

CONSTRUCTION SUPPLY CHAIN INTEGRATION OVER THE INTERNET AND WEB TECHNOLOGY

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The construction industry operates through often extended lines of business partners with very diverse backgrounds and competencies. Since a construction supply chain spans over multiple companies, supply chain management highlights the importance of cross-enterprise integration. Therefore, coordination and collaboration among all links of a construction supply chain are essential for success of construction projects. But, construction supply chain integration requires a cost-effective information and communication platform that links multiple companies. The Internet and Web technology have emerged as the most cost-effective means for driving supply chain integration. E-business on the Internet is based on cutting edge software frameworks—a generic open, end-to-end infrastructure of interoperable software solutions that provide functions enabling business communicate efficiently over the Internet. These technologies will all have an increasingly profound influence on the company's business and supply chain processes because they reinforce competitiveness in the construction markets. This paper argues that Internet and web technology are the most effective means for achieving construction supply chain integration. It presents a study of various e-business applications and discusses the potential of e-business frameworks for construction supply chain optimization.

Keywords: e-business, e-procurement, internet, supplier, supply chain, website.

INTRODUCTION

The search for major improvements in the construction supply chains has received a great deal of attention from several authors (Allan *et al.*, 2000; Atkins. and Wild, 2000; Pillans and Langford, 2000). Millet *et al.* (2001) found that most clients use supply chain management in their procurement of goods and services for the organization's core business activities. Large gains in efficiency can be realized by addressing the issues surrounding the interfaces between organizations in the construction supply chains (Fernie *et al.*, 2000). Besides, it is crucial for the organizations within a supply chain to effectively coordinate activities and resources involved in their processes. This coordination of activities is the core of supply chain management.

The availability of new information and communication technologies is changing not only the way in which products and services may be transitioned, but also the way in which organizations and teams operate. The Internet infrastructure and Web represent an increasingly important worldwide channel for e-commerce and business-to-

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business transactions (Simon *et al.*, 2000). While information about construction products, vendors and tenders is becoming more accessible on the Internet through HTML-encoded documents, the potential of business-to-business, business-to-consumer, teams-to-teams and consumer-to-consumer in the construction supply chain is largely unrealized. E-business on the Internet is based on cutting edge software frameworks– a generic open, end-to-end infrastructure of interoperable software solutions that provide functions enabling business communicate efficiently over the Internet. These frameworks will all have an increasingly profound influence on the company's business and supply chain processes because they reinforce competitiveness in the construction markets.

This paper argues that Internet and web technology are the most effective means for achieving construction supply chain integration. It presents a study of various e-business applications and discusses the potential of e-business frameworks for construction supply chain optimization.

CONSTRUCTION SUPPLY CHAINS

A supply chain consists of series of individual activities or processes involved in the transformation of raw materials into a final product that is purchased by a client (Levary, 2000). A supply chain in construction can be considered as a process of series of activities transforming raw materials into finish products (e.g. roads or buildings) and services (e.g. design or budget) for use by a client irrespective of organization boundaries (Cox and Thompson, 1998). It includes all those activities associated with transforming goods from raw materials stage through to acceptance of the product or service by the client. Because of the project based nature of the construction industry and the fragmentation of the construction process, within the construction supply chain, there are many different organizations performing unique activities. For each organization in the supply chain, its client is the succeeding organization in the supply chain and its supplier is the preceding organization.

Unlike other industrial sectors, the construction industry consists of three distinct but interdependent supply chains, namely: building and assembly; professional services; and materials supply (Cox and Thompson, 1998). The building and assembly supply chain is a set of activities, which begins with a formal tender, running through the bidding process, award/contract onto building and assembly of a finished product on a construction site. The materials supply chain is a set of activities, which begins with formal receipt of a request for quotation, running through the award/contract onto delivery and fixing of materials on a construction site. The professional services supply chain is a set of activities, which begins with a formal tender or a request for proposal, running through the award/contract onto delivery of professional services for a client. The type of relationships organizations have with their clients and suppliers may vary from one project to another project. Relationships across the construction supply chains should extend beyond the exchange of goods or services to include design, distribution, marketing, sharing of information and specialist services.

