

December 2002

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Rahul Singh

*University of North Carolina, Greensboro*

Lakshmi Iyer

*University of North Carolina, Greensboro*

A. Salam

*University of North Carolina, Greensboro*

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## Recommended Citation

Singh, Rahul; Iyer, Lakshmi; and Salam, A., "AGENTS AND WEB SERVICES IN AN E-SUPPLY CHAIN" (2002). *AMCIS 2002 Proceedings*. 204.

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# AGENTS AND WEB SERVICES IN AN E-SUPPLY CHAIN

**Rahul Singh, Lakshmi S. Iyer, and Al F. Salam**

University of North Carolina, Greensboro

rahul@uncg.edu   lsiyer@uncg.edu   amsalam@uncg.edu

## Abstract

*Supply Chain Management (SCM) is a strategy adopted by top management to respond to competitive pressures in the market place. The SCM strategy incorporates methods and systems that aid in continuously improving the organization's processes to optimize the creation of goods, information and services from suppliers to business customers to consumers. Growing web-enabled applications and standards provide the needed resources for electronic collaboration among suppliers and customers. However, for a realistic implementation of business processes that can be shared and accessed by business partners, there is a need to incorporate intelligence as part of the implementation process. In this research-in-progress, we plan to develop a framework for the intelligent exchange of knowledge that is critical to the effectiveness of processes in an e-supply chain environment in the digital economy.*

**Keywords:** Intelligent agents, e-supply chain, Web services, supply chain management, infomediaries

## Introduction

Companies across the globe are facing increasing competition in many industries due to factors such as market maturation, emerging technologies and globalization. This has led the companies to find ways to improve business practices to increase profitability and shareholder value. One such approach adopted by senior management to cope with these challenges is supply chain management (SCM), which has become increasingly important in recent years. Kalakota and Robinson (1999) define a company's supply chain as a complex network of relationships that organizations maintain with trading partners to source, manufacture, and deliver products and services. SCM thus refers to the methods and systems that help continuously improve the organization's processes to optimize the creation of goods, information and services from suppliers to business customers to consumers (Poirier and Bauer, 2000). Not only are processes inside the company addressed, but also optimization takes place regarding supplier, customer and other partner relationships. Supply chain management thus expands the notion of integration beyond a single company to encompass all related trading partners in the supply chain by shifting the focus outside the organization's walls. Managing a company's supply chain requires the streamlining of a range of information related activities including quotes, bids, purchase orders, order and receipt confirmations, shipping documentation, invoices and payment information (Yang and Papazoglou, 2000).

The Internet and emerging technologies have great potential in aiding organizations achieve this integration. Business-to-business (B2B) e-commerce (EC) is an area that encompasses buying and selling goods and services electronically between organizations. Internet B2B EC has several benefits such as: lowering cost dramatically across the supply chain, adding new dimension to customer service, increase ability to enter new markets or redefine business relationships (Simchi-Levi *et al.*, 2000). Companies across the globe have already spent billions of dollars in conducting B2B EC and this growth is expected to be at least a 1000% more in the next four years (approximately \$226 billions in 2000 to about \$2775 in 2004 – source: eMarketer.com).

Growing web-enabled applications and standards provide organizations the needed resource to collaborate (electronically) with suppliers and customers. With an increasing number of parties involved in a supply chain, sharing timely and accurate information between the entities becomes crucial to make the process flows work efficiently. This information sharing and knowledge exchange can be done much easier with technologies such as the Internet as the Internet's global connectivity makes it easier to create information partnerships and allow access to information across the entire chain. However, the potential benefits can be realized only by the effective deployment and use of new technologies to provide the needed relevant information in a timely

manner. Thus, an effective e-supply chain requires the streamlining of a range of information related activities including quotes, bids, purchase orders, order and receipt confirmations, shipping documentation, invoices and payment information (Yang and Papazoglou, 2000). Such activity routinely extends the value chain beyond company boundaries creating the need for dynamic partnerships in physical goods and information sharing to deliver the value proposition to the customer. Enabling and managing such value chain integration over distributed and heterogeneous information platforms, such as the Internet, is a challenging task. Yet, this task has large potential benefits through linking and synchronizing the behaviors of potential partners in the value chain to reduce transaction costs, enable collaborations (Welty and Becerra-Fernandez, 2001). Business use of the Internet is at its infancy and a company's supply chain strategy should have the ability to constantly evolve and adopt to take advantages of the changes and opportunities the technology has to offer.

