Enhanced supply chain management for e-business transactions

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Abstract

This paper reports on the development of an open supply chain management system that is able to support the e-business activities of a contemporary enterprise. The system was first built to address the needs of a Greek textile industry and successfully integrated a workflow management module, a demand-side transactions module and a supply side transactions module with the company’s legacy ERP system. The paper discusses technical issues concerning the development of the overall platform, which is able to efficiently support e-business transactions, independently of the underlying technology and communication protocols used from the related parties. Particular attention is paid to the presentation of the benefits arising from the improvement of supply chain management. The proposed approach aims at increasing the service level and establishing a cooperative environment among all parties involved, while reducing the transactions costs through the appropriate process automation and decreasing the company’s inventory levels due to faster transactions.

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1. Introduction

Information and communication technologies certainly play a pervasive role in the supply chain of an enterprise, since all related activities create, use and share information. At the same time, the growing sophistication of these technologies is a powerful force in opening up possibilities for interrelationships. This has to be considered together with current market and business changes, which compel companies to establish fast, continuous and secure interactions with their trading partners, be they customers or suppliers.

Efficient information integration plays a key role in supply chain management, while coordination of the supply demand relationship, by managing the flow of materials and products and the flow of information with flexible control and feedback mechanisms, is also an important issue (Thomas and Griffin, 1996; Albino et al., 2002; Claudio Garavelli, 2003). The establishment of an open supply chain management system creates opportunities for further improvements in the companies involved. Appropriate linkages may enable enterprises to fundamentally alter their supply chain relationships (Tang et al., 2001) and facilitate reduced inventory requirements. This is
due to the improved information coordination capability of such an infrastructure. As comprehensively discussed in Lieb (2000), companies increase the trend toward outsourcing their inbound and outbound logistics. Thus, efficient exchange of logistics information between shippers, third party logistics providers and buyers is enhanced, leading to streamlined production planning systems and reduced inventory requirements. In addition, such an approach enables companies with new modes of supply chain information flows. As highlighted in Warkentin et al. (2000), such flows were traditionally linear, from one firm to its immediate suppliers or immediate distributors. In other words, information beyond one link in the chain was constrained by lack of formal relationships and did not convey efficiently due to a lack of data representation schemes.

Modern business models and practices require dynamic and easily accessed services (Timmers, 1998). The wide and rapid adoption of Internet is re-setting the rules of how people interact, buy, sell and exchange goods and services. Contemporary ways of trading, allowing interaction between groups that could not so far economically afford to trade with each other, have been introduced. Whereas previously commercial data interchange involved mainly the transmission of data fields from one computer to another, the new model for web-based business, introduced by the advent of the Internet, is typically dependent on human interaction for the transaction to take place. The new model is principally based on the use of interactive selection of a set of options, and on the completion of electronic forms, to specify user profiles, queries, requirements, etc. To be fully interactive, a company needs to be able to understand the business concepts represented in the interchanged data, and apply business-specific rules to trigger the appropriate actions.

Addressing the issues listed above, this paper reports on the development of an open supply chain management system that is able to support the e-business activities of a contemporary enterprise. The system automates efficiently intra-business, business-to-business and business-to-customer processes, while aiming at assisting all parties involved (i.e., customers, suppliers and employees of the enterprise). Section 2 presents the basic components of the proposed system and their integration with a legacy Enterprise Resource Planning (ERP) system of the enterprise. Section 3 discusses various supply chain management issues paying particular attention to the presentation of the benefits arising from the adoption of the system. Finally, Section 4 concludes the paper.

2. The integrated platform

This section reports on the development of the proposed system for the needs of a medium-scale textile enterprise in Greece. Before heading to e-business, the company was running a customizable ERP system, namely the Atlantis ERP by Unisoft S.A. (for more, see http://www.altec.gr/gr/altec.asp?aid=20), for about seven years. It should be noted here that this was not fully exploited, in that neither all of its features and abilities were activated nor all business parts were being monitored. Market and business changes, such as increasing competition and shortening of products life cycle, led the company to the decision that they need to heavily invest in contemporary information technologies to both keep its status and gain competitive advantages. It was clear that such technologies would efficiently aid them to communicate, collaborate, and conduct business activities such as marketing, billing, and continuous customer service. In addition, on their way to embark on e-business, the company needed to exchange data with their trading partners, who may be using different platforms and a variety of data formats. For that, it was necessary to leverage their IT investments and integrate legacy data, residing in the existing application.

