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Intelligent product agents: The key to implementing collaboration process networks?

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Abstract

The promise of process integration between organizations too often remains unfulfilled. To make rapid progress new approaches are needed. Distributed control is a new and exciting opportunity to build more effective process networks for a wide range of applications in logistics and product development. A solution based on distributed control around the consumers of services in process networks is proposed. In logistics it is the physical delivery that becomes the focus for distributed control when you approach the service environment from the service consumer perspective. In collaborative design and manufacturing it is the product model that becomes the focus of control. A service consumer perspective provides key guidelines that help manufacturers and service providers identify the design of process networks that most efficiently add value in different industries and for different applications.

Introduction: From trading process to collaboration process network

The Internet is an enabler to create trading process networks. A list of recent examples [1] includes the alliance between the three big auto manufacturers (General Motors, DaimlerChrysler, and Ford) to establish Covisint (an electronic market for automotive parts suppliers), the launch of RetailLink by Wal-Mart, and the Transfer Process Network by General Electric. In addition, in fragmented industries, a host of third-party-operated electronic markets are emerging. The Economist [2] found more than 750 in existence at the beginning of the year 2000. Examples include e-STEEL for the steel industry, IMX for home mortgage, and Paper Exchange for the paper industry.

The concept of a trading process network can be extended to cover more complex activities and closer collaboration, such as supply chain management and product development. This advanced process network may be defined as a collaboration process network.

The importance of collaboration is especially pronounced in supply chain management and product development. Kranton and Minehart [3] demonstrate how in the supply chain, increasing the number of inter-firm links in the collaboration network has a positive effect on efficiency in situations where individual firms face large idiosyncratic shocks and capacity is expensive. In product development Ahuja [4] presents results from a longitudinal study of firms in the international chemicals industry that indicate how increasing the number of inter-firm links in the collaboration network has a positive effect on innovation.

Not all firms take equally advantage of the opportunity to organize and link processes with other firms. Businesses can be placed in different stages of development, depending on how important the collaboration process network is seen. The stages can for example be defined as by Zurawski [5]: internal information integration, supply chain integration, and customer centric collaboration. The customer-centric collaboration requires a well-developed collaboration process network. Less than one percent are there now, and according to Gartner's current analysis just 15 percent will be by 2004. Customer centric collaboration networks require: "rapid creation and disbanding of supply-chain partnerships as needed to optimize a specific customer order, which will benefit all partners. This requires that pervasive information is available to all, invisible to the consumer, and shared for mutual benefit of the transaction's present set of optimal partners. Partners for one transaction could be competitors for the next."

The challenge in a situation where the required network constantly changes is: "How do you create a collaboration process network including many companies without central planning?"

For example, forecasting, distribution and inventory management across a network of many linked companies is possible using Enterprise Resource Planning systems or Supply Chain Planning and Control systems. However, the requirement is a common IT solution between the participating companies, or a common middle-ware solution, which pretty much amounts to the same thing. Similarly, the challenge in collaborative product development process today is keeping the different participating parties up to date without the need for one common product data management system.

The situation in the example areas - logistics and product development - can be described as a paradox. Creating collaboration process networks that can produce the same range of services as the integrated product development process or integrated supply chain appears difficult - maybe even impossible - without central planning and control. For example Christopher [6] regards central coordination as indispensable in supply chain management. At the same time practice indicates according to Euwe and Wortmann [7] that it is difficult - or maybe even impossible - to get a large network consisting of independent companies to agree on and implement a centralized planning and control solution.

How get collaboration process networks to work?

How is a collaboration process network created? The predominating approach is that links between companies and organizations create the process networks. However, creating a well functioning process network by linking companies is difficult and this is often the main obstacle to implementing more collaborative solutions. The following examples illustrate how organizing a process network around collaborating companies is difficult and how it leads to many practical problems.

An illustrative example is given by Hoover et al [8]. The example is from logistics. A detergent supplier and a diaper supplier in Germany decided to share distribution capacity to grocery outlets. The companies found that they could not do it without a major change effort. Consolidation of loads was not possible until they had harmonized their customer master files. This took several man-months.

