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Improving E-Procurement in Supply Chain Through Web Technologies: The HYDRA Approach

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1. Introduction

A supply chain is a network that enables the distribution options for procurement of both raw and finished materials, which can be transformed into finished goods and distributed to the end customer through various distribution channels. Commonly, the main goal of a supply chain is satisfy the customer's requests as soon as they appear. This process is well-known as e-procurement. E-Procurement is more than just a system for making purchases online. It provides an organized way to keep an open line of communication with potential suppliers during a business process. E-Procurement helps with the decision-making process by keeping relevant information neatly organized and time-stamped. In this book chapter, we covered the e-procurement process in Supply Chain Management borrowing features from service-oriented and event-driven architectures to provide support for supply chain management collaborations, covering the basic concepts and the participants in e-procurement, describing the main functions from the roles of producers, distributors, retailers, customers, and service providers in the e-procurement process, identifying the main information technologies for developing Web-based systems for e-procurement, presenting some selection criteria, implementation strategies, and process redesign initiatives for successful e-procurement deployment and finally discussing research and new trends for e-procurement in order to provide a guide for designing effective and well-planed process models in e-procurement which is an important prerequisite for implementation success. With these aspects, Well-managed e-procurement systems can be developed to help reducing inventory levels. A properly implemented e-procurement system can connect companies and their business processes directly with suppliers while managing all interactions between them. A good e-procurement system helps a firm organize its interactions with its most crucial suppliers. It provides those who use it with a set of built-in monitoring tools to help control costs and assure maximum supplier performance.

2. Basic concepts in e-procurement for supply chain management

As the world's economy becomes increasingly competitive, sustaining competitiveness and the resulting profitability depends less on the ability to raise prices. Instead, firms need to compete on the basis of product innovation, higher quality, and faster response times, all of which must be delivered, in most cases simultaneously and always at the lowest costs attainable. Those competitive dimensions cannot be delivered without an effectively managed supply chain. Firms with the most competitive supply chains are and will continue to be the big winners in contemporary business. The supply chain encompasses all activities associated with the flow and transformation of goods from the raw materials stage through to the end user, as well as associated information flows. Supply Chain Management is the integration of these activities through improved supply chain relationships to achieve sustainable competitive advantage (Handfield & Nichols Jr, 1999).

The definition suggests that all of the links in the supply chain must be strong and well integrated. However, it is argued here that the key link, the one that sets the foundation for the others, is supply management on the input end of the chain (Dobler & Burt, 1996). It is the link in the supply chain that serves as the boundary-spanning activity on the input end of the business where the supplier base is built based on the suppliers' ability to help the firm deliver on the competitive dimensions. It is where industrial marketers come face to face with the demands of the buying firm's supply chain.

The increasing emphasis on supply chain management has sharpened top management's focus on the valued-added potential of supply management. A recent survey suggests that 76% of CEOs expect supply management to contribute to shareholder value as firms continue to move toward more outsourcing (Nelson et. al., 2002). The potential impact on competitiveness and profitability is enormous because the average manufacturing firm spends about 50% of its sales revenue on the purchases of goods and services needed to produce its final product. It is at the supply end of the supply chain where most of the expenditures on supply chain activities exist. This increasing emphasis on supply management, rather than on the more traditional ''purchasing,'' requires that the professional supply manager move beyond the typical transaction focus of purchasing where price and availability were the key factors to be considered in the purchase decision.

The new basics of supply management require that supply managers take a more strategic view of what they do. Those new basics include a comprehensive understanding of target costing, value engineering, supplier development, and electronic procurement (Nelson et. al., 2002). The first three are not really new, having existed as an implicit part of supply management for some time. It is more accurate to say they are being rediscovered. It is electronic procurement, the productive use of the Internet to improve the effectiveness and efficiency of the supply end of the supply chain that is new.

Strategic supply management has the potential for significant value creation for the firm. Business professionals who have long been involved in supply management understand its power to create value. The emergence of e-procurement in the last few years is creating a higher profile for supply management, boosting its visibility to top management. The challenge to those operating on the supply end of the supply chain is to make a convincing business case for what they do. Although CEOs expect supply management to contribute to shareholder value, effective supply managers need to get comfortable with the language of top management to communicate how that value is created. The move to e-procurement provides a unique opportunity for supply managers for two reasons. First, the application of technology to boost competitiveness and profitability is on the agenda of any forward-thinking CEO. Second, the application of technology to supply management, where firms spend most operating dollars, is focusing more top-management attention on that issue. A recent study by Deloitte Consulting of 200 global firms indicates that 30% have begun

implementing at least a basic e-procurement solution whereas 61% are either planning or are considering an implementation (Whyte, 2000).
E-procurement is the linking and integration of inter-organizational business process and systems with the automation of the requisitioning, the approval purchase order management and accounting processes through and Internet-based protocol (Podlogar, 2007). In the Figure 1, the main terms in the e-procurement are shown. According to Kalakota & Robison (1999), the purchasing process is within the procurement process and refers to the actual buying of materials and those activities associated with the buying process.

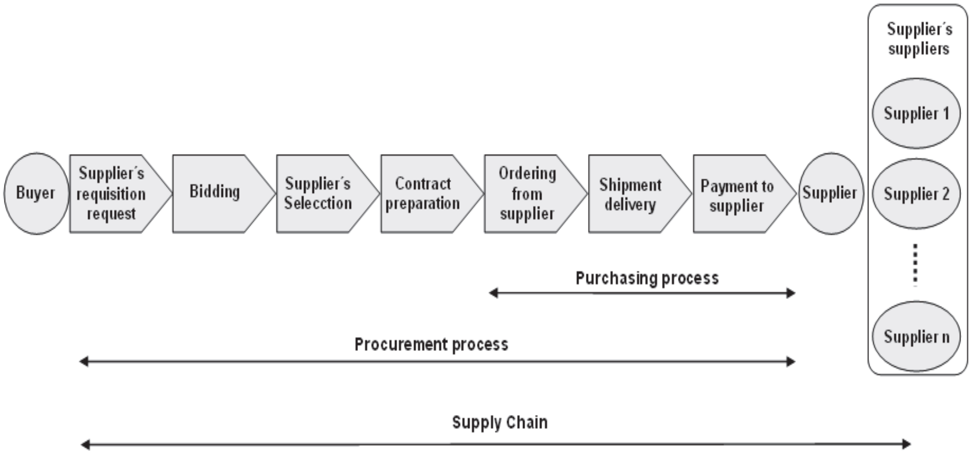

Fig. 1. Main concepts in e-procurement (Podlogar, 2007)

In the supply chain, the procurement process is important, because includes business partners as: suppliers, manufacturers, distributors and customers that use transactions to purchase, manufacture, assemble, or distribute products and services to the customers.
Different structures of supply chain management are discussed below by some authors.

