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Supplier Affiliated Extended Supply Chain Backbones

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Abstract. **E-commerce has progressed from the preliminary stages of brochure-ware to on-line transaction management, and is entering a phase where great opportunities exist in extended supply-chain over the Internet. Currently, much of the focus is on business-to-business e-commerce, where middleman hubs perform broker functions of search and comparison. Their value is derived from providing time and cost savings to participants. As XML semantics and other information sharing technologies become more standardized, and as behavioral aspects of Internet commerce become better established, we would expect the searching and comparison mechanics to become priced at their marginal costs. Business-to-business hubs, or interorganizational systems that do not add value in another way to the chain will find very little margins. In this paper, we examine issues related to Internet extended supply chain backbones from the supplier's viewpoint and discuss the information architecture of a third party software backbone and how it can provide value-added services to suppliers and OEMs via internetworking standards.**

Key Words. **e-commerce, business-to-business hubs, interorganizational systems, extended supply chain, application service provider**

Introduction

''The middleman is dead. Long live the middleman.'' [3]. Business-to-business (B2B) e-commerce is expected to be a trillion dollar business by 2003 according to Forester Research [4], dwarfing by tenfold the estimated transaction dollar total for business-to-consumer (B2C) transactions [10]. B2C e-commerce promises to make significant changes in consumer purchasing behavior and is frequently considered consumer-affiliated. Such an affiliation brings the threat of commodity economics for many retailer's products, as they become represented on a hub solely by price. Furthering a retailer's dilemma, demographic and individual purchasing profile information, considered the ultimate jewel of e-commerce, is now being accumulated and marketed by a third party. Adding to the retailer's quandary is the knowledge that their suppliers have a more direct route to consumers, perhaps able to bypass them entirely. Certainly, there will be winners and losers in this environment, but the customer affiliation of the B2C hubs should provide many positive advantages for consumers.

We focus on the economic advantages of B2B e-commerce or IOSs (see Barratt [1] or Johnston [7]), and in particular extended supply chain settings. We examine the benefits of an extended supply chain backbone and discuss issues related to supplier and OEM concerns. It can be argued that previous attempts at supply chain management software and EDI have failed because of their OEM orientation, rather than their supplier orientation. Frequently, such failures are due to the relative differences in information technology skill sets of the various members of the chain.

Generally, supply-chain systems are conceptualized from the view of a single OEM. The OEM interacts directly with the customer and initiates product and information flows and thus tends to have more influence on the standards used along the chain. Visually, this creates a graph image with one source—the OEM itself (see Fig. 1). The OEM sets standards for quality, price, and information flows such as EDI. Suppliers who serve only one OEM have the advantage and convenience of needing to implement only one set of communication standards, but have the disadvantage and discomfort of reliance on a single OEM for their existence.