The example illustrates how in a logistics network where the collaboration process is organized around companies, it is difficult to consolidate deliveries from different suppliers to the same destination. Consolidation is difficult because each supplier has a distinct relation to the customer and identifies the destination in his own way (and each company has its own customer master files).

However, there were more problems ahead for the detergent and diaper supplier. Providing the needed consolidation with a cost efficient and flexible merge-in-transit service was not possible. Instead the companies had to set up a joint distribution warehouse for consolidating the orders and picking the items to be shipped.

As the example shows, organizing process networks around the firms often leads to difficult problems in information sharing. The scope of collaboration and consolidation is limited if collaboration requires that suppliers have joint warehouse operations and inventory management. The problem is that today setting up collaboration process networks for merge-in-transit services are expensive because the flow of control information is not directly linked to the delivery, but is transferred by separate electronic messages between the supplier and logistics service provider. This process is in effect so complex that it is easier to set up a common warehouse and a common inventory management process, than to integrate the different parties as a supply network in real-time.

Another illustration of the complexity involved in designing real-time logistics networks is the high cost involved in building track and trace systems. Relying on messaging makes track and trace systems outside the database-horizon of an integrated supply chain system very expensive. The reason for this is that each company that is not part of the integrated supply chain needs to update a copy of the tracking database. Each movement needs to be communicated to each participating company to implement a track and trace system that spans the network in real-time. Each new party in the network increases cost and complexity. For example, adding one more transport company to the network in figure 1 creates six new links.

Creating an information hub with a consolidated database only solves the problem temporarily. As soon as a supplier needs to do business with a customer linked to another information hub we encounter the same problem of duplication, but on a higher level.

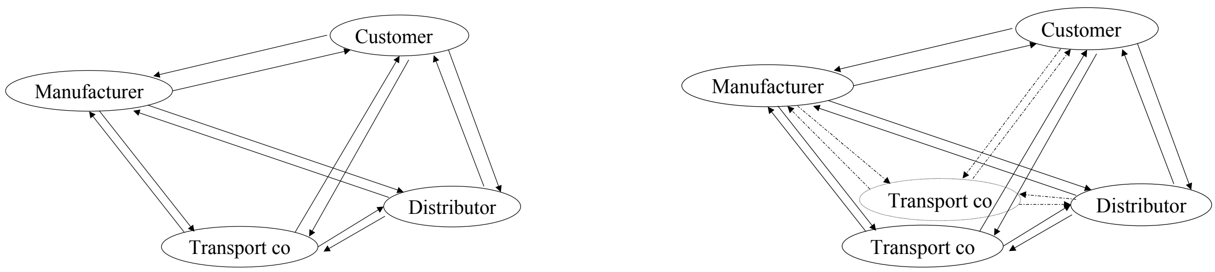

Figure 1: Adding a new carrier adds 6 links

The problems of creating process networks around participating companies are not issues only for logistics services. Miller [9] points out that organizing around participating companies also cause problems in product development. Process networks in product development are typically organized around product owner companies. These companies share sets of product, component and sub-assembly data for supplier companies on a case-by-case basis. Suppliers on their side generate a product model for their internal use, and when required provides a sub-set of the data model for external use. In practice the view to product data and the product model is very limited and also unreliable from the point of view of the networked supplier companies. Manual work is required to coordinate information delivery and data updates between partner companies.

However, there is no reason why process networks have to be organized around companies. Many of the problems encountered could be avoided by creating a network of services for the consumers of services. In the case of the logistics networks the organization can be based on the consumer of the logistics services, which is the delivery unit, not the company. In the case of product development the process network can be organized around the product model.

The idea that a collaboration process network should *not* be organized around the firm was first popularized by Hagel [10]. Hagel shows how creating a new type of service provider, the infomediary that administers the consumer's personal data and profile, makes it possible to create a range of valuable new opportunities for both the consumer and the supplier of consumer services and products. For example, marketing efforts in a car rental company can be efficiently channeled to those consumers with plans to travel and that request proposals and more information through their infomediary.

Focusing the process network on the product, instead of the end customer is also possible. Brussel et al [11] describe how in holonic manufacturing the network of production and assembly services is created around the product. The product to be manufactured or assembled is represented by a software agent that is responsible for controlling value adding operations inside the manufacturing plants. Both computer manufacturers and car manufacturers use this approach on the factory floor to deal with customization efficiently.