2.1 Different structures of supply chain management

Moreno-Luzon & Peris (1998) addressed level of decision-making centralization and level of formalization-standardization as the basic organizational design variables of the contingency model relating to quality management. Formalization can be defined as the degree to which roles and tasks performed in the organization are governed by formal rules, and standard policies and procedures. If higher level of flexibility is required by the organization, then level of formalization should be low whereas if the organization requires a rigid structure then higher level of formalization will be suitable. Degree of formalization can be explained by the existence of independent department responsible for supply chain management and the strategic positioning of the department and the degree of centralization which reflects the scope of responsibilities and the power of supply chain department within the organization (Kim, 2007). The concept of formalization refers to ''the extent that the rules governing behavior are precisely and explicitly formulated and the extent that roles and role relations are prescribed independently of the personal attributes of individuals occupying positions in the structure''. In other words, formalization describes the degree to which work and tasks performed in the organization are standardized (Dewsnap & Jobber, 2000; Mollenkopf et al., 2000; Manolis et al., 2004).

Bowersox & Daugherty (1995) and Daugherty et al. (1992) suggest that the concept of formalization in supply chain management perspective can be consistent with it in organizational perspective. They define formalization as the degree to which decisions and working relationships for supply chain activities are governed by formal rules and standard policies and procedures.

Centralization can be defined as the pattern of authority distribution for various departments within the organization. The management decides the authority distribution pattern on the basis of objectives to be achieved and type of strategy to be followed by the organization. For example, defender's strategy is cost oriented, so centralization should be high whereas prospector's strategy is product innovation oriented, so lower level of centralization will be suitable. Centralization is defined as the extent to which the power to make supply chain management decisions is concentrated in an organization (Mollenkopf et al., 2000; Manolis et al., 2004). Higher degrees of centralization correspond with concentration of decision making authority at more senior levels (Dewsnap & Jobber, 2000).

The degree of centralization is determined partly by hierarchical relationship between supply chain management department and other functional areas over the control and responsibilities for supply chain management activities (Leenders et al., 2002). According to Bowersox & Daugherty (1995) and Tsai (2002), three structural components-formalization, centralization and specialization have considerable influence on organization performance. Factors favouring centralization include standardization of products and business processes, cost reductions created through opportunities to allocate resources efficiently and economies of scale and improved levels of knowledge and expertise through the dedication of staff and resources (Droge & Germain, 1989). Decentralization offers business units autonomy and control over key functional activities, supporting the principle that business units must carry responsibility for major decisions if they are to be held accountable for performance (Johnson & Leenders, 2006). Potential advantages of centralization include greater buying specialization, coordination of policies and systems and consolidation of requirements. Meanwhile, decentralization improves service and lowers costs by pushing decision-making responsibility closer to the end user, promotes closer working relationships between suppliers and end users and provides increased opportunities for end users to manage total cost of ownership factors (Leenders & Johnson, 2000). There can be other objectives like cost, flexibility, quality and innovation on the basis of which organization structure can be decided. The competitive dimensions can include cost, quality, flexibility, and delivery performance among others (Corbett & Van Wessenhove, 1993; Minor et al., 1994; Vickery, 1991). Supply chain structure can be defined on the bases of organization's strategy. As defenders, prospectors and analysers have different strategies, there should be a strategic fit between their supply chain and competitive strategies. To achieve strategic fit, supply chain activities of an organization must support their objectives.

Supply chain structure has been defined and classified in a number of ways in the literature. A very simple way of describing supply chain structure differentiates between organizations on the dimension of centralization or decentralization (Ghoshal, 1994). One of the major problem of decentralized organization is that the goals of the agents are not aligned with the overall goal of organization (Dirickx & Jennergren, 1979; Milgrom & Roberts, 1992).Different business subunits have their own objectives .To pursue their private interests, these units may choose to send false, or biased, information to headquarters and other departments (Jennergren & Muller, 1973). Companies must adjust their organizational structure and management processes to adapt to changes in the external competitive environment or its strategy in order to maximize performance (Galunic & Eisenhardt, 1994). The two extremes (prospector and defender) are consistent with findings put forward by the other authors, e.g. Burns and Stalker (1961) and Porter (1980). They labelled these extremes the mechanistic and organic management system, respectively. Burns and Stalker (1961) explicitly mention that mechanistic firms have a functional organization structure with high level of formalization i.e. extent to which rules and roles are precisely and explicitly formulated. Organic firms, on the other hand, have low level of formalization.

Mechanistic firms have a hierarchical structure and the way of coordination between the members of the organization is limited to vertical, that is, between superior and subordinate. Mechanistic systems are appropriate in stable conditions and have a functional organization structure, a high degree of formalization, and many rules and procedures. Organic systems are most appropriate in changing conditions and are characterized by loose structures and few rules. Miles & Snow's (1978) prospector corresponds with Burns and Stalker's organic system and Porter's differentiation strategy, while the defender strategy corresponds with Burns and Stalker's mechanistic system and Porter's cost leadership strategy. Analysers combine cost-leadership and a mechanistic system orthogonally with differentiation and an organic system. That is, they either spatially or temporally separate innovation and operation, but do not do both in the same part of the company or at the same time (Volberda, 1998). According to Chopra & Meindl (2001), a product-focused organization performs many different functions in producing a single product whereas a functional-focused organization performs few functions on many types of products. A product focus tends to result in more expertise about a particular type of product at the expense of functional expertise that comes from a functional manufacturing methodology. Hybrid organizational structure approach is defined as the structure having features of both centralized and decentralized structures (Leenders & Johnson, 2000). While previous research has found that the hybrid organizational model is the most commonly used within large supply organizations (Johnson & Leenders, 2006), there is still considerable variation with respect to how the hybrid model is implemented.

In 1960s, matrix structures became a popular organizational framework for managing new product and service development. Matrix organization approach manages coordination of activities across unit lines within the organization. The matrix combines the benefits of project and functional organizations by integrating the work of various specialists. The matrix structure operates through a two-dimensional system of control: a project/product-line chain of command and a functional chain of command (Lawrence et. al., 1982). Project managers retain responsibility for developing products, while functional managers concentrate on the organization's capability to make use of up-to-date technical knowledge (Katz & Allen, 1985). On the basis of above arguments we have main organization structure types of supply chain departments as mechanistic, organic and matrix structure.

According to Min & Zhou (2002), when structuring a supply chain network, it is necessary to identify who the partners of the supply chain are. Meanwhile, Cooper et al. (1997), suggest a guideline to structure a supply chain network, these structures are: (1) the type of a supply chain partnership; (2) the structural dimensions of a supply chain network and (3) the characteristics of process link among supply chain partners.

The supply chain can be analysed in two dimensions, horizontal and vertical structure. According to Lambert et al. (1998), the horizontal structure refers to the number of tiers across the supply chain, while the vertical structure refers to the numbers of suppliers and customers represented within each tier (See Figure 2).

