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The semantic web: a catalyst for future e-business

Janet K. Durgin
Lockheed Martin Aeronautics, Forth Worth, Texas USA, and
Joseph S. Sherif
California State University, Fullerton, California, USA and
California Institute of Technology, California, Pasadena, USA

Abstract

Purpose – This paper aims to advance research that portrays the semantic web as the future web where computer software agents can carry out sophisticated tasks for users.

Design/methodology/approach – The paper discusses the major factors that affect the performance and reliability of information services for the web, namely the distribution of information, which has resulted from the globalization of information systems, the heterogeneity of information sources and the sources' instability caused by autonomous evolution.

Findings – Man stands at the threshold of being able to create the semantic web, in terms of declaratively representing objects that are already human-readable on the web. The next step is to make it the dynamic semantic web by encoding procedures in web material as first-class objects.

Practical implications – Semantic web technology will work with extensible mark-up language, which will enable electronic commerce by: defining languages that provide support in defining, mapping, and exchanging product data; functioning from the development of standard ontology that will cover various business areas; and utilizing efficient translation services that will require areas of standard ontology.

Originality/value – The paper tackles one of the most pressing issues of the creation of programs that collect web content, process the information and exchange the results with other programs from diverse sources.

Keywords Cybernetics, Supply chain management, Operations management, Electronic commerce

Paper type Technical paper

Introduction

Research has indicted that the semantic web is the future web. Content on the internet will be structured so that computer software agents can carry out sophisticated tasks for users. The semantic web will promote the eventual creation of programs that collect web content from diverse sources, process the information and exchange the results with other programs. Business-to-business may become the most important application area of semantic web technology in terms of market volume within the next decade. In order for e-businesses to integrate their supply chains into semantic web technology to support the new web, business processes will have to be analyzed and retooled. New frameworks should be developed and information techniques updated to accommodate extensible markup language (XML). A large percentage of traditional supply chain management (SCM) will migrate to electronic-supply chain management, where web-enabled supply chain execution will be a necessity for any company or industry to survive.

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The augmentation of search engines with adaptive populations of intelligent agents will lead to significant competitive advantage in the virtual business world. As with any other technological shift in past decades, the shift to the semantic web will be bumpy. E-supply chain innovators will gain control over industry sectors by reconfiguring their supply chains using e-commerce technology to connect to trading partners. Those business participants, who are aware that the change is coming and have taken necessary setup within their e-commerce environments, will definitely have the competitive advantage in the e-marketplace of the coming decades. The purpose of this paper is to advance research that examines the culmination of information on the semantic web, distribution of information, heterogeneity of information sources, creation of programs that collect web content from diverse sources for the purposes of information collection and exchange with other programs. Aspects of the subject presented include consideration of the following:

- How does the semantic web differ from the existing world wide web (WWW)?
- What characteristics does the application need to visit web sites with quite heterogeneous structures, often from different industries?
- Will the augmentation of search engines with adaptive populations of intelligent agents lead to significant competitive advantage in the virtual business world?
- What steps must be taken by e-business participants to accommodate for the shift when it happens?
- Will the virtual business world be ready to adapt to another transition?

The WWW serves as a leading vehicle for information dissemination by offering information services, such as product information, group interactions, or sales transactions. Three major factors affect the performance and reliability of information services for the web, namely the distribution of information, which has resulted from the globalization of information systems, the heterogeneity of information sources, and the sources' instability caused by autonomous evolution. The semantic web is the future web, in which content on the internet will be structured so that computer software agents can carry out sophisticated tasks for users. The semantic web will promote the eventual creation of programs that collect web content from diverse sources, process the information and exchange the results with other programs. In order for semantic web technology to work, XML will have to play important roles in XML-enabled electronic commerce. This is accomplished by:

- languages with a defined data model and rich modeling primitives that provide support in defining, mapping, and exchanging product data;
- standard ontology will have to be developed covering various business areas; and
- efficient translation services for which standard ontology does not exist or in which a particular client wants to use ones own terminology and needs this terminology translated into the standard.

There are already significant constraints on current web technology, which inhibit the e-supply chain flow. Given that the web will be migrating/integrating into the semantic

web, e-commerce will have to be XML-enabled by the use of languages defining data models and rich modeling priorities defining, mapping and exchanging data. A large percentage of traditional SCM will migrate to e-supply chain management, where web-enabled supply chain execution is a must for any company or industry to survive. E-supply chain innovators will gain control over industry sectors by reconfiguring their supply chains and by using e-commerce technology to connect to trading partners.

The inception of the semantic web came hand in hand with the birth of the WWW in 1989. This web was the realization of an aspect that was part of the development efforts of the web, which was set aside to the web of multimedia human-readable material. Currently, different layers of the semantic web are progressing through the various stages of development rapidly. Fensel *et al.* (2003) defined the semantic web as "specifically machine-readable information whose meaning is well defined by standards: it absolutely needs the interoperable infrastructure that only global standard protocols can provide." The web of today, as a glorified television channel, is only one part of the original plan by the developers.