The orientation of the supplier is somewhat

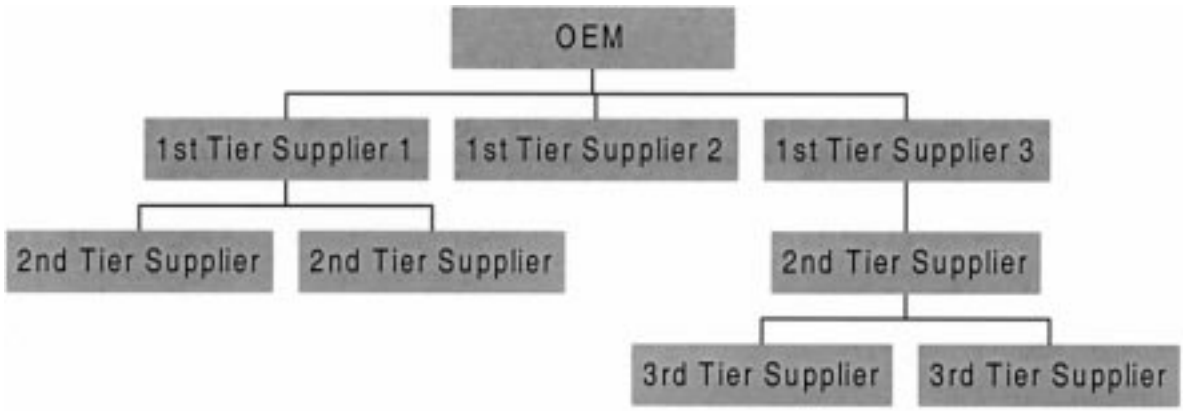

Fig. 1. *View from the OEM.*

different, as the supplier may interface with more than one OEM as well as more than one second tier supplier. Their view is one of a graph with multiple sources (see Fig. 2). As we would expect, different OEMs adhere to different standards, have different manufacturing paradigms, and have different objectives, so difficulties arise when optimization across two graphs with common nodes is attempted from different sources.

We examine the issues in extended supply chain from the viewpoint of the supplier. This is the orientation encouraged by the Automotive Network Exchange (http://www.anxo.com/) in their development of their next generation supply chain software. We also present the results of a survey performed by the University of Northern Iowa of suppliers and OEMs with regard to their future supply chain endeavors.

JIT and QRM

Historically, supply chains have developed for many reasons, generally as an attempt to reduce costs by introducing competition. In many manufacturing industries, the rise of just-in-time manufacturing in the 1980s led to outsourcing of many unskilled and

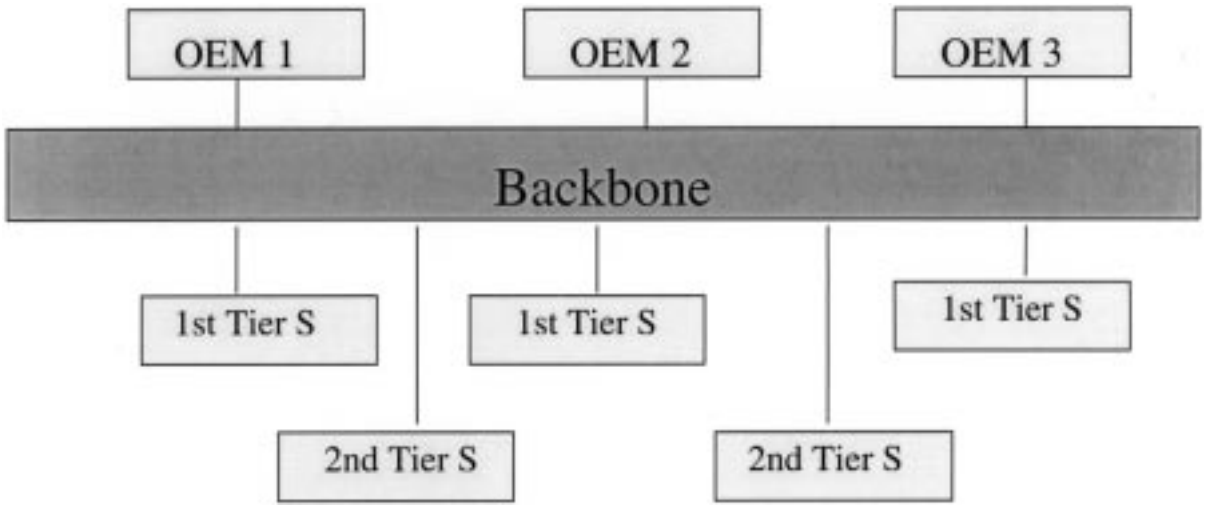

Fig. 2. *Supply chain backbone.*

subassembly jobs. At the time, no software existed to track orders, share process information, or coordinate scheduling, so the primary effect of the change was to introduce competition along the non-core aspects of the value chain and many believe to avoid paying union wages for those tasks. As supply chain and EDI software became more accessible, the value of this forfeited information became more apparent.