Feature modeling technology [12] originally developed in late 80’s is an ideal tool to represent product model data. Instead of representing only mathematical geometry or technical drawings, this technology makes it possible to represent product features, manufacturing operations and attributes like color, surface finish and tolerances. In some of the prototype systems intelligent feature models offer data for automated process planning in manufacturing operations. Such networked operations potentially add value of a product **and** update the product model in real time.

The common theme here is distributed control, or bottom-up control. Instead of linking companies and controlling the whole complex network from the top-down, the idea is to distribute control to the moving parts of the network. Bonabeau and Meyer [13] call this "swarm intelligence".

Agents are implemented as software components that are able to communicate with each other. In practice, this means that they are objects capable of communication over a computer network using some communication protocol that all agents involved in the communication are able to understand. Object oriented and distributed programming is used for doing the actual agent implementations. Object oriented programming offers the concept of encapsulation [14], which signifies that only the object (agent) itself knows what information it contains and what functionality it has, giving access to other agents only through method interfaces. Distributed programming again offers real-time bi-directional communication over computer networks like the Internet [15], therefore allowing true negotiation and collaboration between software agents.

The practical problem is how to control value creation efficiently in multi-agent environments. Game theory and its application to evolutionary stable strategies for living organisms indicate that design of distributed systems are very sensitive to conflicting interests (see for example Maynard Smith's [16] work on evolutionary stable strategies). It is not simply a matter of distributing control, but also of finding common goals and simple procedures for enforcing adherence to the common goal. Collaborative process networks present similar challenges to understanding the phenomena well enough to define goals and procedures for individual agents in the process network. As pointed out by Littman [17], it is usually easier to define the goals of individual agents in an adversarial environment (as in two-player games) than in a coordination (or collaborative) environment. Multi-agent-based models in social science, as for example Castelfranchi [18], focuses on understanding these issues, related to phenomena observed in society. In economics there is extensive work on understanding the effect of collaboration from the firm perspective [3, 4].

However, work on how best design collaboration process networks on the operational level is lacking. Individual examples on organizing process networks around service providers and consumers can be found. There is also extensive research on technological solutions for distributed control [19]. What is missing is applied research that address the question of how to best organize collaborative process networks and how to select the common goal around which a distributed process network can be assembled. In this paper it is proposed that a more efficient organization can be found by focusing on service provision and consumption rather than on firms.

Note on methodology

The research question is how to best organize collaborative process networks. Since the process networks in existence today are still very simple from a service perspective, a constructive research approach is necessary. When there are no good examples available to study then examples need to be created. The principle is to design process networks that can provide more advanced services and test the design in industrial environments.

Two experimental process networks were created. The first for distribution logistics, and the second for product development and manufacturing. The systems development and research work was carried out in close collaboration between the research institute and industrial companies faced with the challenge of how to best organize process networks to better support their business.

Theory for business management and strategy in the new technological environment is created based on identifying the obstacles to advanced services in today's environment, and asking how these constraints are affected by re-organizing the process network around the consumer of services in the two experimental situations. Based on observations of the impact of the construction we can then proceed to improve designs and to formulate recommendations for business practice and further research. The result is practical guidelines for management on how to design a process network that could better provide advanced value-added services and with higher flexibility.

Collaborative process network for distribution logistics

To study process networks for improved distribution logistics we have developed a control system around intelligent shipments and demonstrated its functionality for tracking deliveries for international investment projects. This ongoing pilot implementation with distributed tracking of project deliveries can then be used to study the creation of advanced logistics services in a project delivery environment.

The distributed control solution is also to be tested in business to business electronic commerce of maintenance, repair and operations (MRO) products. The test is on merging diverse material flows in the logistics network without the need for inventory management. The goal is to consolidate shipments from several suppliers for one end-customer delivery, i.e. replace consolidation in a distribution warehouse with merge-in-transit distribution. Merge-in-transit can provide significant benefits in such situations, but implementations have this far been limited between a restricted number of large companies due to the difficulty of managing the information related to the shipments [20]. By working with the MRO distributor we hope to be able to show how the information infrastructure can be simplified by distributing control to individual shipments.