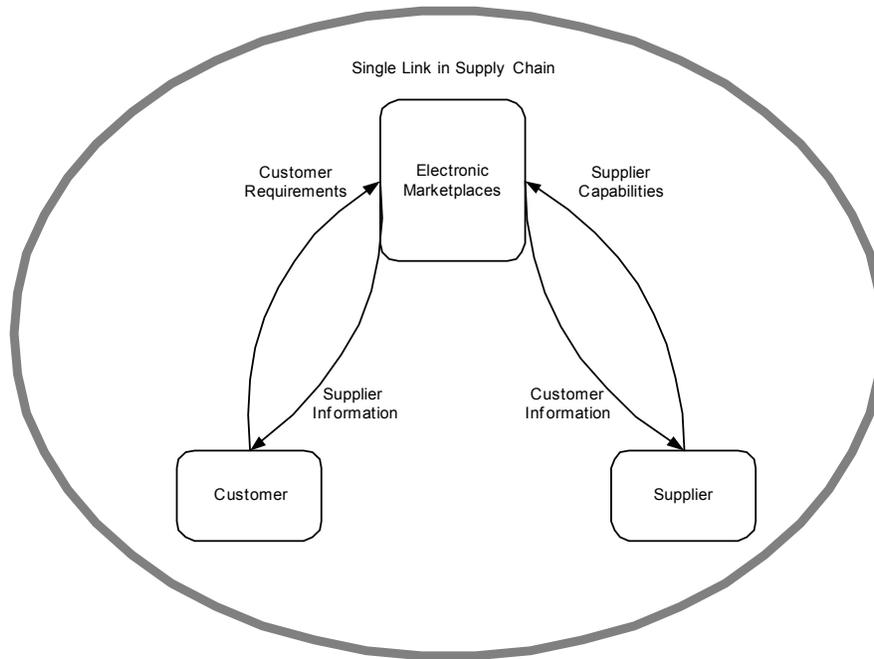
Web services are an industry-wide response to fill the need for a flexible and efficient business collaboration environment. These services are designed to be used and accessed by people, businesses, and other web services. Web services can be accessed by a wide range of intelligent connected devices, both wired and wireless. Three core standards such as Simple Object Access Protocol (SOAP), Web Services Description Language (WSDL), and Universal Description, Discovery and Integration (UDDI) form the foundation of web services. These standards have been widely adopted by industry participants such as Microsoft, IBM, Oracle, Sun Microsystems and Hewlett-Packard. Web services are a more cost effective and standards-based solution compared to Electronic Data Interchange (EDI), and proprietary B2B solutions. This is possible through the use of standards-based widely adopted Extensible Markup Language (XML) and related set of technologies. XML and related technologies facilitate the creation, standardization and sharing of structured and unstructured business documents related to trading partners. For realistic implementation of business processes that can be shared and accessed by business partners, there is a need to incorporate intelligence as part of the implementation process. Recently, Intelligent Agent and Agent oriented systems have gained a lot of attention for their potential as a model based abstraction to enable various facets of B2B EC applications (Papazoglou, 2001). Collaborative agents work together by sharing process knowledge to achieve operational synergies while user agents represent goal-oriented activities of individual entities in the system. Such multiagent models provide a rich abstraction to enable the process involved in an Internet enabled supply chain where entities that exhibit self directed behaviors must coexist and achieve a system wide objective. This article provides such a framework that incorporates intelligent agent architecture with web services architecture in the context of an e-Supply Chain.

## **Enabling e Supply Chain Infomediaries in Virtual Marketplaces**

### ***Activities in a Supply Chain and the Role of the Market Place***

Bakos (1998) identifies three primary functions of an economic marketplace: matching buyers and sellers, facilitation of transactions and providing an institutional infrastructure. The processes involved in typical supply chain (link) transactions begin with the generation of the customer requirements and end with order fulfillment. Enabling processes that comprise a supply chain link requires generating the demand requirement of a customer. This triggers the search of suppliers who can meet the needs of the customer. Suppliers that can meet the demand requirement, including time, cost, quantities and various other needs, are searched to identify a set of suppliers that can fulfill the demand requirement. Customers go through a decision making process of selecting a supplier from the set of matching suppliers that can fulfill the demand. This process may involve additional negotiations between the customers and suppliers to establish the terms of the agreement and additional facilitation of the transaction. The schematic in Figure 1 illustrates the role of the electronic marketplace in enabling the processes in a supply chain network.

