A semantic web service environment for B2B and B2C auction applications within extended and virtual enterprises

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A B S T R A C T

Existing web services specifications lack an appropriate semantic framework for the creation and operation of emerging manufacturing systems such as the supply chains and extended/virtual enterprises (EE/VE) in order to execute business processes over internet. Semantic web services (SWS) technology aims to add sufficient semantics to the specifications and implementations of web services to make possible the (automatic) integration of distributed autonomous systems, with independently designed data and behaviour models. Defining data, behaviour and system components in a machine understandable way using ontologies provides the basis for reducing the need for humans to be in the loop for routine system integration processes. In this paper we present the design and implementation of a unique bid auction application for procurement automation within supply chains embedded in extended and virtual enterprises. We show how emerging semantic web services technologies such as the web services execution environment (WSMX) facilitate the creation of such applications, and we discuss the advantages of such applications.

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1. Introduction

Web services represent a step forward in enabling collaborations between various entities on the web and in overcoming the interoperability problems that may appear. B2B (Business to Business) partners can benefit by allowing business entities to expose their capabilities and to make use of their functionality. Information systems based on a service-oriented architecture which are able to integrate different functionalities and to offer a virtual component model that abstracts from the peculiarity of specific implementations, seem to be a very appealing solution. The web services execution environment [28] supports common B2B and B2C (Business to Consumer) scenarios, acting as an information system representing the central point of a hub-and-spoke architecture. If two partners wish to communicate, they simply abstract their functionality to WSMX, not one to each other. A clear distinction is made between the interface and the implementation of a service. This allows registration, discovery, composition and execution without knowledge of the location of their implementation and implementation technology. Furthermore, this distinction supports the semantic definition of a service

even when its implementation is not necessarily based on semantic technology but perhaps on a legacy system. WSMX tackles and addresses the requirements occurring in B2B and B2C collaborations, serving as a reference implementation for WSMO.

In the highly competitive environment, the suppliers of wares within B2B and B2C collaborations need frequently to fight against similar suppliers to win orders. Within the constraints of quality, quantity and delivery deadlines, the suppliers have to quote the most attractive possible prices to retain or win custom against the rivals. From the customers' perspective, it is an attractive proposal to make the potential suppliers some form of auction process in order to select the best supplier at a given time. This paper describes the various auction processes that could be entered into and, as an illustrative example, it describes how web services execution environment could be used to implement an auction process. Sample descriptions in WSML ontologies within the WSMX environment are also presented to exemplify the convenience of developing such auction processes.

This paper is structured as follows: Section 2 following offers an introduction and overview of the thinking underlying extended enterprises (EE) and virtual enterprises (VE). In Section 3 we introduce semantic web services concepts and technologies. Section 4 presents the unique bid auction processes that occur in the supply chains that belong to EE and VE. The architecture for the auction or negotiation element is proposed. An application

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example is then presented in Section 5. Finally a summary of the work and proposed future work is presented in Section 6.

2. Extended enterprise/virtual enterprise

2.1. The extended enterprise

The extended enterprise is a term used to reflect the high level of interdependence that exists between organisations as they conduct business. This is echoed succinctly in the definition of extended enterprise offered in Jagdev and co-workers [14,15] as: "the formation of closer coordination in the design, development, costing and the coordination of the respective manufacturing schedules of cooperating independent manufacturing enterprises and related suppliers". Fig. 1 below (after [14]) illustrates the development of the collaboration between enterprises over the past 50 years or so.

The traditional organisational model is characterised as a single organisation composed of multiple departments (i.e. sales, engineering, purchasing, accounting, manufacturing, etc.); the extended enterprise results from organisations or parts of organisations, customers, suppliers and sub-contractors, engaged collectively in the design, development, production and delivery of a product to the end user. The extended enterprise model of manufacturing systems basically views the manufacturing system as one element of a value chain, which delivers service to a customer [3].