The tests have been implemented using a multi-agent application that has been named “Dialog” [21]. Dialog is an object-oriented platform implemented using the Java programming language. The main issues in designing the Dialog platform are the following:

- **Lightweight** concerning computing capacity, installation and maintenance.
- **Peer-to-peer** architecture that avoids the need for third-party infrastructure for communication and discovery between agents.
- **Scalability** is the most important issue, obtained as a result of the two previous issues.
- **Equality between parties** signifies that agents are able to communicate with each other no matter what computing hardware they are running on. The platform is used in the same way on a big mainframe, a PC or an embedded device.

All these design issues are essential for a system, where every physical object can have its own associated software agent. Furthermore, this agent has to be able to discuss directly with entities of any size, ranging from multi-national companies to agents of other physical objects.

These same design issues have been implemented and tested both for tracking of project deliveries (shipment agents) and business-to-business exchange of sales forecasts (company agents). What is common to both of these implementations is that there are only one or two different kinds of simple agents. Their power comes from the ease of installing them in great number, where each agent can perform its own limited function of the complex system that it belongs to.

An important obstacle to creating a process network capable of providing advanced value added services by linking companies is that each company is reluctant to change their own systems to create a link. One way around this fundamental obstacle is to centralize control, but this solution makes it difficult to extend the network beyond a small core group of key suppliers and customers [7].

An alternative approach is to distribute control between collaborating companies. For a logistics network this would entail centralizing the control to the shipments that move between the companies in the logistics network. The principle is to design the process network around the common goal of delivering the product.

The first practical hurdle is cleared when we have correctly identified the product to be delivered as the consumer of logistics services in the process network. The consumer of logistics services in the process network is the individual package or dispatch unit that is transported, warehoused and handled, and not the company that has ordered the product or the transportation.

Leveraging the control capability of control agents for shipments is fundamental to successful design of distributed control in the process network. The agent becomes the consumer around which the different companies can configure a service environment providing a range of services from track and trace to life-cycle maintenance and asset management.

Product centric control

How do you organize the process network around intelligent consumer agents in practice in the process network for logistics services? A solution that is easy to implement is to link a control agent to the individual package or dispatch unit based on the identity of the product or shipment. It is essential that individual products and shipments have an identity of their own. This identity can be linked to an address in the Internet that contains an agent processing and storing the information needed for the delivery. The identity can be a simple manually readable code, but in most situations automatic identification methods, such as bar codes or radio frequency identification tags, work better [22].

If a decentralized approach is used for the control system, rolling-out and scaling up can be very quick. When you organize around the consumer agent you don't need a standard reference location or a universal name server, or even a standard process. It is enough that everyone agrees to take instructions from the shipment or product, and that the agent has incorporated the sufficient instructions for the service provider to perform the required tasks.

To illustrate the effect of reorganizing around the agent - the intelligent consumer of services - consider the effect on scalability in the process network when it is reorganized around the individual package or dispatch unit.

When the logistics network is organized around participating companies a large number of links is needed for each new party that is included. This is represented by the two dimensional network in figure 2.

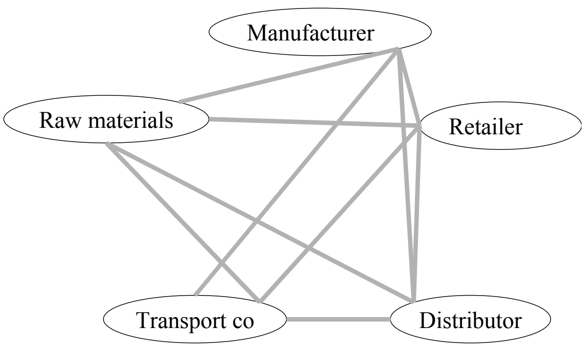

Figure 2: Company centric process network

Introducing an intelligent agent for the delivery in effect introduces a new dimension in the control space. Service providers can be linked to each other as before, but service providers can also be linked to the delivery.

The different types of links creates three dimensions for control:

- Material flow linking companies in a chain for handling and moving the shipments. Instructions can be passed to successors in the chain, but feedback to predecessors is not possible.
- Information flow linking any number of companies point-to-point. Instructions can be passed between any companies that have defined when and how to collaborate.
- Intelligent material flow linking shipments to service providers. Instructions can be passed to successors in the chain and feedback information can be passed to any company that is linked to the shipment's control agent. The shipment's control agent becomes the control hub both for logistics execution and network links.