One of the undesirable side effects of JIT for suppliers was the shifting of inventory from the OEMs to those suppliers. ''Inventory is merely the physical correlate of deficient information,'' [2] and deficient information was abundant and thus expensive. EDI was designed to automate some of the processes in a supply chain and thus regain some of this information, but the skill set of the suppliers made this process very difficult. This was especially true if the supplier had relationships with more than one OEM, and each OEM had different EDI requirements.

As process re-engineering became more common and better understood, companies realized that their customer-oriented business processes extended beyond their enterprise resource planning (ERP) boundaries, and that there was not enough information available to make that extended process efficient. JIT and quick response manufacturing (QRM) are manufacturing paradigms that recognize this difficulty and encourage the OEM to develop very close ties with a minimal number of suppliers. With fewer suppliers, each relationship could be richer leading to an easier exchange of information. QRM [12] takes this a step further, encouraging OEMs to treat suppliers as internal divisions and encouraging suppliers to ''open their books'' to the OEM [5]. Naturally, this depth of relationship would fit well with some suppliers and not well with others. From the OEM's viewpoint, tight integration of software and scheduling made possible great reductions in manufacturing lead times, leading the OEM possibly into new markets based on its new level of responsiveness. From the supplier's viewpoint, they were possibly losing their information asymmetry advantage, and likely exposing profit margins or other sensitive information. This was in exchange for a seemingly more permanent site along the chain.

QRM in particular requires suppliers to rethink their measures of efficiency and change their employee reward structures from being based on traditional cost-based metrics to being based on lead-time reduction. This single-minded focus on reducing lead times requires entire supply chain members to coordinate information exchange well beyond what EDI was designed to provide. It frequently requires suppliers to abandon their manufacturing requirements planning (MRP) software investment in favor of supply chain oriented software.

Outsourcing and Application Service Providing

Information technology (IT) costs have always been a significant problem for suppliers, as their core-manufacturing competency is generally unrelated to information systems. IT costs are forecast and included in a balance sheet upon contract bids and the forecast amount itself is rarely an issue. The more import issue is the accuracy of the estimate. Suppliers express concern as to the variance of this figure from year to year and frustration at their inability to understand and predict IT costs. This frustration has contributed to a new form of outsourcing called application service providers (ASPs). ASPs provide access to software on a fixed or per usage cost basis. MRP and ERP service providers, including Oracle and SAP, are among the larger companies trying to satisfy this market desire to fix these costs. Many smaller ASP companies exist, providing outsourcing in areas from procurement, billing, insurance, and general accounting. Manufacturing systems [9] describes some companies who are currently providing limited supply chain outsourcing.

In their book, *Blown to Bits*, [2] the authors talk about the separation of the economics of things and the economics of information. The economics of things, tangible material and people, are well known. For a discussion of the economics of information, see Shapiro and Varian [11]. Historically, the two economies have been awkwardly bundled, resulting in concessions by one of the competing forces. The unbundling of the two fundamentally different economies creates vast opportunities for efficiency gains and economies of scale. ASPs manifest this unbundling. In general, they are generally designed to substitute for an internal business process rather than exist in service to a supply chain. The business model is solid and we should expect to see such businesses grow and prosper over the next several years.

Survey Results: Current Problems with Information Exchange Systems

A recent survey commissioned by DCI industries (Waterloo, Iowa) and carried out by the Market Development Program at the University of Northern Iowa (http://www.uni.edu/mdp/mdp.html) confirms the existence of the problems commonly associated with current systems and lends insight into the visions of many of the 1st tier suppliers surveyed. We present some of the summary findings below. The survey consisted of twenty OEMs and eighteen suppliers in manufacturing of automobile, construction, and agricultural machinery.

The Internet is the future. All OEMs and suppliers recognized that the Internet is the medium on which future EDI and supply chain communications will transact. Several suppliers commented that they are delaying EDI software purchases in the hope that less expensive and easier to use Internet applications become available. There appears to be some reluctance on the supplier's behalf to buying resource planning (RP) software as a web-based service, but many of the suppliers felt their concerns could be addressed. Security and lack of control were among the most sited issues.