A primary role of the electronic marketplace is to provide information to buyers and sellers about customers, products and services available to them in the marketplace. This informs the critical decision process of matching buyers with certain product/service needs and suppliers who can provide goods and services to meet. Grover and Teng (2001) focus on this critical information providing role of the market and identify the roles played by electronic intermediaries – infomediaries, that enable the information processes of the electronic marketplace. Infomediaries are a business model adopted by emergent organizations in response to enormous increases in the volume of information available and the critical role it plays in enabling processes in electronic markets. They perform a critical role in both Business-to-Business (B2B) and Business-to-Consumer (B2C) electronic marketplaces in uniting buyers and suppliers in the virtual marketplace and orchestrating the transactions between them.



**Figure 1. The Role an Electronic Market Place**

Infomediary have potential in enabling supply chain processes in the B2B marketplace since the process of matching buyers and sellers in a supply chain typically entails many services provided by the infomediary business model. Infomediaries provide valuable services to the B2B marketplace by deciphering complex product information for the benefit of both suppliers and buyers and assists in finding suppliers for buyers' needs and buyers for suppliers' products and services. Infomediaries provide independent and observed assessment of the commitments of the individual buyers and sellers and facilitate the development of collaborative relationships in the links of the supply chain. Working on an information-push or an information-pull model, infomediaries help in informing buyers and sellers in the virtual marketplace of new products, services and opportunities that may be useful to them. Infomediaries facilitate commercial activities between buyers and sellers and help in establishing relationships between them that goes beyond single transactions and forms the basis for a long-term, trustful, collaborative relationship between entities in the virtual marketplace.

In the infomediary enabled business model, customers and suppliers provide representations of their need for products or services or their capabilities in creating various products and services to the infomediary. This information is typically communicated to the infomediary by communicating their respective demand or supply functions which contains information about the nature of the products or services needed, the price that the customer may be willing to pay, the quantities needed and information about the time frame in which the product or service is needed by. Infomediaries then have the basis for matching the needs of the customers with the capabilities of the suppliers. This forms the primary function of the infomediary through matching the needs of the suppliers and the buyers. The schematic in Figure 2 outlines the information flows for infomediaries in enabling transactions in virtual marketplaces.

In addition to matching customer needs with the capabilities of the suppliers, the infomediary becomes a vital resource in the virtual marketplace as the enabler of transactions and a repository of knowledge about customers, suppliers and the nature of exchange between them. Grover and Teng (2001) provide a detailed description of the value-added activities provided by infomediaries in the virtual marketplace. The focus of this article is the development of a model to automate the knowledge processes and goal-oriented actions in this business model.