2.1. Analysis and design issues

To make business transactions more efficient, two major issues had to be considered in detail: the technology that a system able to address the above changes should be based on, and the underlying business processes of the company (Froehlich et al., 1999). The system envisioned certainly had to fit
the overall organizational context and be flexible enough to easily address arising opportunities. The global expansion of communication infrastructure should also be exploited, since it could provide the company with the potential of creating competitive advantages by electronically doing business with their trading partners, being they customers or suppliers.

To efficiently represent the information flow in an e-business oriented enterprise system, a company has to consider whether its trading partners already use an enterprise system or even have any experience in doing any kind of business electronically. If not, applications delivering the required functionality via a standard browser over the Internet seemed to be the most appropriate solution (Karacapilidis and Sideridis, 2001). The justification was that such an application could always be kept up-to-date, while there would be no need for any installation at the partner’s site, since they would only need to establish a connection to an Internet Provider. In addition, a web-based application could be accessible from anywhere, thus relieving the restriction of only using the user’s regular desktop. Another argument was that, following such an approach, the company could maintain a closer communication with its partners, in that all parties would become a part of each other’s operations and activities. For instance, problems experienced by a customer could be immediately reported to the company, either directly or through the foreseen application’s centralized database, thus avoiding unnecessary delays.

In case that one or more trading partners of the company already used an enterprise system, things are more complicated since these might run on different platforms and/or use different data formats (Bakos, 1991). What needed is to think about a solution that could integrate legacy data, residing in the existing applications. The computer-to-computer transfer of business information, known as Electronic Data Interchange (EDI), was first considered. EDI is traditionally based on a collection of standard message formats and elements dictionary and has provided businesses with a way to exchange data via any electronic messaging service. However, it was concluded that adoption of EDI implies certain tasks and limitations. First, the company would have to conduct a thorough analysis to determine precisely how they are going to move their business data to and from the predefined EDI formats. At the same time, what needed was flexibility in doctrinaire standards that do not fully meet their business needs.

### 2.2. XML and EDI issues

A series of industrial standards and tools have been already developed around the XML (eXtensible Markup Language) syntax. XML was developed by the World Wide Web Consortium (W3C, see http://www.w3c.org) and can efficiently aid companies embark on e-business, in that it provides the appropriate data format for the related applications (Glushko et al., 1999). More specifically, XML may convey both the contents and structure of a business document, and it has rapidly imposed itself as a popular format for representing business transactions on the web. At the same time, it is fully flexible, in that it allows a company to set up the document structure that best fulfils its business needs. The structure of an XML document can be formally described in a Document Type Definition (DTD) or an XML schema, whereas appropriate software tools can validate an XML document against a DTD or a schema definition.

A representative example of the use of XML in our framework is given in Fig. 1. The left part of the figure illustrates the XML schema used to represent an order (schemas describe the structure of an XML document), while an XML file corresponding to a specific order of a customer is shown in the middle part. Having built the appropriate accompanying CSS (Cascading Style Sheets) file, a user is able to view this order (through a web browser) in a much more convenient mode, as that shown in the right part of the figure.

Taking the above into account, our approach was built on the well-tried combination of EDI and XML technologies (Webber, 1998). The proposed framework can efficiently support interaction and cooperation between various types of companies, while the required functionality is
delivered over the Internet. The system can efficiently support communication with companies that have their own legacy, EDI-based, enterprise systems. Moreover, all types of interaction with such systems do not affect the traditional working methods of the related companies.