The second goal for the web, which was dependent on the first, was that of one imagining a project that used the web in its work, and then used a map in cyberspace that entailed all the dependencies and relationships that defined how the project was going. The computer renders the scene visibly as a software agent doing anything it can to help people deal with the bulk of the data. Thereby taking over the tedium of anything that can be reduced to rational processes.

We are now at a crossroads in the evolution of the web. The web has evolved from a relatively static collection of pages and links to a dynamic interactive interface with semantic information. We are at the verge of being able to create the semantic web, in terms of declaratively representing objects that are already human-readable on the web. The next step is to make it the dynamic semantic web by encoding procedures in web material as first-class objects.

Bradbury (2003) asserts that "One of the biggest problems with the web and with knowledge management tools is that information is dumb. The data contained in web sites and knowledge management systems does not know what it is." This makes web searches very difficult, turning up hundreds of thousands of results that are completely irrelevant or only partially related to your subject matter. The semantic web project, initiated by Berners-Lee (2001) the creator of the WWW, has been designed to make web and knowledge management data more intelligent. It works by encoding metadata into information that helps to describe not only that information, but also the information's relationships with other pieces of data. In this way, the user can augment traditional, hyperlinked connections with a new type of semantic link. Thus, creating an invisible matrix in which information is connected by meaning.

Semantic web links can be powerful when used in a commercial context. If the user operates in a vertical sector such as food production, he or she may have thousands of pages on an intranet detailing different aspects of processes and products. Searching through them could be difficult, but if the user has semantically encoded them, he or she may find it easier. For example, the user will be able to start with a particular ingredient and ask the browser to find all foods that use more than 10 mg of that product. Eventually, it is predicted that the semantic web will lead the e-commerce sector of the online business world.

Warren (2003) iterated:

> The World Wide Web of today suffers from a defect that stems from its original design. The Web is based on the use of the Hypertext Markup Language (HTML), which allows a page's author to define broadly how it will look on computers across the globe. HTML works well in providing a common language to achieve that goal; however, it says nothing about what the data is for, i.e. about its semantics.

The semantic web will bring structure to the meaningful content of web pages, creating an environment where software agents roaming from page to page can readily carry out sophisticated tasks for users. The semantic web is not a separate web, but an extension of the current one, in which information was given well defined meaning, better enabling computers and people to work in cooperation (Berners-Lee, 2001; Berners-Lee and Fischetti, 2000). The essential property of the WWW is its universality. The power of a hypertext link is that anything can link to anything. Berners-Lee articulated:

> Web technology, therefore, must not discriminate between the scribbled draft and the polished performance, between commercial and academic information, or among cultures, languages, media, and so on. Information varies along many axes. One of these is the difference between information produced primarily for human consumption and that produced mainly for machines. To date, the Web has developed most rapidly as a medium of documents for people rather than for data and information that can be processed automatically. The Semantic Web aims to make up for all this.

The strands of the web are identified by a variety of terms: wires, wireless, relationships and financial transactions, in which the relationship strands take the form of customer intimacy, electronic commerce, electronic selling, partnerships, alliances, mergers, acquisitions, hostile take-overs, virtual teams, and knowledge networks. The web speaks the language of business and organization as well as technology (Lloyd and Boyle, 1998).

Berners-Lee (2001) raised the issue of "trust systems" in which a common language for machines to communicate over the web, and resource description framework (RDF) will simplify the exchange of information about documents across the world. In order to understand how RDF will tie into e-SCM and the move to the semantic web across the e-business sector, a comprehensive approach is taken to understand web ontology.

Web ontology

In the semantic web, the basic layer of data representation are standardized as the RDF. RDF is based on existing standards of XML, universal resource identifier (URI), and unicode. Built on top of RDF, the Ontology layer is being developed by the World Wide Consortium's Web Ontology Working Group. Warren (2003) explained that the problem is that while XML provides syntax for the semantic web, and a way of constructing semantics, it does not enforce a common semantic structure. RDF is an attempt to do that. RDF has a simple structure, consisting of a series of triples, each of which has a subject a verb, and an object. The subject and verb must be a (URI), and it is throughout the use of the URIs that the uniqueness of the object is defined. Ontology and logic follow RDF and URI by establishing vocabularies to define words.

An example of how the semantic web will work in the real world for the average user is as follows:

(1) Lucy issues instructions for her software agent to follow hyperlinks in the request to ontology where key terms are defined;

(2) after getting treatment information from the doctor's computer and schedule information from Lucy's and Pete's computers, the agent goes to a provider finder service;

(3) the finder service sends out its own agents to look at semantics-enhanced insurance company lists and provider sites;

(4) Lucy's agent interacts with the selected individual provider sites to find one with suitable open appointment times, which it tentatively reserves; and

(5) the agent sends the appointment plan to Lucy and Pete at Pete's home (per Lucy's request) for their approval (Berners-Lee, 2001; Berners-Lee and Fischetti, 2000).