The flow of physical products as well information about needs, requirements, specifications and orders in a typical building and assembly supply chain is shown in figure 1.

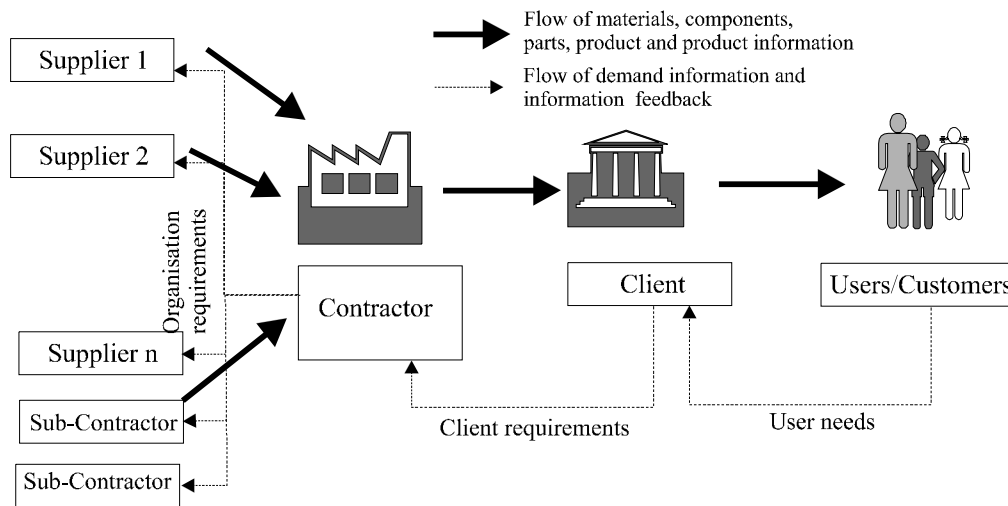


Figure 1: Flow of physical goods and information in a construction supply chain

An organization, supplier or service provider of a specific project, product or service can belong simultaneously to several supply chains. Some organizations along supply chains establish long-term commitments and ties with suppliers and thus create mutual dependency. However, other organizations establish short-term commitments since they may not need one another in a long-term basis.

A number of authors identified that problems associated with the construction supply chains are related to the fragmentation of the construction process, lack of information integration and poor communication and coordination. Therefore, supply chain management has focused on closer interactions among parties involved in the flow of goods from supplies to the end user. However, much of the research to date has concentrated on improving relationships between clients and contractors, and in particular the formation of partnerships and alliances (Millet, *et al.*, 2001).

THE INTERNET AS A MEANS FOR SUPPLY CHAIN INTEGRATION

The construction industry has many more buying and selling organizations than other industries such as motor or pharmaceutical industries, where few companies dominate the market. Due to the wide spread of site locations, the industry is geographical dispersed. Therefore, a construction supply chain typically spans over multiple partners such as the client, contractors, house builders, designers, consultants, suppliers, installers and users. In order to optimize the entire supply chain system cross-enterprise coordination and special business relationship must be established among the organizations along the construction supply chain.

As part of engineering the business, organization planners capture business processes in models and implement them as enterprise applications. They changed their way of working by moving from a functional approach towards a business process approach. These applications include among enterprise resource planning (ERP), enterprise project planning (EPP), enterprise workflow (EW), enterprise quality management (EQM), and supply chain management (SCM). The trend has been to include more outside entities such clients, users, service providers and suppliers into the supply chain management. This means that evolving information and communication technologies such Internet applications ranging from portals to E-commerce/E-business

sites must easily integrate with existing enterprise applications over the Internet infrastructure. Coordination and collaboration among all links of a construction supply chains are essential for supply chain integration. To operate across business boundaries, enterprise process applications must follow a standard transaction exchange protocol. The protocol must be flexible, reliable, and scalable to provide efficient operation within entire supply chain. With a common framework in place, one protocol can handle all transactions in the supply chain. Consequently two different organizations in the supply chain can standardize their interfaces and extend them over an existing framework. Supply chain integration requires cost-effective information systems that links multiple organizations over a network. This can now be met by the Internet infrastructure, Internet applications and Internet intermediaries. The Internet infrastructure consists of the telecommunications companies, Internet service providers, Internet backbone carriers, access companies and end-user networking equipment – all of which are the electronic link that ties different construction supply chain partners- contractors, house builders, suppliers, installers, designer, consultants, clients and users. The Internet applications involve software products, protocols and frameworks that help facilitate Web transactions over the Internet infrastructures. They are the fundamental basis for e-business and other functionality on the Internet. The Internet intermediaries include Web content providers and market makers or market intermediaries.