The increased availability of communications and information technology tools and the emergence of a truly global telecomputing infrastructures support the extended enterprise model. The extended enterprise can be considered as a both a driver and a consequence of advanced information and telecommunication technology. The implementation of business-to-business (B2B) eCommerce systems is fully realised in extended enterprises. It is the seamless exchange of information on top of an existing long-term relationship that distinguishes the extended enterprise from other forms of long-term collaboration such as a supply chain relationship.

The principle of the extended enterprise system is that its suppliers and customers are not separate entities, they are all part of the "larger us" [4]. Thus, while the supply chains and logistics chains are part of the extended enterprise, its success is greatly influenced by the speed and efficiency with which information can be exchanged and managed among the different business partners. As an example, collaborative engineering and production requires efficient electronic management of engineering and production information. Thus it is important that the participating enterprises have sufficiently sophisticated IT and decision support tools and mechanisms to make the integration possible. It is also important to have the maximum degree of compatibility among partners' IT systems [1].

Porter suggests that competitive advantage often derives as much from linkages between activities as it does from the individual activities themselves [20]. Linkages basically represent the relationships between the performance of one value activity and that of another. Linkages can thus refer to relationships between the activities in the organisation itself and to the links that the organisation has with its suppliers and customers. Porter identifies each of these links as a source of potential competitive advantage, because they represent the relationships between the way one value activity is performed and the cost or performance of another. Linkages are found within the activities occurring in the organisation itself and within the links that the firm has with its suppliers and customers and that each of these links is a source of potential competitive advantage. By focusing on specific links, an organisation can gain a competitive advantage in the related business process. In today's terms this competitive advantage is achieved using Internet and eCommerce technologies and in particular, B2B and B2C approaches.

2.2. The virtual enterprise

As with the extended enterprise where, more often than not, existing supplier/buyer (or supply chain) relationships are strengthened through the use of ICT technologies, the availability of ICT technologies can also facilitate the formation of entirely new enterprise networks.

Zhao et al. [30] define a virtual enterprise as: "a virtual enterprise is a term often used to describe such collaborations when the participating organisations are distributed over large geographic areas and come from multiple independent companies. A virtual enterprise allows its member organisations to respond collectively to favourable market conditions for new product development in situations where the members individually would be unable to respond effectively". In principle, small and medium size companies participating in a virtual enterprise, get access to the resources of a large organisation while retaining the agility and independence of a small one, thus resulting in the following benefits:

- Access to a wide range of specialised resources,
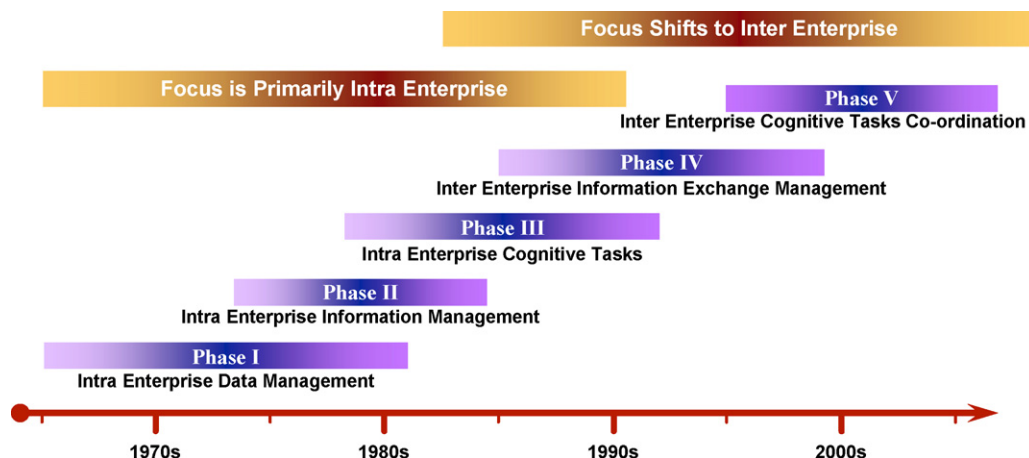- Presentation of a unified face to large corporate buyers,

Fig. 1. Evolution of the extended enterprise.