Fensel *et al.* (2003) emphasized that several components must come to fruition in order for the semantic web to work as predicted, including languages, ontology, and tools, inclusive of editors and semiautomatic construction, ontology environments, reasoning services, annotation tools, tools for information access and navigation, and translation and integration services. For example, new languages will need to provide formal syntax and formal semantics to enable automated processing of content. The languages will need to provide standardized vocabulary referring to real-world semantics, enabling automatic and human agents to share information and knowledge. Ontology for investigating artificial intelligence research inclusive of knowledge engineering, natural language processing, and knowledge representation will become inherent.

Advanced tools must be effective and efficient to work within the intricacies of the semantic web to support its full power of the technology. Formal languages must be able to express and represent ontology and semi-automatic construction must engage the ability to build new ontology. Reusing and merging ontology must be able to reuse existing ones. Annotation tools will link unstructured and semi-structured information sources with metadata. Tools for information access and navigation will enable intelligent information access for users. And translation and integration services between different ontologies will enable multi-standard data interchange and multiple view definitions. It is predicted that the business-to-business area may become the most important application area of semantic web technology in terms of the market volume. Companies like VerticalNet that builds many vertical marketplaces face the problem of integrating heterogeneous and distributed product information. This company and many others like it, makes use of ontology-based integration techniques to reduce the level of effort required to provide integrated solutions for B2B marketplaces.

Electronic commerce and the supply chain

Electronic commerce (EC) is one of the most promising applications of information technology introduced to the business world in recent years. EC is revolutionizing SCM and has enormous potential for manufacturing, retail and service operations, online stock trading, online banking, and online retailing. Murphy (1999) promoted that e-commerce requires that organizations build a web presence that removes the need for an intermediary in financial transactions. This requires organizations to radically

redefine key business processes. They must implement new business and accounting software products that accommodate these newly defined processes.

Organizations are building a public highway to electronic markets, with intranets that give private access to information distribution and housekeeping activities and Extranets that accommodate specialized markets and secure trading areas. Factors driving business over the internet include ease of access, low cost of participation and efficient electronic transactions. While improved access and lower costs have helped speed up acceptance of the internet, e-commerce transactions are having a significant impact on global trade. However, adapting accounting and business software to accommodate e-commerce presents significant challenges to management information systems (MIS) and finance departments. EC has been termed by some as the "second Internet revolution." EC is evidenced globally as the internet has become an integral part of many peoples' daily lives, just as television and telephony did in past decades. The tools and techniques to enable trading over the internet are becoming mature, and EC is growing extremely rapidly around the world.

The internet's WWW has become the primary driver of contemporary EC. Gunasekaran (2002) defined EC as:

> . . . the process of conducting business electronically among various entities in order to satisfy an organizational or individual objective. A key ingredient is the advertisement and procurement of goods and services over the Internet.

EC and the internet, as the electronic medium, have the potential to:

- reduce actual transaction time and processing time;
- shrink distances and timescale;
- lower distribution and transaction costs, speed product development;
- provide more information to buyers and sellers; and
- enlarge customer choice and supplier reach.

EC can be defined from four perspectives:

(1) *Communication perspective*. The deliverer of information, products/services or payment over telephone lines, computer networks or any other electronic means.

(2) *Business process perspective*. The application of technology towards the automation of business transactions and work flows.

(3) *Service perspective*. A tool that addresses the desire of firms, consumers and management to cut service costs while improving the quality of goods and increasing the speed of service delivery.

(4) *Online perspective*. Provides the capacity to buy and sell products and information on the internet along with other online services.

The most applicable description of EC links it to trading: EC is trading by means of new communications technology. It includes all aspects of trading including commercial market creation, ordering, SCM and the transfer of money. At the application level, typical technologies include telephone, fax, electronic data

interchange (EDI), electronic mail, electronic funds transfer and the internet, more specifically the web.

EC extends existing business models and reduces costs while extending existing distribution channels and may even introduce new distribution possibilities. Within the virtual environment of the e-marketplace, EC enables completely new business models or gives them a much greater importance than they had before. Shopping agents, online marketplaces, and auction houses, which make comparison shopping or meditation of shopping processes into a business with its own significant revenue leads to the new task. The task for the new web customer is to find a shop that sells products one is looking for, acquire it in the desired quality and quantity and at the desired time, and to pay as little as possible for the product. From the technology arena, this happens by shopbots being developed that visit several stores, extract product information, and present it to the customer in an instant market overview. The wrappers use a keyword search, together with assumptions on regularities in the presentation format for stores' web sites and text extraction heuristics, to find information about the requested product.

This technology has two severe limitations:

(1) the effort of writing a wrapper for each online store and required extensive wrapper maintenance; and

(2) the product information extracted by shopbots using such technology is limited, error prone, and incomplete.