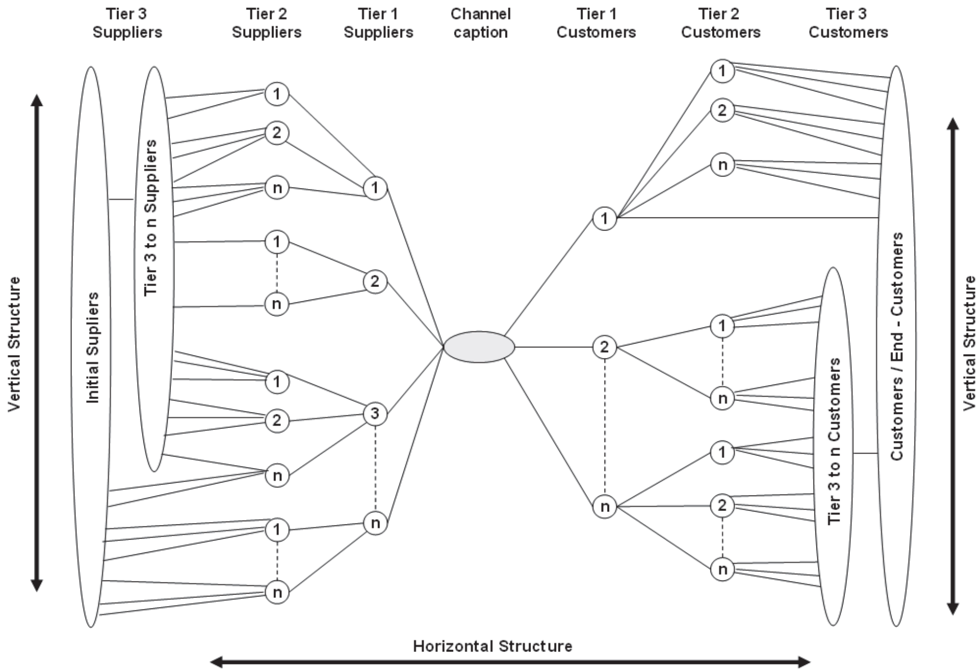

Fig. 2. Supply chain network structure (Adapted from: Lambert et al, 1998)

In its simplest form, a supply chain is composed of a company and the suppliers and customers of that company. This is the basic group of participants that creates a simple supply chain. These participants are discussed below.

2.2 Elements and participants in e-procurement supply chain management

E-procurement (electronic procurement, sometimes also known as supplier exchange) is the business-to-business or business-to-consumer or Business-to-government purchase and sale of supplies, work and services through the Internet as well as other information and networking systems, such as Electronic Data Interchange and Enterprise Resource Planning (Baily, 2008). Typically, e-procurement Web sites allow qualified and registered users to look for buyers or sellers of goods and services. Depending on the approach, buyers or sellers may specify costs or invite bids. Transactions can be initiated and completed. Ongoing purchases may qualify customers for volume discounts or special offers. E-procurement software may make it possible to automate some buying and selling. Companies participating expect to be able to control parts inventories more effectively, reduce purchasing agent overhead, and improve manufacturing cycles. E-procurement is expected to be integrated into the wider Purchase-to-pay (P2P) value chain with the trend toward computerized supply chain management. E-procurement is done with a software application that includes features for supplier management and complex auctions. The new generation of E-Procurement is now on-demand or a software-as-a-service.

There are seven main types of e-procurement:

1. **Web-based ERP (Enterprise Resource Planning):** Creating and approving purchasing requisitions, placing purchase orders and receiving goods and services by using a software system based on Internet technology.
2. **e-MRO (Maintenance, Repair and Overhaul):** The same as web-based ERP except that the goods and services ordered are non-product related MRO supplies.
3. **e-sourcing:** Identifying new suppliers for a specific category of purchasing requirements using Internet technology.
4. **e-tendering:** Sending requests for information and prices to suppliers and receiving the responses of suppliers using Internet technology.
5. **e-reverse auctioning:** Using Internet technology to buy goods and services from a number of known or unknown suppliers.
6. **e-informing:** Gathering and distributing purchasing information both from and to internal and external parties using Internet technology.

e-marketsites: Expands on Web-based ERP to open up value chains. Buying communities can access preferred suppliers' products and services, add to shopping carts, create requisition, seek approval, receipt purchase orders and process electronic invoices with integration to suppliers' supply chains and buyers' financial systems.

The e-procurement value chain consists of Indent Management, e-Tendering, e-Auctioning, Vendor Management, Catalogue Management, and Contract Management. Indent Management is the workflow involved in the preparation of tenders. This part of the value chain is optional, with individual procuring departments defining their indenting process. In works procurement, administrative approval and technical sanction are obtained in electronic format. In goods procurement, indent generation activity is done online. The end result of the stage is taken as inputs for issuing the NIT. Elements of e-procurement include Request for Information, Request for Proposal, Request for Quotation, RFx (the previous three together), and eRFx (software for managing RFx projects). In Figure 3, an e-procurement business model is presented. According to Podlogar (2007), the main elements in the e-procurement are buyers, suppliers and Internet access system. Through this system, the buyer can input their needs using the e-catalog included in the e-procurement program, these needs are the request for procurement. The entire process is totally automated through the electronic interchange. The approval is accomplished online, helping cutting the cycle time.

Due to importance of the e-procurement in the supply chain, some historical developments in supply chain management are described below.

2.3 Historical developments in supply chain management

In today market most of firms have realize the importance of designing, planning and controlling an efficient supply chain. The effect over competitiveness and profit has been analysed form different perspective: economical (Atkins & Liang., 2010), social (Griffith, 2006), technological (Min & Zhou, 2002) and recently from an environmental perspective (Türkay et al., 2004), (Laínez et al., 2008). All those research point out that a modern enterprise does not contend in the market as independent unit, but inside a common network or high level supply chain. Supply chain is a synergy among several business processes with common goals: the acquisition of raw material and its transformation into

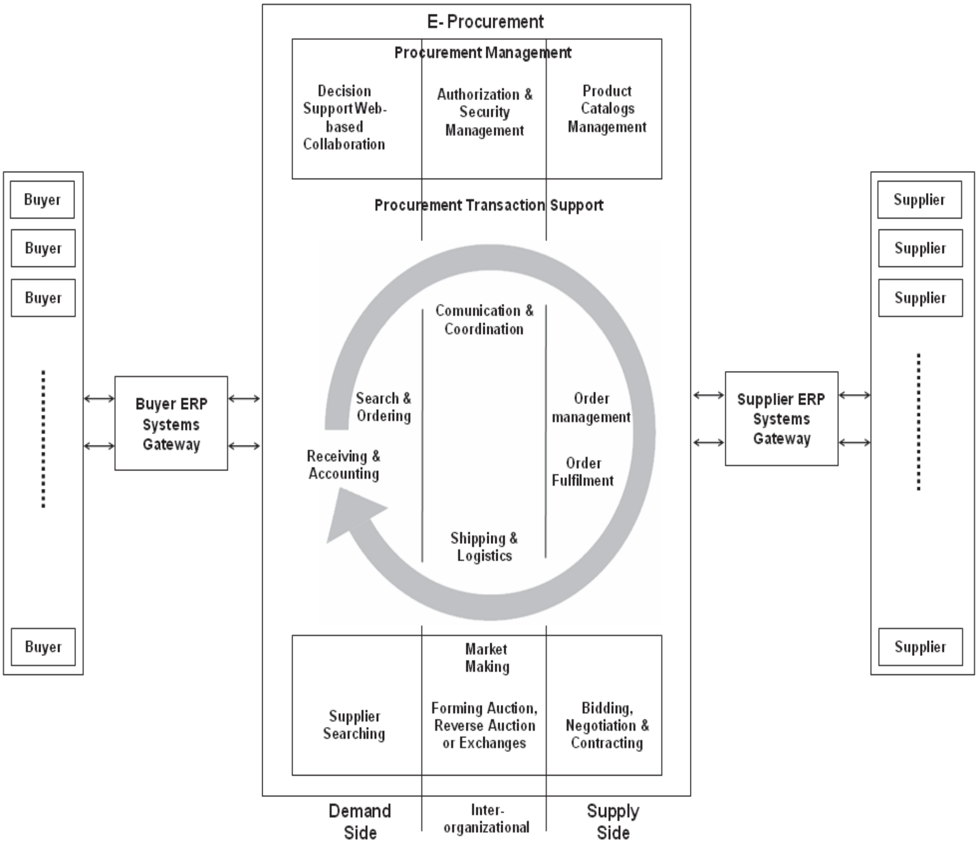

Fig. 3. An e-procurement business model (Gebauer and Shaw, 2002)

consumer goods, the creation of value and common wealth, distribution and promotion to retailer or costumers and information/knowledge exchange among diverse business entities. The capital objective in the supply chain is to improve the operational efficiency, to increase profitability and competitiveness of all stakeholders involved in the supply chain (Chopra & Meindl, 2001). The evolution in the supply chain is a complex process that could be analysed from different point of view:

1. The quantity and relationship among business entities and components. Concerning their components, a supply chain is integrated for many components -element, system or any other function- required to fulfill a customer request. The term function comprises design, operation, distribution, pricing, marketing and customer service among other functions. This definition involves evidently, the manufacturer and its suppliers, but also transporters, warehouses, retailers, and even customers themselves.
2. Due to the variety of functions and components, the evolution of the supply chain is a very complex process (Min & Zhou, 2002).
3. As well, the supply chain posses a forward flow of finished goods and materials and, a second one of information in opposite direction. These are business processes evolving

at their own rhythm and thus, considerably increasing the complexity in the evolution of the supply chain.

Evolution tendencies could be extracted from these perspectives. In first place, there is a clear problem of interoperability because many organizations must cooperate in network through the supply chain. The quantity, frequency and intensity of this cooperation are increasing continually. To solve this problem and to minimize heterogeneity, there is an evident tendency in the search of synchronization and standardization in the core business processes (Cellarius, 1998), (Blanc et al., 2006). The number of connections and functions in the supply chain affects its performance, thus a considerable effort was allowed to manage this complexity (Perona & Miragliotta, 2004). Then, the inherent complexity of the supply chain is one of the subjacent reasons for the creation of managerial approaches that aims to ameliorate the operation and integration of the supply chain. Concerning the information flow, this is maybe the most dynamic research field. Companies are continually searching for means and strategies to improve their flexibility, responsiveness and in consequence its competitiveness by changing their methods and technologies, which include the implementation of supply chain management paradigm and information technology (IT) (Gunasekaran & Ngai, 2004), (Bailey & Francis, 2008), (Verissimo, 2009), (Huang & Lin, 2010). Information Technology (IT) is responsible for an important change in the evolution of the supply chain: that knowledge could be a decisive success factor (Hult et al., 2006), (Craighead et al., 2009).

The supply chain environment is very flexible due to changing demand and pressure from competitors. Determine the software architecture is needed to allow information systems to be realigned with the changing supply chain without effort or delay. In next section, an historical overview of Web technologies for e-procurement is presented.

Some experiences and success stories of adapting e-procurement systems are presented below.

3. E-Procurement systems in supply chain management

3.1 Experiences and success stories

E-procurement is gaining in popularity in business practice and its benefits encourage its adoption in huge domain diversity. Its positive impact on several key performance indicators in different kind of business it is not questioned. As an example (Ronchi et al., 2010) shown the importance of e-procurement for an information technology chain. (Kothari et al., 2007) explain how the adoption and implementation of e-procurement technology within a hotel chain can generate important benefits. (Panayiotou et al., 2004), presents a case study concerning the analysis of the Greek governmental purchasing process, revealing the importance of new services design in this process. Maybe one of the most dynamics domains in e-procurement and typical procurement is the automotive industry; (Perrone et al., 2010) for example, explain how multi-attribute auctions can improve the procurement process in the context of new product development while (Kim, 2006) explain that the supply chain can generate more value if e-procurement is synchronized and involves corporate executives. Thus e-procurement enable: (1) On-line procurement and access to the global supply chain, (2) Effective auction process (quality, quantity and adequate price) and (3) Effective cost reduction.

3.2 Web technologies for e-procurement

The features and requirements of the supply chain of the future match the advantages and features of a software component architecture. Information technology support for the next generation supply chain systems is critical. This information technology needs to be: (1) Reusable, and (2) Rapidly changeable. Furthermore, it can be seen that the underlying software architecture of a supply chain solution also needs to be: (1) Agile, (2) Flexible, (3) Deployable over a multi-enterprise scope, (4) Multi-function support when used as a suite, (5) Handle complexity, (6) Enable collaboration, and (7) Enable coordination. We identify the main information technologies for developing Web-based systems for e-procurement.

EDI (Electronic Data Interchange): EDI is the computer-to-computer exchange of formatted electronic messages called transaction sets. The most widely used formats are specified in a U.S. standard, ANSI (American National Standards Institute) X.12, and in an international standard called EDIFACT. An EDI message contains a string of data elements, each one of which represents a piece of information, such as a price, or model number, separated by delimiters. The entire string is called a data segment (Zilbert, 2000). A transaction set usually corresponds to an equivalent paper document or form, e.g. Set 850 Purchase Order. For security, messages can be encrypted. With forms-based software, including Web pages, users can create or display an EDI transaction in a familiar way, without needing to know the transaction number or any details of the underlying formats. With the growing use of Internet, the transmission costs of EDI-based documents have been reduced. However, the development of EDI translators is still expensive because the codification of EDI documents is complicated due to their emphasis in the data consistency. An alternative to this proposal that eliminates several problems of business process integration was CORBA/IIOP.

CORBA/IIOP: CORBA/IIOP stands for Common Object Request Broker Architecture/Internet Inter-ORB Protocol. CORBA is an industry standard from the Object Management Group -- largely the UNIX/Linux/not Microsoft community. Client programs send requests to a common interface called the Object Request Broker. The ORB sends each request to the appropriate object (application code and data) and returns the results. The standard allows this to be accomplished in a distributed computing environment, across languages, operating systems, hosts and networks. CORBA is essentially a messaging protocol and has helped promote the use of messaging (store & forward/publish & subscribe) as a technical approach to systems integration (Boldt, 1995). IIOP makes CORBA usable on a TCP/IP network (the Internet). CORBA objects can be embedded in a Web page and executed via Java applet. This allows a Web page to be interoperable with remote applications accessible via the Internet. However, CORBA does not offer interoperability for the business processes in a supply chain management. This is mainly to that each commercial partner (represented as a node in CORBA) must execute its own ORB which is highly dependent of the CORBA implementations. This originates a great problem of interoperability in the development of commercial activities among the participants of the supply chain. In order to solve the interoperability among the CORBA implementations, Microsoft proposed an alternative approach well-known as DCOM.

COM/DCOM and ActiveX: Component Object Model/Distributed Component Object Model and ActiveX are Microsoft's Windows-oriented methods for developing and supporting interoperable program component objects. Together, these tools provide ways for Windows-based applications to interact and exchange data (Horstmann & Kritland, 1997). DCOM supports the TCP/IP protocol necessary for Internet- and web-based data interoperability. However, DCOM presents certain lacks of interoperability in the supply chain management. All the business processes of the participants in a supply chain should be executed under the Windows platform. Furthermore, in DCOM the messages that are sent between a client and a server have a format defined by the DCOM Object RPC (ORPC) protocol. By this reason is necessary to use mechanisms for translating the messages in order to a different system can interpret and to act in the request/responses of involved participants. Although DCOM solves some issues of interoperability caused by the incompatibilities among the implementations developed by different technology suppliers, these still persist when diverse operating system platforms are involved. The Java programming language was designed with the purpose of solving these issues of interoperability.