Another feature of the system is that it can easily support communication with partners who do not have an IT background or previous experience in using an enterprise system. In addition, our approach is based on the use of interactive selection of a set of options and on the completion of user-friendly electronic forms. Such forms avert users from making mistakes and are easily completed. This is basically achieved through well-designed drop-down menus and selection methods such as clickable boxes and buttons.

The proposed approach also provides the appropriate XML schemas and modules to support business-to-business interaction. These can be exploited and seamlessly integrated with the enterprise system of a company to initiate a series of related actions. Finally, due to the advantages of XML, in that it can be adapted according to the needs of various systems and users, our platform is based on an open architecture that can be easily extended to address alternative data formats and structures.

Messages sent and received by the system are in XML format. In cases where a supplier’s enterprise system is based on EDI, the appropriate
conversion is taking place. All messages submitted and received by such companies adhere to their legacy EDI format. The overall system provides any-to-any format transformation and multiple communication protocols. In other words, it overcomes the limitations of classical EDI and provides an enterprise with alternative ways of performing electronic transactions.

2.3. Implementation issues

The supply chain management system proposed consists of three main modules (see Fig. 2), which deal with the internal workflow management, the demand side transactions (being held between the company and its customers) and the supply side transactions (being held between the company and its suppliers). In the rest of this section, we provide a brief presentation of their specifications together with some technical details of the underlying technology.

2.3.1. Internal workflow management module

This module mainly deals with the processes, and the related documents accompanying them, that are triggered by the reception of an order from a customer. It is based on clearly specified business models of the company under consideration; however, it has been kept open and extendable to address the requirements of any other enterprise. Information related to an incoming order is embedded in the company’s existing ERP system, which in the sequel issues the necessary production orders. Similarly, ERP provides the module with the input needed to monitor the route of an order throughout the company’s production units.

The module relies on Microsoft’s BizTalk Server 2000, which has been successfully tested in various enterprise settings (more than 1800 organizations have already adopted it to integrate applications and processes across the Internet, see http://www.microsoft.com/biztalk/evaluation/customers). BizTalk Server 2000 provides all tools and methodologies needed for the transformation and routing of business documents, as well as monitoring of the related processes. Moreover, it has been extensively reported that BizTalk Server 2000 reduces the development time and cost of integration.
projects; this is basically due to the provided support for industry standards (such as EDI and XML) as well as to its library of more than 300 adapters for popular applications and technologies. In our case, exchange of documents is done in W3C-standard XML (Glushko et al., 1999), while all document transformation follows the W3C-standard XSLT (Extensible Stylesheet Language Transformations).

Among the tools provided and integrated in our platform are: (i) **BizTalk Messaging Manager**, which automates the process of setting up trading profiles and agreements to exchange business documents with applications and trading partners over the Internet. This management technology is based on a graphical user interface (Fig. 3, top); (ii) **BizTalk Orchestration Designer**, which provides a visual environment to design and build dynamic distributed business processes (Fig. 3, bottom); (iii) **BizTalk Editor**, which easily creates and edits XML document schemas (Fig. 4, top); (iv) **BizTalk Mapper**, which easily transforms one schema into another generating W3C-standard XSLT files for transforming documents (Fig. 4, bottom).

### 2.3.2. Demand side transactions module

This is a web-based application, through which customers can put an order by filling in some specially designed forms. Moreover, the module allows customers to monitor the status of an order, view the pricing lists and offers of the company, and consider his/her personal account files. Much attention has been paid to keep the related user interface as friendly as possible. The tool is also based on XML technologies and relies on
Microsoft’s Commerce Server 2000 and SQL Server 2000. The tool is fully customizable to the needs of any user involved, providing easy user profiling and management, transaction processing, product and service management, and targeted marketing and merchandising.