Current statistics revealed that two-thirds of the world's businesses now operate globally, in global markets, global operations, global financing, and global supply chains. Many components have supported this move to global business such as falling trade barriers, the proliferation of strategic alliances, such as joint venture, licensing arrangements, research consortia, supplier partnerships, and direct marketing agreement (Russell and Taylor, 2003).

Organizations utilizing EC have found that the open standards provided by internet technologies are easy to implement, quick to learn and fast and efficient to use. The capabilities and opportunities afforded by an internet-based electronic marketplace significantly improve the productivity and competitiveness of participating companies, whether they are suppliers or customers. The internet houses an online global marketplace that operates 24 h a day, with millions of sellers, buyers, products and services. Tables I and II (Gunasekaran, 2002) reflect what internet-based EC enables companies to do.

Operations management and e-supply chain management

Operations management deals with the design and operation of productive systems. The term "operations" is presented as "a function or system that transforms inputs into outputs of greater value." Considering there are many forms of operations, the transformation process may encompass:

- the physical, as in manufacturing operations;
- the location, as in transportation or warehouse operations;
- the exchange, as in retail operations; and
- the physiological, as in health care;

1. Shorten procurement cycles through the use of online catalogues, ordering and payment
2. Cut costs on both stock and manufactured parts through competitive bidding
3. Reduce development cycles and accelerate time-to-market through collaborative engineering, product, and process design, regardless of the location of participants
4. Gain access to worldwide markets at a fraction of traditional costs
5. Ensure that the product, marketing information, and prices are always up to date
6. Significantly increase the speed of communication, especially international communication
7. Drastically reduce purchasing and production cycles
8. Reduce the cost of communications directly and speed up communication can reduce inventory and related inventory and purchasing costs
9. Promote closer relationship with customers and suppliers, e.g. web sites enable companies to maintain customers and suppliers apprised of developments that concern them and practice effective relationship marketing
10. Provide a quick and easy way of exchanging information about a company and its products, internally and externally
11. Take advantage of alternative sales channels and tap new market niches

Table I.
Internet-based e-commerce functions

Organizational functional areas	E-commerce applications and/or contributions	E-commerce tools and systems
Marketing	Product, promotion, new sale channels, direct savings, reduced cycle time, customer services	B2B commerce, internet ordering, web site for the company
Purchasing	Ordering, fund transfer, supplier selection	EDI, internet-purchasing, EFT
Design	Customer feedback, research on customer requirements, product design, quality function deployment, data mining and warehousing	WWW integrated CAD, hyperlinks, 3D navigation, internet for data and information exchange
Production	Production planning and control, scheduling, inventory management, quality control	B2B, e-commerce, MRP, ERP, SAP, BAAN, Peoplesoft, IBM e-commerce
Sales and distribution	Internet sales, selection of distribution channels, transportation scheduling, third party logistics	Electronic funds transfer, online TPS, bar-coding system, ERP, WWW integrated inventory management, internet delivery of products and services
Human resource management	E-recruiting, benefit selection and management, training and education using WWW	E-mails, interactive web sites, WWW based multimedia applications
Warehousing	Inventory management, forecasting, scheduling of work force	EDI, EFT, WWW integrated inventory management
Supplier development	Partnership, supplier development	WWW assisted supplier selection, communication using internet (e-mails), research on suppliers and products with WWW and intelligent agents

Table II.
Application of e-commerce in operations

- the psychological, as in entertainment; or
- the informational, as in communication (Russell and Taylor, 2003).

For the purposes of this paper, operations management is presented in the paradigm of the electronic-business. Any form of trading transaction that occurs over the internet is considered "e-business." Electronic business can be business-to-business, which is communication and trade between businesses only, or business-to-consumer, which is communication and trade between businesses and consumers. The supply chain encompasses all activities associated with the flow and transformation of goods and services from the raw materials stage through to the end-user (customer), as well as the associated information flows. It consists of all the assets, information, and processes that provide supply.

SCM focuses on managing the flow of goods and services and information through the supply chain in order to attain the level of synchronization that will make it more responsive to customer needs while lowering total costs (Russell and Taylor, 2003).

E-SCM consists of the same components, but factors in the virtual exchange of information over the traditional exchange of telephones, fax machines, teleconferences and e-mails. E-supply consists of the additional networking associated with the functions of the suppliers, producers, distributors, and customers as associated with e-business models that leverage the internet to control the movement within the chain. E-supply chain innovators currently are using electronic connectivity to distribute and coordinate SCM processes across trading partners. The aim is to focus on core competencies and speed up existing cross-enterprise processes. Consequently, changing the way they sell by opening up new sales channels to customers – moving from pure "brick-and-mortar" to "click-and-mortar business models." At least four new generalized e-supply chain business models are emerging, which include virtual manufacturers, virtual distributors, virtual retailers, and virtual service providers. Lapide (2001) reported, "Virtual businesses also profoundly affect the way goods, services, and information flow within an e-supply chain, essentially decoupling physical flows from information flows." Table III (Lapide, 2001) lists the major types of information required to enable virtual business models.