OEMs do not believe that suppliers use EDI to its full potential. Generally EDI is recommended by the OEMs but not required. Most suppliers felt that within five years, all OEMs would require some form of EDI or e-commerce solution for all transactions. Many suppliers felt they had not done adequate research into the EDI or RP product they purchased. Most felt that EDI software was not very user-friendly. Their recommendation to other suppliers was to ignore the cost if possible and buy the most flexible and easiest to use product.

OEMs believe suppliers need to be sold on how RP and EDI systems will gain them favor with current or potential OEMs. Suppliers saw little to no potential effect on their business from impending ERP implementations by the OEMs, such as SAP R/3 systems. Interestingly, none mentioned any potential benefits of such implementations either. One observation was common, though in varying degrees of respondent intensity. The main failure and frustration of EDI is the difficulty of suppliers to implement and maintain the necessary software. This was particularly true of small suppliers, who in many cases didn't have access to or budget for IT professionals, nor did they have the volume to justify such systems (in their opinions).

The survey also presented many shortcomings of some standard RP packaged software, including poor documentation and difficulty of installation and use. There were no complaints about any vendor support otherwise. Regarding product quality, concerns included no support for parts with multiple owners and other complex consignment issues, an inability to track work-in-process, that software did not integrate easily with other systems, and that there was limited support for multiple sites.

Design Issues for an Internet-based Supplier Affiliated Supply Chain Backbone

Internetworking technologies enable new and interesting business concepts that could help coordinate information and scheduling between all-tier suppliers and OEMs, share expensive IT resources of labor and software, and provide extranet views for customer orders all the way down to raw materials. We present a framework for a supplier affiliated supply chain (SC) backbone that combines the benefits of ASPs (for scheduling services) with those of B2B hubs (information exchange) and discuss some of the technological obstacles that must be addressed (see Fig. 3). Fingar et al. [3] present a framework for extended supply chain (ESC) applications. We begin with a description of that framework and modify it to accommodate issues primarily related to supplier affiliation.

Fingar identifies four basic business processes which ESC applications must support: inter-supply chain collaboration, small to medium enterprise (SME) collaboration, supplier collaboration, and customer interaction. We look at each of the above individually.

Large OEMs, via acquisition or independent development, likely have multiple supply chain systems operating, and would require inter-supply chain collaboration. Any new system would have to interoperate not only with legacy or ERP systems, but also integrate with existing SC systems. From the ASP viewpoint, any application would also have to eventually integrate with an OEM's various ERP

systems. Fortunately, well-known standards such as remote function calls (RFC), distributed object interfaces, and more recently XML standards are used by the ERP vendors such as SAP and Oracle in anticipation of connecting to external systems. The backbone application would need to support these protocols and be capable of interacting with other backbones.

Even with the standards listed above, there are tactical implementation issues to be worked out. For example, XML is a powerful technology for exchanging self-describing information, but if the supplier doesn't have the ability to support EDI, it is unlikely they will be able to support XML either. As a more recently developed technology, it is unlikely that any legacy RP software would natively support it, implying the need to upgrade to a new product version minimally.

Fingar recognizes the potential within the category of small to mid-size enterprises for value-added services in attempting to optimize across a supply chain, the emphasis being on logistics. There are other opportunities here as well. An application should provide ASP services of MRP, manufacturing resource planning (MRP II), or other advanced scheduling mechanisms in addition to simple EDI types of information transfer. Fingar notes the general lack of computing skills found with many small suppliers and offers this as a solution to both the implementation and maintenance of such a system. As an ASP, the system would be operated and modified remotely, leaving the supplier to focus on their core competencies.

Fingar observes that a supplier may participate in multiple supply chains, and that supplier collaboration can have dramatic effects. We maintain that there are more opportunities for collaboration than merely along a product chain. With a properly designed ASP, different suppliers would be allowed to coordinate along some chains and compete along others. IBM and Dell have such a relationship, partners in some product chains and competitors in other product chains. Competitors and partners would be also be able to coordinate shipping schedules and share resources in geographically related areas.