Service providers can be linked to each other as before, but a more efficient route is through the delivery. Figure 3 illustrates the advantage of a control agent for each shipment in organizing the logistics network. For each shipment we can organize the logistics service network around the shipment. This corresponds to viewing the whole system from the perspective of the consumer of logistics services, which is the individual shipments and their control agents.

Making the shipment an active party in the logistics network opens up the possibility for eliminating many of the links between the service providers. Does the retailer need an advanced shipping note to receive the goods, or can the information be provided in electronic format by the shipment upon arrival? Does the transport company need a copy of the shipping documents in electronic format, or is it sufficient that it has access to the shipping documents through the shipment identity? These are just a few examples to illustrate the point. The list of links and messages between organizations that can be replaced by links between the product flow and the service providers can quickly be extended by many more.

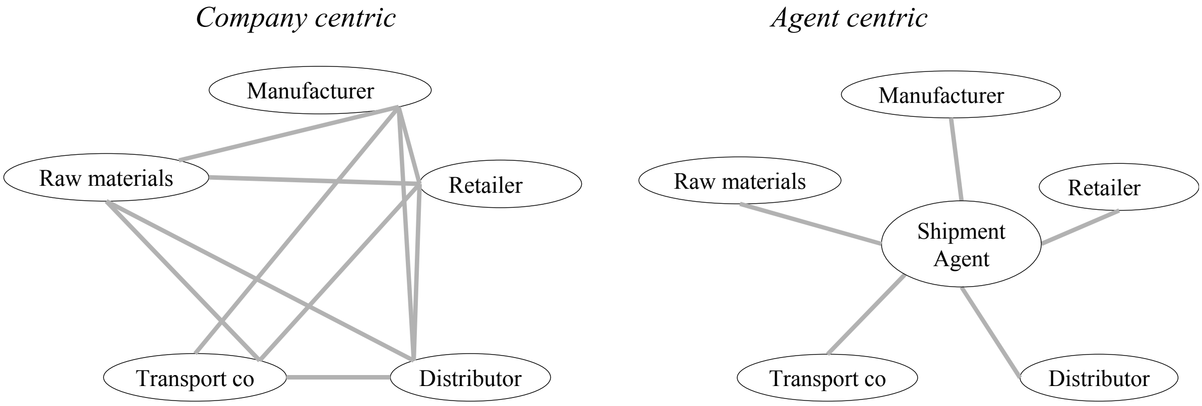

Figure 3: The impact of adding the shipment agent to the logistics network: Seeing the logistics network from a company centric and product flow centric perspectives. Adding the control agent for the shipment makes it possible to focus the service provision and reduce the number of necessary links.

Removing redundant links between organizations, and replacing these with links to an intelligent product flow makes the shipment agents into the infomediaries of the logistics network. This simplifies the addition of new service providers, and even new types of service providers to the network (Figure 4).

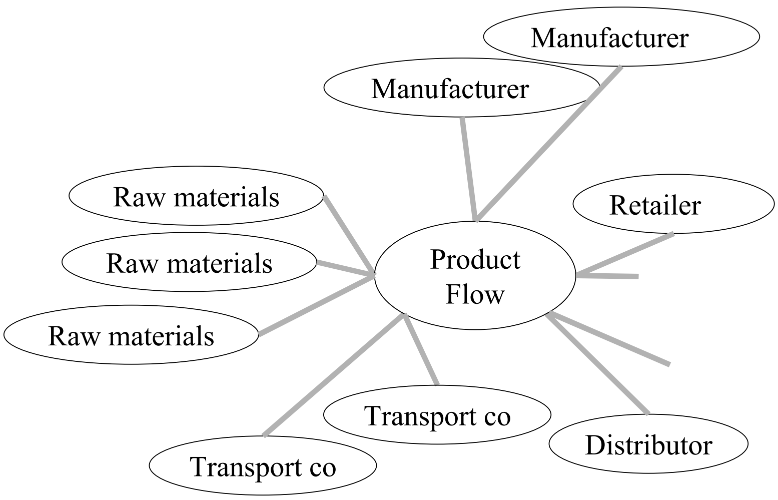

Figure 4: Centering the logistics service network on the individual delivery makes direct connections for transactions between the companies redundant and simplifies the addition of new service providers into the network.

