A SURVEY BASED STUDY ON THE ROLE OF E-PROCUREMENT IN INTEGRATING ERP (ENTERPRISE RESOURCES PLANNING) SYSTEMS USING E-SUPPLY CHAIN

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ABSTRACT

A SURVEY BASED STUDY ON THE ROLE OF E-PROCUREMENT IN INTEGRATING ENTERPRISE RESOURCES PLANNING (ERP) SYSTEMS USING E-SUPPLY CHAIN

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This thesis study is aimed at putting forward the role of e-procurement in relation to the topics of ERP and e-supply chain. In this study, a three-fold literature review of ERP, e-procurement and e-supply chain topics are provided. Then, survey based comparative studies on XML-based standardisation efforts and integration platforms from proven vendors are made in relation to technological infrastructure of these three topics. The generalizations obtained in these studies are intended to form a base for conceptual model development basing on generic web technologies.

Focus of this study is on the relationship, interaction and presedence of *e-Procurement, ERP (Enterprise Resources Planning)* and *e-supply chain* and on the "integration" issue, rather than individual treatment of these topics.

Keywords: e-Supply Chain, e-Procurement, ERP (Enterprise Resources Planning), BPR (Business Process Reengineering)

ÖZ

E-SATINALMA'NIN KURUMSAL KAYNAK PLANLAMA (ERP) SİSTEMLERİNİN E-TEDARİK ZİNCİRİ ENTEGRASYONUNDAKİ ROLÜ ÜZERİNE ARAŞTIRMA TEMELLİ BİR ÇALIŞMA

Akyüz, Göknur Arzu

Yüksek Lisans, Bilgisayar Mühendisliği Bölümü

Tez Yöneticisi: Doç.Dr. Mohammad Rehan

Ocak 2008, 163 sayfa

Bu tez çalışması, e-Satınalma konusunun Kurumsal Kaynak Planlama (ERP) ve e-Tedarik Zinciri konusundaki rolünü ortaya koymayı amaçlar. Çalışmada, ERP, e-satınalma ve e-tedarik zinciri konularında üç yönlü literatür taraması yapılmıştır. Daha sonra; bu üç konudaki teknolojik alt yapı ile ilgili olarak, XML tabanlı standardizasyon çabaları ve sektörün önde gelen tedarikçilerin entegrasyon platformları konularında araştırma temelli karşılaştırmalı bir çalışma yapılmıştır. Bu çalışmadan elde edilen genellemelerin, web teknolojileri tabanlı geliştirilecek kavramsal modellere zemin oluşturması hedeflenmektedir.

Çalışma, e-satınalma, Kurumsal Kaynak Planlama ve e-tedarik zinciri konularını tek başına ele almayıp bu üç konunun ilişkileri, öncelikleri ve entegrasyon konusuna odaklanmıştır.

Anahtar Kelimeler: e-Tedarik Zinciri, e-Satınalma, Kurumsal Kaynak Planlama (ERP) , İş Süreçleri Yeniden Yapılandırma (BPR)

To my dearest brother Gökalp who has always been with me…

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ACCEPTED PAPER DECLARATION

Within the scope of this thesis, a research paper on “Requirements for forming an e-supply chain” by G. Arzu Akyüz and Mohammad Rehan is accepted by International Journal of Production Research (IJPR) with manuscript Ref: TPRS-2007-IJPR-0466 on 2.11.2007. The article is currently at the publisher.

Section 1.2 “Supply Chain Management and the Internet” and Chapter 2“ ERP and e-SUPPLY CHAIN: Internal Integration and beyond” of this thesis are based on this article.

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LIST OF ABBREVIATIONS

ABAP:	Advanced Business Application Programming
API:	Application Programming Interface
APICS:	American Production and Inventory Control Society
APS:	Advanced Planning and Scheduling
B2B:	Business to Business
B2E:	Business to Employee
BAM:	Portal Business Activity Monitoring
BI:	Business Intelligence
BPML:	Business Process Modeling Language
BPEL:	Business Process Execution Language
BPM:	Business Process Management
BPMN:	Business Process Modeling Notation
BPR:	Business Process Reengineering
BW:	Business Warehouse
CFPR:	Collaborative Forecasting, Planning and Replenishment
COM:	Component Object Model
CORBA:	Common Object Request Broker Architecture
CRM:	Customer Relationship Management
DCOM:	Distributed Object Model
EAI:	Enterprise Application Integration
ebXML:	e-business XML
ECR:	Efficient Consumer Response
EDI:	Electronic Data Interchange
ERP:	Enterprise Resources Planning
ES:	Enterprise Services
ESA:	Enterprise Services Architecture
ESB:	Enterprise Service Bus

e-SCM: Electronic Supply Chain

GTIN: Global Trade Item Number

HTTP: Hyper Text Transfer Protocole

HTTP/SSL: Hypertext Transfer Protocol/ Secure Sockets Layer

ICT: Information and Communications Technology

IDE: Integrated Development Environment

IDL: Interface Definition Language

IESC: Integrated e-Supply Chain

IIOP: Internet Inter-ORB Protocol

J2EE: Java 2 Enterprise Edition

JSM: Java Message Service

LAN: Local Area Network

MDA: Model Driven Architecture

OASIS: Organisation for the Advancement of Structured Information Standards

OLAP: On-line Analytical Processing

RDBMS: Relational Database Management System

RMI: Remote Method Invocation

RPC: Remote Procedure Call

SAP: Systems, Applications and Products Development

SAP BI: SAP Business Intelligence

SAP EP: SAP Enterprise Portal

SAP MDM: SAP Master Data Management

SAP MI: SAP Mobile Infrastructure

SAP Web AS: SAP Web Application Server

SAP XI: SAP Exchange Infrastructure

SCM: Supply Chain Management

SEM: Strategic Enterprise Management

SMTP: Simple Message Transfer Protocol

SOA: Service Oriented Architectures

SOAP: Simple Object Access Protocol

SQL: Structured Query Language

TCO: Total Cost of Ownership

UDDI: Universal Description, Discovery and Integration

UN/CEFACT: United Nations Center for Trade Facilitation and Electronic Business

URL: Uniform Resource Locator

W3C: The World Wide Web Consorsium

WAN: Wide Area Network

WS-BPEL: Web Services- BPEL

WS-CDL: Web Services Choreography Definition Language

WSDL: Web Services Description Language

XML: Extensible Mark-up Language

XPDL: XML Process Definition Language

XSLT: Extensible Stylesheet Language Transformations

CHAPTER 1 INTRODUCTION: DIGITAL ERA AND IMPORTANCE OF WEB–BASED INTEGRATION

This introductory chapter opens up with the effects of digital revolution on the global economy. Effects of the Internet on supply chain management and importance of the procurement function in e-supply chain formation are discussed. Then importance of the selection of this thesis topic, methodology followed during the study and the basic research questions involved are mentioned.

1.1. DIGITAL REVOLUTION AND THE GLOBAL ECONOMY

The effects of ICT's (information and communication technology) on national economies are multifold, with ICT's and the digital revolution creating:

- New industries and economic sectors or sub-sectors (e.g. the software industry, cell phones, computers and peripherals)
- New ways of doing business (e.g. e-commerce, globally distributed organisations, integrated supply chains)
- New tasks and opportunities for government (e.g. e-government, privacy policy legislation, ICT industrial policy)
- New issues in economic and political development (e.g. availability of information access, computer literacy, the digital divide)

Thus, the effect of ICT's and the digital revolution are far reaching, affecting the efficiency and productivity of other economic processes, the distribution of economic gains and basic services, and the transparency and accountability of the government (Mansourov 2005). Today's "networked" economy is shaped by three major business trends (Buckhold, 2000):

- Providing fast, global reach
- Speeding the supply chain
- Conducting business electronically

World's economy is becoming more fully integrated (a 'business without borders' environment), with the need for framework for global commerce, increased expectations on visibility and velocity, accessibility, connectivity, and reliability throughout the supply chain (Buckhold 2000).

With these major trends and fundamental shift in the economics of information, today every business is an information business (Leonard and Cronan 2005). Access to knowledge is now a key factor in global economic competitiveness, and Mansourov (2005) counts the following knowledge items required by businesses:

- Knowledge of customer demands, tastes, and requirements.
- Knowledge of and communication with a multiplicity of suppliers, which is critical for controlling costs, reducing inventory time, and speeding design modification and improvements.
- Knowledge of competitors' products, processes, and innovations in order to plan, evaluate, and place products and processes appropriately.
- Knowledge of available and emerging technologies.
- A business' knowledge of its own workforce, its capabilities, training needs, and grievances with management, which are all vital to maintaining the productivity of what is often the most expensive factor of production.
- Knowledge of overall productivity, which is essential to business viability in a constantly changing and increasingly global business environment. Without knowledge of their own productivity information, companies cannot make effective decisions on what products to introduce, discontinue, outsource, and innovate, or how to keep their management and workforce trained for necessary tasks and performing profitably.

Industrial knowledge management[1] also demands large quantities of data and analysis to meet modern global business needs, requiring "decentralized data gathering that can be readily compiled and rolled up to management". For such tasks, most businesses and managers find ICT's, the Internet, intranets, and similar technologies to be the "most cost effective", particularly when businesses expect to operate on an international playing field (Mansourov 2005).

[1] Knowledge management refers to the proces sthrough which the companies create and use their institutional collective knowledge (Barnard, 2005).

Boston Consulting Group (2000) reports that the Internet is enabling fundamental shifts in the economics of trading between businesses, with the compromises on buyers and suppliers being broken, value is being created through both broadening and the deepening of the trading relationships and the sizes and sources of value vary greatly between different industries.

Therefore, the digital divide both within countries and between countries is an issue of economic growth and international competitiveness, whether in agriculture, manufacturing, or services (Mansourov 2005).

1.2. SUPPLY CHAIN MANAGEMENT AND THE INTERNET

A supply chain is a network of facilities and distribution options that performs the functions of procurement of materials, transformation of these materials into intermediate and finished products, and the distribution of these finished products to customers (Rehan 2006). A firm's supply system includes all internal functions plus external suppliers involved in the identification and fulfillment of needs for materials, equipment, and services in an optimised fashion (Burt *et al.* 2003). Recent technological developments in information systems and technologies have the potential to facilitate the coordination among different functions, allowing the virtual integration of the entire supply chain. The focus of this integration in the context of Internet-enabled activities is generally referred to as e-SCM (electronic Supply Chain Management), merging the two fields of SCM (Supply Chain Management) and the Internet. E-SCM will refer to the impact that Internet has on the integration of key business processes from end user through original suppliers that provide products, services and information that add value for customers and other stakeholders (Gimenez and Lourenço 2004).

Supply chain dynamics have been studied for more than three decades. Huang *et al.* (2003) and Chen and Paulraj (2004) classify approaches and initiatives within the scope of SCM into four streams of research efforts:

1) Strategic purchasing
2) Supply management
3) Logistic integration
4) Supply network coordination

A supply chain is more practically defined as a connected network which typically crosses organisation boundaries (Chen *et al.* 2004). The supply chain encompasses every effort involved in producing and delivering a final product or service, from the supplier of raw materials to the customer. Due to its wide scope, supply chain management must address complex interdependencies, such as those in the form of 'extended enterprise' (Muffato and Payaro 2004).

In their previous research by Themistocleous *et al.* (2004), it is mentioned that future competition will not be company against company but rather supply chain against supply chain.

Viswanadham and Gaonkar (2006) define an integrated supply chain network as a group of independent companies, often located in different countries, forming a strategic alliance with the common goal of designing, manufacturing and delivering right-quality products to customer groups faster than other alliance groups and vertically integrated firms.

The diagram given in Figure 1 depicts a generic network of supply chain:

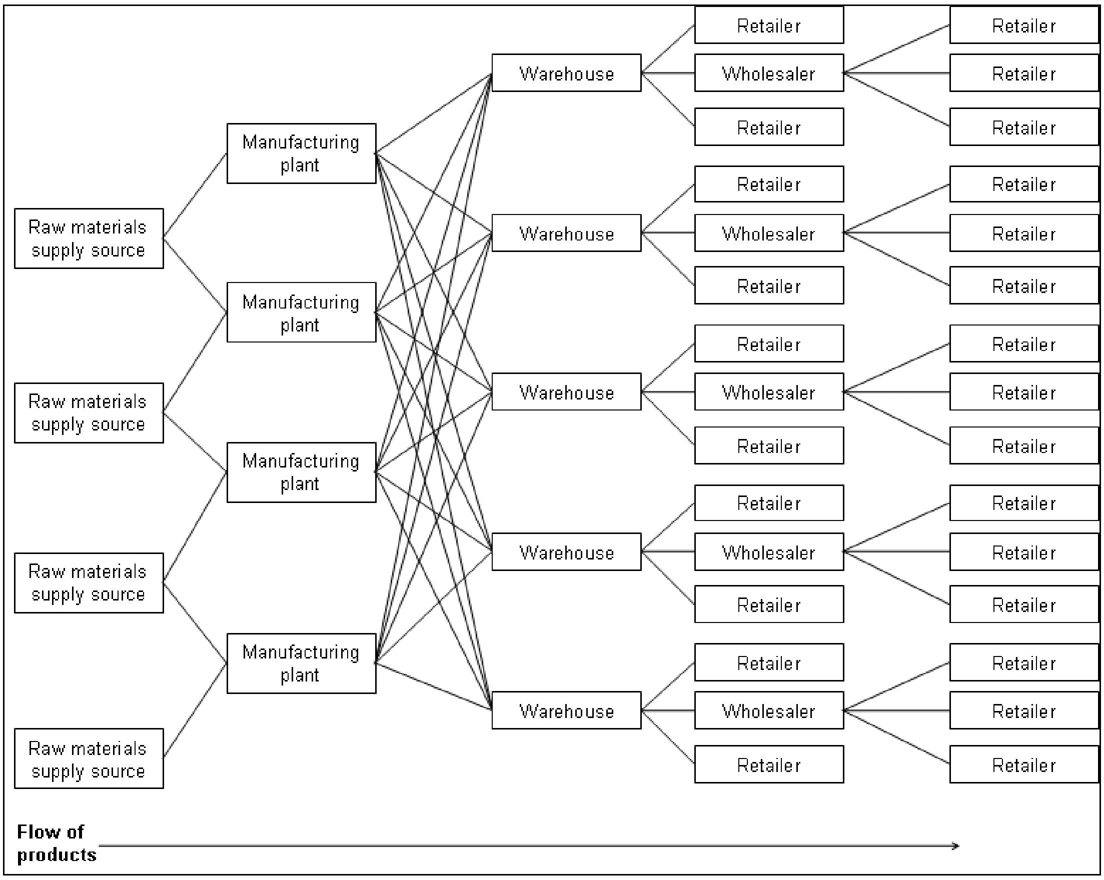

Figure 1 A generic network of supply chain Source: Global Supply Chain Game (gscg.org)

1.3. PROCUREMENT AND THE INTERNET: IMPORTANCE OF E PROCUREMENT IN THE FORMATION OF AN E-SUPPLY CHAIN

In today's IT-enabled global economy with ever-increasing international competitive pressures, improvement at any stage of supply chain interaction is welcome. As such, procurement becomes the core function in supply chain management, which can harvest the benefits of the Internet.

The fact that procurement and fulfilment are the key processes in the supply chain coordination and integration is well mentioned in the literature. Being the business processes providing the critical link between the supplier and the corporate, procurement and fulfilment activities lie at the core of the supply chain integration.

Muffato and Payaro (2004) quote that with the advent of the Internet; procurement became the main process to be redesigned and reorganised. Since the procurement or supplier relationship process consists of a relationship between businesses and needs a large amount of information sharing and transfer, the use of Internet has had major impact on the procurement process. As such, the e-procurement process supports the procurement and sourcing activities via Internet technologies and enables an efficient negotiation between buyers and suppliers (Gimenez and Lourenço 2004).

Various definitions of e-procurement can be seen in different research:

- A technology solution that facilitates corporate buying using the Internet. Essentially an Internet/Intranet based purchasing application or hosted service that streamlines buying trading partners, maximizes trade efficiency across the entire supply chain, and provides strategic e-commerce capabilities in Internet time (Parida and Parida 2005).
- Process which supports the procurement and sourcing activities via Internet technologies and enables an efficient negotiation between buyers and suppliers (Gimenez and Lourenço 2004).
- Electronic acquisition of goods and services in a firm (Turban and King 2006).

- The automation of the procurement processes so that the sourcing, vendor selection, procurement processes, shipment status tracking and payments can be made in an online environment (Bhaskar 2005).

Industrial Findings

According to Aberdeen Research Group (2001), e-procurement allows companies to automate the tactical processes and workflow associated with purchasing. Parida and Parida (2005) referring to InfoTech Research Group ITRG (2002) and Knutsen (2002), also supported the same and reported that e-procurement includes all aspects of the procurement function supported by various forms of electronic communication. As such, covering all aspects of procurement via web-based automation and integration are the key characteristics of e-procurement.

Kothari *et al*. (2005) reported that e-procurement technologies will become an important part of SCM, basing on their survey of 168 US organisations. They emphasise that procurement is well suited to information technology support and automation throughout all its steps, including information gathering, supplier contact, background review, negotiation, fulfilment, consumption, maintenance and disposal and renewal. They argue that definition of SCM suggests that all of the links in the supply chain be strong and well integrated in order to create and deliver customer values for the company's profitability. By definition, an integrated supply chain works for the coordination of all activities concerned with planning, coordinating and controlling goods, services and information (Leonard and Cronan 2005). Kothari *et al*. (2005) further argue that the key link, the one that sets SCM foundation for the others, is the procurement management on the input end of the chain.

As such, e-procurement is mentioned as integral component of an organisation's supplier relationship management strategy, and often as the first major step towards trading partner collaboration, aimed at translating the strategy into successful execution.

Research Findings

Recent technological developments in information systems and technologies have the potential to facilitate this coordination and collaboration, allowing the virtual integration of the entire supply chain. Therefore, the focus of this integration in the context of Internet-enabled activities is generally referred to as e-SCM, merging the two fields of “SCM” and the “Internet”. E-SCM refers to the impact that Internet has on the integration of key business processes from end user through original suppliers that provide products, services and information that add value for customers and other stakeholders (Gimenez and Lourenço 2004). E-supply chains seek to continuously improve the organisation’s integrated processes by electronically monitoring the creation and delivery of products (Leonard and Cronan 2005). The empirical findings of Leonard and Cronan (2002) indicate that an e-SC (electronic supply chain) is more effective than a nonelectronic SC and improves the SC replenishment process in terms of:

- Lower inventory levels
- Lower inventory carrying cost
- Fewer stockouts
- Shorter order cycles
- Lower prices (costs) and
- Greater availability of products

With these improvements in mind, e-procurement is clearly identified in the literature as one of the most implemented and studied within the e-supply chain domain (Gimenez and Lourenço 2004), the most important element of e-business operational excellence” (Davila et al. 2003), an important step towards development of the extended enterprise where the supply chain becomes a continuous, uninterrupted process extended form buyer to selling partners (Afsharipur et al. 2006).

With all these ideas in mind, e-procurement appears as the critical element towards supply chain integration in the form of e-supply chain. As the critical link for e-supply chain formation, a complete chapter is devoted to e-procurement.

1.4. IMPORTANCE OF THE THESIS TOPIC

Importance of the e-procurement and Internet is already put forward in terms of global economy and supply chain dynamics. Selection of this thesis topic as the interaction of ERP- eprocurement-esupply chain also assumes critical importance, since the topic:

- Combines Industrial Engineering and IT.
- Merges two fields of supply chain and Internet, requiring an interdisciplinary approach.
- Requires strong IT infrastructure.
- Requires not only IT-approach, but also business process orientation and managerial/organisational issues.
- Focuses on "integration" among supply chain partners, not only on integration of organisational functions.

The topic is critical because:

- It requires external integration → Beyond ERP
- It requires collaborative planning and joint management of key business processes

  → Beyond simple transactional exchange

  → Beyond e-commerce

  → Beyond Data warehouses

- Involves not procurement function only → Beyond e-procurement

As such, this thesis topic is a very recent, multidisciplinary topic requiring both IT and managerial approaches.

1.5. METHODOLOGY AND THE BASIC RESEARCH QUESTIONS

This study involves three-fold literature review and conceptual, survey-based comparative study. The basic research questions attempted to be answered in this research are as follows:

- What is the role of ERP in e-supply chains?
- Is ERP integration a prerequisite for e-supply chain?
- Is e-procurement a prerequisite for e-supply chain?
- Do e-procurement applications require ERP?
- Is internal integration required for external integration?
- Is there any standard, generalized framework of integration?
- What are the commonalities and differences among these frameworks?

1.6. CHAPTER FORMATION OF THE THESIS

Chapter formation of the thesis is given in below Figure 2:

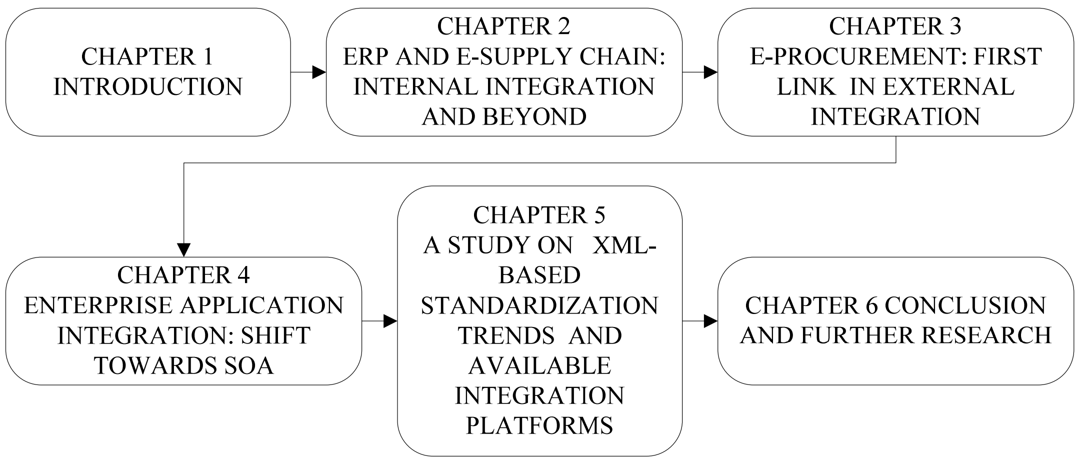

Figure 2 Chapter Formation

Chapter 2 will investigate into ERP and e-supply chain formation relationship. Role of ERP in e-supply chain formation, aims, benefits, requirements and challenges of e-supply chain formation are discussed in this chapter.

Chapter 3 focuses on e-procurement as the critical link of integration. In- depth discussion of e-procurement is given in this chapter, including its wide applicability, current global perspective, benefits, characteristics, functionalities, best practices, challenges, obstacles and next generation characteristics.

Chapter 4 focuses on the service oriented architectures and establishes the importance of service oriented architectures in dealing with the technological challenges of current enterprise application integration and e-supply chain formation.

Chapter 5 includes a comparative study on various XML-based standardisation trends and a study of currently available proprietary application integration platforms from proven vendors. The chapter reveals current lack of standardisation and structural generalisations of application integration platforms.

Chapter 6 includes the conclusion and further research.

CHAPTER 2 ERP AND E-SUPPLY CHAIN: INTERNAL INTEGRATION AND BEYOND

Seamless integration of various functions of an enterprise, both within the organisation and outside the organisation is clearly vital for supply chain interactions among different partners. In this regard, web-based interaction is a concept which must be treated together with the ERP integration. As such, this chapter will:

- Deal with the interaction of ERP and e-supply chain topics.
- Investigate the importance of ERP systems in e-supply chain formation.
- Highlight the aims and benefits of forming e-supply chain.
- Discuss the requirements for forming an e-supply chain.
- Provide a look at technical knowledge and structure for e-supply chain.

2.1 ERP SYSTEMS: FIRST STEP IN INTERNAL INTEGRATION

An ERP system is an integrated software system that spans a range of business processes that enables companies to gain a holistic view of the enterprise. ERP systems provide companies with the means of integrating their business functions into a unified and integrating process, around one database, one application and unified interface across the entire enterprise (Davenport 1998, Ehie and Madsen 2005).

While ERP systems can vary from one vendor to another, they tend to have the following modules and basic features as shown in Table 1. This basic structure mentioned above is based on SAP (Systems, Applications and Products Development) structure (Hayen 2006) and does not include industry-specific solutions such as Defense, Apparel, Banking, Beverage, Insurance and extensions like BW (Business Warehouse), SEM (Strategic Enterprise Management and SCM (Supply Chain Management).

It is evident from the range of functionalities covered that ERP systems up and running represent reengineered, standardized, unified, integrated and implemented way of doing business across the enterprise. Figure 3 shows the components of this structure.

Table 1 Basic ERP functionalities based on SAP structure

FI	**Financial Accounting** FI-GL General Ledger FI-LC Consolidation FI-AP Accounts Payable FI-AR Accounts Receivable FI-BL Bank Accounting FI-AA Asset Accounting FI-SL Special Purpose Ledger FI-FM Funds Management FI-CA Contract Accounting	Designed for automated management and external reporting of general ledger, accounts receivable, accounts payable and other sub-ledger accounts with a user defined chart of accounts. As entries are made relating to sales production and payments journal entries are automatically posted. These activities are conducted via different modules.
CO	**Controlling** CO-OM Overhead Costing (Cost Centers, Activity Based Costing, Internal Order Costing) CO-PA Profitability Analysis CO-PC Product Cost Controlling	Represents the company's flow of cost and revenue. It is a management instrument for organisational decisions. Automatically updated as transactions occur in other modules. Has different sub-modules.
AM	**Asset Management**	Designed to manage and supervise individual aspects of fixed assets including purchase and sale of assets, depreciation and investment management.
PS	**Project System**	Designed to support the planning, control and monitoring of long-term, highly complex projects with defined goals. This module assures project-based consolidation across all other modules.

Table 1 (Continued)

HR	**Human Resources** HR-OM Organisational Management HR-PA Personnel Administration HR-PB Recruitment HR-PD Personnel Development HR-PT Time Management HR-PY Payroll Management HR-TEM Training/Event Management	Complete integrated system for supporting the planning and control of personnel activities, including payroll, training management and recruitment.
MM	**Materials Management**	Supports all the issues regarding the material movement and inventory management. Includes functions such as lot tracking, shelf life follow-up, reorder point processing.
QM	**Quality Management**	A quality control and information system supporting quality planning, inspection, and control at all stages of material movement.
PP	**Production Planning**	Used to plan and control the manufacturing. This module includes bills of material, routing and work center definitions, master production scheduling, material requirements planning, shop floor release and planning.
SD	**Sales and Distribution**	Helps to optimize all the tasks and activities carried out in sales, delivery and billing. Key elements are: pre-sales support, inquiry processing, quotation processing, sales order processing, delivery processing, billing and sales information system.

Table 1 (Continued)

PM	**Plant Maintenance**	Equipment servicing and rebuilding. Interacts with PP.
WM	**Warehouse Management**	Enables "Storage Location", "Storage Types" and then into "Storage Bins" divisions. Placement and removal rules can be configured, stock counts can be done.