Remote Method Invocation (RMI): Java Remote Method Invocation (Java RMI) enables the programmer to create distributed Java technology-based to Java technology-based applications, in which the methods of remote Java objects can be invoked from other Java virtual machines, possibly on different hosts (Hughes et. al, 1999). Java RMI is a mechanism that allows one to invoke a method on an object that exists in another address space. The RMI mechanism is basically an object-oriented RPC mechanism. Java RMI has recently been evolving toward becoming more compatible with CORBA. In particular, there is now a form of RMI called RMI/IIOP ("RMI over IIOP") that uses the Internet Inter-ORB Protocol (IIOP) of CORBA as the underlying protocol for RMI communication. Java/RMI presents difficulties of interoperability. These difficulties reside in the use of the marshalling/unmarshalling of objects which is specific of the Java programming language. In the context of the supply chain, this means the business processes should be written in Java. In order to solve this issue, the World Wide Web Consortium (W3C) proposed a platform-independent description language well-known as XML

XML (eXtensible Markup Language): XML was developed as a way to tag or identify pieces of data within a file or Web page. It is a subset of a 20-year old language called the Standard Generalized Mark-Up Language (SGML). XML is similar in form to HTML (Hypertext Markup Language) which describes the content of a Web page in terms of how it is to be displayed (text and graphics) and interacted with. XML is called extensible because it defines only the techniques of tagging (Bray et. al, 2008). However, XML’s flexibility has given rise to many industry-specific and proprietary vocabularies. These now threaten its potential to serve as a single, global standard for exchanging business-to-business electronic transactions. Just as different companies and industries use a variety of different documents and terms to accomplish the same transactions, so must XML be adapted to the specifics of a company or industry practice (Chen, 2003). By some estimates, more than 30 industry-specific initiatives are underway. RosettaNet is a good example of industry-specific standards being developed upon XML. This consortium of 40 companies in the computer industry have published XML dictionaries for 50 partner interface processes (PIPs) related to catalog updates, pricing, order management, purchasing, and inventory availability (Kraemer et. al., 2007). Another consortium, The Open Applications Group, Inc., has developed PaperXML for paper industry transactions and SMDX for semiconductor manufacturing (Savoie & Lee, 2001). The Chemical Industry Data Exchange (CIDX) has defined more than 700 data elements and 50 transactions based upon XML. Proprietary versions of XML abound -- for example, Ariba’s cXML and CommerceOne’s xCBL, both for procurement, and Microsoft’s BizTalk, a general purpose development tool for XML-based applications (Savoie & Lee, 2001).

Web services: A Web service is a software component that is accessible by means of messages sent using standard web protocols, notations and naming conventions, including the XML protocol (Vinoski, 2003). The notorious success that the application of the Web service technology has achieved in B2B e-Commerce has also lead it to be viewed as a promising technology for designing and building effective business collaboration in supply chains. Deploying Web services reduces the integration costs and brings in the required infrastructure for business automation, obtaining a quality of service that could not be achieved otherwise (Adams et. al, 2003), (Samtani & Sadhwani, 2002). SOA (Service-Oriented Architecture) is an architectural paradigm for creating and managing "business services" that can access these functions, assets, and pieces of information with a common interface regardless of the location or technical makeup of the function or piece of data (Papazoglou, 2003). This interface must be agreed upon within the environment of systems that are expected to access or invoke that service.

BPEL (Business Process Execution Language for Web Services): BPEL is a process modelling language for the representation of compositional workflow structures to coordinate elementary Web service invocations. BPEL builds on Microsoft's XLANG (Web Services for Business Process Design) (Thatte, 2001) and IBM's WSFL (Web Services Flow Language) (Leymann, 2001) combining block structured language constructs borrowed from XLANG with a graph-oriented notation originated from WSDL (Web Services Description Language). BPEL closely follows the WS/Coordination and WS/Transaction specifications. The former describes how Web services may use predefined coordination contexts to be associated to a particular role in a collaboration activity (Cabrera et. al, 2005b). The latter provides an infrastructure that provides transaction semantics to the coordinated activities (Cabrera et. al, 2005a). A BPEL document consists of three parts describing data, coordination activities and communication activities (Little & Webber, 2003). Data tags are used to define a set of external partners and the state of the workflow. Coordination activity tags define the process behaviour by means of traditional control flow structures. Finally, communication activity tags define communication with other Web services through coordination activities by sending and receiving information.

3.3 Best practices in e-procurement

Best-in-class e-procurement performers have long-term, well-thought-out strategies for e-procurement implementation. Many such systems have been implemented in phases, with each new phase building off the successes – and lesson learned – of prior phases. However, all examples of Best Practices in e-Procurement have many things in common. AberdeenGroup, Inc. (2005) identified key strategies used by companies that have achieved best practice status in e-procurement:

- Solicit top management support to help drive system compliance and ensure sufficient funding and resources are made available.
- Focus on ease of use to improve end users' acceptance of the system.
- Don't underestimate change management. Insufficient focus on change management has held back acceptance of many e-procurement systems.
- Make sure processes are efficient before applying automated solutions.
- Clearly define and reinforce metrics for measuring costs, process efficiency, and performance of e-procurement technologies and processes. Where possible, link incentives for both procurement and business units to these metrics.

Though much progress has been made, significant challenges to successful e-procurement implementation remain. Specifically:

- **Supplier enablement.** In the early days of e-procurement, buying enterprises and solution providers underestimated the time, effort, and resources required to enable suppliers to transaction business electronically. Leading enterprises typically use a combination of supplier-enablement approaches. Though tremendous progress has been made in supplier enablement, all involved parties – end users, suppliers, and solution providers – continue to work to make enablement as simple and cost effective as possible.
- **User adoption.** Individual end users and entire business units will naturally resist any change in business processes that takes away buying power and buying flexibility. Over the past few years, user adoption has increased at essentially the same pace as the increase in suppliers enabled. With more products and suppliers on the e-procurement system, users have less reason to try to circumvent the system. Still, end users report that several factors continue to hold back user adoption, including inadequate representation of spending categories within the system, inconsistent purchase requirements, procedures, and supply bases by site or region, and a lack of executive mandates or policies to drive adoption and system compliance. Best Practice enterprises have worked on user adoption for years, and many supply executives at these enterprises have become leading "sellers" of the e-procurement system to end users.
- **Budget and policy support**. In AberdeenGroup, Inc. (2005) e-procurement benchmark research late last year, more than half of research respondents reported that securing budget/policy support for their e-procurement initiative was a challenge that delayed or muted the benefits of e-procurement.

In contrast, the best practice enterprises depicted in AberdeenGroup, Inc. (2005) received top management support and a level of investment needed to gain cost savings, process efficiencies, and the other benefits of e-procurement. However, even supply executives at best practice enterprises would like to see more investment and support of their e-procurement systems.