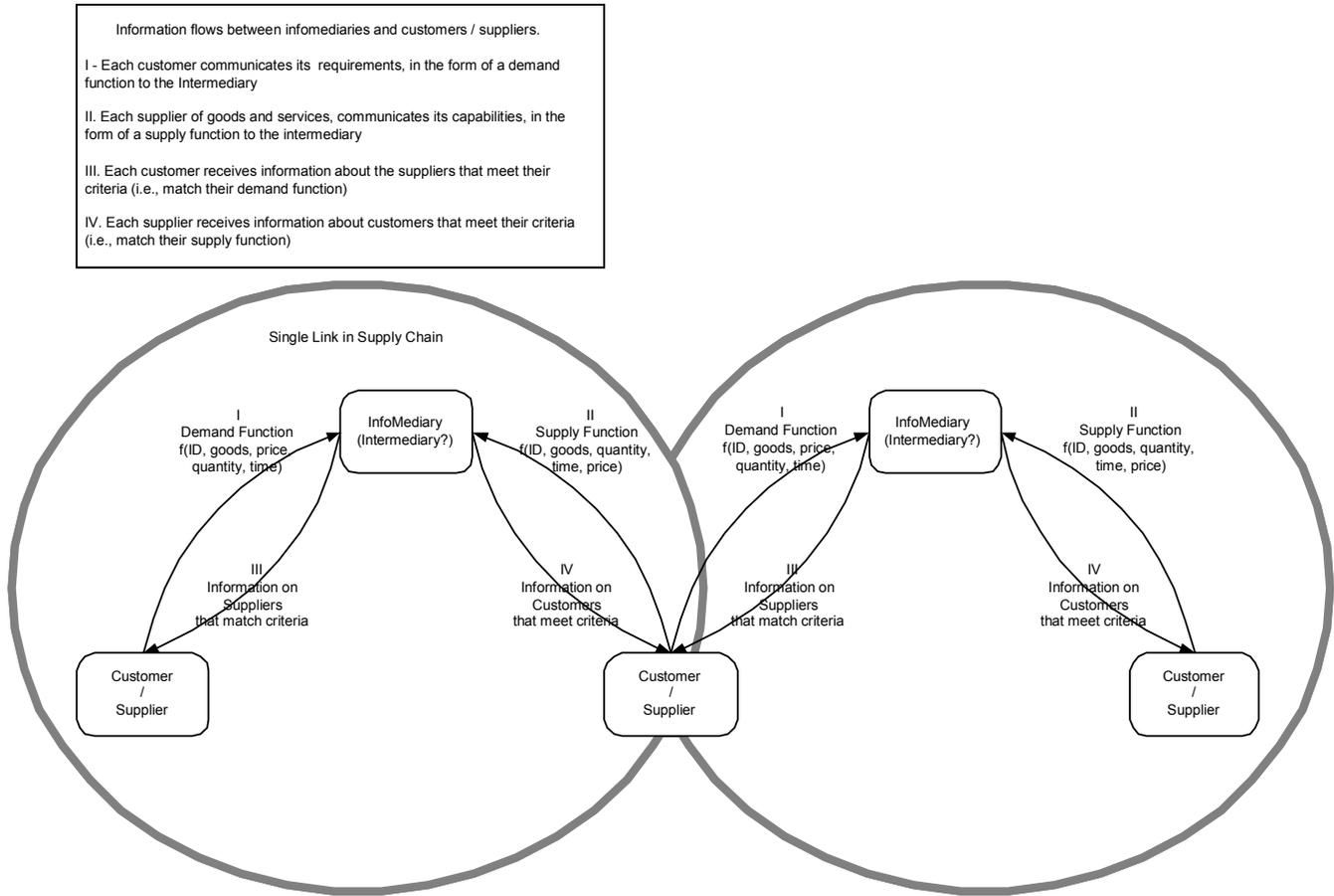


Figure 2. Flows of Information in the Infomediary Enabled Virtual Marketplace

### Theoretical Model

An analysis of the infomediary business model shows that the individual customers and suppliers seek distinct goal oriented information capabilities from the infomediary – they provide decision parameters through their individual demand or supply functions and as a primary requirement, they seek customers or suppliers that can meet their demand requirements. This is a discovery activity that comprises customers and suppliers searching for a match of their requirements in the infomediaries. The result of this activity is the discovery of a set of suppliers capable of meeting their needs. Typically customers will then engage in internal decision making activity to select a supplier, from the discovered set, that best meets their needs. Such a decision process may be influenced by historical information such as past experiences of customers', reliability and trustworthiness of the supplier. The infomediary business model can provide valuable information to this decision processes by serving as the knowledge repository of transactional histories for both customers and suppliers. Once a supplier is identified, the infomediary performs a transaction facilitation role and enables the flow of information between the customer and suppliers which leads to the flow of tangible goods or services between the customer and the supplier. In order to maintain and enable its services, the infomediary will need to collect and maintain post transaction information from both the customer and the supplier. This information is used as knowledge for the discovery process for subsequent transactions. Thus the infomediary model can serve a larger purpose than facilitation of individual transaction; it can enable collaborative relationships between customers and suppliers that are founded on trust that ensues from usage oriented beliefs (Salam, et. al., 2001).

The following three critical roles (discovery, facilitation, and decision support) for the infomediary role are thus outlined:

- Discovery of customers and suppliers that meet each others' requirements

- Facilitation of transactions to enable the flow of information and tangible goods and services between the customers and suppliers in a knowledge rich environment.
- A knowledge intensive decision support process that lead to deep collaborative relationships between partners in the supply chain.