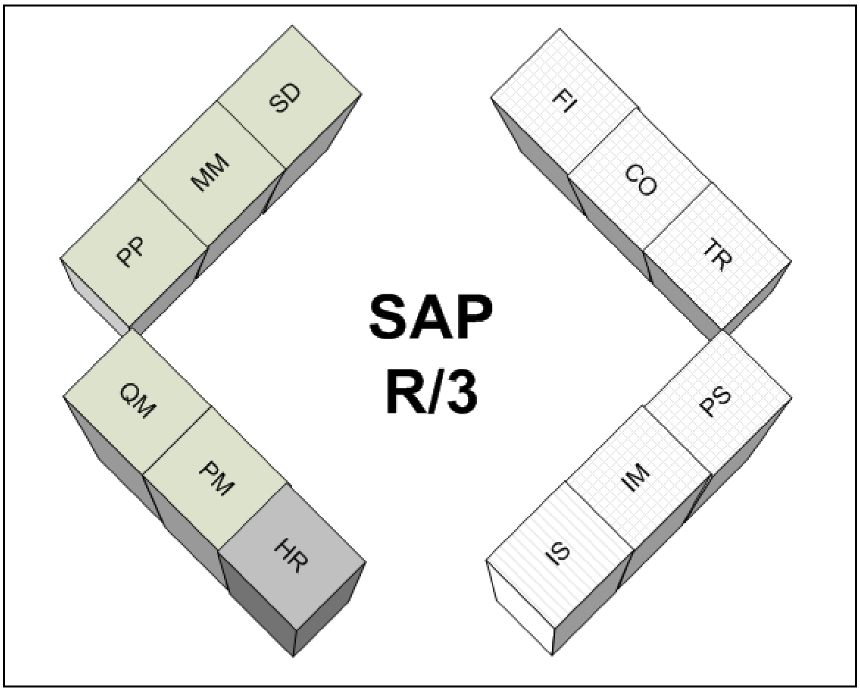

Figure 3 Basic ERP Components

In the literature, there is strong support for the importance of proper internal integration within the corporate before trying to provide external integration. In the evolutionary path to become an integrated enterprise, the company has to pass certain evolutionary stages. Within this evolution, ERP system acts as the first step in internal integration, whereas e-procurement acts as the first link towards the external integration of the company on the way to becoming an integrated enterprise.

The following items from literature provide strong support for staged evolution and need of internal integration prior to external integration:

- On the basis of findings from Burnell (1999) and Stock and Lambert (2001), Campbell and Sankaran (2005) mention that focus on integrating the internal supply chain is necessary before an organisation attempts to integrate its business partners and that a company needs to have its own house in order before trying to integrate with its trading partners. Campbell and Sankaran (2005) emphasise that evolution over the supply chain is a staged process and that an organisation needs to integrate internally before it evolves to a more advanced stage (external integration).

- Angeles (2006) quotes the importance of having interenterprise-wide business systems like ERP as part of the key infrastructure supporting e-procurement initiatives by referring to (Bendoly and Schoenkerr 2005). The fact that capabilities and use of ERP systems can be extended so that the capabilities of the package reaches out to a firm's strategic partners in the supply chain is clearly stated.

- Micro Technologies Inc. (2007) clearly mentions that a properly implemented application infrastructure building on one or multiple ERP systems is the essential starting point for large enterprises planning to enter the world of second generation e-business. They argue that presence of such an infrastructure provides the context for further progress, an enterprise-wide consistent data model, standard processes and integration between core enterprise systems. It is reported that with this essential backbone in place, it is possible to undertake rational long term investments by adding functionality and scope as demand grows. Without the essential first stage investment represented by comprehensive implementation of ERP, this evolutionary approach would not be possible. It is clearly emphasised that creating a networked value chain by linking the extended supply chain into core enterprise processes is key. In large enterprises, it is argued that there will almost never be a single comprehensive ERP backbone but more likely that we will find multiple ERP systems, sometimes not even from the same vendor, making the inter-enterprise integration step into the connected economy even more difficult since it goes far beyond the purely enterprise-focused scope of ERP. In an economy where integration of information to create competitive knowledge is key and where the overwhelming amount of information is increasingly hard to digest, personalized, role-based enterprise portals are reported to be the main component of any future architecture. These portals clearly need to provide single sign-on capability and to integrate all application components (multiple ERP systems, non-ERP systems, any kind of marketplaces and solution for the extended enterprise).

- Bendoly and Jacobs (2005) refer to e-procurement among the bolt-on systems which take ERP backbone as the core, providing the initial step towards external integration. E-procurement focusing on several innovation solutions with a single global ERP system as a foundation is also mentioned in Ghiya and Powers (2005). The need for integrating e-procurement technologies with the core business processes such as inventory, MRP (materials requirement planning), bills of materials, scheduling, inventory, costing systems, and performance reporting systems is clearly emphasised by Davila *et al.* (2003).

- Rehan (2006) counts ERP integration, supplier integration and integration with legacy systems among the key issues to be considered in deploying an effective e-procurement solution.

- Parida and Parida (2005) mention 7 different e-procurement models during the evolution of e-procurement based on Kalakota and Robinson (2000). Starting with EDI networks, change towards portal based structures to enable collaborative supply chains is evident in these models. The presence of internal integration within the corporate before evolving into collaborative integration in the form of e-based supply chains is also clear.

- Bendoly and Jacobs (2005), refer to Supply Chain Compass, a supply chain evolution model developed by (Fox and Holmes, 1998) which defines 5 stages of evolution for a supply chain. In this model, the company evolves starting with fundamental functions running with independent departments at stage I, becoming consolidated at stage II, assuring internal integration at stage III, reaching external integration within the extended supply chain at stage IV, and then moving towards network-centric commerce at stage V.

- U.N. (United Nations) E-Commerce and Development Report (2004) emphasises that e-procurement plays a role as the enabler of e-business, including SME's (small and medium sized enterprises).

2.2 E-SUPPLY CHAIN: INTEGRATION BEYOND ERP

With the recent trends of globalization, competitiveness, stunning developments in information technology and the use of the Internet, more and more transactions are performed on the Internet and it is becoming critical for the firms to rely on Web-based supply chains or e-supply chains (Pant *et al*. 2003). The Internet is becoming a more cost-effective and powerful media for doing business (Rehan 2006), leading to the concept of e-supply chain in which efficiency and effectiveness of the overall supply chain is increased via 'Web-based' connectivity of inter-organisational information systems (Viswanadham *et al.* 2006).

In Luo *et al.* (2001), an e-supply chain is defined as an emerging business strategy that incorporates the power of e-commerce to streamline the manufacturing processes, speed the product cycles, and integrate the supply chain and better response to customers. The paper also defines an integrated e-supply chain network as a hyper network of material flows overlaid with an e-business information network. Therefore, e-supply chains materialized from the application of Internet technologies in the management of supply chain interactions.

A schematic of the highly integrated supply chain is given in Figure 4, as adopted from Pant *et al.* (2003), showing the integration among different parties on the supply chain. In this figure, supplier, customer and distributor systems are integrated with the manufacturers system via the Internet. In its generalised form, we can talk about a number of suppliers, customers and distributors interacting with the manufacturer with similar web-based connectivity, thus forming a network.

Chen and Long (2004) define an e-supply chain as a highly integrated supply chain with electronic links based on the Internet. The complexity and the degree of integration with the suppliers and distributors differ and we can talk about 'highly integrated' and 'partially integrated' e-supply chain systems, as given in Pant *et al.* (2003). The paper shows that in highly integrated Web-based supply chains, we observe complexity for both internal and external operations and the clear need for integrating internal systems via ERP systems. As well as integrating internal operations through standard ERP packages, external connectivity is needed. As partial integration example, the paper mentions web-based ordering and focusing on eliminating both internal and external efficiencies related with ordering process**.**

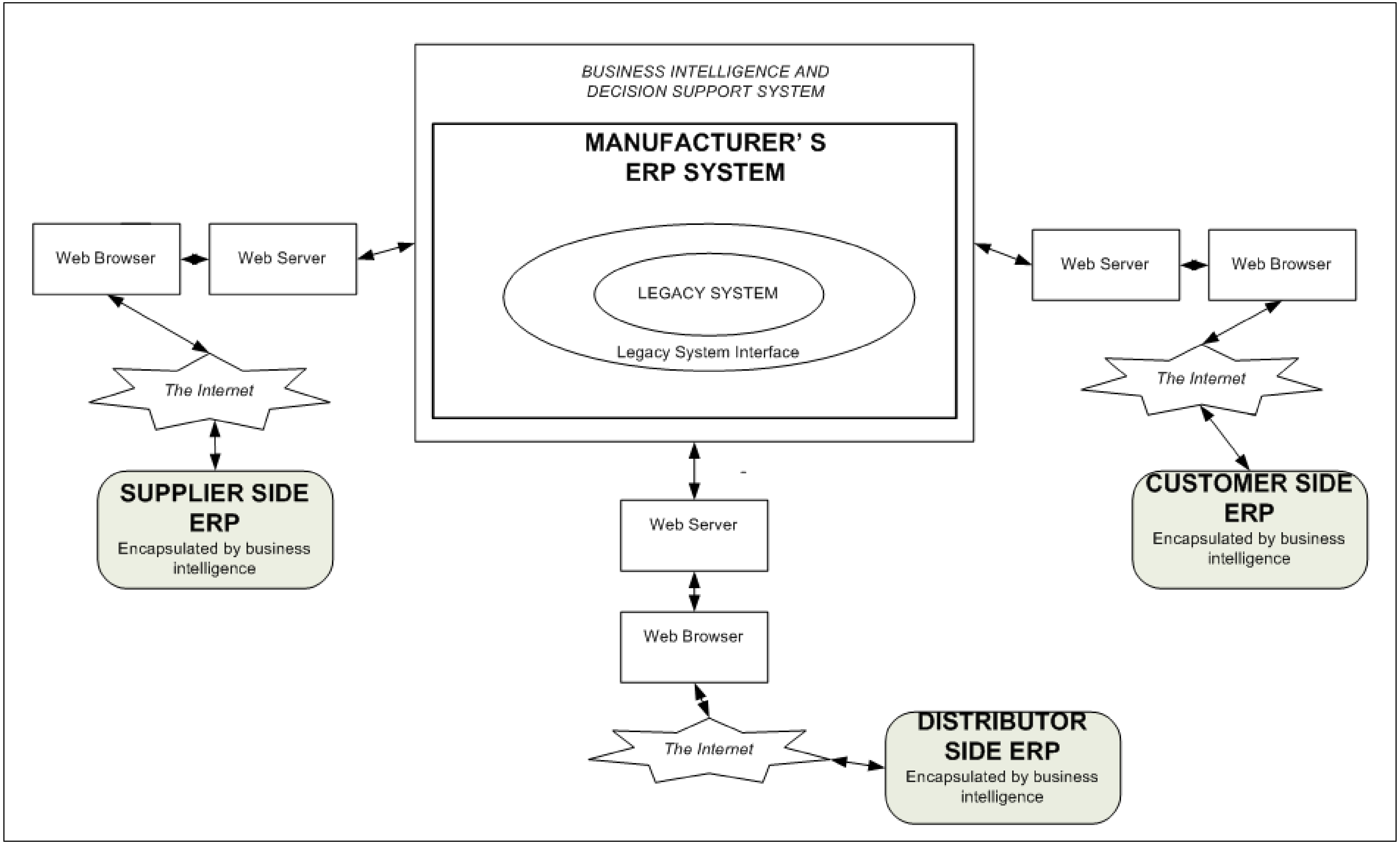

Figure 4 Schematic of highly integrated supply chain Source: Adopted from Pant and Sethi (2003)

2.2.1. Aims and Benefits of Forming e-Supply Chain

In today's digital economy, flexibility, adaptation and responsiveness are critical to success. The Internet appearing as the greatest ICT (Information and Communication Technology) tool, and the 'integration' as the key for efficiency and success; e-supply chains take advantage of the Internet to obtain better integration over the supply chain. Therefore, aims of forming e-supply chain are as follows:

- Effectively leveraging web to redesign, automate and integrate all business functions.
- Seamless coupling to the entire supply chain via the Web, with strong internal as well as external integration.
- On-line, real-time collaboration and synchronization via the Web.

The benefits of realizing these aims by forming web-based supply chain are evident in the literature. In Luo *et al.* (2001), the following are clearly emphasised for e-supply chains and internet-enabled, shared information:

- Brings about a more cooperative business environment.
- Facilitates more interactive approach to supply chain.
- Provides demand data and supply capacity data visibility.
- Provides ability to anticipate and respond to demand fluctuations.
- Provides tools for tightly orchestrating the relationships across the entire supply chain.
- Helps creating operational linkages.
- Helps creating strategic partnerships.
- Helps in breaking down the organisational and functional fences.
- Enhances the flow of information.

In Pant *et al.* (2003), the following appear as the benefits of forming an e-supply chain:

- Streamlining both internal and external operations.
- Ability to provide real-time response to market conditions.
- Ability to provide real-time response to customer queries.

- Ability to undertake real-time, joint demand planning.

In Rehan (2006), greatest advantages mentioned are as follows:

- Obtaining cost savings through integration of the supply chain.
- Overall reduction in the inventory levels throughout the supply chain.
- Reduction in procurement costs.
- Improved vendor management.
- Cycle time reduction.
- Improved profitability.

2.2.2. Different Models of Integration

In the literature, there are various definitions and models for integration. Themistocleous (2004) reports that an enterprise is no longer viewed as a single corporation but it is a loose collection of trading partners that can contact with manufacturers, logistic companies and distribution organisations. Therefore, the need for comprehensive integration of business processes and both intra- and inter-organisational applications are clear to support long-term coordination, survival and growth.

Bendoly and Jacobs (2005) define integration as connecting information systems and bringing about common information and processes together throughout an organisation.

Xu *et al.* (2005) refer to previous work by Romano (2003), mentioning that 'integration can be regarded as a mechanism to support business processed across a supply network at two different levels: intra- and inter-company integration'.

Themistocleous *et al.* (2004) discusses the limitations of ERP systems in handling the inter-organisational integration and the need for building a common EAI (Enterprise Application Integration) that unifies all the information systems. The paper proposes a generic structure which integrates legacy, ERP and e-business systems of different parties throughout the supply chain and defines 'loose' and 'tight' types of information, similar to 'high' versus 'partial' integration previously defined in Pant *et al.* (2003). While making the 'loose' and 'tight' distinction, the degree of process dependency (low versus high), degree of integration (low versus high), type of communication (synchronous versus asynchronous) appear as the critical factors. The basic characteristics of loose and tight types of integration, as defined by them, are summarized in the below Table 2:

Table 2 Basic Characteristics of loose and tight types of integration
Source: Pant and Sethi (2003)

Loose Integration	**Tight Integration**
Focus on exchanging/sharing data among partners	Focus on integrating cross-enterprise business processes and systems
Low degree of process dependency	Highest degree of process dependency
Low degree of integration	High degree of integration
The development of an homogenous, integrated cross-enterprise infrastructure NOT critical	The development of an homogenous integrated cross-enterprise infrastructure critical
Asynchronous communication	Synchronous communication

Campbell and Sankaran (2005) mention integration about customers, internal functions, activities, suppliers, technology, planning, measurement systems and relationships, emphasizing that it is well documented in the literature that the lack of integration between members of a supply chain results in operational inefficiencies that compromise the performance of the supply chain. In their literature survey, they clearly indicate that both internal and external integration needs have to be considered.

Previous research by Burnell (1999) and Stock and Lambert (2001) is referred to in this paper, emphasizing that focus on integrating the internal supply chain is necessary before an organisation attempts to integrate its business partners. The idea that a company needs to have its own house in order before trying to integrate with its trading partners is recapitulated.

All these ideas are also supported by Bendoly and Jacobs (2005), who refer to Supply Chain Compass, a supply chain evolution model developed by Fox and Holmes (1998). This model, given in Table 3, defines 5 stages of evolution for a supply chain, starting with fundamental functions running with independent departments at stage I, becoming consolidated at stage II, assuring internal integration at stage III , reaching external integration within the extended supply chain at stage IV, then moving towards network-centric commerce at stage V.

Table 3 Stages of Supply Chain Evolution Source: Bendoly and Jacobs (2005)

	STAGE I	**STAGE II**	**STAGE III**	**STAGE IV**	**STAGE V**
	THE FUNDAMENTALS	**CROSS-FUNCTIONAL TEAMS**	**INTEGRATED ENTERPRISE**	**EXTENDED SUPPLY CHAIN**	**SUPPLY CHAIN COMMUN-ITIES**
BUSINESS PAIN	Cost of Quality	Unreliable order fulfillment	Cost of customer service	Slow growth margin erosion	Non-preferred supplier
DRIVING GOAL	Quality and cost	Customer service	Profitable customer responsiveness	Profitable growth	Market leadership
ORGANISATIONAL FOCUS	Independent departments	Consolidated operations	Integrated supply chain(internal)	Integrated supply chain (external)	Rapidly reconfigurable
PROCESS CHANGE	Standard Operating procedures	Cross-functional communication	Cross-functional processes	Customer-specific processes	Reinvented processes
METRIC	Predictable costs and rates	On-time, complete delivery	Total delivered cost	Share of customer	New worth
IT FOCUS	Automated	Packaged	Integrated	Inter-operable	Networked
KEY PLANNING	Spreadsheets	Point tools	Enterprise supply chain planning	Point-of-sale supply chain planning	Synchronizes supply chain planning
KEY EXECUTION TOOLS	MRP and other homegrown applications	MRPII	ERP	Customer Management Systems	Network-centric commerce

This model implies that evolution over the supply chain is a staged process and that an organisation needs to integrate internally before it evolves to a more advanced stage of external integration (Campbell and Sankaran 2005).

Muffato and Payaro (2004) define 5 stages for e-business:

- Traditional communication tools
- Internal integration
- Web-based communication tools
- XML (Extensible Mark-up Language) Web-based platform
- Integrated enterprise

Parida and Parida (2005) mention 7 different e-procurement models during e-evolution as follows:

- EDI (Electronic Data Interchange) Networks
- B2E (Business-to-employee) requisitioning applications
- Corporate procurement portals
- First generation trading exchange: community catalogs and storefronts
- Second generation trading exchange: virtual distributor auction hubs
- Third generation trading exchange: collaborative supply chains in the form of trading collaboration hubs
- Industry consortiums: joint venture collaboration hubs

Hayes (2004) categorizes e-supply chain solutions within the range from 'open' to 'closed', basing on the level of integration. Within this range, he mentions ERP systems, EDI, custom interfaces with trading partners, web storefronts, intranet-based procurement systems, e-market places (trading hubs), trading exchanges and collaboration platforms. Basic characteristics, advantages and disadvantages of these solutions are as follows:

- EDI is limited data sharing among ERP systems via custom interface implementations. Although it eliminates a lot of paperwork, speeds up transactions and enables encryption, EDI has disadvantages of having different subsets of standards, lack of semantic rigor in the meaning of various components of EDI messages, formal agreement requirement on mutually acceptable definitions and having high start-up and maintenance costs. Besides these disadvantages, EDI messages are unable to interface with Semantic Web Services since they are not semantically-enabled (Foxvog

2005). In this regard, Lan (2005) mentions advantages of using XML over standard EDI technologies in terms of cost effectiveness and flexibility to implement and operate. A previous work is referenced by Nurmilaasko *et al.* (2002) to emphasise the suitability of XML over EDI technologies. Drawbacks and shortcomings of EDI for e-supply chains are also mentioned in Viswanadham and Gaonkar (2006), such as cost of maintenance and requirement of forming dedicated links, restricting on-demand, and dynamic link formation among new supply chain partners.

- Custom interfaces rely on extranets or virtual private networks implemented on a custom basis and they rely on outside consulting assistance (Hayes 2004).
- Web storefronts are mentioned as a non-classical example of e-supply chain solution with special focus on the seller side (Hayes 2004).
- Corporate procurement systems are reported to have the basic focus of procurement, with significant cost of implementation and maintenance (Hayes 2004).
- Trading hubs are emphasised as supporting many-to-many relationships among trading partners and covering functions of e-catalogs, dynamic pricing, conducting auctions, financial settlement, fulfillment and logistics (Hayes 2004).
- Collaboration platforms in this classification are based more on collaboration and coordination of the partners and they include collaboration in the areas of design, forecasting, planning and replenishment (Hayes 2004).

Basing on these discussions about integration models, it is clear that naming, numbering of the evolution stages are various in the literature. The following points are evident and common for these models:

- Presence of a staged evaluation process.
- Increased degree of collaboration and dependence among supply chain partners, with decreased autonomy of decision making.
- The need for internal integration within the corporate before evolving into collaborative integration in the form of e-based supply chains.
- Change towards portal based structures to enable collaboration.

Therefore, it is clear that e-supply chain is a major step beyond internal integration and many orchestrating effects come along with the achievement of the external integration.

2.2.3. Requirements for forming an e-supply Chain

In the literature, the following appear as the requirements when forming an e-supply chain:

- Replacement of or integration with the legacy systems.
- Standardising and streamlining internal processes – BPR/redesign if needed.
- Adoption, updating or integrating with the existing ERP of the Enterprise.
- Streamlining external processes- BPR/redesign if needed.
- Collaborative planning and joint Management of key business processes.
- Business Intelligence and decision Support.

In this section, all of the above items will be analyzed with respect to past research.

2.2.3.1. Replacement of, or Integration with the Legacy Systems

Presence of legacy systems is inevitable in organisations and these systems may sometimes contain mission critical data, with millions of lines of codes. Although replacement of these systems is necessary for many reasons- such as technology in which they are written becoming obsolete and unsupported or suppliers withdrawing support- totally abandoning these systems by replacing them with new alternative information systems or rewriting these systems is not always possible. This is because some of the functionality and data present in the legacy systems may still be needed, maybe even mission critical, and legacy systems may contain the details of the vital processing algorithms (Bennett *et al.* 2006). Therefore, a way to access the critical data present in the legacy systems is required. Bendoly and Jacobs (2005) also clearly mention the need to integrate the enterprise solutions package modules with their other legacy systems. Therefore, deciding on which legacy systems to abandon and which ones to keep and integrate with enterprise wide solutions is a critical decision to be made as part of the ERP implementation. The enterprise will have problems with 'internal' integration right from the start if integration with the legacy systems is not properly handled. Thus, integrating the legacy system with ERP systems can be considered as the first step towards consolidating traditional, functional and locational silos of information.

The solution to be used in accessing back-office functionality will depend on how much of the system needs to be Internet-enabled. Zoufaly (2002) suggests two basic non-intrusive approaches in this regard:

- **Frontware (screenscrapers)** is an approach used in order to deliver Web access on the current legacy platform. The non-intrusive tools add a graphical user interface to character-based legacy applications, providing Internet access to legacy applications without making any changes to the underlying platform. Because they are non-intrusive, screen scrapers can be deployed in days and sometimes hours. However, scalability can be an issue since most legacy systems cannot handle nearly as many users as modern Internet-based platforms.
- **Legacy wrapping** is the technology that provides a new interface using a conversion programme (wrapper) without changing the interface of the existing software. Although the interface of each legacy system differs, the wrapper will absorb the difference (Yoshioka *et al.* 1998). The technique builds callable APIs (Application Programming Interfaces) around legacy transactions, providing an integration point with other systems. Wrapping does not provide a way to fundamentally change the hardwired structure of the legacy system, but it is often used as an integration method with EAI frameworks (Zoufaly 2002). This technique is also mentioned in Bennett *et al.* (2006), who talk about 'creating new front-ends', typically using modern GUI's and 'wrapping' these systems up in new software. In this case, wrapper design and a good understanding of the interfaces to the legacy systems are critical. This approach enables integration vendors to focus on the communications and connectivity aspects of their solutions, while avoiding the complexity of legacy systems.

Like screen scraping, wrapping techniques are applicable in situations where there is no need to change business functionality in the existing platform. However, none of the above approaches address the problems such as high cost associated with maintaining a legacy system or finding IT professionals willing to work on obsolete technology (Zoufaly 2002).

As a company evolves and seeks external integration with suppliers and customers, the need for considering and examining the legacy systems of the partners also becomes critical (Williamson *et al.* 2004), since presence of legacy systems are valid for suppliers and customers as well.

2.2.3.2. Standardising and Streamlining Internal Processes– BPR/ Redesign if Needed

During ERP implementations, it is well-proven that change in internal business processes is needed towards standardising and synchronising ways of doing business for different business functions. Various implementation cases in the literature support this. The degree of change depends totally on the enterprise and these changes can amount to complete restructuring/reengineering of various internal business functions involved.

Bendoly and Jacobs (2005) clearly state that ERP systems enable organisational standardisation, including the standardisation among different locations belonging to the same enterprise. This results in improving ways of doing business at substandard locations, bringing them in line with others.

Standardised firm-wide transactions and centrally stored enterprise data are also referred to by Hendrics *et al.* (2007) for facilitating the governance of the firm.

The role of ERP systems for streamlined processing of business data and internal, cross-functional integration are mentioned by Gupta and Kohli (2006), emphasizing the role of ERP in struggling with data redundancy, information inconsistency, incompatible information systems and inconsistent operations policies.

Therefore, it is clear that a successful ERP implementation forces organisations to standardise, restructure and streamline the ‘internal’ functions, all the reengineering efforts being handled within the scope of ERP implementation.

2.2.3.3. Implementation, Adoption or Updating of ERP System

Since forming an e-supply chain requires integrating business functions beyond the enterprise boundary and assures connectivity with suppliers and customers, a sound base of integration for all in-house activities around a centralized database is needed. As such, let it be a new ERP implementation, or adaptation/updating of a previously existing ERP system, a sound ERP infrastructure system up-and-running is the greatest enabler towards forming an e-supply chain. Therefore, ERP systems become the backbone for the e-supply chain.

Enabling position of ERP systems for improvement, development and growth is also clear in the literature. In Bendoly and Jacobs (2005), the following diagram (Figure 5) clearly shows the central position of ERP to integrate different systems like SCM, CRM (Customer Relationship Management), Data mining, Data Warehousing:

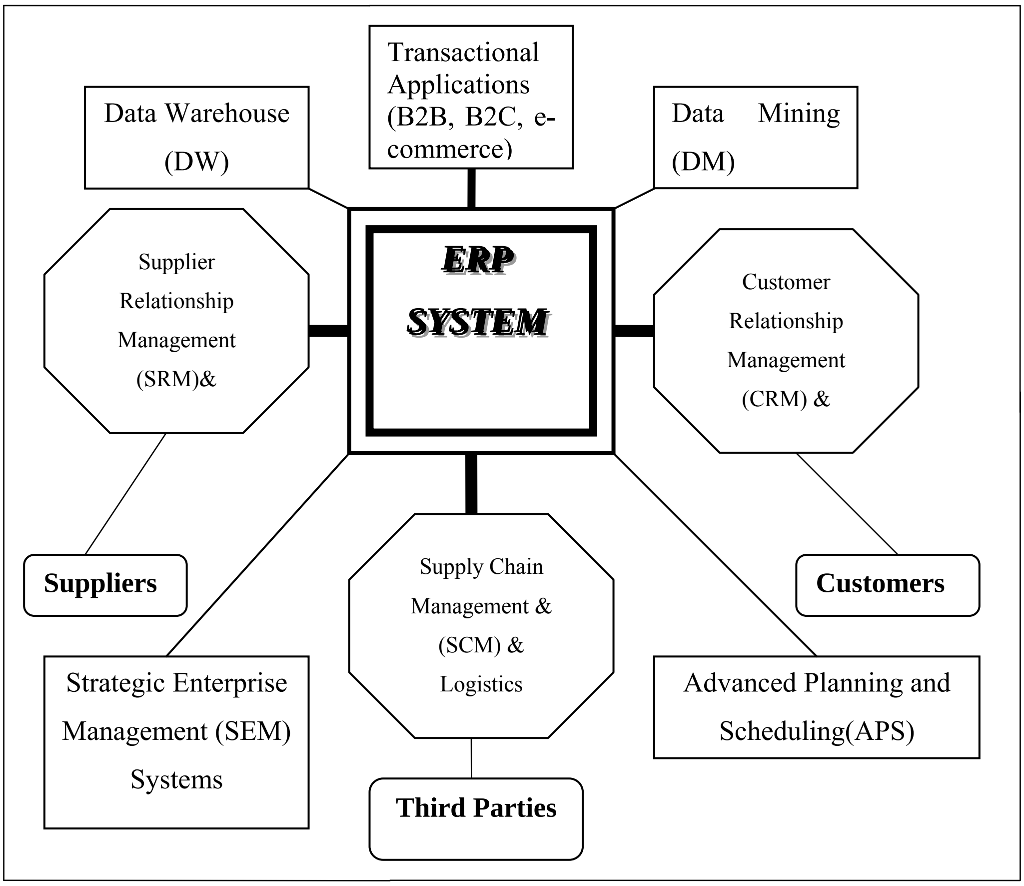

Figure 5 Enabling Position of ERP Source: Adopted from Bendoly and Jacobs (2005)

It is argued that ERP can be used to help firms create value and it is emphasised that value creation by ERP usage is attained by the following:

- Integrating firms activities.
- Enabling organisational standardisation.
- Eliminating information asymmetries.
- Providing on-line and real time information.
- Allowing simultaneous access to same data for planning and control.
- Facilitates intra-organisation communication and collaboration needs.
- Facilitates inter-organisation communication and collaboration needs, laying the foundation for external integration.