The Internet has many more advantages than other electronic link – it is based on open standards and it grants universal access to a wide audience like construction supply partners (anytime, any place, anyone, almost). Also its cost is lower. But most of all, the key power of the Internet is a new system architecture consisting of hub and spokes (Lee and Wang, 2001). The overall network forms a hub-and-spoke system with the participants' internal information systems (i.e., ERP or other enterprise applications) being spokes (see figure 2). The information hub is a node in the network where multiple partners interact in pursuit of construction supply chain integration. The solution allows a single hub-and-spoke integration between an organizations' information systems, and those of its trading partners – instead of multiple connections necessary using traditional Electronic Data Interchange (EDI) solutions. Therefore, construction supply chain partners can interact and collaborate through the information hub following certain agreed-upon protocols, known as frameworks.

A central hub over the Internet infrastructure is more flexible, involves less connections and is more cost effective for the industry and companies.

E-BUSINESS APPLICATIONS

A number of different definitions of e-business or e-commerce are given or implicit in the literature. According to (Jones *et al.*, 2000) “ E-business is the carrying out of business activities that lead to an exchange of value, where the parties interact electronically, using network or telecommunications technologies”. The most popular e-business channel is the Internet infrastructure (Levary, 2000; Weaver *et al.* 2000; Glushko *et al.*, 1998).

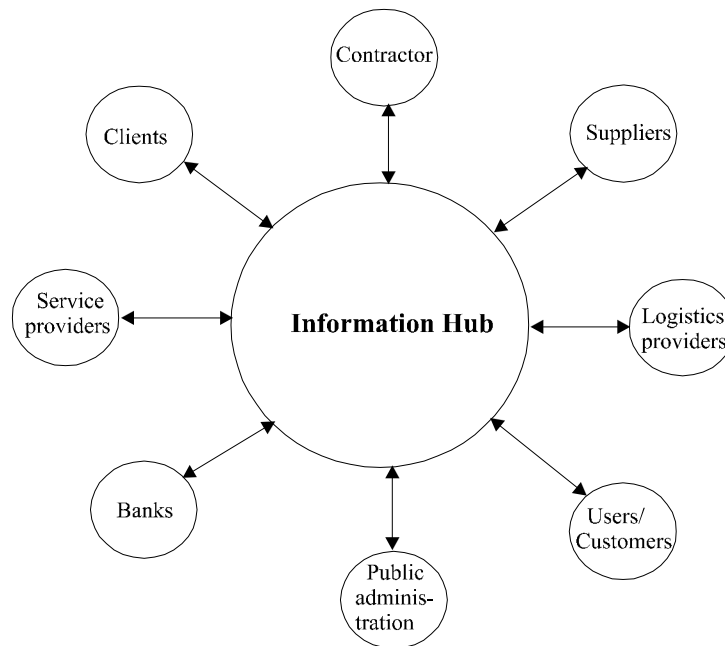


Figure 2: The Information Hub

In this paper, we use the term e-business in construction to describe the domain of interest that reflects the diversity of activities in the construction supply chains affected by recent developments in the use of network and communications technology such as Internet infrastructure and Web-based technologies. Taking an inclusive view and based on the definition given above and in line of view of Commerce Net, we therefore include in the e-business in the construction supply chain the exchange not only physical products and services, but also information and knowledge, such as plans, specifications, tender documents, etc.