Real-time coordination collaboration	Demand-supply
Information (joint order-fulfillment status)	Information (joint supply chain planning and scheduling)
Configuration information	Production schedules
Inventory availability	Sales forecasts
Sales order quotes	Inventory availability
Promise dates	Replenishment requirements
Sales orders with changes	Material requests
Acknowledgments	Logistical resource availability
Shipping dates	Shipment plans
Delivery dates	Promotional plans
Advance shipment notices	Product design and specifications
In-transit status	New-product introduction plans, merchandising plans

Table III.
Information needed to enable virtual business models

Badoc (2001) stated that:

> Rapid order fulfilment puts manufacturing at the heart of supply chain performance. The plant is where all elements of the supply chain come together, where planning, marketing sales, purchasing and distribution coalesce into items of exchange that have value to the end-customer.

Therefore, information arising from the process of manufacturing-specifically detailed, accurate, real-time production status information has value to partners across the supply chain. Plant systems software vendors have begun to recognize the importance of varying the contextual presentation of plant-centric information generated by application processing software, which accesses what is required to add value beyond the confines of the walls of a plant. Some have begun to add the necessary intelligence to ensure greater contextual range, along with the intelligence to disseminate information as rapidly as possible to ensure that it can make a difference. This is relevant regarding event-trigger circumstances in which a collaborative decision must be made to recalibrate production scheduling to meet customer order expectations.

This development of intelligence that leads to a greater contextual range will be a main precursor that precludes an organization's ability to support semantic markup. As the ontology for semantic markup continues to evolve and the search capabilities become more "intelligent," e-business participants will be able to utilize the speed of the semantic web in each part of the chain. E-businesses that have not realized this important issue, as they plan for future business, will fall severely behind the curve in the competitive e-marketplace.

Within the business environment on the global scale, the push for workers to "work faster" is ever prevailing. In the electronic manufacturing services industry, "faster" means satisfying customer demands as soon as orders arrive or even sooner. This instant gratification is what's behind the push to integrate web-based processes into the supply chains. Basically, when an end-user wants a product, competitive issues force the entire chain to react with lightning speed (Briant and Mraz, 2000). The latest crops of software solutions are helping the industry move towards that once unreachable goal – visibility of the entire supply chain (*Food Logistics*, 2001). It is widely believed that the company most closely aligned to end-users at the point of sale will eventually become the channel master and control its supply chain. Over the past few decades, power has shifted away from manufacturers and toward retailers in consumer markets and toward end-users in industrial markets. Over time, electronic connectivity afforded by the internet and WWW is expected to change supply chain control drastically. Innovative companies or those who are termed "e-supply chain innovators" (e-SCIs) will gain control by reconfiguring their supply chains by using new e-business technology to connect to trading partners.

Supply chain collaboration across the internet is not as simple as everyone thought it would be. One reason is that context, not content, is the most important aspect of the information that's made available to stakeholders. Context is fast becoming the ruling principle for successful e-supply chain execution. Supply chain collaboration on the web has proven more difficult than people realized, despite a voluminous real-time exchange of information. Supply chain networks are designed principally to serve the objective of rapid fulfillment of customer demand. Real-time electronic connectivity will enable e-SCIs to execute integrated, cross-enterprise processes with trading partner operations. This capability will move these leaders from enterprise-centric

supply chains toward synchronized, electronically connected supply chains where one process drives multiple enterprises. Over time, electronically connected supply networks will include not only traditional players such as suppliers, manufacturers, and distributors, but also a number of non-traditional intermediaries. Included among these nontraditional players are contract manufacturers, virtual manufacturers, virtual distributors, virtual retailers, virtual service providers, fulfillment service providers, and hosted online trading exchanges such as digital marketplaces. Some of these new internet-savvy intermediaries may never own assets or take ownership or touch a single good on a physical basis.

Firms are increasingly embracing integrated web-based or e-supply chains because such chains are believed to enhance efficiency and competitiveness. Although the e-supply chain movement has received a significant boost from a variety of off-the-shelf supply chain software solutions, the creation and implementation of integrated supply chains requires tremendous resources, significant management time and energy. It also requires large organization-wide changes, huge commitment from suppliers and partners, and sophisticated technical infrastructure (Somendra *et al.*, 2003). Frameworks and business models must be carefully thought out and developed. Important issues to be addressed relative to web-enabled supply chain and the e-marketplace remain due to the grim reality that many e-marketplaces vanished from the e-business scene as quickly as they appeared within the past decade. These e-businesses were victims of poor business models, low customer adoption rates and waning venture capital. Survivors of the fall of the e-marketplace industry have retooled their business frameworks and processes.