As such, a successful ERP implementation is the greatest enabler for 'extended' supply chain and appears to be a giant step passed for internal integration. In this regard, a successful ERP implementation means:

- In-house reengineering, streamlining and standardisation efforts are completed within the scope of ERP implementation.
- Different organisational data are now ready for simultaneous access around a single database, forming the basic foundation for better internal communication and efficient on-line, real-time reporting needs.

Only after these stages are completed can we start talking about efficient external integration. Bendoly and Jacobs (2005) talk about ERP as being the 'information backbone' for communication and collaboration with other organisations. Therefore, ERP systems become the backbone for other value-adding systems like APS (Advanced Planning and Scheduling), CRM, SRM (Supplier Relationship Management), call center management, e-procurement, e-auction, e-commerce, data warehouses, and project management. Bendoly and Jacobs (2005) talk about these systems as 'bolts-on' systems, taking ERP systems as the core. Among these systems, the author emphasises two systems, CRM (Customer Relationship Management) and e-procurement, using the results of a 2004 survey questionnaire based on APICS's (American Production and Inventory Control Society) mailing list. Basing on the results of this survey, the author argues that CRM and e-procurement systems have the top ranking for implementation. These two bolts-on systems appear as the key to provide better linkages to the extended supply chain. As such, CRM improves the linkages to customers and enhances communication on the downstream side of a firm's supply chain, whereas e-procurement systems provide linkages to suppliers and strengthen relations on the upstream side of the supply chain.

Leopoulos and Kırytopoulos (2005) also treat ERP systems as a core component of an extended supply chain and clearly emphasise the fact that ERP systems are examined as a component of e-commerce applications. In the conclusion section of their article, they strongly state that the implementation/adoption of ERP systems are inevitable to operate in an e-business environment. In the ordering defined in five-stage evolution model of Muffato and Payaro (2004) mentioned earlier, internal integration of a company appears prior to e-based business integrations. This also supports the idea of internal integration around ERP prior to web-based integration.

Therefore, it can be easily argued that integration of different functions at the enterprise level around a sound ERP implementation forms the basis of extended enterprise integration in the form of an e-supply chain, with CRM and e-procurement systems having the top priority, as being the critical links at downstream and upstream sides of the supply chain.

2.2.3.4. Streamlining External Processes- BPR/Redesign if Needed

Assuming that the enterprise has completed its internal housecleaning, restructuring, business process reengineering and functional integration via ERP, the next step towards seamless integration over the supply chain is the integration with suppliers and customers.

Putting critical add-ons like e-procurement or CRM on top of the existing ERP system may require still further business process reengineering related with critical processes, such as procurement approval cycles, order fulfillment or handling of customer complaints.

Pushmann and Alt (2005) clearly discuss the need for seamless integration with the existing ERP systems and talk about the need for 'e-procurement adaptors' which can allow integration with the backend systems. They emphasise the need to redesign the procurement processes for successful e-procurement activities and mention the following as main focuses of redesign in procurement practices:

- Reduction or elimination of authorization stages.
- Regulation of exceptions.
- Elimination of paper, including automation of procurement stages.
- Integration of suppliers in the entire process chain.

Procurement and fulfillment are again suggested as the key processes within the supply chain, which require redesign and reorganisation in Muffato and Payaro (2004). Presence of an ERP system working before the initiation of an e-procurement system is also suggested in one of the Italian cases mentioned in the paper.

Bendoly and Kaefer (2004) report, after the analysis of 115 firms, that transactional efficiencies gained by B2B e-commerce technologies are greater in the presence of an ERP system and these effects are magnified when ERP implementation specifically precedes B2B e-commerce activities. Therefore, presence of an ERP system together with strategic sequencing and relative timing of the ERP and e-commerce implementations can impact the efficiencies of e-commerce applications.

In the light of these ideas, it is clear that providing efficient and effective interfaces with the existing ERP backbone together with reengineering of business processes related with the suppliers and customers are required for obtaining 'external' integration.

2.2.3.5 Collaborative Planning and Joint Management of Key Business Processes

Once the enterprise has reached the maturity of external integration with suppliers and customers on the Web, the next step in the evolution is to be able to perform collaborative planning and joint management of the critical business processes. This involves forming strategic alliances and long-term partnerships with suppliers and customers, basing on mutual trust and win-win strategy.

Since 1995, new forms of collaboration are seen in information-sharing relations. The focus of these forms include not only a passive exchange of information between partners, but also a more proactive approach through common planning and synchronisation of activities and business processes (Skjoett-Laersen *et al*. 2003). In this regard, CFPR (collaborative forecasting, planning and replenishment) definition taken from ECR (Efficient Consumer Response Movement Organisation Europe, 2002) is as follows: 'A cross-industry initiative designed to improve the supplier/manufacturer/retailer relationship through co- managed planning processes and shared information' (Skjoett-Laersen *et al.* 2003). CFPR involves many players in an extended supply chain who provide information such as product usage and forecasts to all the players in that supply chain (Bendoly and Jacobs 2005).

Therefore, the concept of e-collaboration and collaborative planning over the Web goes beyond simply e-buy and e-sell activities. The concept includes sharing of:

- Information
- Decisions
- Processes
- Resources (Wang 2005)

In such form of integration, the aim is to be able to obtain visibility/transparency and assure collaboration in the following functions:

- Planning
- Forecasting
- Design
- Development
- Management and service

Joint problem solving and improvement for any of the above functions are essential for such collaboration; therefore, the concept is really broad and aimed at obtaining strategic partnerships. Benefits of e-collaboration are well-discussed in (Wang 2005). To obtain these benefits, the basic types of information to be exchanged with suppliers and buyers are mentioned in Nguyen and Harrison (2004) as follows:

- Materials and inventory position
- Product availability

- Price information
- Purchase orders and changes
- Vendor receipt/acceptance
- Invoice payments
- Status reporting

In Ho and Lin (2004), some of the major collaborative scenarios are given as follows:

- Product life cycle collaboration
- Engineering project collaboration
- Customer order and inventory collaboration
- Distributor-reseller collaboration
- Supplier and procurement collaboration
- Demand planning collaboration
- Warehouse management and freight collaboration

Besides standard operational planning, the need for long-term business planning, ability to perform feasibility checks for new orders or change requests across the network, mutual exception handling ability, multi-sourcing coordination and performance measurement are also needed within the scope of long term collaboration.

At advanced levels of collaboration scenarios, knowledge, experience and competencies are also shared in addition to basic business transactions and information (data related with demand, order planning, promotion and production).

Therefore, information visibility among partners, including shop floor status, design-related information and sales forecasts, is the key to such a wide -scope collaboration. In this regard, willingness to share information is the basis of the partnership. Lack of mutual trust and unwillingness to share information among the partners appear to be the greatest obstacles on the way of e-collaboration. Skjoett-Larsen (2003) support these ideas by referring to a previous survey and emphasises that issues of more organisational nature, like trust, lack of discipline and collaborative goals, are the real barriers towards CFPR initiatives.

To sum up, the ability to engage in collaborative planning and making joint decisions with both suppliers and customers are critical components of forming e-supply chain. Therefore, assuring basic external connectivity of sales and purchasing functions over the Internet is not sufficient to form e-supply chain. To be able to capture the real benefits of e-collaboration, much more than web-based exchange of operational transactional data is needed.

2.2.3.6 Business Intelligence and Decision Supports for All the Partners

In the previous section, it is clearly emphasised that more than simple e-buying or e-selling is needed to establish an e-supply chain. Since forming strategic business alliances and long term relations are in question, not only operational-level, transaction-based information sharing is involved. Exchange of information at tactical and strategic levels is needed as well. This definitely requires proper reporting, decision support and business intelligence mechanisms for each partner, backed up by their running ERP systems. Therefore, this means there is a clear need to support the ERP systems with reporting, data mining, data warehousing, decision support and business intelligence tools. Therefore, integrating such tools to obtain real-time managerial decision support becomes the real issue. Many ERP-based platforms, such as ®SAPs NetWeaver BI (Business Intelligence), are currently in use towards this aim.

Ability to have multiple views of an enterprise in the form of info cubes using OLAP (on-line analytical processing), drill-down reporting capabilities to enable reporting at different levels of detail, exception broadcasting and adding BI reports to portals appear as critical functionalities for business intelligence and decision support.

2.2.4. A Look at Technical Knowledge and Structures Used for Developing e-supply Chain

Over the past few decades, organisations have accumulated multiple generations of technology including monolithic, 2-tier, and 3-tier client/server architectures and now the industry is focusing on service-oriented architectures. Rogers (2003) mentions various key technologies for integration, including message-oriented access and transactional middleware, integration server software, information portals, application server deployment platforms, technology and application adaptors, workflow modelling and coding tools. Common use of XML and Java, portal-based, tiered architectures, and adaptor-based integration servers are the most frequently used technologies in this regard.

2.2.4.1 Common Use of XML and Java as Software Architecture

In the literature, it is clear that many of today's integrated supply chain management systems use Web technology as the supporting infrastructure. Lan (2005) mentions this by referencing the previous work by Dalton *et al.* (1998). Since web-based integration over the Internet requires significant amount of electronic data interchange among different supply partners, use of common protocols and standards gain tremendous importance. Lan (2005) mentions that HTTP (HyperText Transfer Protocol) , server-side Java, and XML are mostly used as software architecture and emphasises the need for some interfacing with old technologies, such as aging ERPs and legacy systems and by referring to Zieger (2001).

In Williamson *et al*. (2004), use of web development technologies such as XML and Java is again counted among standard phases to be passed to obtain inter-organisational integration. In Boyson *et al.* (2003), current use of different systems and standards is clearly emphasised.

Yen *et al. (*2002) talk about 'indispensability' of a common protocol to implement the connection of heterogeneous environments belonging to different partners within the supply chain. Some of the basic functionalities to be provided by an Internet-based information interchange are mentioned as follows:

- Transactional integrity
- Connection stability
- Authentication
- Non-repudiation of messages

Yen *et al.* (2002) emphasise a significant movement toward employing XML-based formats and technology and the search for standardisation in the EDI community. The fact that different rivals, such as ®IBM, ®Microsoft, ®Sun and ®Oracle all support core XML standards and major ERP software vendors such as ®SAP, ®Peoplesoft and ®Oracle becoming 'XML-enabled' are clearly mentioned. Yen *et al.* (2002) discusses Microsoft's BizTalk, XML-based cross-platform application, to enable B2B communication as a case study.

In Xu (2005) the fact that large ERP vendors have incorporated XML syntax into their products and Microsoft BizTalk Technology are emphasised. SAP NetWeaver platform is another example of ERP packages being XML enabled, as well as providing Java support on this platform via SAPs J2EE Engine of the SAP Web Application Server used for the Java and JSP components.

In Muffato and Payaro (2004), XML web-based platform is counted among the standard implementation stages suggested. After the company passes the stages of using traditional standard communication tools, enterprise integration and use of web-based tools, fourth step towards e-commerce applications is given as 'XML based platform'. The paper talks about four cases, Italian companies, using XML Web based platforms.

Besides Microsoft's BizTalk, other XML-based e-commerce frameworks such as RosettaNet and ebXML (e-business XML) are seen in the literature as initiatives of standardisation. In brief, these frameworks have the ability to support business processes definitions via XML schemas and to use standard messaging protocols such as HTTP (Dogac and Cingıl 2003).

To summarize, XML appears at the core of the standardisation and integration efforts to develop different integration platforms and frameworks. Various XML-based standardisation efforts will be further discussed in detail in Chapter 5.

2.2.4.2. Portal-based, Tiered Architectures

Portal-based, tiered architectures are frequently seen in the literature. Boyson *et al.* (2003) talk about a portal-based, three-tier e-supply chain integration solution by referring to a pilot project for US Department of Defense (DoD). It is mentioned that 'three-tier' architectures are developed to provide robust SCM systems. The integration system used in US Department of Defense (DoD) is again given by Lan (2005) as an example of 3-tier architecture. In this structure:

- The first layer used corresponds to **'Web Portals'** which provide access to suppliers and customers.
- The second layer is defined as a **'Messaging Infrastructure'** which supports portals and provides the link to the underlying **'application layer'**, the third layer. Therefore, it acts like a bridge or central nervous system (Boyson *et al*. 2003) and becomes an intermediary infrastructure.
- The third layer is the **'Application Layer',** being independent of any interface and containing all the business data and logic. This layer is defined to include ERP systems, SCM functionality, APS Systems and decision support/business intelligence systems. Therefore, the application layer acts as a central repository for the data together with the business logic and all the core transactions are designed to happen here. It is clearly mentioned that data and business logic are stored independently in this third layer (Boyson *et al*. 2003, Lan 2005). This three-tier architecture is shown in Figure 6.

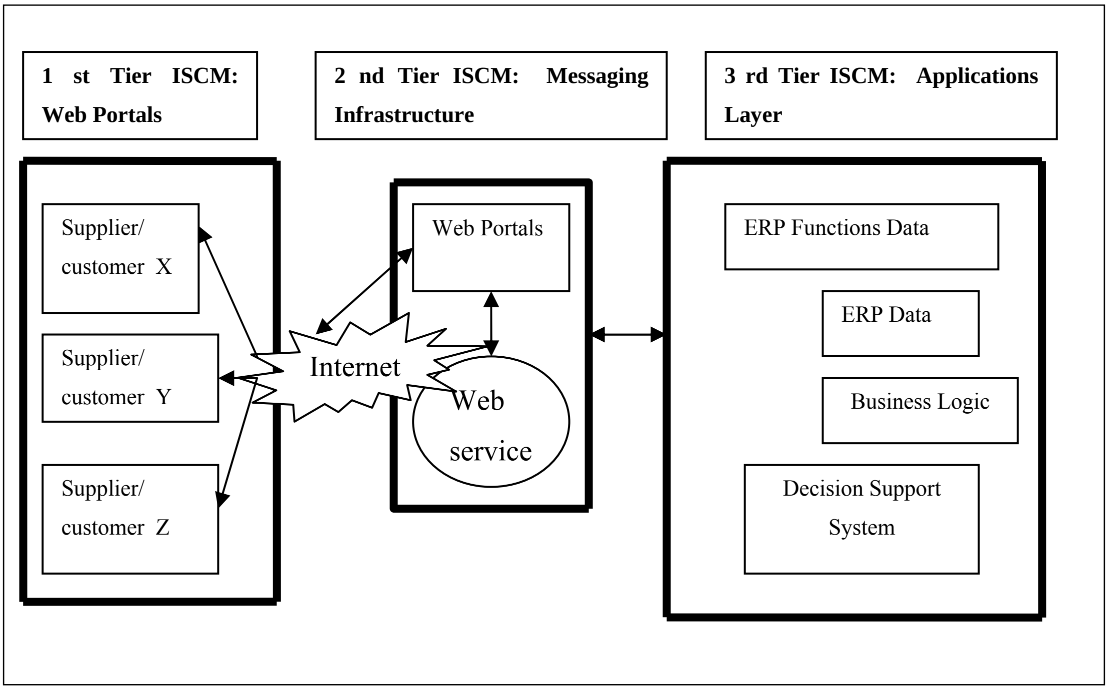

Figure 6 Three-Tier architecture as defined by Lan (2005) Source : Lan (2005)

In this three-layer architecture which is referred to in both Boyson *et al.* (2003) and Lan (2005), the following appear as the strengths of such portal-based, layered architectures:

- Web-based interface at both customer and supplier sides, provided by the web portals. This gives a starting point for accessing the web, assuring standardised interactions with the users, depending on their security clearance/authorisations. While assuring the secure access, this layer can be personalized, depending on the requirements and access classifications of the user.
- An intermediary infrastructure connecting the interface and the underlying application layer provides a clear separation of interface and the core business system. This gives us the opportunity of making plug and play changes to the interface, without making any changes for the underlying business logic.
- Backbone application layer represents the 'integration' of the enterprise -both internal and external- since it includes legacy systems, all the ERP functionality, APS and collaborative planning options.

Such a layered architecture is totally in conformance with and supports the idea that ERP systems are the greatest enablers of e-Supply chains, acting as a real backbone and a common database to support all the additional functions. These ideas are again supported by Xu *et al. (*2005) who suggest a web-based framework for manufacturing coordination. By discussing project ‘Co-Operate’, they suggest a system basing on automotive supply and semiconductor industries. The framework they suggested also uses ERP systems implemented- SAP’s R/3 and APO (Advanced Planner and Optimizer) as the core and utilises XML.

2.2.4.3. Adapter-Based Integration Servers

Microsoft BizTalk Technology and Intersystems Ensemble can be given as examples of such technology. Chappell (2005) introduces Microsoft BizTalk Server 2006 technology as a general model for combining different systems into effective business processes. The technology is based on BizTalk Engine working internally with XML documents, uses adapter technology and standard web services such as SOAP (Simple Object Access Protocol), contains a graphical tool for defining the business process logic, has the schema definition and mapping capabilities basing on XSLT (Extensible Stylesheet Language Transformations) and uses a message box implemented in SQL (Structured Query Language).

Rogers (2003) mentions similar characteristics for InterSystems Ensemble, namely the use of adapter framework, persistent object and message engine, use of common web services, protocols and standards such as XML, SOAP, WSDL (Web Services Definition Language) and graphical business process modeling.

Basic advantages of the technology are briefly the use of common web services and standards, adapter facility providing compatibility with various systems, plug-and-play capability, graphical support for process definitions and ability to connect a number of heterogeneous systems.

A detailed study of integration platforms from proven vendors will be presented in Chapter 5.

2.2.4.4. Other Approaches

In the literature, we can see other different approaches to supply chain integration.

Luo *et al.* (2001) define a graph-based hypernetwork formulation of e-supply chain and then formulate a fuzzy multi-objective optimization problem. The optimised network is also simulated using discrete event simulation to analyze the stochastic behaviour of the network.

A previous work referenced in Lan (2005) is by (von Mevius and Pibernik 2004), which propose a new approach to supply chain process management, based on a new high-level Petri-net called XML-net. XML-nets are mentioned to consist of supply chain data objects and physical supply chain object documents, supporting the exchange of intra-and interorganisational data and offering superior supply chain process modeling capabilities.

Caputto *et al.* (2005) develop a framework for e-supply chains, identifying four sets of organisational structures on the basis of internal integration degree and decision making concentration degree.

Dotoli and Fanti *et al.* define a generic IESC (Integrated e-Supply Chain) basing on graph theory and develop single-criterion and multi-criterion optimization models under structural constraint definitions. Besides cost and total lead time, their model objectives include energy and CO_2 emission, making their model sensitive to environment. They provide Integer Linear programming problem solution to their model.

The difficulty of using such approaches is the integration of the proposed models and formulations with the backend ERP systems in an on-line, real-time manner. Assuring the connectivity of the model with day-to-day transactions of the ERP systems appear to be lacking, although these models are generic formulations with different optimisation criteria.

Agent-based approaches are also seen in the recent literature such as an agent-based decision support system suggested for an e-supply chain in Sadeh *et al.* (2003). For agent based approaches, defining and standardizing the agent behaviour across different platforms seem to be the greatest hurdle.

2.2.5. Security and Trust

Since e-supply chain requires data sharing not only at transactional level but also at tactical and strategic levels among supply chain partners, issues of security and privacy become vital. Clearly, what is needed is beyond transactional security. Assuring identification, authentication, authorisation, privacy, auditability and message integrity for more than one trading side, as well as dealing with intruders, malicious peers and security attacks are major concerns. Main methods used in this regard are multiple digital signatures, different encryption methodologies and HTTP/SSL (Hypertext Transfer Protocol/ Secure Sockets Layer). Among different XML-based frameworks mentioned in the previous subsections, RosettaNet and Microsoft BizTalk use digital signatures and HTTP/SSL whereas ebXML framework uses extended SOAP. As such, current frameworks appear to rely on secure web services.

Besides addressing such technical concerns, establishing clear business policies, rules and agreements among partners in terms of confidentiality of the business processes and business documents are also critical. To maintain trust and collaboration among partners, such policies and agreements have vital importance. Therefore, security is one of the most critical issues to be considered, having both technical and managerial requirements.

2.2.6. A look at the Challenges Involved in Developing e-supply Chain

As can be seen from the scope and requirements of forming an e-supply chain, the implementation of an e-supply chain is a great challenge on the way to become a real e-collaborator. In Pant *et al.* (2003), the challenges involved in the implementation of a highly integrated supply chain are treated under the classification of 'internal' and 'external' challenges. Many concerns such as security, change in business processes, presence of weaker supply chain partners, organisational resistance are mentioned as challenges while trying to achieve both internal and external integration.

The challenges involved in e-supply chain formation can also be classified as technical and managerial/organisational challenges. Assuring the continuity and maintenance of the system is critical throughout the lifetime of the system, posing still further challenges.

2.2.6.1. Technical Challenges

The technical infrastructure of an e-supply chain is inherently much more complicated than the information infrastructure of a single enterprise, as more than one partner is involved. Therefore, necessary sophisticated infrastructure should be provided which can:

- Support on-line, real-time connectivity and visibility among heterogeneous information systems of more than one party, including their legacy systems.
- Handle network-based requirements and security issues, being a critical issue for especially highly sensitive data.
- Guarantee necessary business intelligence/decision support to enable collaborative planning.
- Guarantee training and all related technical skills to install and maintain such an infrastructure.

Therefore, combining possibly inconsistent/incompatible information systems of different parties in a secure, reliable and efficient manner, together with sufficient decision support capabilities, is clearly a technical challenge. These challenges, including the need to have a highly sophisticated technology infrastructure, legacy system considerations and security needs are clearly mentioned in Pant *et al.* (2003).

These are the concerns for the interest of different audience in technical domain, including solution developers and people from networking and security domain.

2.2.6.2 Managerial/ Organisational Challenges

Besides all these technical challenges, there are various managerial/organisational challenges involved in forming e-supply chain, which are of interest for both end users and managerial people. While establishing an e-supply chain, a managerial and organisational approach should be followed that can:

- Guarantee managerial vision, support and commitment (not only from one partner but from all the partners).
- Utilize project management techniques to enable proper planning and project management.
- Overcome internal resistance within the organisations of each partner
- Overcome external resistance and assure mutual trust among all external partners.
- Guarantee compatibility of strategies, objectives and goals among supply chain partners.
- Provide sufficient financial, technical and human resources.

Since external integration of an enterprise is involved in forming an e-supply chain, managerial support, commitment, proper planning, coordination and sufficient resources (financial, technical, human) are needed from more than one partner. Creating and maintaining mutual trust, eagerness to exchange information, willingness to cooperate and collaborate on various business functions are critical challenges which must be met by all the partners in an e-supply chain. In Pant *et al.* (2003), organisational resistance, commitment, time, availability and mutual trust issues are emphasised as challenges, supporting all these ideas.

2.2.6.3. Assuring the Continuity and Maintenance of the System

Assuming a successful implementation of e-supply chain, assuring the continuity and adaptability of the e-supply chain to changing conditions is still a further challenge. Monitoring, performance measurement, control and early warning mechanisms are needed to be developed and agreed upon among different partners.

Common performance indicator definitions and measurement methods, consistent understanding and evaluation of these metrics, agreed-upon review frequencies, compatible early-warning systems and consistent actions to warnings are vital for gaining strategic success and survival of all the partners.

To sum up, the challenges involved in implementing integrated e-supply chains are bigger than the problems faced by an organisation trying to adopt internal systems (like ERP) or external systems (like EDI) (Pant *et al.* 2003). Therefore, any technical and managerial/organisational challenge valid for other types of implementations is amplified in e-integration. This is true because of the presence of multiple, inconsistent technical infrastructures, inconsistent or even conflicting managerial approaches, possibly different corporate cultures and resource bases.

2.3. DISCUSSION

Related with ERP and e-supply chain interaction, strong support is found for the following in recent literature:

- The need to consider internal integration prior to efforts of external integration with suppliers and customers, keeping in mind the legacy systems.
- The need and importance for business process reengineering for both internal and external processes.
- Importance of handling ERP implementations prior to web-based integration efforts towards forming an e-supply chain.
- The need to take previously implemented ERP systems as the core for integration efforts of various 'bolt-on' applications, such as CRM, APS towards forming an e-supply chain.
- Widespread use of XML and Java in various integration efforts.
- Importance of layered, portal based infrastructures.

As companies evolve in their connectivity and integration efforts, ability of supply chain partners to engage in collaborative planning and joint management of critical business activities become the key to efficiency, effectiveness and success of the overall supply chain. Web-based exchange of operational data at transactional level is clearly not sufficient for this aim. The need for web-enabled, on-line, real-time support for managerial decision making to handle 'business intelligence' needs, with proper authentication and authorisation mechanisms is evident.

The challenges involved in forming an e-supply chain and web-based joint strategic management are clearly much more profound than the challenges of an ERP implementation. The majority of the challenges are still organisational and managerial, with amplified technical challenges like network connectivity of heterogeneous systems and web-based security. In today's digital economy, success will be for those organisations which can handle all these challenges towards better web-based integration.

Despite the frequent use of XML, lack of standard infrastructures and frameworks appears to be continuing. Industry is still in search of common standards, protocols and frameworks to integrate different cross-platform applications over the Internet to provide seamless integration among supply chain partners. This issue will be further elaborated in Chapter 5.

CHAPTER 3: E-PROCUREMENT: FIRST LINK FOR EXTERNAL INTEGRATION

The need for staged evolution and assuring internal integration prior to external integration is already emphasised and the importance of e-procurement as being the key function in supply chain formation has already been put forward in the first two chapters. As being one of the earliest add-ons to core ERP functionalities and one of the most implemented within e-supply chain domain, e-procurement topic deserves attention as the critical link towards e-supply chain formation. This chapter will:

- Discuss the basic e-procurement characteristics and functionalities.
- Emphasise the wide applicability of e-procurement.
- Provide a look on current global perspective on e-procurement.
- Highlight best practice requirements, challenges and obstacles.

3.1. BASIC E-PROCUREMENT CHARACTERISTICS AND FUNCTIONALITIES

E-procurement is the automation of the procurement processes so that the sourcing, vendor selection, procurement processes, shipment status tracking and payments can be made in an online environment (Bhaskar 2005). Afsharipur *et al.* (2006) mention the following basic activities for purchasing:

- Determining specification
- Selecting supplier
- Contracting
- Ordering
- Expediting and evaluation
- Follow-up and evaluation

For SAPCO (Supplying Automotive Parts Company) case analysed in their study, procurement steps are defined as requisitioning, order submission, order tracking, receipt processing, payment processing.

U.N. E-Commerce and Development Report (2004) mentions four basic elements for e-procurement as follows:

- **On-line tenders:** with bidders having the ability to search and identify tenders, online forms and automated, online submission capability.
- **Electronic invoices:** ability to allow for issuing and receiving invoices electronically.
- **Electronic payments:** ability to allow for electronic funds transfer with necessary approval cycles through authenticated digital signatures and process management.
- **Automated process integration:** electronic automation of all of the above elements in an end-to-end e-procurement.