The ultimate goal of both the OEM and the supplier is the satisfaction of the customer, though the actual party who satisfies them has become less certain. Currently the OEM is the primary beneficiary of the customer relationship. Internet technologies allow suppliers to directly and easily interact with customers, though developing customer relationships might not currently be their strength. Suppliers who use an ASP to share supply chain information would have significant infrastructure in place to deliver directly to customers, such as dealers or repair facilities. The ASP should provide this level of support.

Software Issues

To implement ESC application in software, Fingar presents six core application drivers: Information boundaries, searching and information filtering, workflow/process management, trading services, event notification, and data/process integration. Information boundaries may be the most interesting issue from the supplier's viewpoint. The application database could be holding a supplier's scheduling and pricing information, as well as similar information about that supplier's direct competitor. Complications arise in the backbone architecture due to hosting competitor information. Every item of work in process would need an owner, and the owner would be able to give or withhold permission for viewing that information to any other potential user. Such profile and permission management must be simple to use (drag-n-drop) and simultaneously airtight. This would have to be designed initially into the application and be intrinsic to the central database. Every database query would have to condition upon ownership and permission. It is our belief that existing applications would require a significant rewrite to accomplish this level of security.

ESC software would need to append any report-generating tool, such as an SQL statement builder, to restrict access to proprietary information as well. While this in practice might only amount to appending a ''where clause'' onto every SQL statement, the tool must be safe from overriding or other hacking interventions. Thus, some form of authentication must accompany every request to verify the permission set of the user. Encryption and security in protocols can add significant time overhead to a transaction. Some effort should be put into understanding the implications of particular algorithms and protocols as they relate to execution time and corresponding security level. The other core

application drivers are common to most e-commerce applications and will not be discussed further here.

In addition to these core drivers, we extend the framework by including the following. As a third party, and as a party privy to critical business data of competing firms, there needs to be a solid understanding of information systems auditing and a built-in mechanism to produce the required documentation see Greenstein [6]. Transaction verification and event notification would need to be modified to document direct changes to the database that previously would have been done via EDI. If both companies' information were hosted locally, there would be no value in a VAN, but that information would still need to be accessible to the supplier's accounting staff.

As a third party ASP hosting business critical information, significant effort would have to go into backup and recovery mechanisms. With traditional VANs, transactions were logged and available to be used in the event that the information would be needed later to settle disputes. It would behoove the designer to mimic this sort of transaction process, even to the point of creating a virtual VAN internal to the system. This would insure proper logging and recovery could be accomplished using well-understood principles. It would also be a tool to support legacy EDI systems. See Kumar and Hsu [8] for a description of recovery mechanisms.

Ideally, applications would be shared and centralized, but report information and layout would be specific to a particular company. A mechanism for creating customized reports and storing them for later retrieval would need to be incorporated. There are many such tools currently available, but the source code would need to be modified to restrict accessible information based on permission sets. Though important, this degree of modification would not be technical challenging.

The application should be designed to allow for outsourcing of hardware and/or bandwidth. For example, companies exist which allow for the outsourcing of bandwidth (Exodus) and others provide server farms (IBM) as service providers of bandwidth as well as operating system and database backup services. Such services provide the ability for immediate hardware and bandwidth scalability and, depending on the skills of the ASP, offer the option of outsourcing operating system maintenance to perhaps more skilled specialists.

A final consideration in this architecture is standards. Many standards such as XML, the English keyboard, or IP itself are not particularly remarkable as stand alone technologies but their strength is in the network externalities created by the standardization of the technology. Currently, capable web developers are short in supply, making technology standardization choices essential. Developers must be aware of issues related to Internet proxy servers, different browser interpretations and possibly different Java Virtual Machine implementations. Increases in bandwidth should allow for more flexibility in client interfacing technologies, enabling richer human to computer interaction as intelligent executable content can be downloaded more quickly.