Business benefits

The efficiency benefits for participating companies are substantial from creating a process network that actually can be implemented in practice without extensive systems integration efforts.

For logistics, quick benefits can be derived from a merge-in-transit solution that is easy to implement and extend to new companies. The benefits depend on the type of product and supplier capabilities.

An example where we have detailed analysis is the supply of maintenance, repair and operations (MRO) supplies. In MRO supplies a B2B e-marketplace that has customers demanding one-drop delivery for orders with many different items, the re-organization of control reduces or eliminates the need for warehousing. The merge-in-transit service reduces the need for keeping product in distribution warehouses for all items where suppliers can promise delivery within the lead-time for delivery to the customer. Consolidation is achieved in the logistics network as a new value added service by, for example, a transport company or a local distribution service provider.

The situation for a Finnish MRO wholesaler illustrates the development drivers towards merge-in-transit operations. The company offers its customers around 2.500.000 products that are supplied by 500 individual suppliers. The number of stock keeping units is so vast, that the wholesaler could not possibly store all the products in its own warehouse. A large number of the products have therefore been delivered directly to the customer by their respective suppliers. The result has been that the customer receives several deliveries to have one order fulfilled. To improve its customer service by providing a single delivery for a single order, and to further reduce the units flowing through its warehouse, the wholesaler launched a project to employ merge-in-transit with selected suppliers.

The benefits of merge-in-transit compared to direct deliveries result from lower receiving costs for the customer and lower transportation costs in situations where the suppliers are shipping less than truckload amounts. The logistics costs in the MRO wholesaler case were assessed both for the former direct delivery model and for the planned merge-in-transit distribution model [23]. The cost savings resulting from moving to merge-in-transit were found to be approximately 13 percent for a typical order. In some cases the savings were up to 20 percent compared to the direct deliveries. The difference resulted mainly from savings in transportation.

The merge-in-transit distribution mode also helps to reduce warehousing costs, as the number of stock keeping units can be lowered in the wholesaler's warehouse. The cost savings result from reduced operational costs in the delivery chain as one handling and storing phase is left out. At the same time the transportation costs may also decrease with merge-in-transit, depending on the geographical locations of the suppliers and the availability of logistics service providers able to perform consolidation. Depending on product, the inventory holding costs may be of great importance. Especially for products with short lifetime or high price erosion, the removal of an intermediate warehouse results in major savings in inventory holding costs, thus making merge-in-transit a very attractive alternative.

Another example is from a network of suppliers delivering plant and process equipment to the building site of a new production facility. The benefit of merge-in-transit, or merge-at-destination for the project delivery chain is also substantial. This is because it is costly to keep inventory at the project site, as unnecessary investment in secure storage space are needed to store the deliveries. However, the need of project components is linked to the arrival of other components, and the need for keeping inventory at the product site can be rapidly decreased with a merging and call of services.

Implementation benefits

For implementation and operating process networks there are benefits from a distributed approach.

The development of information sharing practices with the suppliers and the logistics service providers has proven to be cumbersome with the traditional Electronic Data Interchange means. After seeing the first demonstration of the use of product centric control in merge-in-transit, the representatives of the wholesaler and the logistics service provider in the MRO case noted the following to be the most promising benefits of product centric control and the key enablers for extending their merge-in-transit operations:

- Removal of costs with EDI transactions,
- Facilitation of electronic communications, especially the opportunity for automated communications with smaller partner companies not capable of implementing an EDI-connection
- Availability of up-to-date information everywhere in the delivery chain

In the creation of a logistics network around the consumer of logistics services the individual delivery can be used as the access point to the control information. This is a cheaper alternative to creating EDI links to ensure that messages arrive in time and are not lost. Electronic access to the control information can for example be achieved using a bar-code or RFID on the delivery unit that links to the delivery specific control agent. The operating cost consists of the tag and the work needed for reading the tag. Using this approach more suppliers can be included to a lower cost. The cost of implementation is a reader that is linked to the Internet at supplier and at the logistics service provider's key nodes.