## **Agents and Web Services Enabled e-Supply Chain Model**

The following provides a detailed description of the information requirements and flows of each entity in the model:

**Customer.** Each customer is represented in the virtual marketplace by a customer agent. For the purposes of this discussion, the terms customer and customer agent are used interchangeably since the agent represents the customer in the virtual marketplace. New customers are responsible for registering themselves in the marketplace thereby making the customer an entity for subsequent transactions. Registration creates an entry for the customer in the directory of the infomediary and provides the customer with metadata information on the structure of demand requirements to be communicated to the intermediary (retrieve an XML schema from the infomediary).

Activities of the customer agents are triggered by the customer communicating a demand requirement to the discovery agent of the infomediary (information flow “I” in Figure 2). The receipt of the customer demand requirement, by the infomediary, is a trigger for a sequence of activities of the discovery agent in the infomediary and culminates in the customer agent being supplied with a list of suppliers that are able to meet this demand. This list of potential suppliers is taken to the human customer representatives and the customer agent works with them to identify a supplier with whom the customer can work.

The identity of the chosen supplier is communicated to transaction agent of the infomediary with a request to facilitate the transaction between the customer and the identified supplier. This information (information flow “III” in Figure 2) is classified as the pre-transaction information which contains all required operational details of the ensuing transaction between the customer and the supplier.

**Supplier:** Each supplier is represented in the virtual marketplace by a supplier agent. New suppliers register themselves with the infomediary thereby making them available to meet customer requirements. Suppliers provide information on the products and services that they can provide by publishing their supply functions to the infomediary (information flow “II” in Figure 2). This communication may be done asynchronously and in parallel with Information flow from a customer. This provides required input to the discovery agent of the infomediary in serving the discovery function to match customer needs with supplier capabilities.

Like customers, suppliers also receive information on the set of customers that match their demand requirement, irrespective of whether they choose to engage in transactions with the supplier. In other words, if a supplier is on the list of suppliers, identified by the discovery agent, whose capabilities match a certain customer needs, information about the customers and the suppliers are sent to all individual parties involved (information flow “IV” in Figure 2). This allows suppliers to continually assess their operational capabilities and enhances the information flows in the market.

**InfoMediary:** Each infomediary has 2 classes of agents that fulfill its activities in the supply chain.

**Discovery agents:** These agents serve as the primary interface between buyers and sellers and are responsible for matching customer requirements with supplier capabilities (information flows “I” and “II” in Figure 2). They receive information on customer needs and receive information from suppliers about their capabilities. They perform a matching function to match the capabilities of suppliers and customers.

**Transaction Agents** – facilitate the transactions between the customer and their choice of supplier. This agent is primarily responsible for facilitating all pre-transaction information flows that are required to complete the transaction.

Transaction agents also collect post transaction information about the experience of the buyers and sellers about the nature of the transaction. This information is primarily concerned with the satisfaction of the buyer and the seller about the ensued transaction. The actual flow of materials and operational transaction information that deals with the individual transaction will be beyond the scope of the final system model.

## Summary

In the current digital economy, market dynamics dictate that an e-supply chain business strategy embrace all the partners in the value chain. Emerging technologies have the potential of offering unprecedented opportunities for suppliers and buyers to connect and establish mutually beneficial and profitable relationships. Most companies often rely on phone, fax, e-mail and EDI to facilitate these relationships thus lacking the flexibility needed in today's environment (IBM Special report, 2000: [www-3.ibm.com/e-business/resource/pdf/26711.pdf](http://www-3.ibm.com/e-business/resource/pdf/26711.pdf)). XML technology is now beginning to set the standard for the collaboration of trading partners offering tighter integration and information sharing. However, there is a need to incorporate intelligence with decision support capabilities to fully realize the benefits in implementing such technology to streamline business processes in a supply chain. Such a system should be able to make local optimization decisions for operational efficiencies of each process that is consistent with system wide goals of delivering the value proposition to customers. In this study, we have presented a framework that incorporates intelligent agent architecture with web services architecture in the context of an e-Supply Chain. In this framework, the intelligent agents play three different roles: match customer and supplier requirements, enable the transactional information flow and aid in the decision support process that will strengthen the collaborative relationships among trading partners.

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