Gebauer *et al.* (2001) mention the following main functionalities of as basing on Motorola's non-production procurement:

- Catalogue Management
- Requisitioning
- Approval
- Purchase order
- Fulfilment
- Payment

Wang and Miller (2005) define the lifecycle of a PO (Purchase order) as given in Figure 7, with the corresponding stages mentioned in Gebauer *et al.* (2001):

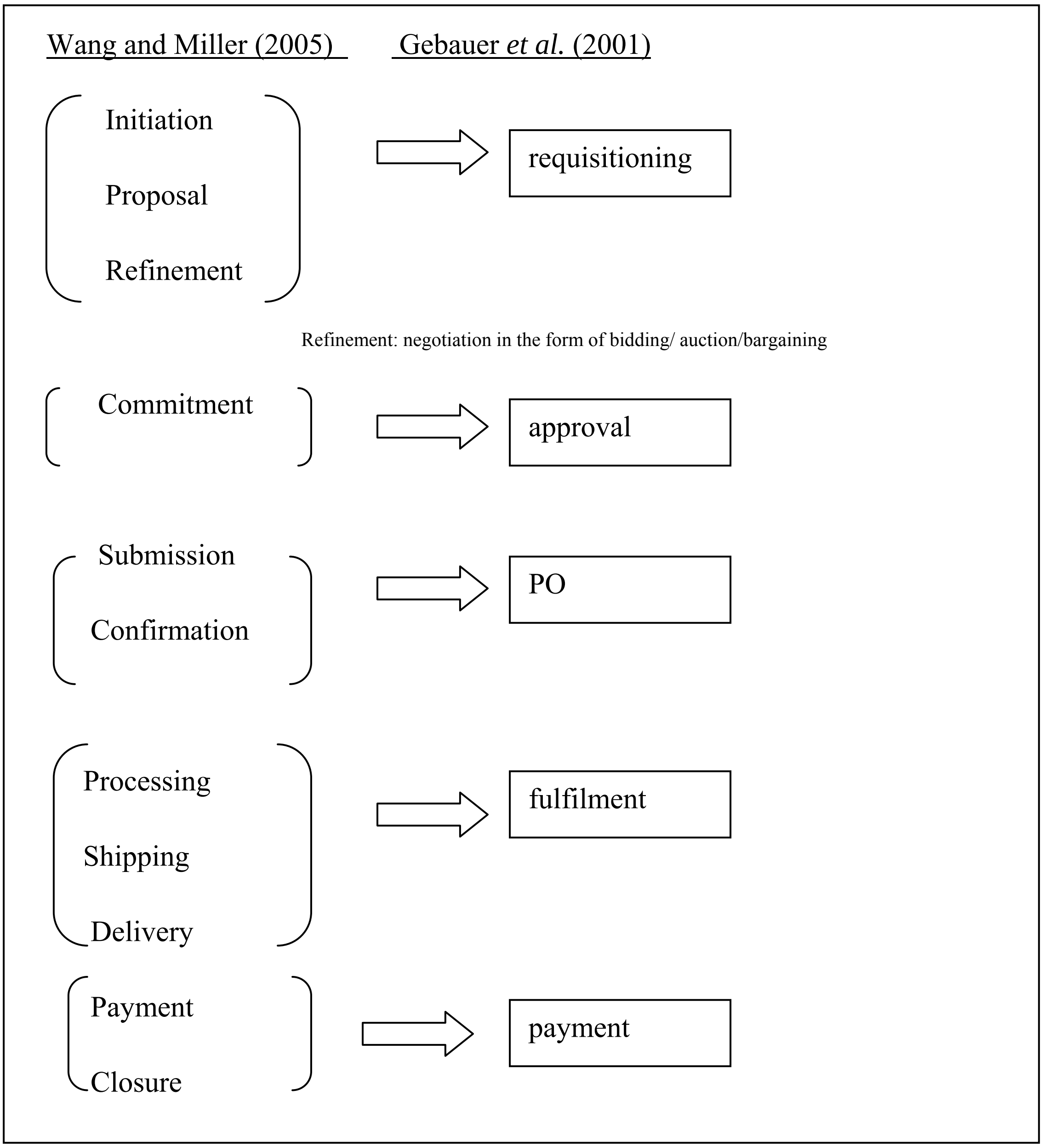

Figure 7 Comparative stages of e-procurement Sources:

Wang and Miller (2005), Gebauer *et al.* (2001)

It is worth noting that the term PO is used by Wang and Miller to cover the whole cycle, whereas the accustomed usage makes the distinction of "PR" (purchase request) and "PO".

For e-procurement, Afsharipur *et al.* (2006) define the following activities:

- Advertising tenders
- Electronic submission of tenders
- Electronic ordering
- Internet sourcing via third parties
- Electronic mail between buyers and sellers
- Electronic mail in contract management
- Research into supplier markets
- Integration of procurement with financial and inventory systems

Although different naming of the stages and activities are present in the literature, it is clear that e-procurement intends to automate the full procurement cycle, starting with tendering and ending with payment and closure, with all the backend integration with financial and inventory systems. It is evident that other forms of collaborative planning and coordination are possible only when this full procurement cycle is handled seamlessly.

3.2. WIDE APPLICABILITY OF E-PROCUREMENT

E-procurement solutions have broad appeal because they span across the market sectors and industries (ciol.com 2007). The term ''e-procurement'' has become a subject of discussions in both the private and the public sector (Panayiotou et. *al*. 2004). From manufacturers to online retailers, from health sector to governments, all firms perform some sort of purchasing function. Besides private and public sector companies, automating procurement function is critical for government as well, as being the largest purchaser of the economies (U.N. E-Commerce and Development Report 2004).

3.2.1. Various application examples

Below are some different e-procurement applications from diverse sectors seen in literature:

- Kothari et *al.* (2005) discuss e-procurement as "an emerging tool for the hotel supply chain management" and specifically emphasises the importance of e-Procurement as "an integral component of SCM".

- Tatsis *et al.* (2006) present a study on the state and development of e-procurement in the Greek food and drink industry, based on four case studies with some of the largest organisations in the industry.
- Muffato and Payaro (2004) study implementation of e-procurement and e-fulfilment processes with a comparison of cases in the motorcycle industry based on two Italian motorcycle companies: Ducati and Aprilia.
- Liao *et al.* (2003) investigate a case study of e-commerce in the Taiwanese military organisation by diagnosing and preventing procurement faults, constructing a transparent procurement environment, and enhancing military procurement efficiency, and attempting to establish an e-market environment via web-based architecture on e-procurement procedure.
- Australian Government (2005) investigates e-procurement implementation cases in governments of 5 different countries (Italy, New South Wales, New Zealand, Scotland and Western Australia). It is clearly emphasised that "public e- procurement is embedded in and shaped by diverse socio-technical and institutional contexts, the details of which are described in each individual case study" (Australian Government 2005).
- Gebauer *et al.* (2001) mention 'Motorola' case, based on "TIGERS" project, the acronym for Motorola's Total Integrated Global Electronic Requisitioning System.
- Based on Andersen Consulting findings, Panayiotou *et al.* (2004) mention Cisco, Chevron and Eastman Chemicals as some of the adopters of e-procurement systems worldwide, demonstrating substantial improvements.

3.2.2. A Turkish application example

E-tendering implementation present in the Institution of Public Tenders can be mentioned as an important Turkish application of e-procurement. This self-governing regulatory and auditing institution is legally responsible from the Public tenders and has implemented an e-tendering solution (Tender Information System) in 2004. Second revision of the system is made in 2005 under the name of "Public Purchasing Platform" and it is currently in use (Akkaynak 2005).

The organization has strong determination of benefiting from IT technologies in public purchasing. Akkaynak (2005) and Gül (2006) reports the following basic aims for the system implemented:

- Providing standardization, efficiency, visibility and process integrity to the complete tendering process.
- Preventing corruption and unlawfulness in the purchasing process.
- Assuring right and efficient use of public resources by providing spend discipline.

The system covers the tendering process for the purchases of goods, services, construction work and consultancy. Different types of tenders and claim management are supported (ihale.gov.tr). The current system is composed of four different modules:

- Management
- Bidder
- Citizen
- Analysis

Zengin (2006) summarises the basic functionalities of the system as follows:

- Electronic announcement of public tenders.
- Assignment of unique tender numbering and receipt of this tender number via the Internet, all other processes being performed via this number.
- E-querying if the winners are prohibited from public tenders.
- Formation of e-tender statistics.
- Providing citizen access to query the results.

In compliance with the regulations of Institution of Public Tenders, Turkish State Materials Office provides electronic catalog for various classes of materials under its responsibility (dmo.gov.tr).

3.3. CURRENT GLOBAL PERSPECTIVE OF E-PROCUREMENT

We have entered a new era of supply management, one which requires a new mindset, new skills, new strategies, and new technologies both to thrive and survive (Minahan 2007). This new era is best described as next-generation of supply techniques designed to drive long-term and sustainable improvements in supply costs, performance, and value impact. Minahan (2007) defines this as an era where:

- The supply management function looks beyond driving internal efficiencies to optimize visibility, efficiency, and performance across a constantly-shifting, global network of supply partners.
- Sourcing decisions and subsequent supplier management strategies are based not just on price or even total cost of ownership (TCO), but on overall network performance, risk management, and the value impact of supply on core business goals and differentiators.
- Automation investments provide comprehensive functionality and decision support for the complete supply management lifecycle — from initial spend visibility and analysis through continuous performance measurement and improvement.
- Supply management team is entrusted with (and contributes value to) a broader portion of corporate spending and strategic business goals.
- Supply management function is measured not just on near-term cost reductions, but the ability to contribute value to the business-in the form of supplier innovation, risk management, and continuous improvements- on a long-term and sustainable basis.

As the critical link towards web-based supply chain formation, next generation e-procurement systems should be able to satisfy the needs of this era of supply chain excellence.

Main pressures driving e-procurement adoption are basically automated procurement processes, reduced maverick spend, centralised procurement processes, improved spend visibility, reduced transaction costs and improved compliance (Aberdeen Group 2006).

Firms who have implemented e-procurement systems have reported to be enjoying significant savings, often in the range of millions of dollars (ciol.com 2007). From the outset, even the most rudimentary e-procurement applications have been reported to be able to deliver some level of process efficiency and cost benefits to a procurement organisation by replacing a brutally inefficient manual/paper-driven workflow and enabling a self-service requisition capability for the extended enterprise. Today, automating the requisition–to-pay process remains the most significant objective of an enterprise's e-procurement initiative (Aberdeen 2006). Since reductions in procurement costs fall directly to the bottom-line of an enterprise's income statement, there is increasing awareness of the importance of making purchases against negotiated contracts and reducing any type of non-contract or maverick spend (Aberdeen Group 2006). With increasing pressures on these bottom lines, organisations are looking at various ways to drive down costs. This has given a different definition to the way procurement has been functioning making it the strategic arm for cost reduction (Bashkar, 2005).

Afsharipour *et al.* (2006) emphasises the same fact by mentioning "to date more or less all studies on e-procurement report large efficiencies regarding process and procurement costs". They report the impact of e-procurement on enterprise compliance and spend management initiatives, referring to Aberdeen Group 2004 findings as in the below Table 4:

Table 4 E-procurement Impact (Average Performance) Source: Aberdeen Group (2004)

Performance Area	Before e- procurement	After e-procurement
% of spending that is off-contract (maverick)	38%	14.2%
Price savings on maverick purchases brought into compliance	-	7.3%
Requisition-to-order cycles	20.4 days	3.8 days
Requisition-to-order costs	$56	$23
% of spend under management of the procurement group	56%	69%

Table 5 also summarises quantified benefits of e-procurement applications as quoted by various literature.

Table 5 Quantified benefits of e-procurement applications

Reference	Quantified Benefits
Tatsis *et al.* (2006) refer to a European study conducted in year 2000,	Reduction in transaction costs of up to 90%, Lead-time reductions of up to 60% and Purchase prices reductions of up to 10%.
Tatsis *et al. (2006)* report another study, conducted among 14 companies of different sizes	Process cost reductions of 60–80%
Davila et al. (2003)	Purchasing transaction cost reductions of 42 per cent in, associated with less paperwork, which translates into fewer mistakes and a more efficient purchasing process
Miller (2006)	Reaping benefits often to the tune of millions of dollars” Enjoying returns that may measure up to 300% of the initial investment in just 3 years”.
Mitchell (2007)	Between 5 % and 15% savings on indirect spending, with 8-month pay-back periods, hard savings coming primarily from volume discounts and reduced off-contract spending, as well as from implicit labour savings when the activity-based cost of a purchase is reduced from US$75-150 to US$10-25.

Besides these striking and quantified cost savings, the literature contains various non-quantified classifications of benefits companies expect to see by automating the tactical processes and workflows associated with purchasing. These are summarized in the below Table 6.

Table 6 Non-quantified E-procurement benefits

Turban *et al.* (2006)	• Increased productivity of purchasing agents • Lower purchase prices of different types of goods and services • Better streamlining of information flow, business processes and workflows involved in purchasing • Eliminating maverick buying (i.e., buying from unauthorized buyers) • Reduced order fulfilment and processing times • Reduced number of suppliers the firm is dealing with • Better invoice reconciliation and dispute resolution • Reduced administrative processing cost per purchase order • Better integration of budgetary controls into the procurement process • Minimized human errors • Better monitoring and regulating buying behaviour
Angeles (2006), based on survey covering 185 firms	• Reduced paper-based transactions across the enterprise • Automation of some parts of the procurement process • Reduced cost of generating purchase orders • Reduced cycle time • Freed up procurement team for value added work • Staff focused on their primary duties • Quicker finding of purchase items • Improved order accuracy • Aggregate spending to achieve economies of scale • Better analysis and monitoring of global corporate spending • Increased control over supplier base and supplier prices • Gained control over off-contract buying • Reduced maverick buying • Promoted collaborative design/ development with suppliers • More favourable contracts negotiated • Simplified process of identifying new suppliers
Parida and Parida (2005), referring to ITRG InfoTech Research Group (2002)	• Increased process efficiencies leading to immense savings • Ability to link into existing systems, such as ERP • Reduced lead times within the procure-to-pay cycle, in some cases by 50% • Self-invoicing on behalf of clients • Streamlined business processes, common catalogue and month-end reconciliations and increasing transaction accuracy • More engagement with strategic product management on the buyer side, leading to better contract negotiation • Reduced maverick spending • Inventory reductions leading to huge savings
Parida and Parida (2005), referring to Davila *et al.*, (2002) and Presutti (2002)	• Cost savings • Process efficiency • Better information flow between buyers and suppliers • Reduced maverick spending • Streamlined processes • Better inventory levels

Table 6 (Continued)

U.N. E-Commerce and Development Report (2004)	• Reduction of prices through competitive bidding and transparent negotiation with suppliers • Reduction of bureaucracy, including "overheads"- money spent on administration of services rather than their delivery
Ghiya and Powers (2005), referring to the Intel's indirect purchasing	• Reduced system architecture • Centralized procurement system attached to the communication backbone • Improved and standardized data models • Proven data architecture in use globally • Reduced IT operations management overhead • Scalability of core system components • Extensibility to other modules and third party applications • Visibility of data
Rehan (2006)	• Savings from reduction in the cost of ordering non-production goods • Reduction in cycle times • Increased customer satisfaction • Ensured streamlining of the procurement process and eliminated administrative overheads • Cross-business entity analysis for better contracts and pricing
Panayiotou *et al.* (2003)	• Improved control of vendor relationships • Accurate fulfilment of the processes • Improved effectiveness of the purchasing • process • Achievement of higher service levels • Reduced prices from the key suppliers • Reduced inventory carrying cost • Reduction of the order cycle
Afsharipour *et al.* (2006)	• Price reduction • Improved contract compliance • Shortened Procurement cycle times • Reduced administration costs • Enhanced inventory management • Improved visibility of customer demand • Improved visibility of supply chain • Reduced operating & inventory costs • Increased accuracy of production capacity • Enhanced decision making • Improved market intelligence

In the network world, enterprises have learnt a lot more about the shortcomings in their procurement processes and have seen the advantages in automating them. The success of B2B eCommerce only helped the growth of e-procurement (ciol.com 2007). Miller (2006) reports that the increasing number of success stories point to the growing recognition of e-procurement advantages, indicating an increased optimism towards automation in spite of the slowing down of global economy.

Today, it is clear that initial wave of e-procurement applications are over with significant benefits are harvested. According to a newer study by the Aberdeen Group, "The 2006 E-Procurement Benchmark Report: E-Procurement 2.0", enterprises are not only embracing the second wave of solutions, they are relying on them for significant process improvements, cost savings, and overall optimization of their procurement initiatives. The respondents of this year's survey are reported to be handily outpaced the 1998, 2001, and 2004 e-procurement benchmarks previously delivered by Aberdeen. On average, the enterprises participating in the 2006 benchmark report are reported to obtain the following:

- Increased their spend under management by 38%
- Reduced their requisition-to-order cycles by 84%
- Reduced their requisition-to-order costs by 59%
- Reduced their maverick spend by 40%

Rightworks.com (2007) compares the first generation e-procurement applications with current applications and clearly emphasises the need for new generation of e-procurement applications to support management and controlling of global procurement spent for multi-site corporations with complex requirements. It is mentioned that automating the front end of the procurement process only does not deliver the full potential value for corporations interested in improving internal efficiencies and reducing costs. To provide maximum benefit to a company, an e-procurement system needs to:

- Deliver more than desktop requisitioning.
- Support for the entire purchasing lifecycle.
- Have a flexible and comprehensive content strategy.
- Have analytics enabling real-time visibility and support for accurate and integrated sourcing decisions worldwide.

To maximize the benefits from their technology investment, the need to distinguish the crucial differences between simple e-procurement and "Global Spend Management" is mentioned. It is reported that for a global corporation, procurement operations must address basically:

- Corporate as well as regional business process issues across different organisations.
- Local procurement, in which users located in different regions, must be able to procure locally in their languages, using their currency of choice while leveraging their corporate global contracts.
- A single e-procurement system with global multi-site capabilities to handle local issues such as taxation, language, and currency while providing visibility into enterprise-wide spend patterns and metrics.

A single implementation powering the entire global purchasing process are said to increase internal processing efficiencies, lower total cost of ownership, while facilitating real-time procurement and market intelligence—helping to identify savings opportunities and strategic global sourcing.

It is argued that today's procurement solutions cannot deliver these requirements. Since they are still built on legacy client-server based technology, they are said to be internally focused, limiting the ability of corporations to connect to a global supply base of potential trading partners. It is further argued that given the hybrid architecture of these systems rooted in client-server technology, difficulty of integration with internal ERP systems and external partner systems becomes a critical issue. Today' s global needs not met by the current solutions are presented as today's e-procurement dilemma and the various differences are put forward while comparing simple e-procurement and next generation e-procurement which can assure global spend managemen**t.** As such, previous e-procurement applications which were mainly oriented towards procurement function automation are now being replaced with next generation systems which have the basic characteristics of:

- **Scalability, flexibility and reliability**: as opposed to client-server architectures using multiple software with different data models, the need for a technology infrastructure built on 100% Internet with a single data model is emphasised to reduce the IT complexity and to enable a single instance global implementation.

- **Comprehensive business functionality which can deliver global process efficiencies:** As opposed to e-procurement systems having basic integration with ERP infrastructures (requisitioning, purchase order management, receiving, returns and settlement), next generation e-procurement solutions are reported to:
  - ✓ Automate the full end-to-end business process on-line.
  - ✓ Provide self-service access to all users.
  - ✓ Support both internal and external purchasing, driving interenterprise collaboration and trading by integrating seamlessly to multiple e-business networks.
  - ✓ Provide access to a dynamic global supply base, ensuring that a company is working with the right combination of trading partners at any particular point in time.
  - ✓ Support project-based environments, providing the benefits of maintaining and tracking activity and budgets by projects, such as identification, separation, planning, visibility, and accountability.
  - ✓ Solve the challenges of content management and presentment.
- **Support for complex, distributed environments for global enterprises:** In today's global companies, systems require multiple instances of their software to be implemented. These software need to address the multi-language, multi-currency support; support for variety of buying processes, business rules, workflow, content presentment needs, authorisation levels and pricing policies; providing high level of personalization offering an easy-to-use and user-friendly application.
- **Greater management visibility for improved strategic sourcing and decision making:** Assuring efficient consolidating and reconciling information from multiple ERP systems is vital for supporting strategic management decisions and contributing to the effective analysis, sourcing, and procuring of all goods and services across the enterprise. With only this consolidation and reconciliation that analysis of on-line, real-time, accurate procurement data- not in an ad-hoc manner but on a regular basis- is possible.

Rehan (2006) mentions the following key characteristics to be considered in deploying an effective e-procurement solution:

- Ease of use, continuous interface.
- Functionality and flexibility.
- Intranet-based deployment to all clients.
- Approval and business modelling capabilities.
- Document -based workflow capabilities.
- On-line, real-time access to key procurement information.
- ERP integration.
- Supplier integration.
- Unique buying organisation support.
- Integration with the legacy systems.

Allen (2003) mentions the following functionality to be looked for:

- A dual path process in which repeat purchase orders are sourced through catalogues and approved requisitions are converted to purchase orders.
- A hierarchical work flow approval capability.
- Content management functionality.
- Application programming interfaces to affected systems such as A/P (Accounts Payable), GL (General Ledger), Fixed Assets etc.
- Supply base management (approved suppliers lists).
- Self-serve requisitioning and receiving- empowers the users.
- Self-serve supplier access-empowers the suppliers.
- Purchase card functionality.
- Control data management capabilities.
- Catalogue content management.

It is evident that today's e-procurement solutions are beyond simple requisition and purchasing automation systems and that, supply chain excellence era demands much more from e-procurement solutions. These requirements are clearly beyond simple requisitioning and order management systems. To summarise, next-generation e-procurement solutions should provide comprehensive full-cycle functionality, seamless ERP and supplier integration, hierarchical workflow and content management and very rich personalisation and managerial decision support capabilities to meet today' s needs of global trade. Success in managerial visibility is totally dependant upon efficient and regular consolidation, reconciliation and reporting from multiple ERP systems.

3.4. E-PROCUREMENT BEST PRACTICES

Literature reveals applications with different scope and characteristics, with various best practice guidelines and lessons learned from different case studies.

U.N. E-Commerce and Development Report (2004) mentions the following characterictics given in Table 7 to summarize best practices in terms of different e-procurement functions.

In this table, it is emphasised that "best practice" column will generally require the implementation of a comprehensive e-procurement solution with an ideal level of resources, and the "alternative" column can be an option for cases with more limited resources.

Table 7 E- procurement Best Practice functions based on UN Report (2004)

Function	Best Practice	Alternative
Quoting/Tendering	Buyer makes the tender information available on-line and allow the suppliers to submit tender documentation electronically	Buyer accepts inquiries and sends tender documentation by e-mail
Ordering from the supplier	Buyer transmits orders to the supplier using open standards	Buyer orders directly from a catalogue (e.g. From supplier website or e-mail offer) using e-mail, fax, or hard copy
Payment	Buyer pays suppliers by electronic means with receipt sent electronically	Payment made electronically and receipt sent by post
Liasing with suppliers	Via secure e-mail	Via e-mail and fax
Browsing supplier catalogs	Supplier maintains an on-line catalogue (self-hosted or within an e-marketplace) to be browsed electronically	Buyer may accept the catalogue data electronically and upload into shared internal systems
Internal approval process	Automated and implemented electronically	Documented internal approval process with objective criteria put in place
Receiving invoices/statements	All suppliers submit their invoices electronically and then the invoice is matched with the order. Invoice approved electronically.	Objective criteria implemented for approval of payment to suppliers on receipt of paper or e-mailed invoice
Accessing e-marketplace	Buyer accesses supplier catalogue in an open marketplace (open access, open standards)	Buyer accesses supplier catalogue in a closed marketplace (open access, open standards)

The e-procurement benchmarking report by Aberdeen Group (2004) classifies the e-procurement users as “laggards”, “industry averages” and “best-in-class” applications based on their characteristics in terms of process, organisation, knowledge, technology and performance metrics. In their classification, the best-in-class companies are reported to have enterprise wide deployment, coverage of full source-to-pay process, detailed and near-real-time visibility into compliance, usage and spend management. Presence of metrics for costs, adoption and compliance reported regularly and linked to financial goals and incentives is mentioned. The following strategies and approaches are reported for enterprises reaping greatest value from their e-procurement investments:

- Elevation of e-procurement from a tactical transaction management activity to a strategic source-to-pay initiative.
- Secured senior executive support.
- Shifting the bulk of supplier enablement and catalogue management tasks to third parties.
- Clearly defined cost, process and performance metrics for measuring success.

As best practice requirements, Rehan (2006) clearly mentions the need for the following:

- Improving the internal processes and activities of the organisation’s procurement system.
- Establishing common procurement data definitions across suppliers and commodity groups.
- Improving access to certified/approved suppliers, identifying the needs for new contracts quickly.
- Identifying sources of alternative supply quickly, streamlining procurement processes, providing enhanced supplier performance visibility.
- Developing and monitoring dynamic supplier performance metrics.

Angeles (2006) mentions the following business practices that support e-procurement:

- Involving preferred strategic suppliers in planning for e-procurement.
- Selecting e-procurement software and services following the development of a solid business case.
- Consolidating suppliers and contracts.
- Understanding preferred supplier technology plans and their ability to support e-procurement initiatives.
- Enforcing on-contract buying with preferred suppliers.
- Centralising control of contracts, product data, catalogue data, catalogs and price updates for indirect procurement.
- Implementing and maintaining computerised rules governing procurement.
- Reengineering all affected business applications effectively.
- Reducing the number of suppliers.
- Analysing purchasing behaviours of end users.
- Deploying a "balanced" catalogue selection strategy.
- Giving individual and unit spending a lot of visibility.

Allen (2003) clearly emphasises that e-procurement should be conceived as "a multi-dimensional, complex business change effort", not a "software installation effort". The formula for successful implementation is given as: "building on the foundation of people, then reengineering the business processes around best practices and finally applying the right technology". In terms of people, executive sponsorship and cross-functional implementation teams are counted as vital.

Basing on Intel's indirect procurement success story, Ghiya and Powers (2005) report similar ideas, the success beginning with business process analyses that leveraged the available technology. It is clearly mentioned that sufficient time spent in understanding the "as-is" process is vital to ensure a solid "to-be" process, with special focus on data. They clearly report that "technology only" approach would have limited success.

Basing on 5 different government application cases, Australian Government (2005) reports that e-procurement can be an instrument in public sector reform and mentions the following key findings towards an effective implementation:

- E-procurement is not a uniform technology or design.
- E-procurement is also a strategic decision, and therefore, a good business design is vital.
- E-procurement is not a technical solution, but an "end-to-end" business solution.
- Technical integration and managing technical standards are critical to project success.
- Even modern, technical tools are not sufficient to ensure success.
- A solid business case can provide the framework for a successful e-procurement program.
- An effective communication program can assist with change management.
- Collaborative behaviour can promote usage and understanding.
- Servicing e-procurement requires skilled resources.
- Benchmarking and knowledge management can advocate support among stakeholders.
- Policy reform is influential in e-procurement implementations.
- Effective strategies can improve supplier adoption and deliver value.
- Flexibility in process development and support structures can ease transition and promote adoption.

Allen (2003) reports the following items to be involved in purchasing and supply chain management best practices, by referring to a study conducted jointly by McKinsey and Arizona State University and published in (2002):

- A focus on total cost of ownership, not incremental price discounts.
- A focus on continuous improvement.
- A fact-based understanding of suppliers and supply base.
- A focus on strategic rather than tactical.
- Developing a world-class supplier network, utilising value-added partnerships as appropriate.

- Strategically applying the latest technology tools to improve knowledge base.
- Enhanced supplier integration.

Allen (2003) reports the following underlying organisational principles for world class organisations as follows:

- Collaboration up and down the supply chain.
- Empowering the users.
- Enterprise-wide sourcing.
- Centralizing strategic activities.
- Pushing the tactical activities as close to the requisitioner as possible.
- Requisitioning of the recurring items to be conducted by the user via pre-sourced catalogue items.
- Professional buyers intervening only to add value.