Research and new trends for e-procurement is presented below in order to provide a guide for designing effective and well-planed process models in e-procurement which is an important prerequisite for implementation success.

3.4 Research and new trends for e-procurement

Today businesses need to constantly adapt and reconfigure their IT assets, systems, and business operations to meet changing customer demands; compress business cycles; and differentiate from competition. New trends for developing e-procurement system are addressed in adopting different architectural styles. For instance, when an enterprise uses the SOA architectural style, it does not address all the capabilities needed in a typical supply chain management scenario. SOA does not have the ability to monitor, filter, analyze, correlate, and respond in real time to events. These limitations are addressed with an EDA (Event-Driven Architecture). An EDA combined with SOA, provides that ability to create a supply chain management architecture that enables business. An EDA is an architectural paradigm based on using events that initiate the immediate delivery of a message that informs to numerous recipients about the event so they can take appropriate action (Sriraman & Radhakrishnan, 2005). In this context, an event is a trigger that typically corresponds to the occurrence of some business activities, for instance, the receipt of an order. An EDA comprises event consumers and event producers. Event consumers subscribe to an intermediary event manager, and event producers publish to this manager. When the event manager receives an event from a producer, the manager forwards the event to the consumer. If the consumer is unavailable, the manager can store the event and try to forward it later. Then, the primary value of EDA is that it allows companies to identify and respond to events coming from supply chain management collaborations that need to be addressed by one or more systems through event management. The events, collected via an EDA, can be analysed and correlated to identify relevant patterns, and then aggregated to build up information that is needed to solve the procurement problem. With this process, companies can proactively address and respond to real-world scenarios in real time. A commercial toolkit is provided by TIBCO™ in order to enabling real-time business through a Service-Oriented and Event-Driven Architecture. TIBCO™ developed a set of applications in order to provide the following benefits where an enterprise can: 1) Improve ability to support new and changing business objectives, 2) Expand and extend the value of existing applications, and 3) Reduce the cost and risk of deploying new business services.

Another trend is to simplify the enterprise integration and middleware problem. As a solution, the ESB (Enterprise Service Bus) has emerged as software architecture in order to provide fundamental services for complex architectures via an event-driven and standards-based messaging engine (the bus). The ESB is an enterprise platform that implements standardized interfaces for communication, connectivity, transformation, portability, and security. An ESB implementation must cover: 1) Standards-based communication infrastructure, 2) Standards-based connectivity, 3) Standards-based transformation engines, 4) SOA for application composition and deployment, and 5) Standards-based security. Unlike the EAI (Enterprise Application Integration) approach, an enterprise service bus builds on base functions broken up into their constituent parts, with distributed deployment where needed, working in harmony as necessary. An example of an ESB implementation is the Fiorano ESB™ (Fiorano Enterprise Service Bus™) that incorporates tools and infrastructure enabling businesses to easily integrate existing systems both within and across enterprises with standards-based technology.

As proof-of-concept, we developed a middleware-oriented integrated architecture that offers a brokerage service for the procurement of products in Supply Chain Management scenarios. This brokerage service is called HYDRA.

4. HYDRA as an e-procurement system

HYDRA provides a hybrid architecture combining features of both SOA and EDA and a set of mechanisms for business processes pattern management, monitoring based on UML sequence diagrams, Web services-based management, event publish/subscription and reliable messaging service. In e-procurement scenarios, a wide variety of distributed applications needs support of a brokerage service. A typical application example is a workflow management system on top of a distributed platform in an organization with a few departments. A brokerage service with reduced functionality should for instance meet the requirements of local transactional processing of data and business processes. As another example, a distributed application can also work between different organizations. The nature of such an application can be very generic, i.e. the system must be capable of working with different locations and changing communication media, for example it might also include mobile users. A brokerage service needs to cooperate with a whole spectrum of underlying services, as mentioned above. In next section, we present and describe the internals and layer of our middleware-oriented integrated architecture for e-procurement.

4.1 Middleware-oriented integrated architecture for e-procurement

The middleware-oriented integrated architecture has a layered design. Furthermore, our proposal presents a component-based and hybrid architecture, borrowing features from SOA and EDA. In an SOA context, our approach acts as a BPM (Business Process Management) platform based on the SOA paradigm, facilitating the creation and execution of highly transparent and modular process-oriented applications and enterprise workflows. In an EDA context, our approach provides a software infrastructure designed to support a more real-time method of integrating event-driven application processes that occur throughout existing applications, and are largely defined by their meaning to the business and their granularity. Regardless of the event's granularity, our proposal focuses on ensuring that interested parties, usually other applications, are notified immediately when an event happens. These features are performed by our brokerage service. Its general architecture is shown in Fig. 4. Each component has a function explained as follows:

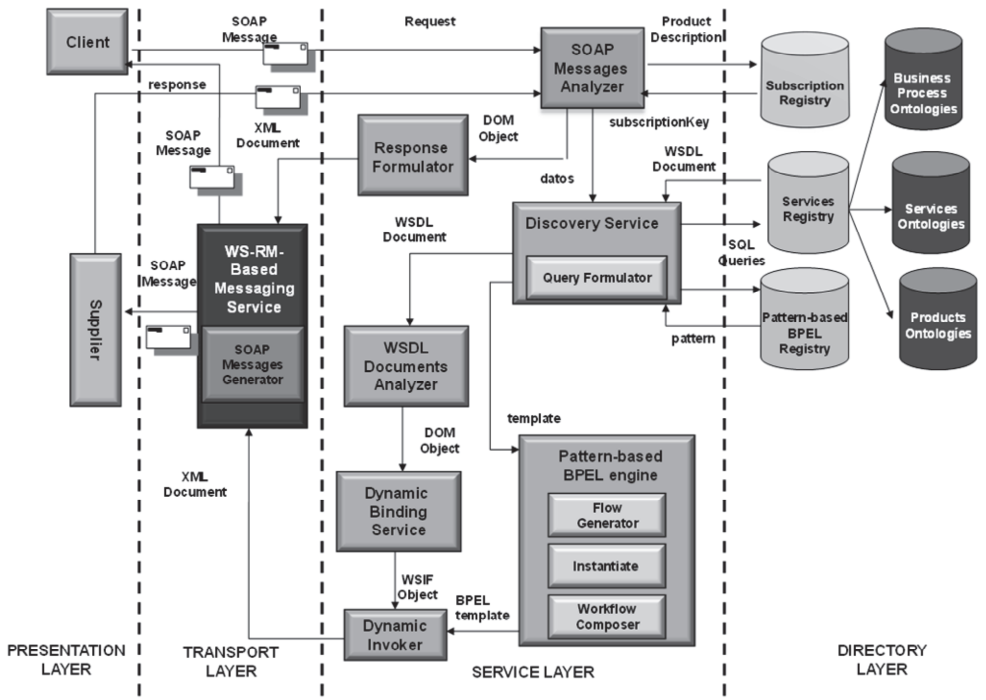

Fig. 4. The middleware-oriented integrated architecture for e-procurement

SOAP Message Analyzer: This internal determines the structure and content of the documents exchanged in business processes involved in supply chain management collaborations.