Commerce Server 2000 admittedly offers an easy way to build tailored and effective e-commerce solutions. By providing the application framework, together with sophisticated feedback mechanisms and analytical capabilities, it allows for quick development of sites that optimize the customer experience and help establishing closer relationships among the trading partners. More specifically, Commerce Server 2000 provides features for user profiling and personalization (allowing the association of a user’s profile with the processes of content delivery), catalog management, order processing, globalization (ability to work with multiple languages and currencies), and analytical business reports. Its basic tools comprise: (i) Business Desk, which provides the means for a centralized, web-based management of users, products and services, and marketing campaigns; (ii) Profile System, which handles issues such as authentication to use a site and advanced targeting and personalization of users; (iii) Business Processing Pipeline System, which helps in tailoring orders and merchandising processes to fit the users requirements, while being able to easily modify them upon business changes; (iv) Product Catalog System, which is able to manage millions of
products, offer custom catalogues, etc., and (v) a set of development and administrative tools and pre-built business components.

Finally, SQL Server 2000 has been proven to be an ideal platform for launching the above set of applications. Its basic features include reliability, robustness, industry-leading performance, scalability, and appropriate management tools. In addition, it provides rich support for XML, easy Web access to database information, and powerful analysis tools, coupled with high availability and tight security. As argued in a recent report of the eWeek magazine (Dyck, 2002), SQL Server 2000 has the simplest and easiest-to-deploy Web services features, through its free and fully supported SQLXML add-on. More specifically, SQLXML allows data to be returned to clients making Web service calls to an SQLXML-enabled Web server. Simple queries can be published as Simple Object Access Protocol (SOAP) services (http://www.w3.org/TR/SOAP), and customers are able to transform output XML data before sending it back to the caller.

2.3.3. Supply side transactions module

This module manages the electronic interchange of business documents with the suppliers, thus fully covering the supply chain of the company. In its current version, the tool is not based on the web; instead, it offers data mediation services among the information systems (i.e., ERPs) of two enterprises. A drawback arising here is that the supplier companies should have a satisfactory level of information technology infrastructure. However, future versions are planned to be fully web-based, in line with the demand side transactions module described above. As illustrated in Fig. 2, integration of the three modules described above takes place through the Microsoft’s Biztalk Server 2000.

Whenever customers want to interact with the enterprise, they have to fill in the appropriate web forms and submit a message to the system. Messages sent through the web interfaces may be also converted to any known format required. Additionally, the system is able to handle documents of any type, thus providing flexibility for future extensions. As made clear from the above, the proposed framework by no means affects the existing trading partners. There will be no change in the working methods they use, nor they will need any extra software or hardware resources. On the other side, customers will only need Internet access and a web browser to interact with the company. The web forms designed provide them with a user-friendly interface, thus such companies will not need much effort and investments to get fully acquainted with the proposed way of doing business.

The proposed framework relies on two servers using the Microsoft’s Windows 2000 Advanced Server operating system. One of them stands for the system’s front-end (web server) running Microsoft’s Commerce Server 2000 and BizTalk Server 2000 applications, while the other for the system’s back-end (database) running SQL Server 2000. The 3-tier architecture of the proposed system is illustrated in Fig. 5.

To give a better insight on the inter-working of the proposed system’s components, consider the case of an incoming order. Through the appropriate web forms, a customer is able to easily submit his/her order. The corresponding business document (in XML format) is received from the Demand Side Transactions Module. BizTalk Server 2000 then handles the routing (and transformation, whenever needed) of this document, according to processes defined with the help of Orchestration Designer. In the case of an incoming order, the company’s legacy ERP system is activated together with the Internal Workflow Management Module. These two modules collaborate in order to issue the necessary production orders. In case that there is a need for replenishment, BizTalk also activates the Supply Side Transactions Module. Generally speaking, BizTalk Server enables the overall platform to achieve integration of the legacy ERP system with the above three modules through the processes of document transport and routing, data transformation, application integration, and process automation.