E-business is becoming a primary means of trading in the European construction industry. This is demonstrated by the proliferation of portals, e-commerce and e-business sites in the construction industry such as eu-supply.com, b2build.com, buildpoint.com, econstroi.com, arried.com, buildonline.com. Thus, from the current literature (see, for example [Jones *et al.*, 2000; Simon *et al.* 2000; Weaver *et al.*, 2000]), we found a set of types of e-business currently of interest or being used in the construction supply chains:

- Business-to-Business (B2B): includes electronic trading, electronic tendering, online bidding, online surplus auctions, procurement planning, online request for quotations, online cataloguing, electronic exchange of information, online project management, virtual enterprises, electronic banking.
- Business-to-Consumer (B2C): includes online retailing, online consulting, online real state, online servicing, online training.
- Intra-organizational: includes enterprise workflow, co-operative design over the network, managing and sharing documents and drawings, online meetings.
- Consumer-to-Consumer: includes online actions, online services.

The distinction between B2B and B2C is not always easy to make and many e-business companies in the construction industry play in both arenas such as eu-supply.com; B2builb.com and BuildOnline.com. Clearly, some companies provide only B2B solutions, as in the case of BuildPoint.com (which provides specialized

bidding and procurement services over the Internet). Others, such as econstroi.com are clearly in the consumer market. According to the Organization for Economic Cooperation and Development (OECD) 80% of e-business value is in business-to-business transactions (OECD, 1999). Figure 3 shows some of the e-business types that support the construction supply chain integration over the Internet infrastructure.

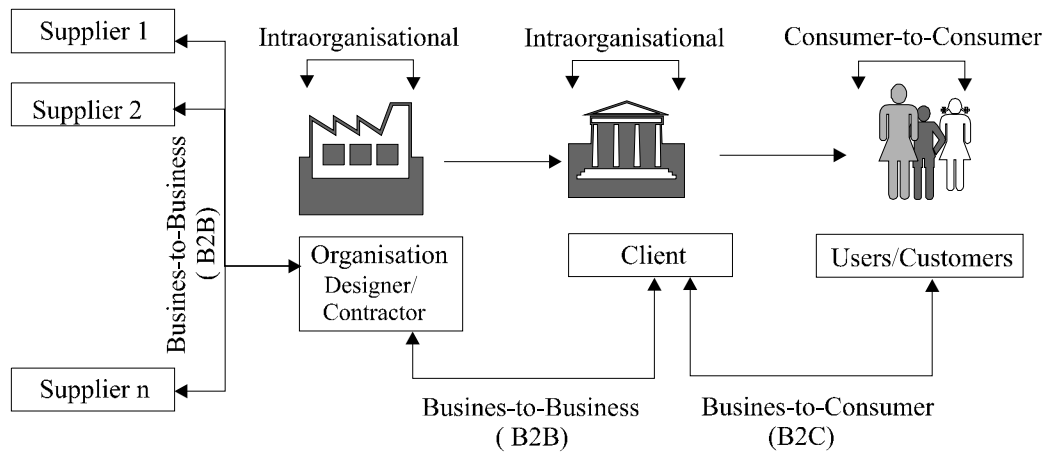


Figure 3: Types of e-business in the construction supply chain system

From the above classification of e-business and the various stages of the construction delivery process we may synthesize a very coarse description of e-business in the construction supply chains as shown in table 1.

Table 1: Common e-business processes in the construction supply chains

Process	Description
e-procurement	Procuring direct or indirect projects, parts, components, materials, plant, services, experts and manpower, as well as handling value added services. Disseminating and gathering information about projects, components, services, or plant
e-Commerce	Transactions across the space between the buyer and seller in the supply chain involving, projects, parts, components, materials, or plant
e-Logistics	Delivering parts, components, materials, plant, information, energy to the point where they are needed
e-Collaboration	Facilitates coordination of various decisions and activities beyond transactions among supply chain partners. Collaboration among teams in a virtual space such as collaborative design, planning and project management. Information across business partners such as orders, invoices or plans and specifications. Product change management.
Customer self-service	Online services such technical assistance, training, or guides, available for users and customers
Auctions	Auctions of assets, parts and components

e-Procurement

A typical construction company needs to procure a variety of products and services from different suppliers and subcontractors. The B2B helps to manage the complexity of the procurement process. Numerous companies including buildonline.com, eu-supply.com, b2build.com, buildpoint, econstroi.com, mercosurdigital.com, citadon.com offer web-based, enterprise procurement solutions and services for the construction industry. The solutions include: tendering services, procurement

planning, suppliers search and bidding online. These solutions enable their client companies to reduce operational costs and increase efficiency by automating the entire services supply chain.