Overall Benefits to Supplier-Affiliated Chains

This combination of ASP and B2B over the Internet would lead to many benefits to suppliers and OEMs including the following. Suppliers can outsource MRP software management and focus entirely on their core competencies. Using an ASP, suppliers can firmly establish IT costs and not be concerned about cost variance or poor cost estimates, as they now would be under a fixed cost contract with a third party. This stable pricing aspect benefits OEMs as well.

Suppliers in remote locations can have modifications made to their applications remotely, rather than pay for a technician to physically travel to their location. The programmer making those changes could be remote to the application server as well. This saves the supplier the direct cost of consultant travel and the indirect cost of the associated unproductive time.

Suppliers can provide OEMs sensitive information regarding scheduling or even allow direct manipulation of their MRP without compromising asymmetric information advantages. Thus, it would satisfy the strategic integration needs of JIT and QRM without the negative side effect of exposing sensitive financial information, which is frequently revealed as a side effect in QRM.

Suppliers would not need to continuously monitor for operating system security problems, nor would they have to understand database issues of backup and restoration. They would only be responsible for having a browser and an Internet connection. These

technologies come installed in most PCs today, and the associated costs are well known and competitive.

All improvements to scheduling algorithms and optimization routines would be immediately available to all subscribing parties. All bug fixes would also be centralized and require no client side patch installation. No client side installation should ever be necessary.

The costs of Internet-based EDI are essentially zero. Traditional EDI can be performed by a central core of IT professionals, relieving smaller suppliers of the responsibility of building and maintaining such systems. OEMs can request a formatting change for a document to one location rather than to many locations. The supplier in most cases would not need to be alerted of such formatting modifications. OEMs requiring interfacing of ERP systems to suppliers would be dealing with IT professionals and thus people more technologically proficient, as well as people genuinely interested in making that aspect of business efficient.

Final customers or dealers should be able to query the backbone to determine extranet information such as projected delivery time for a particular replacement part. This access should be universally available, given proper user permission, via a web browser from anywhere in the world at any time.

During development of this system, several drawbacks were noted. First, internetworking technology development environments have improved significantly over the past few years, but client/server debugging is still awkward at best. Documentation is frequently incomplete as well. Improvements in thread management and database connectivity tools would be welcomed. The legal maneuvers and market direction concerning Java technologies have made people tentative to adapt pure Java solutions, and led some companies such as SAP to implement their Internet solutions using very thin clients, which provide a much less rich interface. Other standards are still emerging or being finalized, including very important security and encryption protocols.

Firewalls and other security mechanisms provide companies with essential protection, but frequently make client/server programming very difficult. Furthermore, such protection varies at each possible client site, and thus no unique centralized solution may exist that would enable ubiquitous access. Larger OEMs tend to be more protective as they tend to have more to lose.

Developers with e-commerce experience as well as domain knowledge of supply chain and discrete manufacturing issues are not easy to find in many locations, neither are they easy to retain. Fortunately, the distributed nature of the application makes distributed collaboration easier, though hardly trivial.

Conclusions

''Every business is an information business.'' [2] The concept of ESC applications delivered securely over the Internet has great potential, though complications and security issues make it non-trivial to implement. Standards for data interchange such as XML combined with current industry initiatives such as the RosettaNet project (www.RosettaNet.org), Biztalk (www.Biztalk.com), and the ANX project are establishing the document exchange framework for future ESC systems. XML alone is natural evolutionary step, likely to benefit OEMs substantially, though unlikely to address the concerns of suppliers unable to manage EDI software. The inevitable changeover from VANs to Internet as the medium for document interchange will likely be a slow and trying endeavor.

Combined with the benefits of ASPs, ESC applications have potential for providing profound gains in material inventory and information efficiencies in complicated supply networks. Much research currently goes into optimizing supply chains from the OEM viewpoint and thus customer's viewpoint. However, if different supply chains contain the same node, there may not be an optimal solution for both OEMs simultaneously. As the supplier is frequently the key to success regarding JIT or QRM implementations, more effort needs to be put into technologies that address supplier concerns.

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