Organizational checklist for readiness of e-supply chain participation

Recent research from the Council of Logistics Management (2003) provided a practical hands-on approach for logistics management to leverage modern technology, particular to the use of the internet, with best features of advanced SCM techniques. A survey to measure order performance (invoices shipped complete/total invoices) revealed that speed and visibility were two key factors in an organization's ability to differentiate between "best" and "average" customers (Mazel, 2001). Survey participants reported the minimum expected time to acquire raw materials into their process is approximately 18 days. The replenishment cycle was longer, taking on average of up to 30 days. The demand for speed is evidenced in the frequency of customer orders. Among the respondents, almost 40 percent report that their best customers ordered on a daily basis, while an additional 22 percent ordered two or four times a week, suggesting the dilemma. As firms invest in tools and processes to enable customer to place orders on a daily basis, there is still a tremendous lag time of 18 to 30 days before orders are received and the fulfillment process is completed. Real-time adaptability provides firms with a tangible advantage by enabling them to get to market faster than their competitors. Thus, further proof that soon there will be a great divide between e-businesses: those who are ready to support the semantic web and those who are not.

Components of the e-supply chain

Many steps will have to be taken before an online business participant will be able to benefit from the increased efficiency and faster transaction time semantic web intelligent

mark up technology will provide. A few components of operation management that affect the supply chain are EDI, just in time (JIT), and quick response.

Electronic data interchange

EDI is computer-to-computer exchange of business documents without human intervention. EDI is integrated in a company's EC system. EDI helps to reduce inventory, foster JIT management, promote engineering interchange, and improve work scheduling. Companies that have implemented EDI reported benefits of expedited purchasing processes, reduced transaction cycle times, higher inventory turnovers, faster response times, and overall improved service.

Just in time and quick response

JIT systems are computer systems that enable companies to produce and deliver finished goods "just in time" to be sold. JIT is the idea of producing only necessary units in the necessary quantities at the necessary time. A type of JIT system used in the fashion industry is called quick response. Quick response creates electronic connections that link companies to the production and distribution chains. Quick response is a two-way system: one direction speeds the apparel down through the distribution channels, and the other direction feeds back results to each of the companies on the electronic chain. As a result, all levels of the fashion industry, from suppliers of fibers to the mills that weave these fibers into fabric, to the factories that sew garments, to the retail stores that sell the garment, to the consumer are connected to in the electronic chain (Barnes, 2003). Several different technologies are used in the quick response communication process. These technologies include the bar code standard, portable computer terminals, scanners for data collection, established data communication formats, and networked organizations. By combining all types of electronic and computer-mediated-technologies, the fashion industry has developed a new way of doing business and created electronic partnerships among suppliers, producers, distributors, and retailers. Software is currently being developed and coded to work with semantic markup that will connect the information of these components in a much faster time than current web technology supports.

Multi-agent system

While search engines have become the major decision support tools for the internet, there is a growing disparity between the images of the WWW stored in search engine repositories and the actual dynamic, distributed nature of web data. In a study, which proposed to attack this problem using an adaptive population of intelligent agents mining the web online at query time, discussion of the benefits and shortcomings of using dynamic search strategies versus the traditional static methods in which search and retrieval are disjointed was conducted (Menczer, 2003).

Research presented a public web intelligence tool called MySpiders, which is a threaded multi-agent system designed for information discovery. The performance of the system was evaluated by comparing its effectiveness in locating recent, relevant documents with that of search engines. Results suggested that augmenting search engines with adaptive populations of intelligent search agents could lead to a significant competitive advantage. The realization led to the matter of the challenges of evaluating such a system on current web data along with the introduction of three novel metrics for this purpose.

Multi-agent systems require adaptability to perform effectively in complex and dynamic environments. Agents should be able to benefit from dynamically adapting their decision-making frameworks. A decision-making framework describes the set of multi-agent decision making interactions exercised by members of an agent group in the course of pursuing a goal or set of goals. The decision making interaction style an agent adopts with respect to other agents influences that agent's degree of autonomy (Barber and Martin, 1999).

The complex and dynamic characteristics of many problem domains challenge multi-agent systems to be adaptive and flexible while producing consistently effective and efficient solutions. Previous research suggests a broad range of adaptation mechanisms useful for agent-based systems. Barber *et al.* (2000) proposed that agents should, in addition, dynamically adapt their decision-making interaction styles to their run-time situation. This type of adaptation occurs at the organizational level and constitutes a form of organizational restructuring in which the control relationships among agents are allowed to change during system operation.

Algorithms

Technologies for web services facilitate the creation of business-process solutions in an efficient, standard way; however, the automation of process integration with web service technologies requires the automation of discovery and composition of web services. There are two existing problems of the web service-based business process integration:

(1) the discovery of web services based on the capabilities and properties of published services; and

(2) the composition of business processes based on the business requirements of submitted requests (Juhnyoung and Park, 2003).

