univ. of Toronto.

Gummesson, E., 2000. *Suhdemarkkinointi 4P:stä 30R:ään.* 2nd ed. Yrityksen Tietokirjat & Evert Gummesson, Jyväskylä. 453 p.

Haapasalo, H., Uutela, P., and Pajari, S., 2002. Developing co-operation in SME manufacturing network – fundamental concepts from the steel product industry. *In Proceedings of Conference on Small Business Research,* University of Kuopio, Kuopio, Finland.

Helaakoski H., Feng S.C., Jurrens K.K., Ojala K., and Kipinä J., 2004. Collaborative Software Agents in Steel Product Industry, *The IASTED International Conference on Artificial Intelligence and Applications*, Innsbruck, Austria, accepted.

Iskanius, P. and Haapasalo, H., 2003. Developing order-delivery process in manufacturing network case of steel product industry. *In Proceedings of 20th International Manufacturing Conference - IMC-20*, Cork, Ireland.

Jennings, N.R. and Wooldridge, M.J., 1998. Applications of Intelligent Agents. *Agent Technology: Foundations, Applications, and Markets*. Jennings, N.R. and Wooldridge, M.J (Eds.), Springer, pp. 3-28.

Jennings, N.R., Corera, J.M. and Laresgoiti, I., 1995. Developing Industrial Multi-Agent Systems. *In Proceedings of ICMAS'95*, San Francisco, The AAAI press/The MIT press, pp. 423-430.