Oracle newsletter (2006) quotes top 10 strategies for e-procurement as follows:

- Assuring user training and acceptance.
- Choosing right suppliers on the basis of their technical capabilities.
- Complementing e-procurement or requisitioning tools with other tools to link e-procurement workflows with related business processes.
- Choosing to work with catalogue outsourcers to handle the burden of building and maintaining the content, generally on a more cost effective basis.
- Revising approval thresholds upwards to lessen the burden on purchasing department.
- Using e-procurement as a way to let users purchase non-catalogue items.
- Leveraging supplier networks.
- Simplifying and automating business processes.
- Using proper reporting.
- Maximizing benefits to end users.

U.N. E-Commerce and Development Report (2004) focuses on public sector implementations and clearly specifies the need for consultation with representatives from government and private sector, as well as applying a consistent approach across all the spheres of the government. The report emphasises the need to use a phased approach, with each phase requiring careful consideration. The phases suggested are as follows:

- Establishing goal and vision.
- Identification and analysis of the regulatory framework.
- Analysis of existing processes.
- Process reengineering.
- Choosing a solution and platform.
- Formulation and implementation of a plan.

As can be seen easily from the above-mentioned best practice guidelines and principles, many themes are repeatedly and consistently emphasised, such as need for reengineering, user training and acceptance and need for metrics. In that regard, best practice guidelines in the literature appears mature and consistent. Best practices clearly reveal that e-procurement systems are not simple requisitioning and purchasing automation systems.

To sum up, best practices materialise from awareness that e-procurement is not a uniform technology or design and that e-procurement is not a technical solution, but an end-to-end business solution, which is a strategic decision needing a good business design, commitment from every involved party and phased approach.

3.5. CHALLENGES AND OBSTACLES TO IMPLEMENTING E-PROCUREMENT

As a non-uniform, strategic end-to-end business solution which passes enterprise boundaries, clearly e-procurement implementations involve various challenges. Literature mentions various classifications of challenges:

- Rehan (2006) mentions two basic challenges:
  - ✓ Defining and integrating various processes and harmonizing operations between the organisations, suppliers and distributors.
  - ✓ Implementing a technology on top of existing enterprise systems that will work to bring the desperate systems and the new procurement software together to improve operations.

- Chen and Rankin (2006) mention the following four basic sources of challenges basing on their study on AEC (architecture-engineering-construction) sector:
  - ✓ Technological
  - ✓ Human
  - ✓ Financial
  - ✓ Environmental

In this classification, compatibility with other technologies, security, reliability, software or hardware solutions and frequency of upgrades are counted among the basic technical issues. Lack of an affordable solutions and concerns about security are clearly mentioned. The human issues include a lack of knowledge about the new technology, mistrust or fear of the new technology and poor management. Difficulties of shifting the mindsets of people to develop confidence of using new technologies are clearly emphasised as the greatest obstacle. Under financial challenges, they mention long payback periods and lack of sufficient investment for new technologies.

- Aberdeen Group report (2004) on challenges of e-procurement success mentions that supplier enablement, user adoption, and budgetary and policy support challenges delay or mute the benefits of e-procurement. Other challenges mentioned to be cited by the respondents include adopting processes and functionality to sufficiently support procurement and compliance management requirements for non-cataloguable items, such as contingent labour, printing, and travel.

- The following set of challenges to e-procurement applications are mentioned in the findings of Angeles (2006) survey:

a) Technical challenges:

- ✓ Lack of standard interchange formats.
- ✓ Hard to take spend data from e-commerce driven transactions and connecting it to the rest of purchase transaction data collected through other systems.
- ✓ Immaturity of e-procurement software.
- ✓ Lack of infrastructure to collect transaction data from more than one e-commerce application.
- ✓ Immaturity of marketplace services.
- ✓ Hard to keep controls and data management standards when adding other procurement systems.
- ✓ Immaturity of consulting services.

In this regard, lack of infrastructures is directly related with the inherent ability of the modules making up the application to cohere internally. Lack of standard interchange formats is an indication of the degree of external integration and the ability to integrate with the third-part hardware. Therefore, assuring both internal coherence and external connectivity are the real challenges.

b) Human and organisational-related challenges:

- ✓ Internal end user resistance to learn multiple procurement systems and procedures.
- ✓ Immaturity of suppliers.
- ✓ Difficulty of eliminating “maverick” buying.

- ✓ Project cost overruns in rationalision/implementation, training and indirect costs.
- ✓ Pricing model immaturity.
- ✓ Lack of benchmarkable reference implementation.

Among these items, immaturity of the suppliers is a clear indication of lack of preparedness of the suppliers for e-procurement. Difficulties of eliminating "maverick" buying point out to the problems of reengineering the supplier evaluation and authorisation process. Project cost overruns reveal the problems with inefficient project management and cost control skills. Catalogue creation and maintenance is counted as one of the most significant expense items incurred during implementation.

- Australian Government reports the following set of challenges while mentioning e-procurement implementation cases in governments of 5 different countries (Italy, New South Wales, New Zealand, Scotland, and Western Australia):
  - ✓ Managing competing priorities and policy reform.
  - ✓ Communicating and managing change.
  - ✓ Developing the skill base.
  - ✓ Ensuring interoperability of systems and standards.
  - ✓ Managing authentication and security.
  - ✓ Integrating the end-to-end procurement process.
  - ✓ Benchmarking performance.
  - ✓ Managing information.
  - ✓ Acquiring and maintaining suitable skilled personnel.

- Supplier enablement and user adaptation are presented as the biggest challenges by Vinimaya Inc. (2007).

- Afsharipur *et al.* (2006) mention development cost, system integration, culture, development time and security as the 5 major impediments for e-procurement implementations and they give the following summary of barriers identified by referring to previous literature:

    - Security of transactions.
    - Lack of supplier e-procurement.
    - High cost of technology.
    - Lack of legal framework.
    - Lack of technical expertise.
    - Lack of e-procurement knowledge.
    - No real business benefit identified.
    - Data exchange standards lacking.
    - Lack of business relationships.

It is clear from all these challenges that organisations are still struggling with various technological challenges and obstacles besides ever-present human-and organisational related issues. Since the implementation passes the enterprise boundaries, we are faced with multiple ERP systems to be integrated and this makes the challenges involved much more profound when compared with the challenges of an ERP implementation.

3.6. DISCUSSION

Applicability of e-procurement in various sectors and both tangible and intangible benefits of e-procurement applications are well-discussed in literature. With benefits often to the tune of millions of dollars Miller (2006), Tatsis *et al.* (2006), Davila *et al.* (2003), Rehan (2006) and Panayiotou *et al.* (2003) provide various classifications of benefits of e-procurement. Applications are seen in various sectors, such as hotels (Kothari *et al.* (2005), military Liao *et al.* (2003), food and drink (Tatsis *et al.* 2006). The reason for e-procurement solutions having broad appeal is this broad span across the market sectors and industries (ciol.com 2007). Applications from diverse sectors reveal consistent and similar results. Commonalities in the literature are evidently seen in Table 6, some of which are purchasing cycle time reductions, transactional benefits and streamlined operations. Afsharipour *et al*. (2006), Panayiotou *et al.* (2003), Rehan (2006), Turban *et al.* (2006) mentioned in the table definitely support these commonalities. Tremendous cost savings and benefits of implementing e-procurement systems, as reported by application cases, suggest that savings and benefits are beyond transactional efficiencies, with all the business process reengineering and back-end integration efforts contributing to aligned supply chain integration. As such, these savings contribute significantly to global competitiveness of the partners in today's demanding digital economy. Afsharipour *et al.* (2006), Tatsis *et al.* (2006) and Davila *et al.* (2003) provide quantified support in this regard. The author holds the opinion that these significant savings are beyond discussion and that literature in this area is mature.

Literature also provides strong support for the importance of procurement in supply chain management. Procurement function represents the vital link for supply chain collaboration, since it requires connectivity of material management, order management and financial functions of the trading partners involved. Muffato and Payaro (2004), Kothari *et al*. (2005), (Gimenez and Lourenço, 2004), Davila *et al.* (2003) and Afsharipur *et al*. (2006) referenced previously clearly put forward web-based procurement as the critical link in supply chain management.

Success in harvesting the benefits of Web technologies in this critical link lies in seamless integration of the e-procurement applications with the backend functions of the partners. As such, successfully implemented and running ERP backbone assumes a significant importance towards reaping the benefits of web-based procurement. This importance is explicitely mentioned by Bendoly and Jacobs (2005), Ghiya and Powers (2005), Angeles (2006), Rehan (2006), Davila *et al.* (2003) and Micro Technologies Inc. (2007).

As such, e-procurement applications seamlessly integrated to ERP backbones form the basis of global supply chain integration, making e-procurement the first step towards the formation of e-supply chains, which require collaborative planning and joint management of supply chain partners. Clearly, this type of ultimate web-based collaboration is beyond web-based procurement only. In this regard, author holds the opinion that a successful e-procurement application is the proof that enterprise has made a giant step towards establishing ultimate e-collaboration and that a sound ERP backbone with a successful ERP implementation already in place is the key to any further web-based collaboration effort. Staged evolution models mentioned in Section 2 and (Gimenez and Lourenço 2004), Afsharipur *et al*. (2006), Campbell and Sankaran (2005) referenced previously are definitely in line with these ideas.

During the literature review performed, the author did not come across with conflicting or counter results for the importance of e-procurement from benefits or supply chain formation viewpoints. Author's personal opinion is also in line with these consistent results. Therefore, no counter arguments are presented in the discussion.

In this chapter it is made clear that today's e-procurement solutions are beyond simple requisition and purchasing automation systems. As end-to-end business solutions requiring integration with the backend systems of more than one enterprise, challenges involved in the implementation are multifold. As an implementation initiative requiring business process reengineering and involving people at various positions, handling managerial and organisational challenges are only possible with full commitment and training of all the parties involved. Best practices have proven that only the organisations which can really grasp and handle the managerial issues can be successful.

Besides all these managerial and organisational challenges, literature reveals that today's e-procurement systems are still struggling with various technological challenges and suffering from lack of standardisation in message exchange formats, data management and infrastructures. Assuring seamless connectivity among incompatible systems in a secure manner still remains to be the greatest hurdle. The issue is not only integrating basic ERP functionalities and overcoming network and security problems, but also obtaining proper data consolidation and regular managerial reports. As such, next generation e-procurement systems are to overcome these standardisation difficulties and they should provide a more comprehensive set of functionalities which can answer the needs of a global enterprise, enabling implementation of multiple instances worldwide together with efficient managerial decision support and visibility.

In that regard, assuring interoperability, lack of data and message exchange standards, authorisation and security issues still remain to be the greatest technical challenges to be handled.

CHAPTER 4. ENTERPRISE APPLICATION INTEGRATION (EAI): SHIFT TOWARDS SERVICE ORIENTED ARCHITECTURES (SOA)

As it is made clear from the previous chapters, greatest challenge of e-supply chain formation is the integration of cross-application processes in a seamless manner. Organisations are in the search of architectural solutions to overcome the greatest challenges. Thus, this chapter will:

- Focus on the service oriented architectures (SOA) as the recent trend in cross-platform enterprise application integration.
- Provide basic philosophy, concepts and available technologies of SOA
- Discuss the benefits and importance of SOA for e-supply chain formation

4.1. ENTERPRISE APPLICATION INTEGRATION (EAI)

Modern businesses need functionality that is both distributed and centralized. Existing systems, such as Enterprise Resources Planning (ERP), Customer Relationship Management (CRM), Supply Chain Management (SCM) serve the needs of key segments of the organisation. Besides this basic need, Woods and Mattern (2006) emphasises the need for a flow that moves from one system of record to another, with the context for the process kept outside of any of the existing systems. It is mentioned that the traditional way of building enterprise software is not well-suited to these new requirements and does not take full advantage of the new world of networks, reusable services, and distributed data. Treating an application as a self-contained world no longer meets the needs of business. With successful implementations in place, the next challenge facing companies is the integration. The real question put forward is: "*How could all of the best-of-breed applications be made to work together to serve the needs of the cross-application processes that were becoming the key to increased efficiency and innovation?*" (Woods and Mattern 2006). The proliferation of enterprise applications made integration of applications as important as the functionality of the applications themselves (Woods and Word 2004).

Microsoft whitepaper (2006) clearly mentions this by saying:

"The problem for IT departments is typically not insufficient functionality; rather, it is that critical business systems such as customer relationship management (CRM) and enterprise resource planning (ERP) operate in isolation from other critical business systems—despite the fact that business processes often span multiple applications. To obtain an end-to-end view of a complex business process necessitates integration of information and process silos".

Microsoft emphasises that an integrated supply chain requires you to connect systems from the factory floor to the storefront and across trading partners, facilitating business processes that span systems, and people, within and across organisational boundaries. This further streamlines the critical business-to-business processes by automating decisions and providing real-time visibility. Definitely, this covers legacy systems integration from different parties as well.

Therefore, enterprise application integration is defined as the process of tying together multiple applications to support the flow of information across multiple business units and IT systems (Sweat 1999).

EAI is about interoperability and information synchronization across multiple applications (mainframe, packaged or purchased systems, and custom application systems). EAI enables sharing of information, not just within an enterprise or organisation but within a business environment that includes a company, its suppliers and its customers. Messaging, connectivity and security are counted as the basic services needed of an EAI solution (Pan 1999).

The need for developing systems in heterogenous environments to accommodate an endless variety of hardware, operating systems, middleware, languages and data stores are clearly mentioned in (Bih 2006).

Literature reveals different integration levels:

- At its highest level, IBM divides application integration into two essentially different approaches:

- ✓ **Process Integration** - the integration of the functional flow of processing between the applications.
- ✓ **Data Integration** - the integration of the information used by applications (ibm.com).

- SAP NetWeaver platform defines four levels of integration as:
  - ✓ **People level:** Includes portals, collaboration and multi-channel access.
  - ✓ **Information level:** Business intelligence, knowledge management and master data management.
  - ✓ **Process level:** business process management and integration broker.
  - ✓ **Application level:** Database and operating system abstraction, J2EE and ABAP (Woods and Word 2004).

- Bih (2006) clearly emphasises the need for any integration platform to support all of the following types of integration, besides leveraging existing assets in the form of legacy systems integration:
  - ✓ **User Interaction:** being able to provide a single, interactive user experience.
  - ✓ **Application connectivity:** communications layer that underlies all of the architecture.
  - ✓ **Process Integration:** choreographs applications and services.
  - ✓ **Information integration:** federates and moves the enterprise data.

- HimalayanTechies (2004) defines the integration types as follows:
  - ✓ **Data level:** Extracting, transforming and manipulating data and Metadata Management using XML.
  - ✓ **Application level:**
    - o Integration of business logic, transaction management, application and web services using component architecture.
    - o Adapter-based integration, dealing with rules, content routing and event-based transactions and transformations, forming the backbone for Enterprise Application Development.

- ✓ **Process level:** Involves the process and workflow modeling approach to integration.

- Ciol.com (2002) mentions integration at Business Process, Application Integration, Data and platform integration levels and defines the following types of integration:

  - ✓ **Data-level EAI:** is the process, techniques and technology of moving data between data stores. This can be described as extracting information from one database, processing that information as needed, and updating it in another database. It may also include the transformation and application of business logic to data that is being extracted and loaded.
  - ✓ **Application interface-level EAI**: refers to the leveraging of interfaces exposed by custom or packaged applications. Developers leverage these interfaces to access both business processes and simple information. Using these interfaces, developers can bundle many applications together, allowing them to share business logic and information. This type of EAI is most applicable to packaged applications such as SAP, PeopleSoft, and Baan, which all expose interfaces into their processes and data. In order to integrate those systems with others in the enterprise, developers must use these interfaces to access both processes and data, extract the information, place it in a format understandable by the target application, and transmit the information.
  - ✓ **Method-level EAI:** is the sharing of the business logic within the enterprise, or between enterprises. For example, the method for updating a customer record may be accessed from any number of applications by invoking a common shared method, typically residing on a shared application server or distributed object infrastructure.
  - ✓ **User interface-level EAI:** is a more primitive, but still necessary, approach to integrate applications by using their user interfaces as a common point of integration (also known as screen scraping). For example, mainframe applications that do not provide database- or

business-process-level access may be accessed through the user interface of the application.

Although naming and classification differs for these integration levels in the literature, it is evident that handling the business processes and people interface are just as important as the data management side of the issue.

Regarding the enterprise application integration, many different technologies emerged so that a cross-application, integrated view of enterprise applications was created, based on the new possibilities of the Internet and emerging technology standards such as HTTP and XML. Woods and Mattern (2006) mention the following technologies for integration:

- **Portals:** web-based user interface technology that enables one user interface to connect functionality from different applications. Portals could bring together UI elements from different applications, as well as gathering information from different sources and displaying them in one place. Therefore, they are visual interfaces between a user and all of the underlying applications and information, bringing together diverse parts of a business. They are designed to be role-based and tailored to specific needs.
- **Data warehouses:** collect data from various related, possibly distributed, databases within the applications in one place, creating a single and unified view of distributed information.
- **Enterprise Application Integration (EAI) technology**: involves engines that allow one application to send an XML message to another application. The receiving application could send a response back. All sorts of alerting, monitoring, and triggering happen in central systems for routing and transforming messages.
- **Business Process Management Applications:** allow for process modeling and management coupled with EAI technologies to create a way to define and execute processes in the center. It involves separation of process definitions and enterprise data.
- **Application servers:** a new sort of structure for applications based on standards such as Java 2 Enterprise Edition (J2EE), powering all the integration tools.

These new technologies started to bridge the gap among isolated enterprise applications and enabled some cross-application coordination and development, however bringing in a new set of problems*: "integration of the integration technologies".*

A brief survey on the history of various e-commerce and integration frameworks reveal "a clear shift from client/server technology towards integrated and adaptable businesses basing on web services" with changing business requirements and technological advances.

Güner (2005) mentions this trend by saying *"nowadays, approach to application integration is moving towards from information oriented to service oriented systems"*. Historical evolution of this trend is depicted in the below Figure no 8:

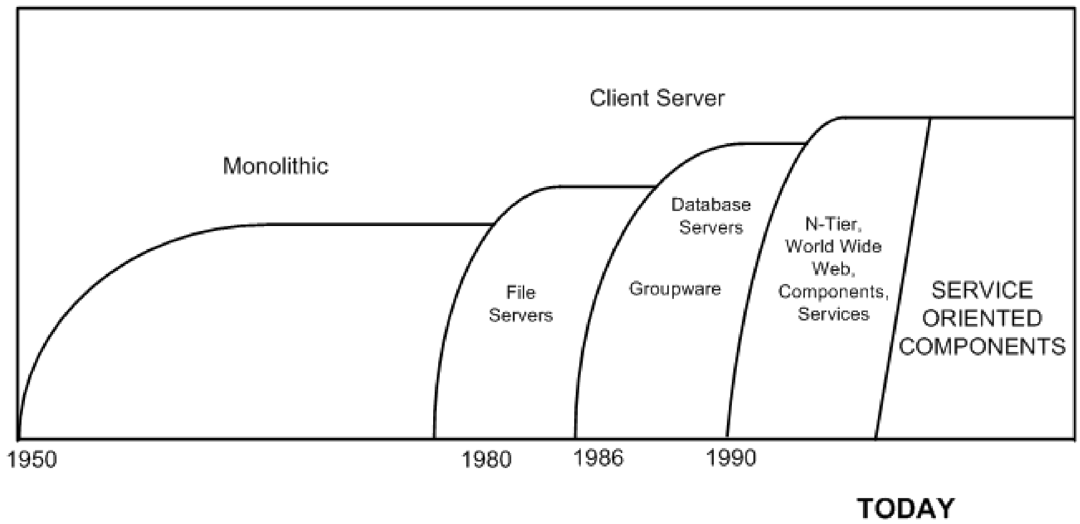

Figure 8 Historical evolution of application integration Source: Based on (Güner 2005) [2]

[2] SAP views "today" as till 2010, since SAP plans to complete the SOA transition till 2010.

The trend is clearly seen in the SAP's transition from initially mainframe based standard software R/2 to its current web-services based technology. This transition is depicted in Figure 9.

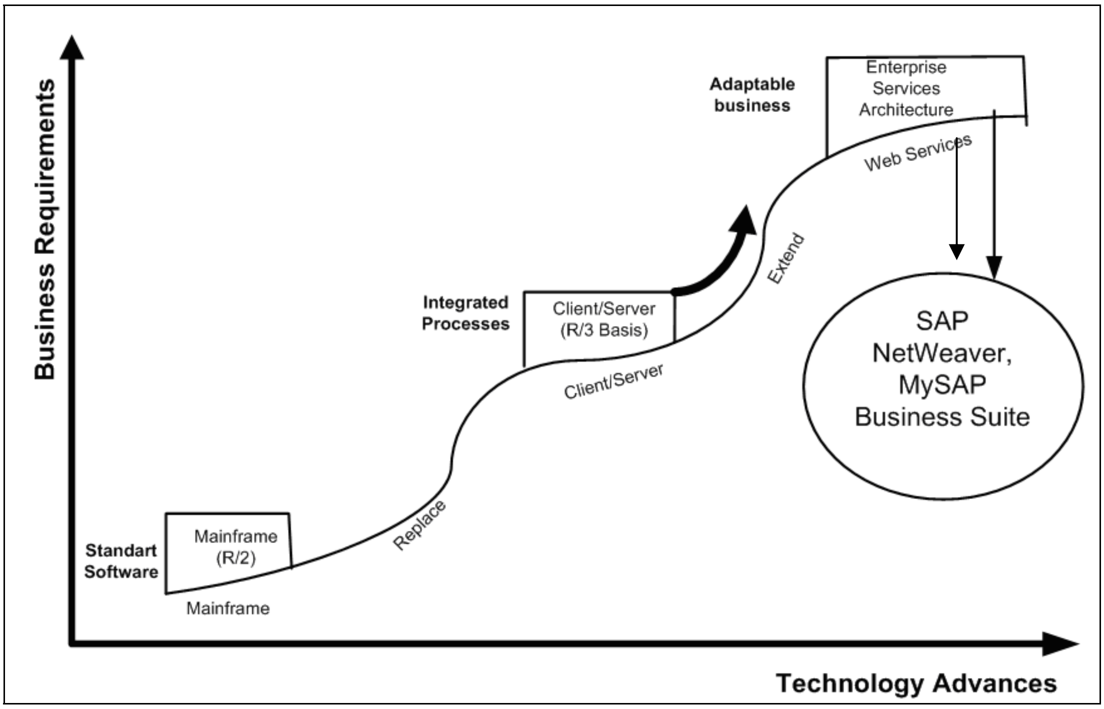

Figure 9 Technology transition towards ESA Source: Woods and Word (2004)

Figure 10 shows how SAP conceives of this trend today:

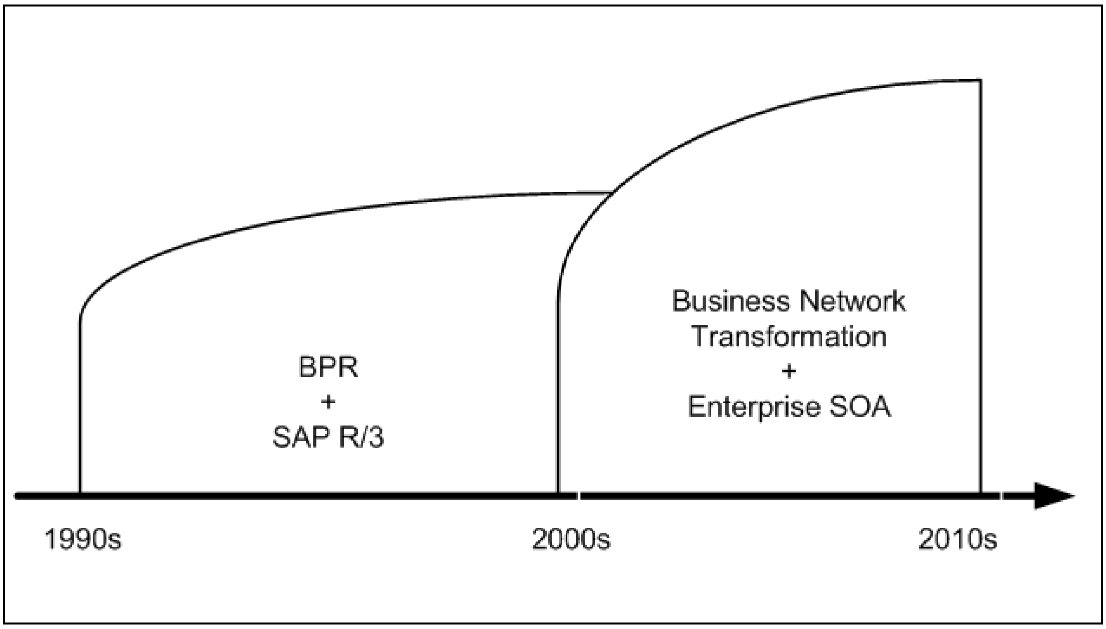

Figure 10 Transformation towards SOA, as seen by SAP Source: SAP Forum Presentations, Ankara, December 2007

This evolutionary transition is also supported by (Nickull 2005), who mentions the following evolutionary steps for the evolution of enterprise systems. Table 8 reveals a clear shift from monolithic systems to service oriented components:

Table 8 Evolutionary steps towards SOA, Source: Based on Nickull (2005)

Evolutionary Step	**Description**
Monolithic	Large scale applications using a procedural coding methodology.
Structured or object oriented	Dividing applications into units of logic based on functionality. The first step of SOA.
Clients and servers	The logical progression of Object orientation-bundling groups of functions on the server and invoking them from client.
3-tier	Adding an extra layer for interaction.
N-tier	Layered request-response calls between applications. Portal development relied on this concept.
Distributed objects	Heterogeneous system of many distributed objects.
Components	Aggregating objects into logical components that achieve specific functionality and creating interfaces to these components.
Service oriented Components	An environment of components interacting in a peer-based environment using interfaces based on widely accepted standards to offer services.

4.2. SERVICE ORIENTED ARCHITECTURES (SOA)

Evolution towards SOA for application integration, thus e-supply chain formation, is already made clear in the previous section. Thus, SOA deserve further attention as the recent trend.

Service oriented architecture (SOA) is an evolution of the component based architecture, interface based design and distributed systems and the Internet in general (Nickull 2005). SOA refers to the architecture for software systems in which services are the fundamental building blocks, to any system that exposes its functionality as services (Earl 2005). SOA are an emerging approach that addresses the requirements of loosely coupled, standards-based, and protocol-independent distributed computing (Papazoglou and Heuvel 2007). Typically business operations running in an SOA comprise a number of invocations of these different components, often in an event-driven or asynchronous fashion that reflects the underlying business process needs. To build an SOA, a highly distributable communications and integration backbone is required. This functionality is provided by the Enterprise Service Bus (ESB) that is an integration platform utilizing Web services standards to support a wide variety of communications patterns over multiple transport protocols and delivering value-added capabilities for SOA applications (Papazoglou and Heuvel 2007).

The basic idea of SOA paradigm is that a system is designed and implemented using loosely coupled software services with defined interfaces that can be accessed without any knowledge of their implementation platform. By overcoming interoperability limitations, SOA allows existing software systems to be integrated by exploiting the pervasive infrastructure of World Wide Web (Canfora *et al.* 2007).

Service orientation is a means for integrating across diverse systems. Each IT resource, whether an application, system, or trading partner, can be accessed as a service. These capabilities are available through interfaces. However, complexity arises when service providers differ in their operating system or communication protocols, resulting in inoperability. Service orientation uses standard protocols and conventional interfaces—usually Web services—to facilitate access to business logic and information among diverse services. SOA allows the underlying service capabilities and interfaces to be composed into processes. Each process is itself a service, one that offers up a new, aggregated capability. Because each new process is exposed through a standardized interface, the underlying implementation of the individual service providers is free to change without impacting how the service is consumed (Microsoft 2006). Service orientation is an approach to organizing distributed IT resources into an integrated solution that breaks down information silos and maximizes business agility. The approach modularizes IT resources, creating loosely coupled business processes that integrate information across business systems. Critical to a well-designed service oriented architecture is producing business process solutions that are relatively free from the constraints of the underlying IT infrastructure, because this enables the greater agility that businesses are seeking. As such, SOA ultimately enables the generation of new dynamic applications, sometimes called composite applications (Microsoft 2006).