Service Registry: it is the mechanism for registering and publishing information about business processes, products and services among supply chain partners, and to update and adapt to supply chain management scenarios.
Subscription Registry: it is the mechanism for registering interactions in which systems publish information about an event to the network so that other systems, which have subscribed and authorized to receive such messages, can receive that information and act on it appropriately.
Discovery Service: This module is used to discover business processes implementations.
Given the dynamic environment in supply chain management, the power of being able to find business processes on the fly to create new business processes is highly desirable.
Dynamic Binding Service: This component binds compatible business processes described as Web services. The binding of a Web Service refers to how strong the degree of coupling with other Web Services is.
Dynamic Invoker: This module transforms data from one format to another.
WSDL Document Analyzer: it validates WSDL documents that describe business processes by their interfaces which are provided and used by supply chain partners.
WS-RM-based Messaging Service: it is the communication mechanism for the collaboration among the actors involved along the whole chain.
Response Formulator: This component receives the responses from the suppliers about a requested product/service.
Workflow Engine: This internal coordinates Web services by using a BPEL-based business process language. It consists of building a fully instantiated workflow description at design time, where business partners are dynamically defined at execution time.
According to the emphasis on automation, our architecture can be accessed in two modes of interaction, either as a proxy server or as an Internet portal. In the first mode, the brokerage service can interoperate with other systems or software agents. In the second mode, our architecture acts as an Internet portal that provides to the users a range of options among the Web services available through the brokerage service. Finally, the HYDRA architecture has a layered design following four principles: (1) Integration, (2) Coordination, (3) Monitoring and (4) Management, which are described next.

4.2 Supply chain coordination in HYDRA

Orchestration is currently presented as a way to coordinate Web services in order to define business processes. The utility of Web services is further enhanced by the introduction of mechanisms for composing them in order to generate new Web services and applications. The composition of Web services is defined as a process that enables the creation of composite services, which can be dynamically discovered, integrated, and executed to meet user requirements. In HYDRA, a composite Web service is obtained by the orchestration of several simple Web services. Composite Web services can be created in both design and execution time. In HYDRA, for the execution of a composite Web service it is firstly necessary to locate a suitable template from the BPEL repository that describes the intended commercial activities. In this schema, the templates are completely determined since commercial partners are known beforehand. For instance, in a purchase order scenario of books, the client might be interested in buying a book in the store that offers either the lowest price or the minimum delivery time. If a client wants to buy several books at the lowest price, HYDRA will retrieve the location of the BPEL workflow template that uses the purchase- criteria selected from a database. Once the template is located, HYDRA uses the

WSDL document and the related configuration files in order to instantiate them. HYDRA obtains the templates that can be used to find the suppliers that offer the product required by the client. A query to a database containing the WSDL documents provided by HYDRA can retrieve the appropriate Web services to obtain a number of pieces of commercial information like price, delivery time, quantity, and purchase access point of the product. The related WSDL documents are then analysed, and all the relevant information is retrieved and used to complete the templates. The instantiated templates are allocated in a BPEL engine for execution. To communicate with the running workflow, HYDRA builds SOAP messages containing the information provided by the client. Following our example, the client sends to the running workflow, the book code and the required quantity in a SOAP message. The workflow verifies also that the sum of all the quantities is at least the quantity requested by the client. If it is not true, an empty list is sent back to the client as response, which means that client's request could not be completely fulfilled by any of the registered stores. Whenever the workflow has been successfully terminated, it sends back to the client the list of suppliers satisfying his requirements. Then, the workflow is de-allocated from the workflow engine. After the client selects the suppliers, a BPEL template for placing a purchase order is now retrieved from the repository, completed and executed as described before. By enacting this workflow the purchase orders are sent to the suppliers and the corresponding answers from each supplier are eventually received.

A wide variety of other composite Web services involving some optimization criteria have also been developed and tested, like minimum delivery time and distributed purchases, to mention a few. In the next section, we describe how business processes descriptions can be monitored at execution time. This is one of the more relevant aspects of HYDRA in relation to the deployment of business processes.

4.3 Process activity monitoring and process management in HYDRA

The need to conduct business in real-time is among the most daunting yet strategic challenges facing today's enterprise. Enterprises that operate in a supply chain management scenario can instantly detect significant events to identify problems and opportunities, and manage the appropriate response to reap significant profits and build competitive advantage. For these reasons, enterprises are turning their attention toward implementing solutions for real-time business activity monitoring (BAM) (Dresner, 2002). In this context, HYDRA offers capabilities for business activities monitoring. For the monitoring process, it is necessary to listen to the request/response SOAP messaging of Web service-based business collaboration. The SOAP messaging identifies the participants and their communications during the long-running interactions of the participants in the collaboration. For this end, HYDRA intercepts all SOAP messages to generate a UML sequence diagram from the information about the participants and the order in which the messages are exchanged. For the monitoring of activities, a set of Java classes has been developed to represent a UML diagram in a SVG (Scalable Vector Graphics) representation that can be visualized in an SVG enabled Internet browser. The exchange of SOAP messages during some kinds of business collaboration may be developed very quickly. Therefore, to avoid reducing the performance of the Web services execution, the dynamic generation of UML diagrams uses a buffered mechanism to deal with a fast pacing production of SOAP messages.

As Web services become pervasive and critical to business operations, the task of managing Web services and implementations of our brokerage service architecture is imperative to the

success of business operations involved in supply chain management. Web services Management refers to the problem of monitoring and controlling the Web services themselves and their execution environment, to ensure they operate with the desired levels of quality (Casati et.al, 2003). In this sense, we developed a basic web services manager with capabilities for discovering the availability, performance, and usage, as well as the control and configuration of Web services provided by HYDRA. The underlying technology used for the implementation is JMX (Java Management eXtension), but conceptually could be extended to support other management technologies such as CIM (Common Information Model) and SNMP (Simple Network Management Protocol) (Sidnie, 1994). The JMX architecture consists of three levels: instrumentation, agent, and distributed services. JMX provides interfaces and services adequate for monitoring and managing systems requirements. This functionality involves abstracting resources by using components called MBeans (Managed Beans) and remote instrumented resources, accessible through JMX connectors. The main component for web services management is a JMX Bridge, which acts as a bridge between the collection of resources managed by JMX and Web services. In HYDRA, Web services interfaces to JMX are available. Rather than provide a JMX specific Web service interface, HYDRA provides a Web service interface to a manageable resource. Under our approach, the resources can be implemented on different technologies because it is only necessary to define a Web service interface for a resource. In order to do this, we used MBeans to represent the resource being managed.
To illustrate the functionality of HYDRA, we describe next an e-procurement scenario that integrates several products and services among clients, suppliers and providers that has already been implemented.

4.4 An e-procurement scenario in HYDRA

The case study describes how our brokerage service facilitates the shopping distributed that is offered by an enterprise namely SurteTuDespensa that sell first-necessity products.
Suppose the following scenario:

1. There are a set of enterprises that sell first-necessity products, which have been registered previously in HYDRA. In particular, an enterprise namely SurteTuDespensa that has registered its products and its business processes as Web services in the UDDI node of our brokerage service. Screenshots of the enterprise SurteTuDespensa are depicted in Fig. 5.
2. A potential client (enterprise) starts a supply chain to procure products by requesting a purchase order by means of Web services.
3. In this scenario, we approach the fundamental problem of determining how a client can discover and invoke the Web services available to carry out e-procurement?