A proposed solution to these problems comprises multiple matching algorithms. A micro-level matching algorithm, which matches the capabilities of services with activities in a process request; and macro-level matching algorithms, which are used to compose a business process by identifying services that satisfy the business requirements and constraints of the request. The solution from the macro-level matching algorithms is optimal in terms of meeting a certain business objective, e.g. minimizing the cost or execution time, or maximizing the total utility value of business properties of interest. The existing web service standards, UDDI and BPEL4WS, can be used and extended to specify the capabilities of services and the business requirements of requests, respectively.

Information filtering via metagenetic algorithms

The implementation of evolutionary techniques for information filtering and collection from the WWW will tie into the semantic web. Intelligent agents will be built to facilitate a person's search for information on the web. A study by intelligent agents has been developed that uses a metagenetic algorithm in order to collect and recommend web pages that will be interesting to the user. The user's feedback on the agent's recommendations drives the learning process to adapt the user's profile with his/her interests. The software agent utilizes the metagenetic algorithm to explore the search space of user interests. Experimental results are presented in order to demonstrate the suitability of the metagenetic algorithm's approach on the web (Zacharis and Panayiotopoulos, 2001).

Shopping bots

Other types of search capabilities engage agents designed to assist consumers in product identification and comparison over the WWW are known as shopping bots. These intelligent agents are a type of shopping aid (Rowley, 2000). Some internet shoppers use online shopping aids to help them search for products and services, and to assist them in making in-depth comparisons among alternatives. A study presented that in comparison of information on salient criteria (i.e. price) from multiple vendors of a specific product, online shopping aids can increase the number of alternatives considered, while reducing search time and costs (Vijayasarathy and Jones, 2001).

Accounting information systems

Accounting information systems provide the logical intersection of the broad fields of accounting and MIS. The purpose of accounting, broadly defined, is to provide information for economic decision making. The domains of external and internal reporting, tax, and assurance services are the major fields of inquiry within accounting. The field of MIS, again broadly defined, addresses the design, implementation, use and management of information systems. AIS coincide with four categories of research issues:

(1) existing accounting research with an IT orientation;

(2) research of new and unexplored IT-orientation;

(3) existing MIS research with an accounting orientation; and

(4) new IT-oriented accounting topics not explored in an MIS context (Murthy and Wiggins).

Emerging areas of AIS are electronic commerce, inter-organizational systems (EDI, extranets), modeling of accounting systems, online analytical processing, proactive information systems, supply chain management, virtual private networks, and software engineering and software metrics. Accounting information systems will be another component affected by the shift to the semantic web, as the research capabilities of the ontology will streamline search capabilities, allowing AIS to work faster.

Conclusion

Research has indicted that the semantic web is the future web. Content on the internet will be structured so those computer software agents can carry out sophisticated tasks for users. The semantic web will promote the eventual creation of programs that collect web content from diverse sources, process the information and exchange the results with other programs. Business-to-business areas may become the most important application area of semantic web technology in terms of the market volume within the next decade. Semantic web technology will work with XML, which will enable EC by:

- defining languages that provide support in defining, mapping, and exchanging product data;
- functioning from the development of standard ontology that will cover various business areas; and
- utilizing efficient translation services that will require areas of standard ontology.

For most users, the main function of the WWW involves the search engine and its capability, in the generalized sense, to match bit patterns to one another. The semantic

web will use three keys, similar to how the English language uses a subject, verb, and object. To simplify, the three keys will work together to define metadata. Using the metadata, search engines will be able to find more precise, detailed information, because the metadata acts as a triplet of matching capability. The semantic web will be composed of different layers, just like TCP/IP, where the layers interact with the layers above and below it. The semantic web will interact with much more detailed information, not just socket or port packet transfer communications. This web is not just passing the information back and forth across the network layers, but is "knowledgeable" about the data. The semantic web will actually review the data in the packets crossing the network layer, instead of merely passing it across the network, thus the difference from the existing WWW's limited abilities.

Participating businesses will be much better off, because users will be able to define attributes to search for, consequently, more precise information will be found. Within the e-supply chain paradigm, the virtual business person will be able to go into a supplier or vendor's web service with the click of a mouse to conduct all ordering instead of using a phone, fax or e-mail system to locate product. The work will be done using the "knowledge and intelligence" of semantic markup, which will enable quickly defined searches that will be acutely defined to the product details in demand. A businessperson could have the ability to be the first to market a product because he or she would not have to deal with the usual resistance of waiting for calls and responses back from vendors. Within a matter of seconds, an order will be able to be placed, have the ability to do accounts payable and accounts receivable, transfer funds from business-to-business to pay for the order, and retrieve payment from a financial account.

In order for e-businesses to integrate their e-supply chains into semantic web technology in support of the new web, business processes will have to be analyzed and retooled, frameworks developed, and information techniques updated to accommodate XML. A large percentage of traditional SCM will migrate to the e-supply chain, where web-enabled supply chain execution will have to be a certainty for any company or industry to survive. E-supply chain innovators will gain control over industry sectors by reconfiguring their supply chains by using e-commerce technology to connect to trading partners.