4.2.1. Critical concepts of SOA

To enable composite application generation free from underlying IT infrastructure, SOA utilizes the following concepts:

Services: A contractually defined behaviour that can be implemented and provided by a component for use by another component. Basic service oriented architecture is given Figure 11:

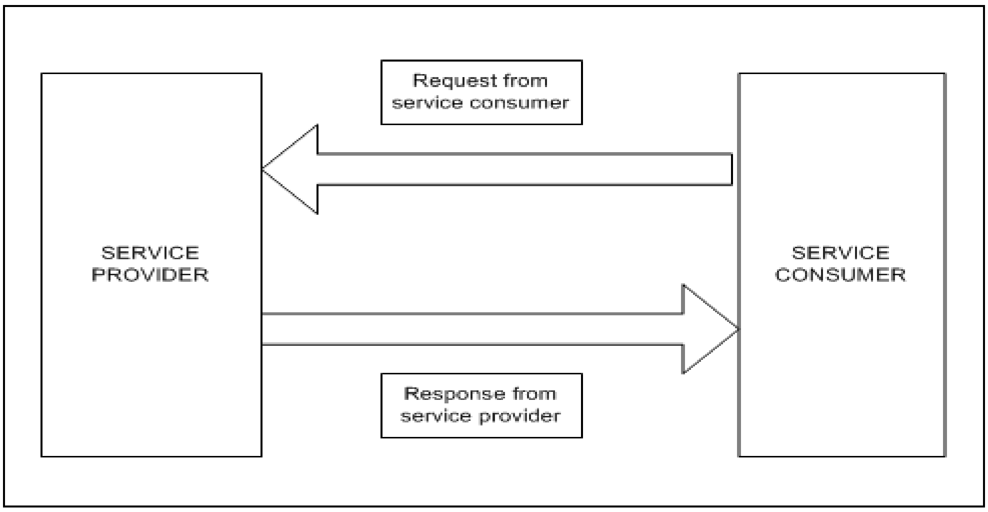

Figure 11 Basic services interaction Source: Bih (2006)

Güner (2005) mentions 6 main service-related entities for SOA service provider, service consumer, service registry, service contract, service proxy and service lease for this interaction. Güner (2005) mentions the services to have the following basic characteristics:

- Discoverable and dynamically bound.
- Self-contained and modular.
- Interoperable.
- Loosely coupled.
- Have a network-addressable interface.
- Have coarse-grained interfaces.
- Location-transparent.
- Can be composed into new applications.

Web Services: Describe a specialized type of software designed to support a standardised way for provision and consumption of services over the Web, through the compliance with open standards such as XML, SOAP, Web Services Description Language (WSDL) and Universal Description, Discovery and Integration (UDDI) (OASIS 2005). The following diagram in Figure 12 shows the basic architectural model and roles of UDDI, WSDL and SOAP for web services:

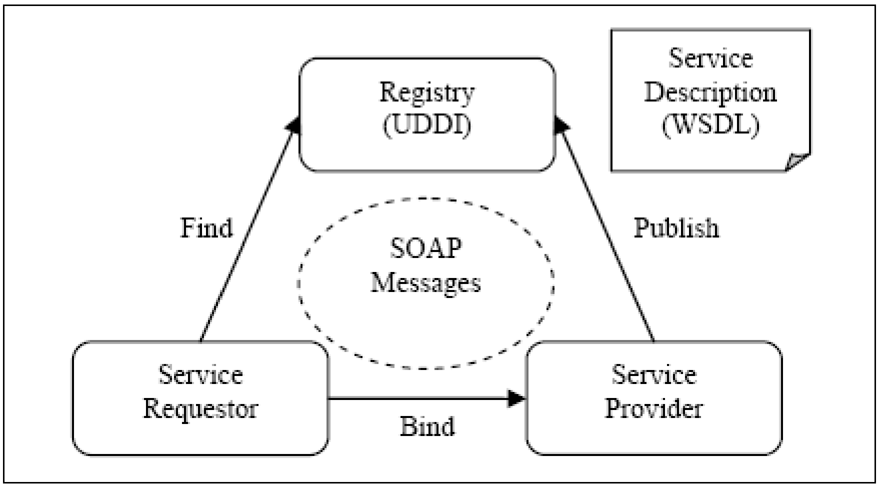

Figure 12 Web Services architecture Source: Güner (2005)

Web services are designed to support interoperable machine-to-machine interaction over a network (Güner 2005). Therefore, Web services are a standard way of creating a self-describing service based on XML that uses the Internet to communicate, where a service is a program that talks to other programs. The self-describing part of web services is the Web Services Description Language (WSDL) and every web service has a WSDL file that describes its interface. This WSDL file, which is expressed in XML, can be used to generate a program automatically to invoke a web service and get information from it. The Universal Description, Discovery, and Integration (UDDI) protocol is a standard for creating a searchable directory of WSDL files so that web services can be located and the WSDL files obtained. UDDI can be used for designing or running a program. Web services frequently use the SOAP standard for transferring data back and forth, although it is possible to communicate in other ways as well (Woods and Mattern 2006).

Web Services, unlike traditional client/server systems, such as browser/web server systems, are not meant for direct end-user consumption. Rather, Web Services are pieces of business logic, having programmatic interfaces and through these interfaces, developers can create new application systems (OASIS 2005). The motivation behind Web Services is to facilitate businesses to interact and integrate with other businesses and clients, without having to go through integration design and/or to expose its confidential internal application details. This is made possible by *"relying on the non-platform dependent and non-programming language dependent XML"* to describe the data to be exchanged between businesses or between the business and its clients, using a WSDL to specify what the service is providing; using a UDDI to publish and locate who is providing the service; and typically using SOAP over HTTP to transfer the message across the internet (OASIS 2005).

With these concepts in mind, SOA represents a structure in which business data and logic are exchanged in a platform-independent manner via defining services (in terms of contracts, implementation and interfaces), exchanging them via service bus and developing reusable service repositories. Krafzig *et al*., (2004) describes this basic structure as in Figure 13:

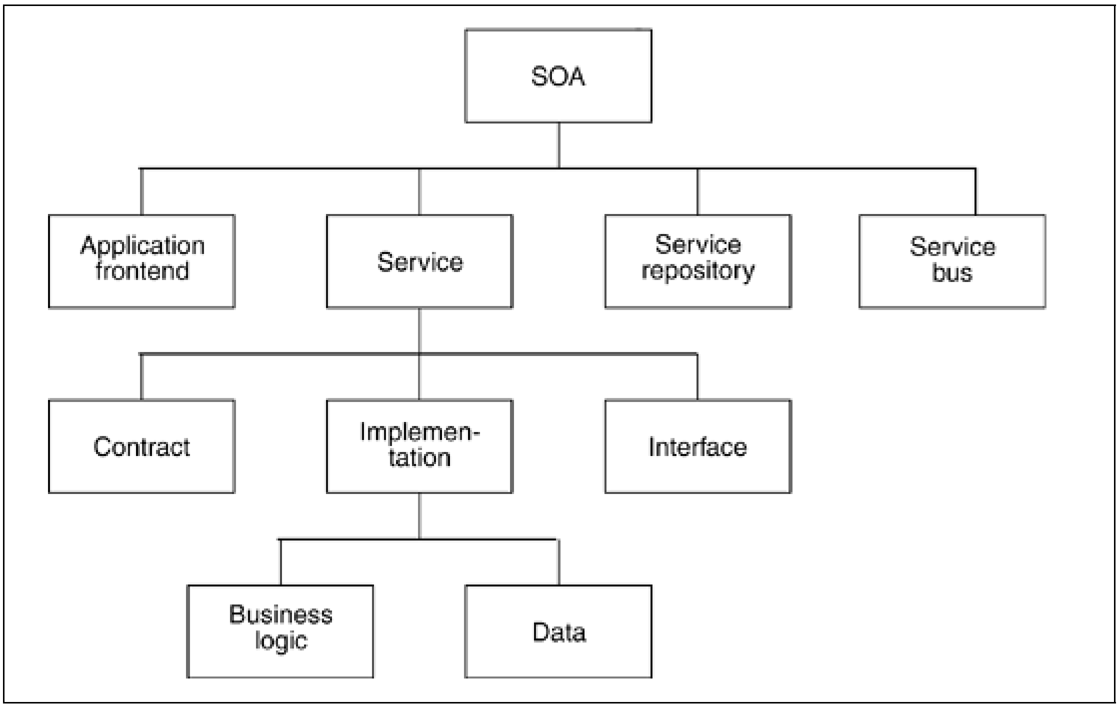

Figure 13 Basic SOA structure, Source: Krafzig *et al.* (2004)

4.2.2. Enterprise Services and ESA

ESA can be defined as "the sum of SOA (Service-oriented architectures) and ES (Enterprise services)" (Feurer 2007). Combined use of SOA and ES allows developing a reusable library of services having service definitions. As such, combined use of BPM (business process management), SOA, XML and Web Services enables the formation of a service-oriented enterprise. This is depicted in Figure 14.

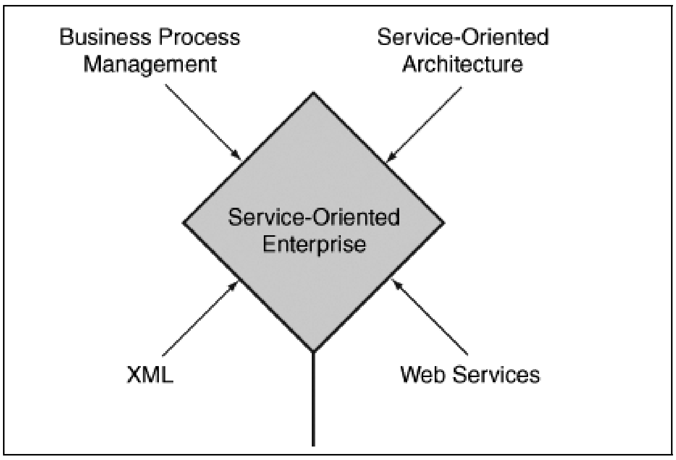

Figure 14 Relationship between ESA and SOA Source: Woods and Mattern 2006

Business process management is the discipline of modeling, automating, managing and optimizing business processes throughout their lifecycles to increase profitability (Khan 2004).

Enterprise services are new service definitions developed, which are typically a series of Web services combined with business logic that can be accessed and used repeatedly to support a particular business process. Aggregating Web services into business-level enterprise services provides a more meaningful foundation for the task of automating enterprise-scale business scenarios (sap.com). Descriptions of enterprise services are stored in the Enterprise Services Repository, which contains not only WSDL files but also models that show how an enterprise service is related to business processes and business objects.

A *web service is* just a standardized interface to a service's functionality whereas an *enterprise service* is a web service designed as a reusable component in process automation. It exists within the larger context of ESA, and it contains metadata about its functionality and about how it connects to other services. Enterprise services are large enough that combining and recombining them is a fairly easy task. An enterprise service, when called, will execute any number of instructions across any number of underlying applications whreas a web service will call only the application to which it is related (Woods and Mattern 2006). An enterprise service is composed of the *service interface* and the *service implementation.* Enterprise services are always a gateway to functionality that is provided by an existing system called a *service provider*.

Not all enterprise applications are able to expose the same amount of functionality with the same level of ease. Enterprise services resting on top business objects, an organized container of functionality and data designed specifically to operate well within an ESA framework, are able to offer a greater variety of service operations more easily than a functionality from an enterprise application that was never designed to provide services (Earl 2005).

Therefore, enterprise services residing within ESA are loosely coupled, and the composition is not hardcoded, but rather, is assembled through process orchestration and modeling. They're just combinations and recombinations of underlying services.

Therefore, reconfiguring the underlying scenarios, business processes, and process steps is the issue (Earl 2005). Therefore, they can be thought of as standardized lego pieces to create composite application. These components are kept in the enterprise services repository to allow for reusability.

Process orchestration is the act of assembling the enterprise services representing components of a process into a composite application that completes the process. The goal of ESA is to create services with enough size and scope that they can be used inside a simple orchestration mechanism (modeling tools) to configure and orchestrate the process. If the services are too small and too granular, the advantages of orchestration are lost. Writing code from scratch is meaningful as well (Woods and Mattern 2006)

Orchestration vs. choreography: Orchestration or choreography of Web Services expresses the combination of Web services in a consequential order to create an executable business process. The difference between orchestration and choreography is that orchestration refers to an executable business process controlled by one of the involved business parties, whereas choreography describes the collaborative work of each involved parties within the whole interaction of web services (Güner 2005). The orchestration and the choreography distinctions are based on analogies: orchestration describes central control of behavior as a conductor in an orchestra, while choreography is about distributed control of behavior where individual participants perform processing based on outside events, as in a choreographed dance where dancers react to behaviors of their peers (In choreography, dancers dance following a global scenario without a single point of control (wikipedia.org).

Composite applications: They are essentially applications built out of services provided by other applications. They are constructed using web services as building blocks (Woods and Word 2004). They are created through modeling rather than through a programming language.

4.2.3. Layered structure of ESA

Layered architecture is an architecture in which data moves from one defined level of processing to another. Layers is an architectural design pattern that structures applications so they can be decomposed into groups of subtasks such that each group of subtasks is at a particular level of abstraction (Black 2007). Figure 15 shows the layered structure of ESA basing on two sources. Rough correspondence of the layers are marked on the figure:

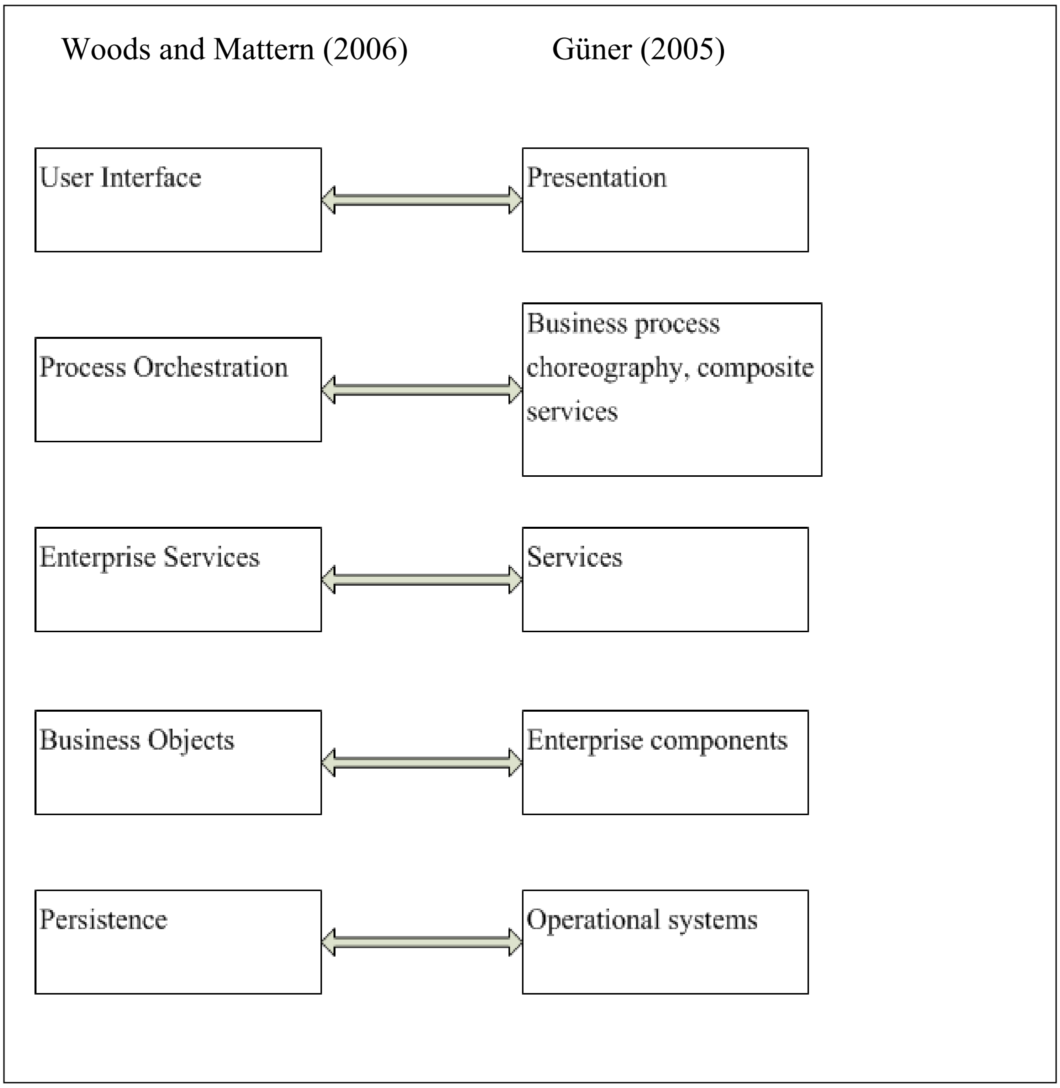

Figure 15 Layered Structure comparison of SOA

In this structure, data residing in the persistence layer is used to form business objects and they utilize enterprise services. These services are orchestrated or choreographed, depending on the degree of collaboration involved. User interface is provided at the presentation layer via portals.

4.2.4. Web services architecture standard stack

The following Figure 16 shows how W3C web services architecture defines a stack diagram for web services to incorporate emerging standards such as choreography and reliable messaging:

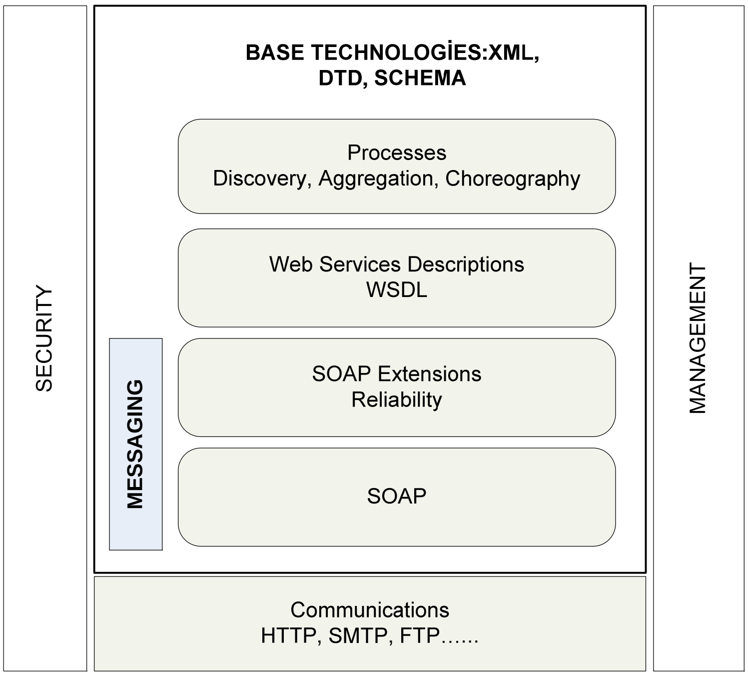

Figure 16 Web service standard stack, Source: Chiusano (2004)

4.2.5. Available Technologies for SOA

The literature shows various available technologies for Service Oriented Architectures. Güner (2005) mentions the following technologies in her comparative study:

Java Message Service (JMS): Java-enabled development interface which supports standardised asynchronous message interaction, also offering the capability of synchronous request/response communication mode. JMS is one of the services defined within J2 Platform Enterprise Edition (J2EE). JMS manages message communication for reliable and stable message transformation, with the features of message persistence and message acknowledgement. JMS supports a variety of message types such as byte-message, object-message and text message. JMS API provides both point-to-point and publish-subscribe messaging models. JMS often supports communication across firewall boundaries. Many vendors extend their provider implementation to support SOAP messaging over HTTP. In this way, HTTP is used as transportation protocol under JMS API and passes SOAP messages as text messages. This is often called as “SOAP over JMS”.

Remote Method Invocation (RMI): is the action of invoking a method of a remote interface on a remote object. The technology allows the invocation of methods across a distributed network of clients and servers with providing management of objects and the ability to overtake them between each machine. RMI is lightweight and supports small sized distributed object-based application development. It involves RMI Registry and it is based on remote procedure call (RPC).

Component Object Model (COM): is a part of Microsoft Windows family of operating systems and it is used to create reusable software. COM is a component based software architecture which allows components from variety of applications to be combined and built into a new higher level software application and it defines a standard for component interoperability.

Distributed Object Model (DCOM): extends COM to support communication among objects on different computers on a LAN, a WAN and the Internet. DCOM restores local inter-process communication with a network protocol and hides the communication details from client components. Architecturally, DOM provides cross-platform development and allows the integration of platform-neutral development frameworks and virtual machine environments to build up a single distributed application.

Common Object Request Broker Architecture (CORBA): is a specification from Object Management Group and it is an object system which provides a framework where objects can communicate with each other in a distributed manner without platform and language dependencies. It defines Interface definition language (IDL), a core API which classifies a communication infrastructure based on Object Request Broker (ORB) for distributed applications and a TCP/IP based communication protocol called as Internet Inter-ORB Protocol (IIOP).

Web Services: is a set of XML-based technologies which aim to provide a standard way for communication of different applications and interoperability of heterogeneous computing environments. Critical concepts of this technology have already been discussed in Section 4.2.1.

Table 9 provides a feature-based comparison of these technologies.

The following conclusions can be made from this comparison table:

- In terms of model development, only Web services provide component oriented service development, whereas all others support object oriented approaches.
- In terms of interface definition language, JMS and RMI have Java dependency and COM/DOM has Microsoft Interface Definition language dependency. As using WSDL, web services represent the language independency.
- Platform independence is present only for web services.
- Interoperability and support for open standards are present only for web services.
- Only web services support both synchronous and asynchronous modes of communication.
- Ongoing work for standardisation in terms of security and transactional support is present for web services.

Table 9 Comparison of various SOA technologies, Source: Güner (2005)

	JMS	**RMI**	**COM/DOM**	**CORBA**	**WEB SERVICES**
Development Model	Object Oriented Messaging Development	Object Oriented Development	Object Oriented Component Development	Object Oriented Component Development	Component Oriented Service Development
Interface definition language	Java Programming Language	Java Programming Language	Microsoft Interface Definition Language	CORBA Interface Definition Language (IDL)	Web Services Definition Language
Coupling	Loose	Tight	Tight	Tight	Loose
Platform Independence	Targets Java platform	Targets Java platform	Targets Microsoft Windows platform	Platform Independent	Platform Independent
Interoperability, support for open standards	Not interoperable, Java Standards	Not interoperable, Java Standards	Not interoperable, Windows Standards	Not interoperable, CORBA Standards	Interoperable Open internet standards
Location transparency	Location transparent, through message provider, vendor-specific	Location transparent, through RMI naming facility	Location transparent, through interface pointers	Location transparent, through CORBA Interoperable object reference	Location transparent, through URL addresses
Communication mode	Asynchronous mode, possible to implement synchronous mode	Synchronous mode, RPC-based development	Synchronous mode, RPC-based development	Synchronous mode, RPC-based development	Supports both synchronous and asynchronous modes
Service Discovery and registry support	Registry of messages by service provides	RMI registry	Service discovery through interface pointers, no registry support	Standard CORBA services, CORBA Naming and Trading Service	Supports through UDDI
Security	J2EE compatible security standards	J2EE compatible security standards	Microsoft Windows compatible security standards	CORBA Security Service	On-going work for standardisation
Transactional Support	Partial	Supports	Supports	CORBA Object Transaction Service	On-going work for standardisation

The table clearly shows that among these technologies, web services represent highest degree of interoperability, platform independency and standardisation. Loose coupling, UDDI and WSDL support characteristics of web services also put the technology ahead of the others. These are clearly vital characteristics for web-based collaboration and e-supply chain formation. Technological challenges of e-supply chain already discussed in Chapter 2 definitely require standardisation and platform independency. As such, web services currently represent the most proper technology for the ultimate integration in the form of e-supply chain.

4.3. BENEFITS OF SERVICE ORIENTED SYSTEMS AND THEIR IMPORTANCE FOR E-SUPPLY CHAIN FORMATION

Various benefits of service-oriented systems are reported in literature. Woods and Mattern (2006) mention the following:

- Greater flexibility.
- Expanded reuse of existing functionality.
- Improved communication between IT and business.
- Faster time to market through improved developer productivity based on model-driven development, removing IT bottlenecks.
- Easier adaptation through modeling and role-based tools.
- Clearly defined roles from the business analysts to the developers.
- Better encapsulation to allow heterogeneity or outsourcing.
- Lower TCO (total cost of ownership).
- A foundation for an ecosystem, which enables the development of an ecosystem of interacting enterprises.
- A foundation for harvesting value from standards.

(Earl 2005) clearly emphasises that SOA is based on open standards. It promotes intrinsic interoperability; it promotes federation, architectural composability and reuseability.

Microsoft whitepaper (2006) classifies the accrual of SOA benefits for the organisation at two different levels: IT organisation and the business user. From IT point of view, the following benefits are reported:

- Simplification of management of distributed resources across multiple platforms.
- Reduced hardware requirements.
- Increased reliability.
- Reduced costs.
- All benefits adding up to a dramatic increase in agility and productivity.

From the business point of view, it is argued that SOA solutions promote the following:

- **Stronger connections with customers and suppliers:** By making dynamic applications and business services available to external customers and suppliers, not only is richer collaboration possible, but also customer/partner satisfaction is increased. SOA relieves critical supply and demand chain processes (such as outsourcing of specific business tasks) from the constraints of underlying IT architectures, enabling better alignment of processes with organisational strategy. This is definitely what is needed for e-supply chain formation.
- **Enhanced business decision making:** By aggregating access to business services and information into a set of dynamic, composite business applications, decision makers gain more accurate and more comprehensive information. They also gain the flexibility to access that information in the form and presentation that meets their needs. This is a giant step towards web-based collaboration, which is one of the critical requirements of e-supply chain formation.
- **Greater employee productivity.** By providing streamlined access to systems and information and enabling business process improvement, businesses can drive greater employee productivity. Employees can focus their energies on addressing the important, value-added processes and on collaborative, semi-structured activities, rather than having to conform to the limitations and restrictions of the underlying IT systems. As such, this is a great contribution to e-supply chain efficiencies.

Canfora *et al.* (2007) consider SOA as a new chance to continue to use and reuse the business functions provided by legacy systems. As such, they mention SOA and web services as a means of modernizing software systems, emphasizing them as valuable options for extending the lifetime of mission-critical legacy systems. Exposing legacy systems as services allows heterogeneous systems to become interconnected and interoperable. Legacy system integration has already been discussed in Chapter 2 among the critical requirements of e-supply chain formation. As such, SOA provides a critical support for legacy systems integration.

SOA are mentioned as means of attaining greater business agility from existing IT investments, a means to connect systems, workgroups, or geographically distributed subsidiaries or to collaborate with trading partners (Microsoft 2006).

With these benefits clearly put forward in the literature, Woods and Mattern (2006) emphasises the importance of ESA because of the below reasons:

- For the first time in IT history, ESA provides a blueprint for all levels of the enterprise architecture, not just for an application but also *for "a platform for flexible automation of business processes"*.
- ESA provides the ability to *"align the business architecture, the application architecture, and the technology architecture"* using a framework that allows all aspects to understand each other. ESA brings the three basic levels together using enterprise services as a *"common building block"*.
- ESA standardises business semantics by providing services that can be used to implement standards and make them useful, or to model and implement relationships among companies.
- ESA allows the *"complexity of applications to be encapsulated in reusable enterprise services that are orchestrated through modeling"*. This makes the development of flexible composite applications possible, allowing new ideas to come to life more quickly and creating a new culture of innovation can be created.
- ESA *"preserves the gains of the previous generation of enterprise applications"* while introducing flexibility. All of the standard processes that made ERP, CRM, and other enterprise applications which are so vital to

efficient operations will stay in place. Instead of being powered by monolithic architectures, however, they will be powered by services. The existence of services is the engine of flexibility. It's not important where these services originate—whether in ERP, CRM, or SCM—because it's now possible to orchestrate them independently. The Enterprise Services Repository incorporates, a central tank of services that are created for customers, and it will include services that companies create on their own. All of these services will be stored for use and reuse, subject to the rules and standards implicit in ESA.