Open issues

The benefits are considerable from moving control to the shipment. Why then has logistics networks not already been built around intelligent shipments?

One significant reason has been a lack of standardization. For flexible amendment and updating of product related information, RFID identifiers and software are needed. Comprehensive technological standards for RFID do not exist, but there are numerous proposals for standards waiting to be ratified at the moment [24, 25]. However these proposals will not solve all the contradictions in the field. On the software side, Auto ID Center is developing standards for presenting and accessing information on the Internet [19], and distributed applications that circumvent the problems associated with standardization are also developed [21, 26].

Even with the standards issues resolved, the challenges to implementation are still significant. The most serious challenge for logistics networks is that service provision companies have invested in IT solutions that are built around company specific delivery and tracking databases. The distributed approach requires that company applications are modularized and can use the tracking and control information provided by the delivery unit's control agent. The issue is that company applications used also by logistics service providers are not at all built on the principle of using external data and application services. For the product centric tracking and tracing to work the design architecture of enterprise system needs to evolve.

Collaborative process network for product development and manufacturing

Now, let us consider product development and production engineering as a second example of organizing collaboration process networks around intelligent software agents. An important obstacle to creating a process network capable for collaborative product development and manufacturing by linking the participating companies is that each company is reluctant to change their own systems to create a link. One way around this fundamental obstacle is to centralize control, but this solution makes it difficult to extend the network beyond a small core group of key suppliers and customers. The alternative approach is to distribute control between collaborating companies. For product design and development this means that the process network should be focused on a single object oriented master product model, which would also serve as the primary link between companies in the design process network. The focus is in product functionality.

As in the example of providing logistics services, the creation of pilot solutions for industry has played a key role in the research on process networks for collaborative design and manufacturing. The focus area has been suppliers of standard components, e.g. castings and molds. A large number of different standard component suppliers compete mainly on price in this business sector. To address the issue of how to differentiate the value offering project was started together with a supplier of castings and molds. An application was built by the research team and piloted by the company. The focus was on supporting the collaborative design and manufacturing process between the customer and the component supplier. The application adds value by serving customers more efficiently in pre sales phases. This has been realized by offering high quality individualized product models around which the collaboration network can be built. The pilot implementation offers interactive design support over the Internet. The service includes downloadable original CAD files to be integrated to the product models of the customer. The service is free and aims at making it easy for the designer to choose components from the assortment of this particular supplier of standard components.

The principle in product centric networks is to design the process network around the common goal of product design. Feature modeling offers the basic technology for creating a collaborative process network for design and manufacturing. The product model itself is the consumer of design and manufacturing services. The model changes in completeness and requirements for more design operations according to which services have been provided. Collaborating companies can now use so called design automates for adding new product configurations. Instead of designing products the companies can concentrate on describing their operations as services that can be added to the product model, on the request of the product model. This way, in the product design process the network is linked through the common product model which after completing all engineering operations is a virtual model of the product. Manufacturing operations can then use the same principle. The product model is also the consumer around which manufacturing operations can be networked.

An example of how organizing around the product model can simplify the process network is from a Finnish supplier of kitchen furniture called Puustelli. The sales representative visits the customer in her home and using a standard product model as the basis, the representative creates a new individual model for the customer. This model is configured to fit the kitchen by changing standard dimension parameters, which in production are used to control the manufacturing and assembly. Cost accounting and delivery control can also be linked directly to the individual kitchen, as well as after sales contacts. The solution eliminates the need for the manufacturer to produce to finished goods stock based on uncertain forecasts, saving significantly in both logistics and obsolescence costs. At the same time the customer can cost efficiently be provided with a product exactly suited to his or her requirements.

How do you organize the process network around the product model in practice? In collaborative product design and manufacturing there is often a situation, in which a company can deliver different kinds of product configurations (for example coatings or color). If the product model is represented by an unique agent in the network, then the company providing coating services can concentrate on describing and implementing coating and painting services. The service provision could then be controlled by the product model agent. The agent dynamically controls both the coating option and resource.

If a decentralized approach is used for the control system, rolling-out and scaling up can be very quick. When you organize around the consumer agent you don’t need a standard reference location or a universal name server, or even a standard process. It is enough that everyone agrees to take instructions from the product model, and that the model's agent has incorporated the sufficient instructions for the service provider to perform the required tasks.