Semantic web searches will allow the user to search for intelligent data within the web page that searches to three variables, XML, RDF, URIs. Characteristics have been presented as to how the application, and many like it, will need to visit web sites with quite heterogeneous structures, often from different industries that will need to retool business models and re-establish standards that will make this kind of web information computer-processable. The augmentation of search engines with adaptive populations of intelligent agents will lead to significant competitive advantage in the virtual business world. As with any other technological shift in past decades, the shift to the semantic web will be a bumpy one. Those business participants who are aware that the change is coming and have taken care of necessary setup, within their e-commerce environments, will definitely have the competitive advantage in the e-marketplace of the near future.

References

Badoc, J. (2001), "The context of e-supply chain management", *Industrial Management*, Vol. 43 No. 5, pp. 20-5.

Barber, K.S. and Martin, C.E. (1999), "Agent autonomy: specification, measurement, and dynamic adjustment", paper presented at Autonomy Control Software Workshop, Autonomous Agents 99, pp. 8-15.

Barber, K.S., Goel, A. and Martin, C.E. (2000), "Dynamic adaptive autonomy in multi-agent systems", *Journal of Experimental and Theoretical Artificial Intelligence*, Vol. 12 No. 2, pp. 129-47.

Barnes, S. (2003), *Computer-Mediated Communication: Human-to-Human Communication Across the Internet*, Pearson Education Inc., Boston, MA.

Berners-Lee, T. (2001), "The semantic web", *Scientific American*, Vol. 284 No. 5, pp. 1-10.

Berners-Lee, T. and Fischetti, M. (2000), *Weaving the Web: The Original Design and Ultimate Destiny of the World Wide Web*, Harper Business, New York, NY.

Bradbury, D. (2003), "Unweaving the tangled web of dumb data", *Computer Weekly*, Vol. 10, pp. 1-7.

Briant, J. and Mraz, S. (2000), "Making sense of the e-supply chain", *Machine Design*, Vol. 72 No. 19, pp. 62-7.

Council of Logistics Management (2003), available at: www.clm1.org

Fensel, D., Hendler, J. and Lieberman, H. (Eds) (2003), *Spinning the Semantic Web*, The MIT Press, Cambridge, MA.

Food Logistics (2001), "The coming e-supply chain", *Food Logistics*, Vol. 42, pp. 17-25.

Gunasekaran, A. (2002), "E-commerce and its impact on operation management", *International Journal of Production Economics*, Vol. 75, pp. 168-97.

Juhnyoung, L. and Park, M. (2003), "Integration and composition of web service-based business processes", *Journal of Computer Information Systems*, Vol. 44 No. 1, pp. 82-93.

Lapide, L. (2001), "Innovators will control the e-supply chain", *Supply Chain Management Review*, Vol. 5 No. 2, pp. 23-30.

Lloyd, P. and Boyle, P. (1998), *Web-Weaving Intranets, Extranets and Strategic Alliances*, Butterworth-Heinemann, Oxford.

Mazel, J. (Ed.) (2001), *IOMA's Report on Managing Logistics*, Vol. 11 No. 1, pp. 9-15, available at: www.ioma.com/

Menczer, F. (2003), "Complementing search engines with online web mining agents", *Decision Support Systems*, Vol. 35 No. 2, pp. 195-213.

Murphy, S. (1999), "Electrified finance systems speed up e-transactions", *Computing Canada*, Vol. 52 No. 6, pp. 1-4.

Murthy, U. and Wiggins, C. Jr (1999), "A perspective on accounting information systems research", *Journal of Information Systems*, Vol. 13 No. 1, pp. 1-5.

Rowley, J. (2000), "Shopping bots: intelligent shopper or virtual department store?", *International Journal of Retail & Distribution Management*, Vol. 28 No. 6, pp. 297-310.

Russell, R. and Taylor, B. (2003), *Operations Management*, 4th ed., Prentice-Hall, Upper Saddle River, NJ.

Somendra, P., Sethi, R. and Bhandari, M. (2003), "E-supply chain", *International Journal of Information Management*, Vol. 23 No. 3, pp. 201-23.

Vijayasarathy, L. and Jones, J. (2001), "Do internet shopping aids make a difference: an empirical investigation", *Electronic Markets*, Vol. 11 No. 1, pp. 75-84.

Warren, P. (2003), "The next steps for the web: putting meaning into the web", *Computing & Control Engineering*, Vol. 1 No. 2, pp. 27-35.

Zacharis, Z. and Panayiotopoulos, T. (2001), "A metagenetic algorithm for information filtering and collection from the world wide web", *Expert Systems*, Vol. 18 No. 2, pp. 99-109.

Further reading

Davies, J., Fensel, D. and Harmelen, F. (2003), *Towards the Semantic Web*, Wiley, Chichesler.

Herman, A. and Swiss, T. (Eds) (2005), *The World Wide Web and Contemporary Cultural Theory*, Routledge, New York, NY.

Corresponding author

Joseph S. Sherif can be contacted at: jsherif@fullerton.edu