- ESA bridges the gap between buy versus build. Instead of buying an application and having to live with whatever can be configured or customized at a high cost, ESA provides products as composite applications based on models that can be changed in part where it makes sense for a business. The paradigm becomes *"buy, build, and compose where you need to"*.

4.4 DISCUSSION

It is evident that these benefits and arguments for the importance of SOA are definitely in line with e-supply chain formation requirements discussed in Chapter 2, from both technological and business perspectives. Encapsulation of legacy systems, obtaining platform independence, preserving the gains of the previous generation of enterprise applications, aligning the business processes, application and the technology architecture are definitely desired properties for e-supply chain formation. Therefore, it can be easily argued that SOA acts as the significant enabler to meet the requirements of e-supply chain formation, serving for the needs of legacy systems encapsulation, better external integration, joint planning and collaboration, business intelligence and decision support needs. This idea is clearly supported by (Bih, 2006) who names SOA as "the new paradigm to implement dynamic e-business solutions".

To emphasise the importance of SOA and web services, Woods and Word (2006) makes the following quote from a Gartner Group Report- one of the most respected research firms in the field:

"There is no alternative to [SOA] and web services as a basis for future software. The issues revolve around the rate of adoption and the purposes for which it is applied." In other words, it's not a question of whether an SOA will supplant today's architecture, but rather, how long it will take to complete this evolution."

Simon Hayward, "Positions 2005: Service-Oriented Architecture Adds Flexibility to Business Processes," Gartner Inc., February 2005.

As such, SOA appears as the critical enabler of enterprise application integration, therefore for e-supply chain formation. Transition to SOA is a radical shift from traditional application development, with the focus of model-driven orchestration of enterprise services, leading to the formation of composite applications development. Various resources, (Gartner Reports, Woods and Word 2006, Earl 2005) support this idea. As ESA continues taking shape, it appears that the basic structure of the future will be the business object, which is a container of functionality where data will be managed and processed. These business objects will then be grouped together into larger containers, on top of which will rest enterprise services that allow for external access to the business objects beneath. The result is that enterprise applications will no longer be user interfaces to monolithic functionality and instead will become user interfaces resting on top of process components composed of related sets of business objects exposed for external use as enterprise services (Güner 2005).

CHAPTER 5. A STUDY ON XML-BASED STANDARDISATION EFFORTS AND AVAILABLE APPLICATION INTEGRATION FRAMEWORKS

Platform independent web-based interoperability becoming the key issue in web-based integration and supply chain formation, various efforts of standardisation are seen in the literature. Various bodies and organisations such as OASIS (Organisation for the Advancement of Structured Information Standards), W3C (The World Wide Web Consorsium), UN/CEFACT (United Nations Center for Trade Facilitation and Electronic Business), BEA Systems, IBM, Microsoft, SAP and Siebel Systems have launched initiatives for reaching global standard of web based data exchange and collaboration among supply chain partners. These standardisation efforts aim at both technical infrastructure and business process modeling. Among these initiatives, ebXML (e-business XML), RosettaNet, BPML (Business Process Modeling Language), BPEL (Business Process Execution Language), WS-BPEL (Web Services- BPEL), XPDL (XML Process Definition Language), BPMN (Business Process Modeling Notation) and WS-CDL (Web Services Choreography Definition Language) are the major ones.

Besides these standardisation efforts of various organisations, there are currently various integration platforms developed by proven vendors. Vendors like IBM, Microsoft, Oracle and SAP provide clear commitment to SOA transition in their products (Gartner Research 2007). Microsoft BizTalk, IBM WebSphere, SAP NetWeaver and Oracle Fusion MiddleWare integration platforms are the major ones in this regard.

With the importance of SOA and web services already mentioned, this chapter will put forward:

- A study of these standardisation initiatives in Section 1.
- A study of various integration platforms from proven vendors in Section 2.

5.1. VARIOUS STANDARDISATION EFFORTS

In this section, the following will be considered as the main initiatives of web based standardisation in the literature:

- ebXML (e-business XML)
- RosettaNet
- BPEL (Business Process Execution Language)
- WS-BPEL (Web Services- BPEL)
- XPDL (XML Process Definition Language)
- BPMN (Business Process Modeling Notation) and
- WS-CDL (Web Services Choreography Definition Language) are among the most critical ones.

Business Process Modeling Language (BPML) (a meta-language for the modeling of business processes, just like XML is a meta-language for the modeling of business data) was the originally proposed language by the Business Process Management Initiative (BPMI) as a means of modeling business processes. However, BPMI has dropped support for this in favor of BPEL4WS, which is further standardized as WS-BPEL to align BPEL with other Web Service standard naming conventions (wikipedia.org). Therefore, BPML and BPEL4WS are not included in the above list.

Besides these numerous efforts, there exists huge number of WS-series standardisation efforts for reliability, security, trust, addressing, eventing and notification such as WS-Security, WS-Reliability, WS- Eventing (Bender 2005). For the purposes of scope and not losing the focus of e-supply chain and business process management, these are not included in the analysis. A summary table is developed for the above-listed 7 initiatives to represent various characteristics of them. The summary table given in Appendix 1 includes supporting party, focus, vision, characteristic and various other properties for each initiative. Basing on the basic characteristics and the comparison table given in Appendix 1, the following are worth mentioning about these initiatives:

- **Focuses are not the same:** While ebXML and RosettaNet are more focused on facilitiating e-trade among supply chain partners, XPDL has the focus on process diagrams. BPEL and WS-BPEL aim at web services orchestration whereas WS-CDL is aimed at choreography definition. BPMN focuses on creating business models.

- **Visions and aims differ:** Vision of ebXML is to create a single set of internationally agreed upon technical specification that consists of common XML semantics and related document structures to facilitate global trade (Doğac and Cıngıl 2003). RosettaNet framework is aimed at developing an XML-based standard electronic commerce interfaces to align the process between supply chain partners on a global basis (Doğac and Cıngıl 2003). BPEL intends to provide a business process modeling language that is executable and it provides a means for formally specifying business process models and interaction protocols (ibm.com). WS-BPEL tries to aim at aligning the Web services and BPEL. XPDL defines a format standardized to interchange Business Process definitions between different workflow products like modeling tools and workflow engines (wikipedia.org). WS-CDL defines an XML-based language that describes peer-to-peer collaborations of participants by defining their common and complementary observable behavior, where ordered message exchanges result in accomplishment of a common business goal (w3c.org). BPMN is a standardized graphical notation for drawing business processes in a workflow and it is mapped to both XPDL and BPEL (omg.org).

- **Standardisation efforts include data definition and description, as well as business process definitions and workflow:** These initiatives deal with both SOA and BPM sides. However, not all of them are addressed in one standard. Among these standards, XPDL and BPMN have more focus on BPM side, whereas BPEL, WS-BPEL, WS-CDL are on the SOA side. As such, these initiatives represent efforts towards the convergence or merger of BPM and SOA.
- **Only BPEL and WS-BPEL represent executable languages:** In the table, not all of the initiatives are executable languages. WS-CDL is an examle of "non-executable business process description language" or an implementation language. For WS-CDL, the role of specifying the execution logic of an application will be covered by other specifications such as WS-BPEL or

XPDL. As such, WS-CDL does not depend on a specific business process implementation language (w3c.org).

- **Degree of support for process definitions and graphical process diagrams vary:** Having the basic design intention of handling process diagrams, XPDL and BPMN have naturally stronger support for process definitions and diagrams than the others.

BPMN defines a business process diagram which is based on a flowcharting technique tailored for creating business models of business process operations. One of the drivers of BPMN is to create a simple mechanism for creating business process models while handling the complexity of business processes and to provide a standard notation that is readily understandable by all business stakeholders (White 2007). BPMN is intended to serve as common language to bridge the communication gap that frequently occurs between business process design and implementation. As such, BPMN will be constrained to support only the concepts of modeling that are applicable to business processes. This means that other types of modeling done by organisations for non-business purposes such as the modeling of the following organisational structures, functional breakdowns and data models are out of the scope of BPMN (bpmn.org).

As a modeling notion, BPMN is more than just a diagram, since each element has defined process semantics, abstracted from implementation details, but BPMN has no official XML schema, i.e. no interchange format (Silver 2007). XPDL 2.0 was explicitly created to capture all the elements of BPMN 1.0 for interchange, but from a diagram portability perspective, not a model portability perspective. In this regard, Silver (2007) critisises BPMN to omit the business semantics while focusing too much visuality and graphics.

Therefore, it can be argued that BPMN focuses on visuality but lacks the XML schema definitions of the business processes whereas BPEL –which is strong in execution and schemas- does not contain elements to represent the graphical aspects of a process diagram. Omitting certain semantics and process constructs, it is not possible in BPEL to model and execute any process. Thus, it is clear that some initiatives are stronger at graphical support and representations and others are stronger at the definition and execution sides, not meeting the complete set of needs. This idea is supported by Silver (2007) who argues that *"neither XPDL nor BPEL today meets the real need of the BPM community, which is a portable serialisation of process models- not diagrams, models - that is independent of implementation architecture"*. It is argued that in the absence of business process data model, XPDL had an opportunity to become the de facto serialization standard for BPMN.

- **Support for orchestration and choreography definitions differ:** In this regard, choreography definitions are the WS-CDL's basic focus whereas BPEL and WS-BPEL are aimed at orchestration definitions.

  BPEL is an orchestration, not a choreography language, the primary difference being in scope as mentioned in Section 4.2.2. Therefore it is not possible, in BPEL, to model and execute any business process. For this reason, BPEL is often used in conjunction with programming languages, for example Java, or extended by the proprietary scripting languages inherent to commercial implementations of workflow or integration broker engines. In most practical cases, therefore, the lack of completeness and formality of BPEL means that processes designed with it need to be extended or compiled to code, similar to traditional programming. This deprives BPEL of many of the advantages (wikipedia.org).

  As a choreography definition language not depending on any implementation, WS-CDL can be used to specify truly interoperable, collaborations between any type of participant regardless of the supporting platform or programming model used by the implementation of the hosting environment. WS-CDL may couple with other languages such as those that add further computable semantic definitions. Each participant, adhering to a WS-CDL collaboration representation, could be implemented using completely different mechanisms such as applications, whose implementation is based on executable business process languages (WS-BPEL, XPDL) or applications, whose implementation is based on general purpose programming languages (Java, C#) (w3c.org).

- **BPEL and XPDL are entirely different yet complimentary standards which can easily coexist:** Being an "execution language", BPEL is designed to provide a definition of web services orchestration, specifically the underlying sequence of interactions and flow of data from point-to-point. For this reason, it is best suited for straight-through processing or data-flows used for application integration. The goal of XPDL is to store and exchange the process diagram, to allow one tool to model a process diagram, and another to read the diagram and edit, another to "run" the process model on an XPDL-compliant BPM engine. (wfmc.org). XPDL defines a XML schema for specifying the declarative part of workflow and it is designed to exchange the process design, both the graphics and the semantics of a workflow business process. XPDL contains elements to hold the X and Y position of the activity nodes as well as the coordinates of points along the lines that link those nodes. This distinguishes XPDL from BPEL which is also a process definition format, but BPEL focuses exclusively on the executable aspects of the process (wikipedia.org).

  For this reason, XPDL is not an executable programming language like BPEL, but rather a process design format that literally represents the drawing of the process definition. This allows XPDL to store a one-to-one representation of a BPMN process diagram. For this reason, XPDL is effectively the file format or serialization of BPMN, as well as any non-BPMN design method or process model which use in their underlying definition the XPDL meta-model (wfmc.org). As such, XPDL captures the diagram while BPEL captures the process semantics (Silver 2007).

- **Product categorization and classification are taken care of only for RosettaNet:** This appears as a characteristic of RosettaNet and it is achieved through RosettaNet Technical Dictionary which specifies classes of products using their properties in XML DTD s. Partnership interface definitions use GTIN (Global Trade Item Number) to identify the products (Doğac and Cıngıl 2003).

- **WS-BPEL provides full web services support:** In WS-BPEL, process model is layered on top of the service model defined by WSDL and at the core of the model is the notion of peer-to-peer interaction between exposed services described in WSDL (OASIS 2007). As such, it is designed to provide full web services support.
- Security issue has reliance on extended SOAP and WS-Security and dominant messaging protocol is SOAP

From all these discussions, it is evident that standardisation initiatives attempt at both architecture and business process management sides. Exchange of business processes and workflows are just as important as the related infrastructures for web-based collaboration and it appears that standardisation initiatives are far from being complete for both BPM and SOA sides. Therefore, it can be easily argued that lack of standards in terms of both SOA and BPM still prevails. Kamoun (2007) also supports this idea and emphasises that *"growing interest in BPM – SOA solutions has generated a wide spectrum of protocols and tools, which are not all compatible among others"*. In this wide spectrum, recognition of BPEL as de facto SOA orchestration language is clearly emphasised. Gartner presentations also support WS-BPEL becoming a core standard. However, they mention the reconciliation efforts with WS-CDL and BPMN as the basic weakness of WS-BPEL. Kamoun (2007) also mentiones this, emphasising that *"BPMN and BPEL were not originally designed to work together"*, clearly indicating the lack of maturity and lack of compatibility in these standardisation efforts.

Gartner Researches rate OASIS and W3C as "strong positive" among the organisations that drive standard developments. In this regard, Kamoun (2007) clearly emphasised the need for the convergence of BPM and SOA solutions. Key facilitator for BPM-SOA convergence is mentioned as the adoption of industry-wide technology standards which:

- Allow the architecture to be portable and operational independently from specific vendors and technologies (including hardware, software, and operating systems)
- Allow smooth integration of compatible tools and real-time business processes across heterogeneous deployment environments

These two points are vital for e-supply chain formation, since portability, platform independency and seamless integration across heterogeneous tools are exactly the needs for e-supply chain formation. Thus, development adoption and maturity of such standards will definitely be a giant step made towards meeting the technical challenges of e-supply chain formation. It can easily be argued that future of seamless application integration and e-supply chain formation lies in these standardisation efforts. Chapter 2 already emphasised that e-supply chain formation involves both technical and organisational challenges and this chapter revealed the multiplicity and immaturity of BPM and SOA standards. As such, maturity of standards in both lanes and their compatibility (in other words, BPM-SOA convergence) are needed to handle the multifold challenges of e-supply chain formation. Alignment of technical infrastructure and business processes across heterogeneous platforms will surely be the key for e-supply chain formation. To sum up, development of standards will be a giant step towards the long journey of ultimate web based collaboration.

5.2. AVAILABLE APPLICATION INTEGRATION FRAMEWORKS

This section will focus on the following as today's most critical proprietory integration solutions coming from proven vendors:

- Microsoft BizTalk
- IBM WebSphere
- SAP NetWeaver
- Oracle Fusion MiddleWare SOA suite

An architectural study of these platforms will be made in this section.

5.2.1. Microsoft BizTalk Model

(Chappell 2005) introduces Microsoft BizTalk Server 2006 technology as a general model for combining different systems into effective business processes. BizTalk Server 2006 R2 builds upon the Business Process Management and SOA/ESB capabilities and BizTalk Server 2006 R2 provides a single platform for a wide range of business-to-business communication options.

The main components and characteristics of the technology are as follows:

- BizTalk Engine working internally with XML documents.
- Use of adapters for sending and receiving messages, an adapter being an implementation of a communication mechanism. Web services come into role as implemented in the adaptors, allowing exchange of XML documents via SOAP.
- Presence of pipelines, providing a way to convert documents to and from XML and enabling other services such as validation and authentication.
- BizTalk Editor for defining schemas using XML Schema Definition language (XSD).
- BizTalk Mapper for defining translations/mappings between schemas basing on XSLT transformation. Complex mappings are also made possible by the use of various categories of functoids, such as mathematical, conversion, logical, cumulative or database functoids.

- A graphical tool- Orchestration Designer- for defining the business process logic.
- Use of BPEL, which is built entirely on Web services and the ability to exporting/exporting process definitions made using the Orchestration designer to/from BPEL.
- Business rules engine to define additional complex set of business rules to be evaluated. This functionality interacts with the business process definitions- orchestrations- rules defined here can be associated with XML documents and can be called upon from within orchestrations.
- A message box implemented in SQL and interacting with orchestrations.

A generic schema showing the basic components, functionality and interaction among these components is given in Figure 17.

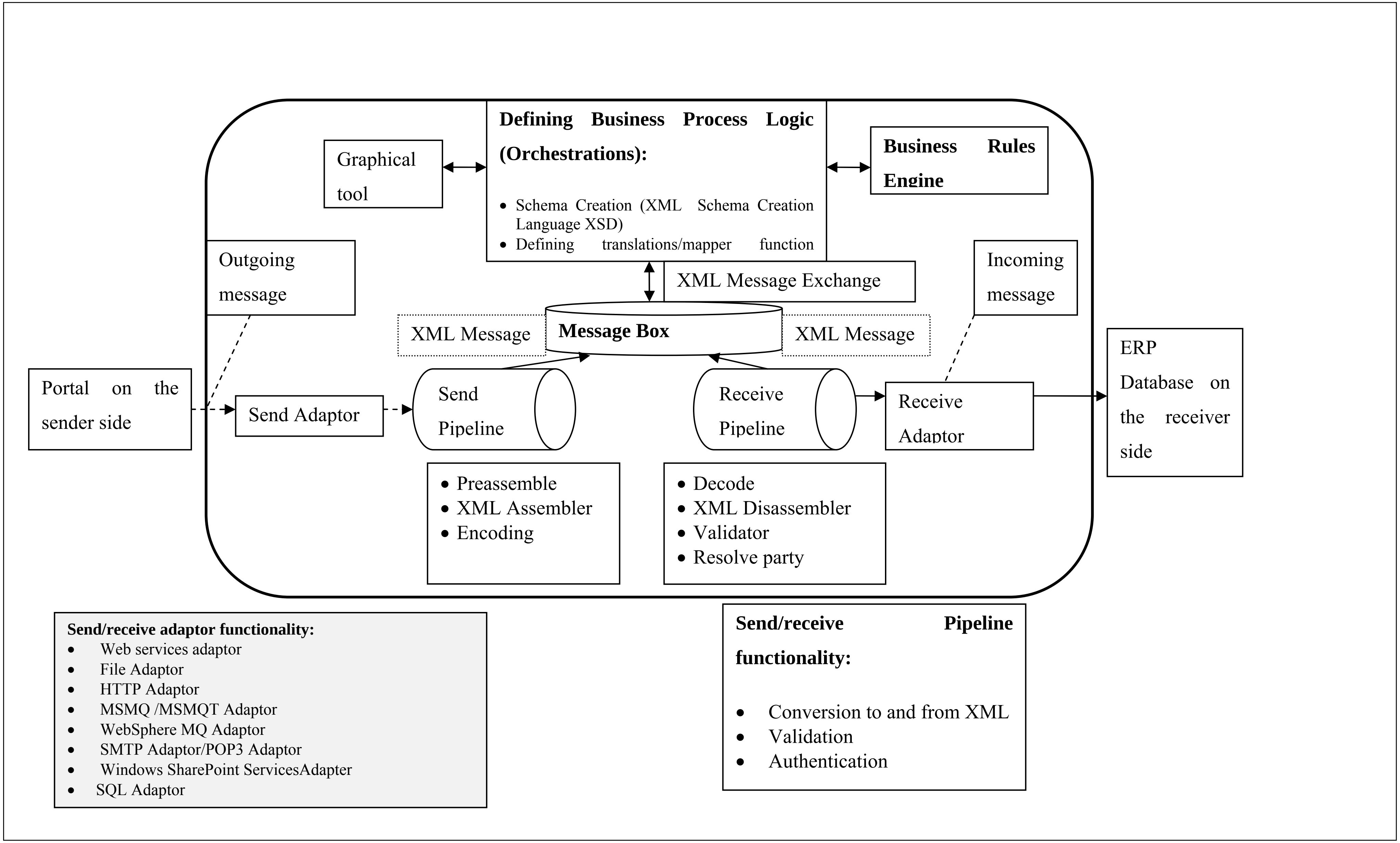

Figure 17 Microsotf BizTalk Server Platform Structure Source: Adopted from Chappel (2005)

5.2.2. IBM WebSphere Integration Architecture

IBM s WebSphere Integration Architecture enables an enterprise to form a tight linkage between business requirements and technology solutions. MDA (Model Driven Architecture), SOA (Service Oriented Architecture) and BPM (Business Process Management) are the three key concepts for this architecture (Simmons 2005). Figure 18 below depicts the layered structure, basic components and functionalities for IBM Websphere:

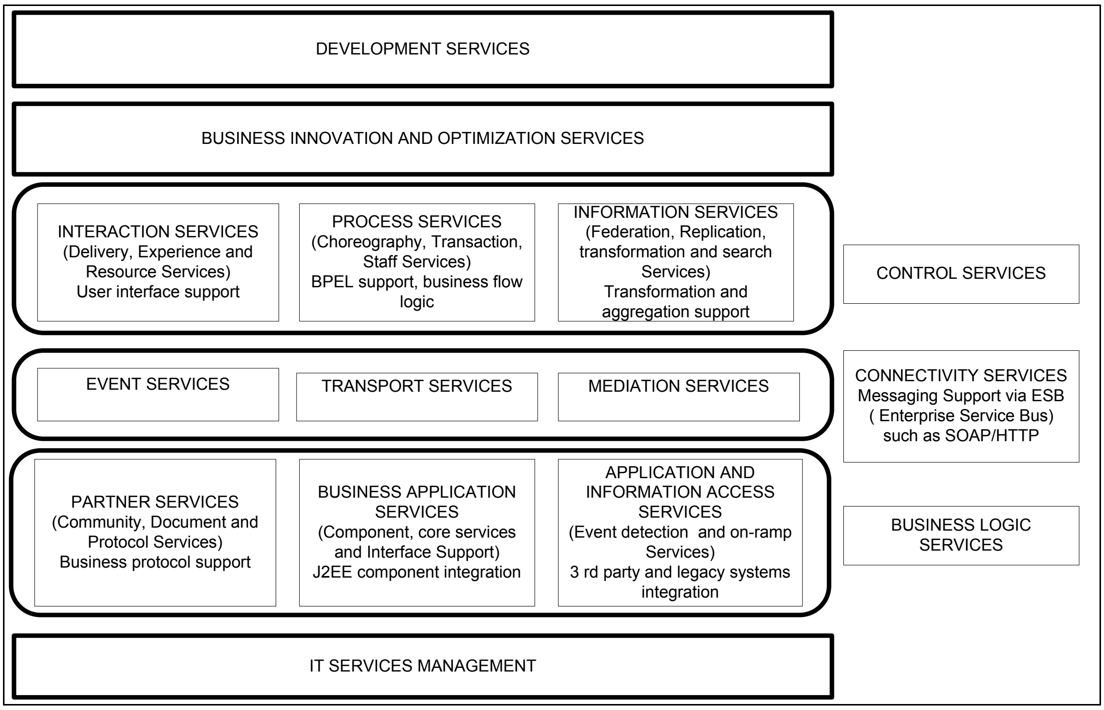

Figure 18 IBM WebSphere Architecture Source. Adopted from Simmons (2005)

The architecture uses 6 layers and characteristics of the technology are as follows:

Connectivity services: provides the infrastructure to support and instantiate the Enterprise Service Bus (ESB). Transport, event and mediation services are provided through ESB which supports multiple messaging topologies and patterns along with implementations such as SOAP/HTTP. As such, ESB becomes the extended enterprise's arterial system providing messaging, notification and invocation services across the enterprise's various operating environments. The requirement to support for heterogenous technologies is reflected in support for multiple protocols within a message flow instance, middleware interoperability, specification of different quality of service (such as persistence, reliability, transactional management) and support for various distribution and routing.

Business logic services: provides the capabilities required for the execution of business logic. Includes partner services, business application services and application information access. Partner services enable support for business protocols such as RosettaNet and EDI. Business application services provide the J2EE run time environment for integration components developed as custom application components coded in Java and running in the application server environment. Application information access provides the capabilities to interact with third party applications (ERP, CRM), custom applications, as well as heterogeneous data sources like RDBMS, XML and non-RDBMS data sources. As such, this service provides the bridging capabilities between legacy applications, pre-packaged applications and enterprise data stores. Event detect services and on-rump services are provided.

Control Services: control the flow of interactions and data among people, process and information services for implementing business processes. Interaction, process and information services are provided. Interaction services provide capabilities required to deliver functions and data to end users meeting end users specific usage preferences. Business flow definitions and executions are provided by business services and BPEL4WS standard is used to describe the orchestration of the business functions. Information services provide the capabilities to federate, replicate, query, analyze and transform data sources.

Development Services: provide a software development platform, covering the entire life cycle of software development, including requirements analysis, modeling and design, component development, testing and code maintenance.

Business innovation and optimization services: provides an infrastructure for continuous improvement and innovation. Includes common event infrastructure services, correlation services and monitoring services. As such, provides necessary monitoring and alarming mechanisms to enable a business to adapt to changing conditions.

IT Services management: Lowermost level which provides management of services for security, directory, system management and resource virtualization, including authorization, authentication and single sign-on capabilities across heterogeneous platforms.

5.2.3. SAP NetWeaver

SAP NetWeaver is SAP's integrated technology platform and is the technical foundation for all SAP applications since the SAP Business Suite. SAP NetWeaver is marketed as a service-oriented application and integration platform. It provides the development and runtime environment for SAP applications and can be used for custom development and integration with other applications and systems (wikipedia.org). SAP NetWeaver is a single, integrated set of technologies used to unify a huge collection of integration and development functionality, including the portal, the data warehouse, EAI, application servers, Business Process Management, and a variety of other systems for supporting mobile devices, for constructing user interfaces, and for distributing data and managing master data (Woods and Mattern 2006).