In product design, standards for the exchange of the product model data have been developed. In product development networks this has led to a situation in which all partners have their own version of a model. It is inefficient and costly to manage dynamic product development or even product changes and updates in such an environment.

Sharing the same product model data would keep the product model consistent and design automation would become more applicable. Making the product model's agent an active party in the process network opens up the possibility for eliminating many of the links between the service providers. Does each party need an update on a design change for their copy of the design, or can the notification be embedded in object links? The list of links and messages between organizations that can be replaced by links between the product model and the service providers can quickly be extended.

The benefits are considerable, why then have process networks not already been built around product model agents?

The product model centric approach requires that company applications are modularized and can use the product information provided by the model's control agent. In today's design process each partner typically concentrates on only it’s own part or functionality of a product delivery process. The companies also typically optimize the size of the model to be used and in the process valuable information for other parties in the process network is lost. It is also typically the product owner company that manages sharing of the tasks and the data. This can be done semi automatically without investments in the product modeling and design automation technologies that would be needed for a product model centric approach.

Manufacturing operations are also commonly described and scheduled using enterprise centric ERP systems, which in most cases prioritize financial data requirements. The integration between product design and ERP systems has been poor because ERP systems descriptions of the manufacturing operations typically don’t include any pointers to product model features.

Conclusions

The difference between developing an integrated network of companies and a process network of services is important to grasp. The flexibility and value creation potential of a open system such as the process network exceeds that of a centralized system by many orders of magnitude. Think of the distributed process network as a market economy and the centralized as a centrally planned economy. In a collaboration process network we potentially have a population of individual consumers, such as shipments that compete in terms of fulfillment cost and service. The OEM:s and shippers that can leverage the service opportunities most will benefit and increase market share which leads to more advanced requirements for logistics services. The service providers that can best accommodate the needs for advanced services also gain on the expense of competitors. This cycle of improvement can continue until there are no more opportunities to reduce costs and improve service. In contrast the integrated control model will forever struggle to provide even the most basic services, such as track and trace, efficiently across organizational boundaries.

However, the efficient provision of advanced value added services in large process networks require a major shift in how we see the network, and think about value creation. There are a number of key steps that need to be taken by different parties to create functioning collaboration process network in the supply chain.

- all parties need to agree on constructing the process network around the actual consumers of services - for example in logistics the shipment and delivery units, in product development the product model
- product manufacturers need to treat the agent for supply chain control and the product model as conventional product features that are developed as integral parts of the product and accessed and used by many different parties over the product life-cycle
- logistics service providers need to abandon the goal of acquiring a central controlling position in the network and instead develop the supply chain control and logistics control functions that manufacturers want to design into the products

The first step is to focus on the consumer of the service provided by the process network, i.e. the delivery unit in logistics, the product model in product design and manufacturing. Today the scope of process networks typically extends to the units of a single company and the group of closest business partners that are prepared to modify their processes and systems. The contrast is significant when the solution is based on control agents. The scope of a process network integrated through control agents extends its scope to the potentially larger group of companies prepared to identify product individuals and to follow control agent specifications in executing their services.

The second step is to develop better methodologies to create and manage the network processes. Change is needed in the product development of the manufacturer. Manufacturers of original equipment, consumer goods, and other industries that use a lot of logistics services need to rethink the relationship between product development and operations. The agent centric control of the process networks requires companies to literally see logistics control and after sales as an integral part of product development. Logistics control is equally integral to the product as the package that the product is enclosed in. A control portal or agent for the product can then also be used to support operations and maintenance, as well as after sales processes.

The implications for management practice in making and delivering the product are also huge for both manufacturing and logistics companies, and require decisive steps. A critical change for all service providers in a process network is to package the service they deliver in such a format that it can be incorporated as part of the product in the product development stage. The implications are significant. Instead of aiming for a controlling position, companies need to start thinking of supplying service components that can be install or delivered upon the request of software agents. There is, for example, a market opportunity for logistics service companies in offering OEM:s and consumer product manufacturers - in addition to logistics services - also the physical components and software agents for distributed supply chain control.

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