2.4. Evaluation results

According to the company’s requirements, the integrated platform should efficiently support
interaction and cooperation between various types of partners (customers and suppliers), while the required functionality should be delivered over the Internet. There was no doubt that the need to exchange information was critical within the company’s business community. The company was earlier convinced that, by integrating computers and data communications into the business process, they could benefit from exchanging information electronically, in that they reduce paperwork, minimize cost and improve response time. The system was implemented in about 15 months. For its implementation, all employees of the IS Division were involved, while two more experienced people, working at a big software house, were hired for part-time work. As described above, the system integrated a set of off-the-shelf tools, thus assuring a robust, scalable and fast development cycle. The major challenge during the implementation was to provide the company with new levels of flexibility, while helping their partners rewrite the rules of their business, and ensure the functionality needed to respond rapidly to future changes. The component-based approach followed was in line with current trends of the development of e-business enterprise systems. As a drawback of the tools adopted in our approach, we mention here that the company has to use a Windows server, which is admittedly less scalable compared with a server running on Unix. Furthermore, as concluded in Fan et al. (2000) regarding various development tools for an enterprise system, there is still room for more sophisticated decision support and coordination mechanisms.

Both during the implementation and at the completion of the project, the employees of the IS Division had to make all users involved in the system aware of what is going on and recognize the advantages and prospects of the new approach. They had to attract their interest and cooperate with them in order to result to a fine-tuning of the system. Upon completion, a 2 weeks training program was performed. The first evaluation results show that the development of the system was a success and a reward of the IS Division manager expectations. Cooperation of all parties involved during the project’s development, exploitation of their expertise and adoption of well-tried and open solutions were certainly the major factors that led to that. Moreover, managerial implications have been only positive till today. The serious involvement of the company’s personnel (from all operational, knowledge, management and strategic level) from the early development
phases gave them the opportunity to reconsider their traditional work practices. Even these that were not fully convinced about the necessity to go ahead and develop the system have only good comments to make today. System users acknowledge the appropriate synchronization of the internal and external work and data flows, improvement of supply chain management, reduction of transactions costs through the appropriate process automation, reduction of errors occurring during the handling of business documents, existence of accurate and on-line information, reduction of the company’s inventory levels and, finally, establishment of a highly cooperative environment between the company and its customers and suppliers. The close cooperation of the development team with all parties involved, both during and after the project’s development, eliminated any misrepresentations of what the system could deliver and in what frame.

Perfective and adaptive maintenance of the system impose problems and challenges the company has to currently face. Most of it concern the Supply Side Transactions Module. As stated in a previous section, one problem was that the supplier companies should have a satisfactory level of information technology infrastructure. Regarding this module, the next version is planned to be fully web-based (in line with the Demand Side Transactions Module). There is also ongoing work on improving the user interfaces of the Demand Side Transactions Module; such improvements concern the, as easy as it could get, completion of the related forms and the expansion of the services offered. Finally, much attention is being paid in both redesigning the reports currently offered and offering additional ones (to all company’s division managers), the aim being to fully exploit the data now stored in the system’s database and further aid decision making processes.

3. Supply chain management issues

This section comments on the major benefits emerged after the installation of the proposed system. These concern the improvement of the buyer–supplier relationship, the reduction of production costs through a more efficient and up-to-date production planning, and the more efficient inventory management.

3.1. Improvement of the buyer–supplier relationship

All organizations have to obtain resources and provide goods or services; this is what is known as the supply chain, value chain or value system of an organization (Porter, 1985; Raedels, 1995; Shepherd, 1998). Value chain analysis describes the activities within and around an organization, and relates them to an analysis of the competitive strength of the organization (or its ability to provide “value-for-money” products or services). The buyer’s first responsibility in source selection is to develop and manage a viable source base. Once such a base is available, the buyer or sourcing team can focus on selecting the right source of supply. While purchasing and supply management has the ultimate responsibility for selecting the “right” source, the selection process can be handled in many ways (Dobler and Burt, 1996; Leenders and Flynn, 1995).