SAP NetWeaver allows you to write programs not only in ABAP —the language that has been used for more than 20 years to write applications in SAP—but also in Java. This helps solve the problem of integrating the integration tools, but still the problem of getting all of these applications to talk to each other remains (Woods and Mattern 2006). Table 10 given below shows the integration components and development and management tools of NetWeaver:

Table 10 SAP NetWeaver Integration platform components, development and management tools Source: Woods and Word (2004)

Integration Components	**Development and management tools**
SAP Enterprise Portal (SAP EP)	SAP NetWeaver Developer Studio
SAP Mobile Infrastructure (SAP MI)	SAP Visual Composer
SAP Business Intelligence (SAP BI)	SAP Composite Application Framework
SAP Master Data Management (SAP MDM)	SAP Solution Manager
SAP Exchange Infrastructure (SAP XI)	
SAP Web Application Server (SAP Web AS)	

Figure 19 given below shows the basic layered structure and different components of SAP NetWeaver, together with the basic function and integration type for each component:

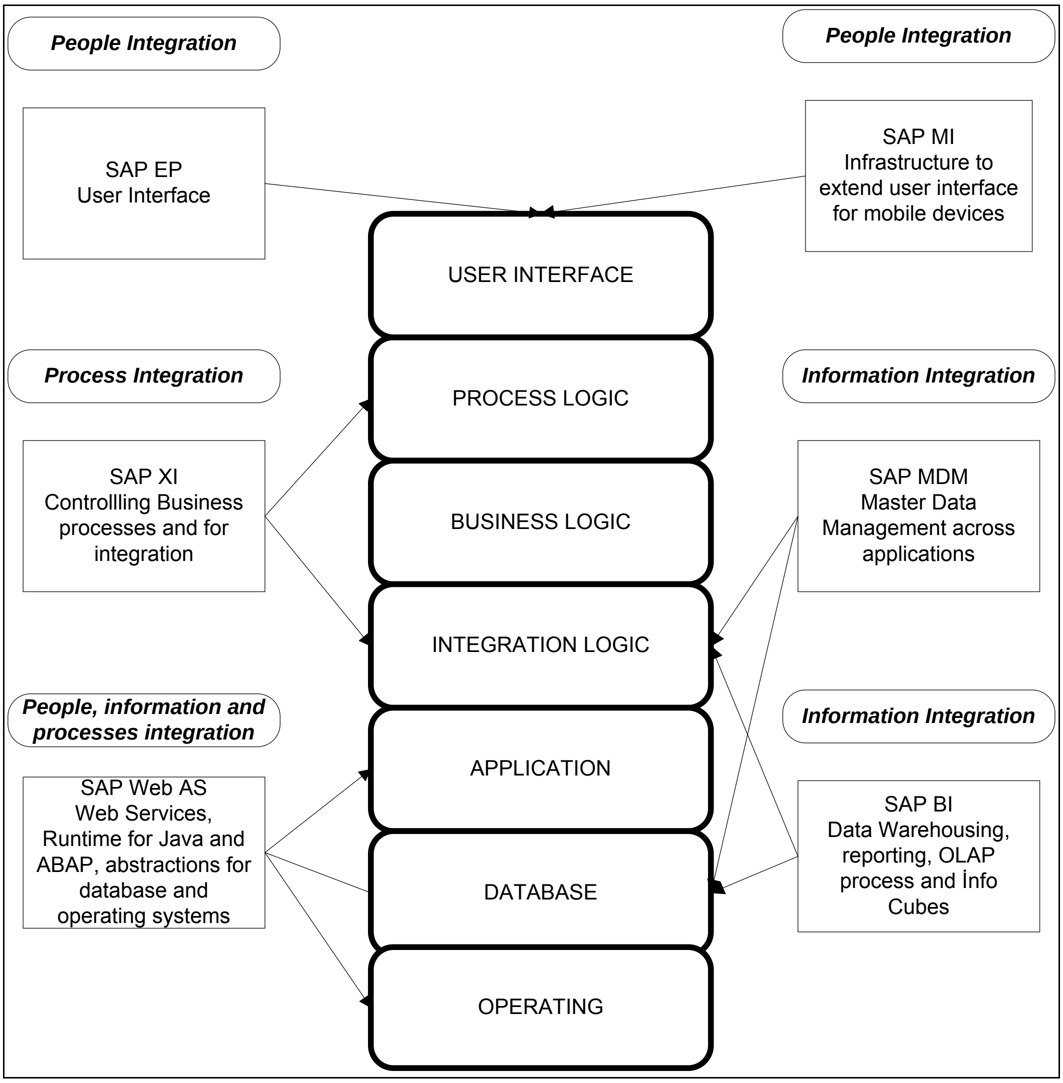

Figure 19 SAP NetWeaver Architecture Source: Adopted from Woods and Word (2004).

Basic functionalities for these components are summarised as follows:

SAP Enterprise Portal (SAP EP): is a set of technologies for creating role-based user interfaces. An interface acts as a central point of access and defines the look and feel of different applications. SAP EP has content content management features and represents the people integration. SAP EP works by providing a page layout template that cuts a page into a bunch of different areas, each of which can be filled with HTML or special programs called iViews. iViews can talk back and forth with other applications or information sources and then present the information to users.

SAP Mobile Infrastructure (SAP MI): Acts like a universal translator for mobile devices by enabling to write one interface that can talk to any device. It resides in the user interface layer.

SAP Business Intelligence (SAP BI): Provides data warehousing functionalities and used to create a unified and normalized view of information from any number of sources. SAP BI provides roll-up and drill-down reporting capabilities and it is used for managerial reporting. Data extraction, transformation, loading and normalization are handled by BI before obtaining Info Cubes. The following figure shows the basic steps of report generation:

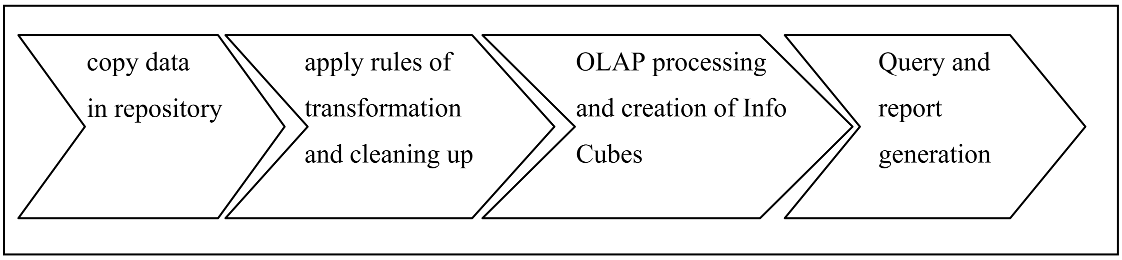

Figure 20 Basic flow of BI report generation Source: Woods and Word (2004)

As such, BI lives at the database layer of the application stack, with a large number of functions for reporting and analysis in the user interface and application layers.

SAP Master Data Management (SAP MDM): is a system for harmonizing information that is distributed across a wide variety of applications. Lives in the database stack and integration logic layers of the stack. Provides metadata management and storage capabilities for master data, which are not tied to any one particular transaction.

SAP Exchange Infrastructure (SAP XI): Acts like a railroad system by data and message traveling between applications and provides a framework to build adapters to each application. Security and guaranteed delivery is provided by this component. SAP XI sets up the housekeeping in the integration and process logic layer of the application stack. Message descriptions and XML transformations are handled with this component. This is the integration component which enables us to use Web services to send and receive messages.

SAP Web Application Server (SAP Web AS): is the foundation on which SAP NetWeaver is built and acts as an engine that drives all of SAP applications. SAP

Web AS supports two languages: J2EE and ABAP code, which is SAP s language for business applications. It is directly involved in all types of integration: people, information and processes. It has the capabilities for load balancing, communicating with the Internet, connecting with databases, building Web pages and creating web services.

Basing on these components, SAP Netweaver provides the following set of tools for building applications:

SAP NetWeaver Developer Studio: An integrated environment for Java coding.

SAP Composite Application Framework: A model-driven development environment for creating composite applications, which use services provided by existing applications as the foundation for building new applications. Allows defining applications using role-based or process-based modeling.

SAP NetWeaver Visual Composer: User interface modeling environment for SAP Composite Application Framework.

The solution Manager: Central platform for program life cycle management, covering all phases.

As ESA evolves, SAP NetWeaver's role is changing from an integration platform to a platform where the composition of new applications and the recomposition of existing objects and enterprise services will take place (Earl 2005).

5.2.4. ORACLE Fusion MiddleWare SOA Suite

Oracle's SOA suite is a complete set of service infrastructure components for building, deploying, and managing SOAs. Oracle SOA Suite enables services to be created, managed, and orchestrated into composite applications and business processes (oracle.com). This application integration foundation pack depends on Oracle Fusion Middleware and the foundation contains the components given in Table 11.

Table 11 Oracle Fusion MiddleWare Integration Platform Components

Component	**Functionality**
Oracle JDeveloper	Complete IDE for Service-Oriented Architecture (SOA) and Java development
Oracle Business Rules	Component used to define and modify business logic without programming. Defines and maintains business rules outside of the related process or application using a separate, more intuitive web-based interface
Oracle BPEL Business Process Manager	Enables process orchestration
Oracle Business Activity Monitoring	Component for building interactive, real-time dashboards and proactive alerts for monitoring business processes and services
Oracle Web Services Manager	Manages the operation of web services and the interactions between these services
Oracle Enterprise Service Bus	Provides messaging and connectivity infrastructure. Acts as the messaging backbone

The following Figure 21 depicts the components of this integration suite:

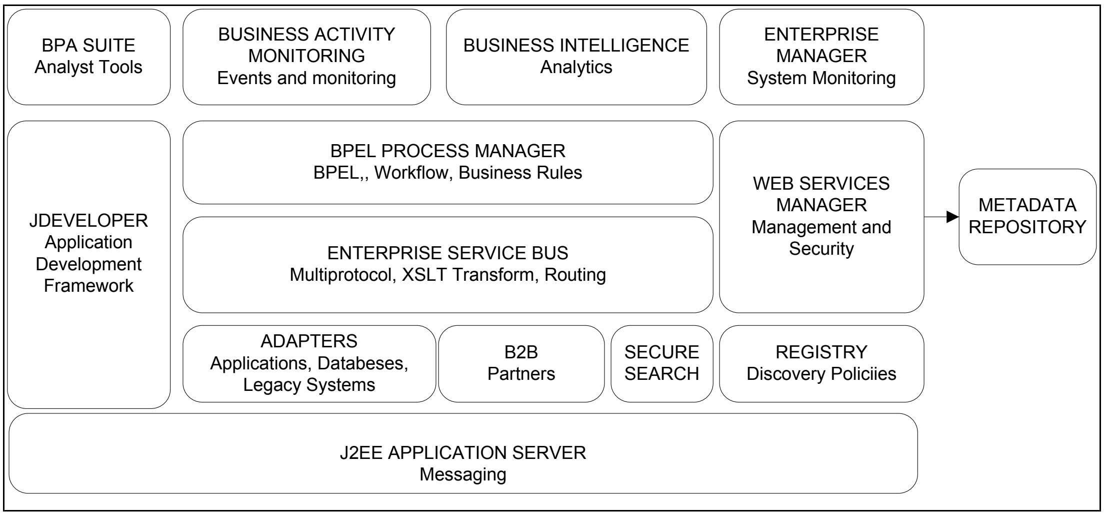

Figure 21 Oracle SOA Platform

Figure 22 below shows how Oracle conceives of these components in terms of layers:

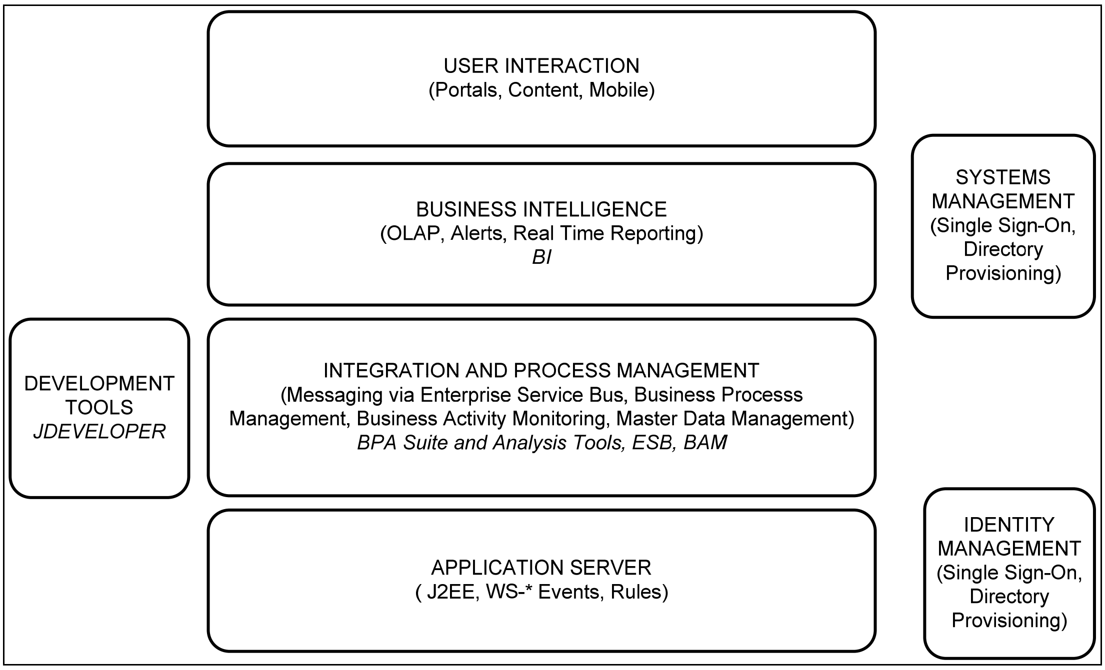

Figure 22 Oracle Integration Platform Layered Architecture

5.2.5. Commonalities and basic design principles

In the table given in Appendix 2, various characteristics of the mentioned integration platforms and mapping of the basic functionalities to their components are summarized. Analysing the architectural diagrams and the summary table reveal consistent results and commonalities for these platforms. The following are worth mentioning:

- Master data management components of the integration platforms provide back-end database integration at both the sender and receiver sides and gives ability to integrate with ERP backbones.
- All of the integration platforms clearly exhibit a service oriented structure. Both the structures discussed and the summary table indicate the SOA characteristics, using web services as the enabler of web-based communication. Ability to use standard web services and creating composite applications from available enterprise services are definitely present in these integration platforms. All of the integration platforms contain development tools to support composite application generation. Therefore, it can easily be argued that SOA plays a crucial role in the architectures of most commonly used integration platforms of today. In Chapter 4 it has been already mentioned that proven vendors have provided their commitment to SOA transitions. As such, previously cited idea that "there is no alternative to [SOA] and web services" is supported by these proven integration architectures of today.

  This SOA approach definitely includes technologies such as SOAP, UDDI and WSDL, all of which use XML and standard communication protocols (like HTTP) as base. Use of a basic standard (such as XML) at the core, a schema definition standard (such as XSD), inclusion of mechanisms for converting documents to/from basic standard such as XML, a mechanism for validating the document against the standard and for translating/mapping between different schemas (such as XLST) are involved.

- All of the integration platforms exhibit layered structures. Hovewer, there is not a one-to-one correspondence between SOA layers defined previously in Section 4.2.3 and different components. One component of an integration platform may be acting in more than one layer, such as SAP XI, which enters into action for both orchestration and service definitions. Similarly, creation of reusable services involves the use of more than one component and interaction of different components at different layers.
- All these platforms include components for business process management. This requires providing the definition of business process logic, having a business process rules engine, relating the business rules to the process logic and relating the messages to the business logic. Easy-to-use, graphical tools and user interfaces for defining and maintaining business logic are also provided. Inclusion of business process management capabilities clearly serves the need for convergence of SOA and BPM in these structures.
- Support for business intelligence is definitely provided and activity monitoring mechanisms are included in all of these platforms.
- Platform independence is provided by the use of web services and adaptors.
- All of them support BPEL standard which was discussed in Section 5.1. This can be considered as the proof of BPEL becoming the de facto standard.

These commonalities observed serve the following basic common design principles:

- **Integrating Business Process Management:** Defining and synchronising way of doing business with the technological architecture is provided by the incorporation of BPM into the integration architecture. This is vital to success of any implementation, which is evident from the best practice guidelines and discussion of challenges involved in ERP, e-procurement and e-supply chain implementations. As such, any integration platform should be able to take care of business process definitions and alignment of business processes with the technology, involving reengineering if necessary. Together with this alignment, this principle ensures the separation between process control and process logic.
- **Layered structures:** For managing complexity and assignment of functionalities, use of conceptual layers is necessary.

- **Portals as user interface:** provides the customization of interfaces and separation of user interface from business data and logic. This enables modifying the user interface while keeping the business data and logic intact, making the portal and back-end integrations independent of the sender and receiver platforms respectively.
- **ESA:** Woods and Mattern (2006) emphasises that use of ESA bring with it the following recurring principles:
  - ✓ *Managing complexity* through enterprise services. Valid theme in the use of enterprise services is the separation of service implementation and interface
  - ✓ *Increasing the use of modeling* in application development to express relationships between services
  - ✓ *Simplifying and accelerating development*, frequently through modeling and patterns
  - ✓ *Promoting reuse* happens through mechanisms such as keeping the Enterprise Services Repository, increasing the number of reusable components.
  - ✓ *Promoting modularity* is a design principles going hand in hand with reusable services. Modular composability, modular decomposability, modular understandability, modular continuity, modular protection are the basic ideas in this regard. (Güner, 2005).
  - ✓ *Promoting service abstraction* provides clear separation of service implementation and interface, guaranteeing that service is independent of any specific infrastructure and technology.
  - ✓ *Improving productivity* occurs through expanded automation and role- and pattern-based user interfaces.
  - ✓ *Increasing flexibility* is based on model-driven development of applications and reusable services.
  - ✓ *Promoting differentiation* occurs because existing systems can be recombined in new ways to adapt quickly to changing conditions and to enable innovation.

- **Separation of concerns:** It refers to the ability to identify, encapsulate, and manipulate those parts of software that are relevant to a particular concern (concept, goal, purpose, etc.). Concerns are the primary motivation for organizing and decomposing software into manageable and comprehensible parts. Appropriate separation of concerns has been hypothesized to reduce software complexity and improve comprehensibility; promote traceability; facilitiate reuse, non-invasive adaptation, customization, and evolution; and simplify component integration. This principle facilitates reuse and evolution of system components or systems as a whole (IBM Research).

- **Separation of business data and logic:** Enables modifying the business rules and logic without changing business data.
- **Scalability:** The fundamental infrastructure should be designed to scale up in order to support current message volume and future growth.
- **Redundancy:** The package should be able to provide redundancy to support fault-tolerant configurations in order to be used as part of the mission-critical application solution.
- **Extensibility:** A good integration solution must be customizable and extensible. A company should be able to add to and change business processes without affecting the underlying applications, and IT should be able to change applications without affecting business processes.
- **Single sign-on:** is clearly the vital design principle needed for proper authorization and authentication.

5.3. DISCUSSION

In this chapter, section one clearly revealed the diversity and lack of maturity in XML-based standardisation efforts, together with the need for the convergence of BPM and SOA standards. Section two put forward structural similarities of various proprietory integration platforms, again emphasising SOA and BPM coexistence for heterogeneous, platform-independent application integration solutions.

Therefore, it can be argued that although the XML-based standardisation efforts mentioned in Section 5.1 are not mature enough, proven software vendors have currently reached consistent architectures using current level of underlying standardisation. Strong backend integration with ERP systems, use of web services, portal-based user interface, composite application development tools, system management tools and business intelligence support overlaid on this basic infrastructure appear as the basic characteristics of application integration. As such, studies made in this chapter support the previous discussions regarding the importance of SOA for application integration.

It appears that SOA is still the current answer for assuring platform independent application integration, which is the basic challenge of e-supply chain formation and ultimate web-based collaboration. In that regard, any development made in terms of standardisation efforts will be a great contribution to web-based collaboration and e-supply chain formation .

CHAPTER 6. CONCLUSION AND FURTHER RESEARCH

This research thesis is intended to reveal the relationship, interaction and presedence among e-procurement, ERP and e-supply chain topics.

The study clearly revealed the need to consider internal integration prior to efforts of external integration with suppliers and customers, keeping in mind the legacy systems. Strong support for the need and importance for business process reengineering for both internal and external processes is found in the literature. Importance of handling ERP implementations prior to web-based integration efforts towards forming an e-supply chain appears as vital. Previously implemented ERP systems act as the core for the integration efforts of various 'bolt-on' applications, such as CRM, APS while forming an e-supply chain.

Towards the long journey of ultimate web-based collaboration, multifold requirements and challenges of e-supply chain, which involve both technological and organisational concerns, are identified and discussed in detail.

There is strong support in the literature that e-procurement applications seamlessly integrated to ERP backbones form the basis of global supply chain integration, making e-procurement "the first step" towards the formation of e-supply chains. Wide applicability and benefits (both tangible and intangible) of e-procurement applications are evident in the literature. There is a new understanding of today's e-procurement solutions and they are beyond simple requisition and purchasing automation systems but rather end-to-end business solutions requiring integration with the backend systems of more than one enterprise with multifold challenges and best practice requirements. In this regard, it is clear that there is increased demand from today's e-procurement solutions to meet the challenges of new supply chain era.

The study put forward the importance of layered, portal based infrastructures and widespread use of XML in various integration efforts. Rise and importance of SOA for application integration, thus e-supply chain formation, is made clear in the study.

Strong commitment of proven vendors to SOA architectures, together with architectural similarities and consistent use of basic design principles in their application integration platforms, are observed in this study. All of these platforms, having common characteristics which provide integration of applications in heterogeneous platforms, serve the needs of cross-platform application integration. Handling master data management, portal-based user interface, business process management, business intelligence support and composite application development in a platform independent manner, these integration platforms appear as the current solution to application integration, thus e-supply chain formation. Definitely these characteristics are in line with today's understanding of e-procurement solutions.

The study clearly revealed the diversity and lack of maturity in various XML-based standardisation efforts for both BPM and SOA lanes. Therefore, it can easily be argues that the need for the convergence and coupling of industry-wide business process management and SOA standards still prevails. As such, adoption of industry-wide technology standards, allowing the architecture to be portable and independent from specific vendors and technologies, providing smooth integration of compatible tools and real-time business processes across heterogeneous deployment environments, is still the answer to challenges of application integration and e-supply chain formation.

Basing on this study and e-supply chain requirements identified, the author suggests the following raodmap to be followed for a company towards e-supply chain formation:

- Legacy systems integration.
- Streamlining internal processes and providing internal integration (ERP implementation, coupled with necessary BPR).
- Streamlining external processes and providing external integration (add-on implementations, coupled with necessary BPR).
- Collaborative planning and joint management with partners.

The author suggests the following future research items:

- The need for maturity of underlying interoperability standards and alignment of SOA and BPM concepts still prevail. As such, the author believes that any effort made in this line of research will be a valuable contribution for e-supply chain, which couples both IT and supply chain management concepts.
- There is lack of research for Turkish perspectives of ERP and e-procurement in the literature. As such, survey based studies to reveal the current status of ERP and e-procurement implementations in Turkey will be valuable contributions. These survey-based studies can include other ERP add-ons such as CRM and SRM.
- Mobile connectivity and mobile commerce are among the needs of current application and they are still hot topics. As such, further research which integrates mobile connectivity and e-supply chain topics will be valuable contributions.

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APPENDICES

APPENDIX A Summary Table for XML Based Standardization Efforts

Standardization Initiative/Property	ebXML	**RosettaNet**	**BPEL**	**WS-BPEL**	**XPDL**	**WS-CDL**	**BPMN**
Supporting party	OASIS (Organization for the Advancement of Structured Information Standards) and UN/CEFACT (United Nations Center for Trade Facilitation and Electronic Business)	RosettaNet, non-profit consortium of major Computer and Consumer Electronics, Electronic Components, Semiconductor Manufacturing, Telecommunications and Logistics companies	IBM and Microsoft	BEA Systems, IBM, Microsoft, SAP and Siebel Systems , voted by OASIS	Workflow Management Coalition (WfMC)	W3C (The World Wide Web Consortium)	Originally by Business Process Management Initiative (BPMI), maintained by the Object Management Group (OMG) since 2005
Focus	Exchange of e-business data in B2B and B2C environments	Development of standard ecommerce interfaces	Web service orchestration definition	Web service orchestration definition	Developing, storing and exchanging process diagrams	Web purposes Choreography definition	Creating Business Process Models
Vision	Creating a set of internationally agreed upon technical specification that consists of common XML semantics and structures to facilitate global trade	Developing an XML-based standard electronic commerce interfaces to align the process between supply chain partners on a global basis	Providing a mean for formally specifying business processes and interaction protocols	Providing alignment of BPEL and web services	Defining an XML schema for specifying the declarative part of workflow and designed to exchange the process design, both the graphics and the semantics of a workflow business process	Composing interoperable, peer-to-peer collaborations between any type of participant regardless of the supporting platform or programming model used by the implementation of the hosting environment	Providing a standard notation that is readily understandable by all business stakeholders. Intended to serve as common language to bridge the communication gap that frequently occurs between business process design and implementation

Standardization Initiative/Property	ebXML	**RosettaNet**	**BPEL**	**WS-BPEL**	**XPDL**	**WS-CDL**	**BPMN**
Characteristic	E-business standard	E-business standard	Block-structured programming language	Block-structured programming language	Graph-structured language	Choreography Definition language	Business process diagramming standard
XML-based?	Y	Y	Y	Y	Y	Y	No XML based schema
Executable?	N	N	Y	Y	N	N	N
Business Process support? (Defining business process logic, sequence and workflows?)	XML Data type definitions and business process definitions in repository	Via partner interface processes (PIP s)	Defines sequence of interactions and flow of data, not graphical workflow definitions	Defines sequence of interactions and flow of data, not graphical workflow definitions	Sequence and structure of process diagrams has XML schemas. Stores and exchanges XML-based process diagrams	Reusable choreography definitions based on XML . Defines full choreography and collaboration.	Provides graphical modeling support , no XML schema for business processes,
Graphical process diagrams?	N	PIP BLUEPRINTS	N	N	Y	Y	Y
Orchestration?	Y	Y	Y	Y	Y	Y	N
Choreography?	Y, Business process specification schema	Y, PIPS	N	N	N	Y, XML based choreography definition	N
Trading Partner information?	CPP (Collaboration Protocol Profile) and CPA (Collaboration Protocol Agreement)	Via master dictionary	N/A	N/A	N/A	N/A	N/A
Registry and repository support?	All business metadata	Via business dictionary	N/A	N/A	N/A	N/A	N/A
Product categorization and classification?	N/A	Via technical dictionary, GTIN (Global Trade Item No)	N/A	N/A	N/A	N/A	N/A

Standardization Initiative/Property	ebXML	**RosettaNet**	**BPEL**	**WS-BPEL**	**XPDL**	**WS-CDL**	**BPMN**
Messaging Protocol?	Does not dictate any particular standard such as SMPT, HTTP or FTP. Extends SOAP	XML and MIME-based. Uses HTTP.	SOAP	SOAP	SOAP (weak support)	SOAP	SOAP (weak support in literature)
Security?	Extended SOAP	Digital signatures and HTTP/SSL	Should be used with WS-Security	Should be used with WS-Security	WS- Security (weak support in literature)	Should be used with WS-Security or WS- Reliability	WS-Security (weak support in literature)

N/A : Not applicable

Y: Yes   N: No

APPENDIX B Summary Table for five different integration platforms

Framework/ Characteristic	Microsoft BizTalk	IBM WebSphere	SAP NetWeaver	ORACLE SOA Suite
Layered architecture?	Y	Y	Y	Y
User Interface?	Portals on sender and receiver side	Control Services/ Interaction service, portals	SAP Enterprise portal/SAP Composite Application framework/ Web Dynpro	JDeveloper , portals
Web Services Support?	Via web service adaptors and ASP.NET	Control Services, Via ESB (Enterprise Service Bus)	SAP Exchange Infrastructure	Web Services Manager
Defining business process logic, sequence and workflows?	Via graphically defined orchestrations, orchestration designer	Via Control Services/ Process service	SAP Composite Application Framework/ Visual Composer	BPA Suite, Web Services Manager
Business rules definitions	Business rules engine	Business logic services and logic services	SAP BI/SAP XI	BPEL Process Manager
BPEL (Business process execution language) Support?	Y	Y	Y	Y
Schema definition and data transformation?	XSD, XSLT, Mapper functions, decoding and encoding handled in pipelines	Information Services/ replication and transformation functions	SAP Master Data Management/ SAP Exchange Infrastructure	Oracle Master Data Management
Event triggering, alarms?	Business rules engine, SQL Server Notification Services	Business logic services/event detection	ABAP/Java Coding, SAP Composite Applications Framework	Business activity Monitoring
Third party application access?	Via adaptors, business logic and transformation	Business logic services/ application and information access	SAP Exchange Infrastructure	Via adaptors
Query, analyze, aggregate data?	Business Activity Monitoring (BAM) portal, generation of different views	Information Services	SAP Business intelligence, Web Application Designer, via data warehouses and OLAP cubes	Business Intelligence
Support for composite application development?	Business process designer	Development services	SAP Composite, Application Framework (CAF)	JDeveloper
Follow-up and monitoring?	Business Activity monitoring(BAM)portal	Business innovation and optimization services	SAP BI	Business Activity Monitoring