e-Commerce

e-commerce over the Internet infrastructure provide online marketplaces where contractors, house builders, suppliers and installers can do business together and efficiently. It is a Web-based service which enables supply chain partners to communicate, negotiate and take part in trading, no matter how geographical far apart they are. Examples of e-commerce providers in the construction industry include b2build.com, buildpoint.com, buildonline.com, eu-supply.com. Some of these companies provide an online market place for delivering the benefits of e-commerce to construction supply chain partners

e-Logistic

The Internet infrastructure provides a natural setting to link supply chain partners to delivery a product or service in tight coordination whenever is needed.

e-Collaboration

e-Collaboration in the construction industry exists in a variety of functions, such as information sharing, collaborative decision making, and product management. For example, citadon.com offers Internet solutions that facilitate rapid communication and collaboration throughout the entire project lifecycle, from financing and planning through engineering and design, procurement, construction, and facility management. They include collaborative project management, collaborative e-commerce and financial services. Buzzsaw.com provide e-collaboration solutions including project work spaces for design sand construction services. These project work spaces allow designers and construction professionals to store, share and manage project documents.

E-BUSINESS FRAMEWORKS

B2C was easier to achieve, given the simplicity of reaching the individual consumer. There are a number of Web applications that support B2C. However, B2B involves engineering the interactions of diverse complex enterprise applications, making interoperability to be a key issue (Simon *et al.* 2000). To achieve interoperability many, companies have formed consortia to develop software platforms. Thus, e-business on the Internet is based on cutting edge software frameworks– a generic open, end-to-end infrastructure of interoperable software solutions that provide functions enabling business communicate efficiently over the Internet- and ever more efficient Web technology that changes the way companies operate on a daily basis. These software platforms act as a information hub to achieve supply chain integration. Consequently, B2B frameworks bridge the gap between business operations across different enterprise applications in the supply chain system, as shown in figure 4.

Depending on who controls the information hub, Lee and Whang (2001) classify the B2B platforms into three models:

- e-Market, serving as a market place for multiple buyers and multiple suppliers on a Business-to-Business based operations
- e-Buyer, controlled by a single buyer for multiple suppliers; and

- e-Supplier, controlled by a single supplier for multiple buyers.

Alternatively, we can divide information hubs into:

- “Market centred” or many-to-many; and
- “Organization centred” or one-to-many

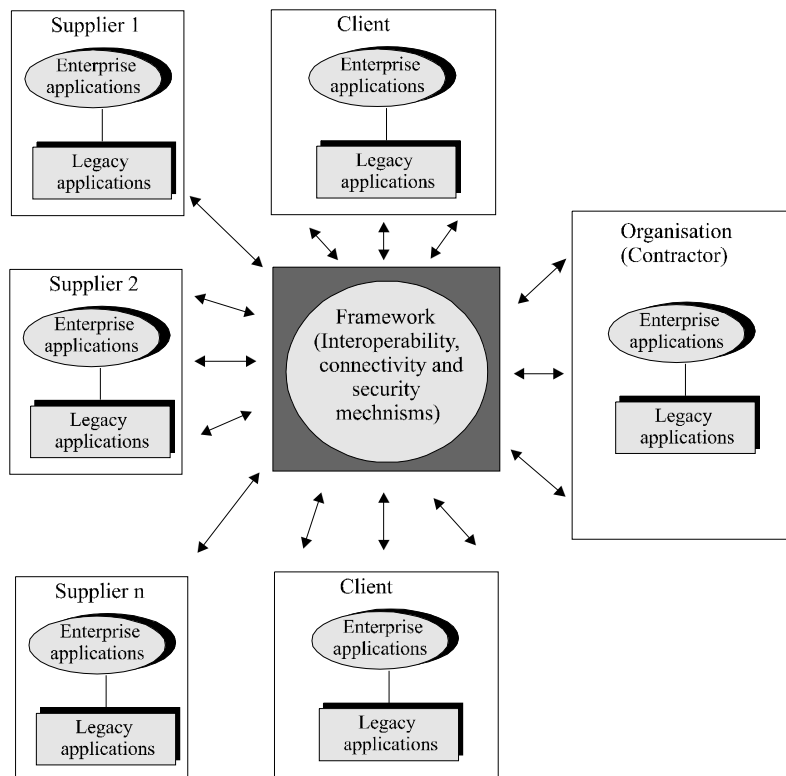


Figure 4: The role of the frameworks in the Business-to-Business operations

There are a number of different frameworks, which take different, approaches and offer various levels of functionality. Table 2 presents some of the most popular e-business frameworks. The information presented in this table comes from the framework providers. According to the documentation provided by the providers, the frameworks listed in table 2 differ significantly in approach and applicability. OBI, RosettaNet, Ariba, Commerce One and Bea WebLogic target particular industry segments. ECO and BizTalk are more generic frameworks. RosettaNet is dependent on the OBI framework. Ariba, Commerce One and WebLogic provide solutions to support Business-to-consumer and Consumer-to-Consumer transactions. Almost frameworks, however, provide specifications for important features such as security, message formats, communication protocols, scalability, and ontology.

CONCLUSIONS

Supply chains are rapidly becoming “business webs” in which business relationships are more focus on the customer satisfaction. E-business gives organizations in the construction supply chains improved efficiency and reliability of business processes through the combination automation and supply chain integration. An overview of the construction supply chain has been presented in this paper. The need for construction supply chain integration has been discussed. Co-ordination and collaboration among

all links of a construction supply chains are essential for supply chain integration. This paper focus on areas where Internet applications can be applied in order to improve business processes in the construction supply chains. The Internet infrastructure provides an open and cost effective link. However, to operate across business boundaries, enterprise process applications must follow a standard transaction exchange protocol. The protocol must be flexible, reliable, and scalable to provide efficient operation within entire supply chain. With a common framework in place, one protocol can handle all transactions in the supply chain.

Table 2: E-Business frameworks

Platform	Industry target	Communi-cation protocol	Security	Feature			
				Message format	Scalability	Ontology	Appli-cations
Ariba B2B Commerce	Buyers, suppliers, market makers, commerce, and service providers	HTTP,URL form encoding	Autenti-Cation in message header	XML documents	Scalable, based on XML DTDs	Collection of XML tags	Ariba Buyer, Ariba Market place, Ariba Dynamic Trade, Ariba Commerce Enterprise Buyer,
Commerce One	Buyers, suppliers, market makers, commerce	HTTP	Unspecified	XML documents	Scalable	XML Commn Business Library	Not specified
ECO Framework	Market makers	HTTP	Optional	XML documents	Sufficient	Common business Library	Not specified
RosettaNet	Buyers, suppliers, IT and semi-conductor manu-facturing	HTTP/CGI	SSL with HTTP; digital certificates and signatures	XML documents	Allows extension of implemen-tation guidelines	Technical and business dictionaries	RosettaNet Business, RosettaNet Technical Dictio-naires, RosettaNet Implemen-tation Framework
BizTalk	Media, advertising	HTTP/MS MQ	Leverages existing Standards	XML,XSL documents	Centralized repositories and processing may limit	Library of XML schemas	BizTalk framework, BizTalk server 2000, BizTalk toolkit
OBI	Suppliers	HTTP	SSL with HTTP;certi cates and signatures	Encapsu-lated EDI documents	One-to-One does not impact scalability	EDI X12 data dictionaries	
Bea Weblogic	Suppliers, service providers	HTTP	Not specified	XML documents, EDI messages	Scalable	Not specified	WebLogic Tuxedo, WebLogic Server

DTD: Document Type Definition; XSL: Extensible Stylesheet Language; EDI: Electronic Data Interchange; SSL: Secure socket layer; XML: Extensible Markup Language

This paper presents an overview of the most recent Internet solutions and applications in place in the construction industry – all of which aiming at construction supply chain integration. A review and of most update e-business framework for enabling business to communicate efficiently over the Internet has been presented in this paper. This paper compares the e-business frameworks based on the important features for achieving improved efficiency and reliability of business processes.

Within the limits of this study, we show how to take full advantage of the Internet and Web technologies for improving business processes in the construction supply chain. Their adoption is taking place, and if they are used in structured manner great benefits can be expected from them.

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