Contrary to the legacy ERP system, where purchasing and supply management was a manual and cumbersome task, the proposed web-based platform facilitates the early supplier involvement. This is an accepted practice in many contemporary firms. After developing a comprehensive list of potential suppliers, the buyer’s next step is to evaluate each perspective supplier individually. Through an elimination process, a list of potential suppliers is developed, which the buying company may be willing to do business with. The evaluation required to determine supplier capability varies with the nature, criticality, complexity and money value of the purchase to be made. It also varies with the buyer’s knowledge of the firms being considered for the order. In addition to costs, specific objectives are established and treated during the selection process, including all technical aspects of the purchase, types of materials and substitutes, the mode of transportation, warranty terms and conditions, payment terms (including discount provisions), liability for claiming and damage, general terms and conditions (for more
details, see Karacapilidis and Moraitis, 2001). All the above refer to an operating situation in which the buyer–supplier relationship must be closer and more cooperative than it might normally be. Literally speaking, it is an informal partnership operation that aims at being a win–win deal.

3.2. Reduction of production costs

The objective of the production planning and control function is to coordinate the use of a firm’s resources and synchronize the work of all individuals concerned with production, in order to meet required completion dates, at the lowest total cost, consistent with the desired quality. Our overall platform facilitates the coordinated efforts required by each user group involved. More specifically, it facilitates the aggregate planning and master scheduling activities, which are certainly top management and staff responsibilities. It also facilitates activities associated with the material and capacity requirements planning, which primarily fall under the responsibility of production planning and control personnel (Dobler and Burt, 1996). Finally, the control of production operations themselves is a joint responsibility of production planning and control personnel and supervisory operating personnel.

As noted in Section 2, the company under consideration had not fully exploited its legacy ERP system. The integration of it in the platform proposed in this paper automated the gathering of the appropriate information, while at the same time eliminated the risk of working on wrong data (e.g. data containing mistakes after the manual introduction of an incoming order). This led to the decision to activate all the legacy system’s features and abilities in order to monitor all business parts.

3.3. Inventory management

The basic objective of an inventory management system is to determine the most appropriate inventory levels. During the development of our system, we adopted the following inventory categories: production inventories (raw materials, parts, and components), MRO inventories (maintenance, repair and operating supplies), in-process inventories (semi-finished products) and finished goods inventories. Our concern focused on the planning and control of production and MRO inventories at various time periods (weekly, monthly and, in some cases, quarterly or even yearly decisions). Complementary to the above aspects, and in order to make more elaborated decisions about inventory management, our overall approach has considered the behavior of the inventory-related costs (Kobert, 1992). More specifically, two basic categories of costs are associated with inventories: inventory carrying costs (opportunity cost associated with inventory investment, insurance costs, property taxes, storage costs, obsolescence and deterioration) and inventory acquisition costs (these are not related to inventory size per se; rather, to the number of orders placed or deliveries received during a given period of time). It should be noted here that inventory management was marginally considered (basically due to the reasons described above) before the company adopt the proposed approach.

4. Conclusions

There is no doubt that the need to exchange information is critical within the business community. By integrating computers and data communications into the business process, companies benefit from exchanging information electronically, in that they reduce paperwork, minimize cost and improve response time (Sodhi, 2001). Following the above lines, this paper has described an open supply chain management system for e-business. The system has been developed for the needs of a textile industry. However, our approach is suitable for any medium or large-scale organization that wants to carry out e-business transactions. To mention some, similar applications may be deployed for the chemical, electronics, computer hardware, manufacturing, telecommunications, transportation or even the public sector.

The major contribution of this work is that the overall framework is able to smoothly interoperate with legacy systems, is designed around open standards for data exchange, and can be easily employed through user-friendly designed web sites.
by any trading partner. Moreover, it integrates a set of off-the-shelf tools that assure a robust, scalable and fast development cycle. We argue that our approach provides companies with new levels of flexibility, while helps innovative and small companies rewrite the rules of business and ensure the functionality needed to respond rapidly to future changes. Moreover, our component-based approach follows current trends of the development of e-business enterprise systems. As a final note, we point out here that in order to precisely calculate the benefits discussed in Section 3, one has to formally define appropriate performance indicators for supply chain management; this is actually one of our future work directions. Having defined such measures, one may continuously monitor the behavior of the system in order to improve its efficiency.

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