HYDRA offers the modality of interaction as an Internet portal. In this mode, there is an option in the main menu called “Distributed Shopping”. In this option, HYDRA displays a graphic interface where the clients can select some products registered and their respective quantities that want to find. The graphic interface of products selection is shown in Fig 6. Once selected the products list, HYDRA displays another graphic interface where the client must choose a sorting criteria. This sorting criterion indicates the form in HYDRA will display the search result. Among the criteria available are lowest price, minimum delivery time, lowest price and minimum delivery time, and all their combinations. Next, HYDRA builds a request to the corresponding Web service. This request returns a list of providers that supply that product according to the selected sorting criteria. The result is shown as a HTML document. At this point, a list of enterprises appears as the product suppliers. Fig 7 shows the graphic interface with the result of the invocation.

Fig. 5. Graphic Interfaces of the SurteTuDespensa enterprise.

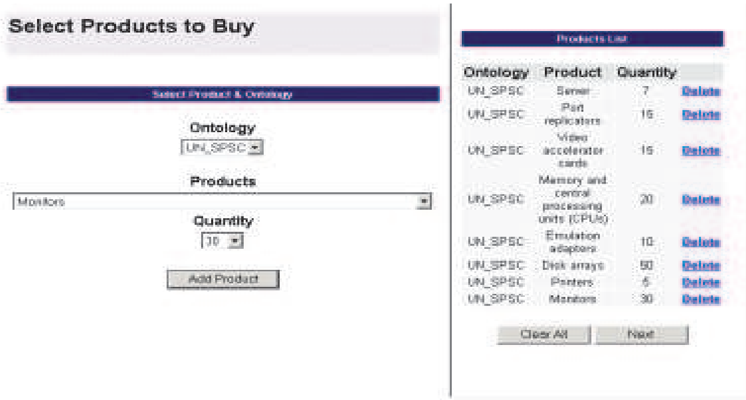

Fig. 6. Graphic interfaces of products selection in BPIMS-WS

Next, the client selects a provider from this list to buy a product. Once selected, HYDRA makes a query to the UDDI node to locate the URL where the PIP 3A4 (Request Purchase Order) is located to obtain and analyze the Web service specification. HYDRA uses sophisticated techniques to dynamically discover web services and to formulate queries to UDDI nodes.

At this point, HYDRA displays a graphic user interface of the Web service specification, enabling the visualization the activities involved in the purchasing order process.The client is then asked to provide the information required to complete the purchase. This graphic interface is shown in Fig 8.

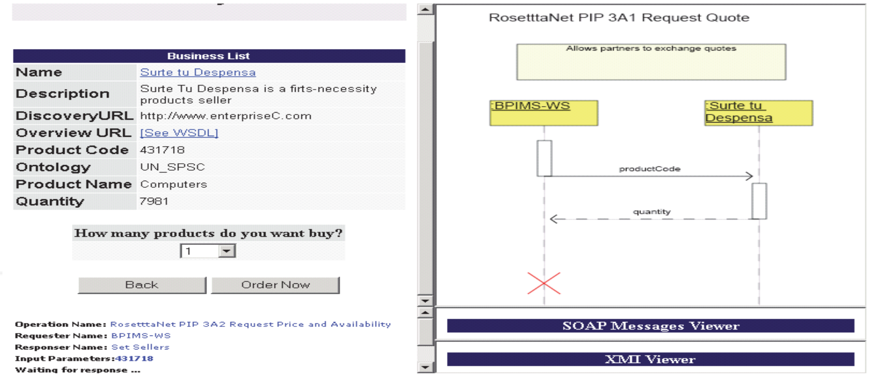

Fig. 7. Screenshot of the result of invoking Web services in HYDRA

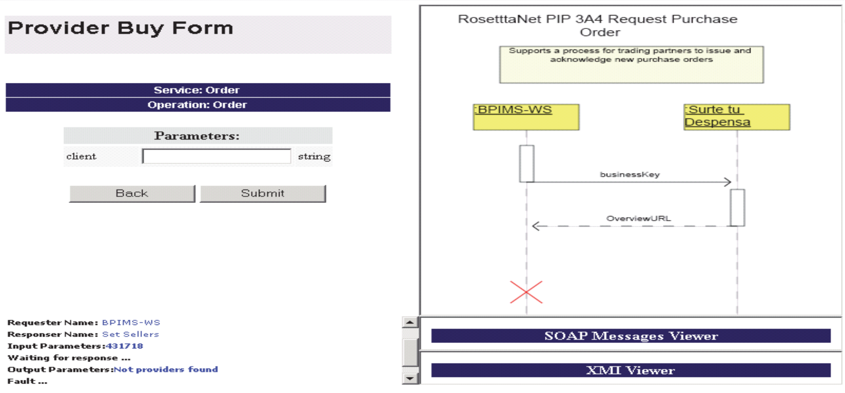

Fig. 8. Screenshot of the Web service specification of a supplier in HYDRA

Upon completion, HYDRA invokes the Web service. Finally, HYDRA shows to the user the results. So far, we have shown only one example that illustrates the business processes integration in HYDRA. However, a wide variety of other cases study involving several optimization criteria have been developed and tested such as shopping with the minimum delivery time, lowest price, specified quantity, and finally with no constraints too.

We envisioned for our proposal, the orchestration of long-term supply chains involving operation research methods to minimize costs, reduce delivery times and maximize quality of service along with artificial intelligence methods to provide semantic matching and to define business partners profile management is now under consideration.

5. Conclusions

Supply chain management is an important yet difficult problem to be addressed in its full complexity. However, we believe that hybrid architecture, borrowing features from SOA and EDA, may provide the fundamental structure in which the solutions to the diverse problems that supply chain management conveys can be accommodated. In this book chapter, we covered the basic concepts and the participants in e-procurement for supply

chain management. Next, we reviewed in depth the main e-procurement system reported in the literature. We presented some experiences and success stories. Furthermore, we identified the main information technologies for developing Web-based systems for e-procurement. In this sense, we addressed web services technologies. We have presented some selection criteria, implementation strategies, and process redesign initiatives for successful e-procurement deployment. Research and new trends for e-procurement were also presented in this book chapter in order to provide a guide for designing effective and well-planed process models in e-procurement which is an important prerequisite for implementation success. Finally as proof-of-concept, we presented a Web-based system namely HYDRA which is a middleware-oriented integrated architecture having a layered design and providing a comprehensive framework for developing business integration, collaboration and monitoring in supply chain management scenarios.
We believe this book chapter will provide a guide for selecting emergent approaches based on internet standards in order to achieve interoperability in the e-procurement process among different participants in the supply chain management. Furthermore, we have provided an architectural style where agile solutions with dynamic compositions of reusable services, integration of real assets and virtual services and context aware and responsive services rendering were discussed.

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Over the past few decades the rapid spread of information and knowledge, the increasing expectations of customers and stakeholders, intensified competition, and searching for superior performance and low costs at the same time have made supply chain a critical management area. Since supply chain is the network of organizations that are involved in moving materials, documents and information through on their journey from initial suppliers to final customers, it encompasses a number of key flows: physical flow of materials, flows of information, and tangible and intangible resources which enable supply chain members to operate effectively. This book gives an up-to-date view of supply chain, emphasizing current trends and developments in the area of supply chain management.