

A Virtual Electronic Call Center Solution for Mass Customization

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Abstract

Since mass customization becomes more and more important as a marketing strategy, companies have to produce highly specialized and individualized products. To satisfy these customer demands manufacturers, suppliers, and retailers build networks and connect their application systems. For this e-commerce techniques are a considerable asset to speed up the inter-company coordination process. In this paper an approach is discussed that supports distributed, but logically integrated business processes, wherein complex and hard to standardize data occur, by applying e-commerce techniques. By doing so, the inter-company data exchange, planning, and coordination of the production process in case of mass customization are improved.

1. Introduction

Mass customization becomes more and more important as a marketing strategy. This requires the companies pursuing mass customization to produce highly specialized and individualized products. To satisfy the demand for individualized products, manufacturers, suppliers, and retailers are forced to build networks, as customers expect a fast and flexible service. Electronic commerce (e-commerce), as abbreviation for any form of electronically conducted business transactions, is a means that supports companies to pursue mass customization. It enables companies to be more flexible and efficient while processing customer orders, and to be more responsive to the customers needs. It is a considerable asset to speed up the inter-company coordination process. Besides, it offers a better opportunity for niche marketing and customer interaction. By blurring and lowering the barriers between companies, manufacturers and suppliers can work together more closely. This simplifies electronic procurement and supports shared business processes, which are distributed over multiple companies. An extreme example of inter-company cooperation is the *virtual enterprise*, where

companies get temporarily networked to fulfill a given business. E-commerce even helps inter-company planning, which is necessary for an effective management of supply chains.

The approach presented in this paper aims at the improvement of business to business interactions in case of mass customization. Especially the automatic collaboration and coordination between (legacy) systems from manufacturers and suppliers, which are often incompatible, is addressed. By using e-commerce techniques, it is shown how the data exchange between manufacturers and their suppliers can be handled efficiently, and how a multi-plant planning and coordination can be done currently in order to achieve shorter response times for the customers.

The following chapter gives a brief introduction in the area of mass customization. Further, open problems and conditions for successfully pursuing mass customization are addressed, and it is shown, where and how e-commerce techniques can improve mass customization. On the basis of these results the approach to an improved business to business interaction is derived and explained thereafter.

2. Mass customization and e-commerce

2.1. Mass customization

Mass customization is a synthesis between mass production and the production of highly specialized and individualized products. It aims at the production of individual products with high quality at cost factors typical for mass production and comparable short delivery times ([1], p. 48). Originally, mass customization was discussed as a marketing concept, which, following the paradigm of customer orientation, automatically results from a constant market segmentation ([2], p. 13): Starting from a mass market, products for specific market segments are offered to satisfy the needs of special customer groups. A further differentiation of markets leads from micro markets and

niche markets to individual markets, which contain the single customer. Above all, small and medium manufacturers were forced so far to follow a strategy of differentiation, as the production of small series was predominant. The number of pieces was not high enough to become a cost leader. Hence, small and medium enterprises, willing to pursue mass customization, have to put their focus on a more efficient production process, being anyway customer oriented. On the other side, large manufacturers have to reach a higher flexibility and a higher degree of customer orientation.

Looking at empirical studies, five instances of mass customization can be classified (cp. table 1, [3]): service customization, self customization, the splitting of the production process, speed management and modularization.

Application systems, especially systems for *production planning and control* (PPC), are important means for a cost-oriented mass customization. However, today's PPC-systems are more oriented on supporting mass production than single-item production. This leads to the problem, that conventional PPC-systems have to be adapted in order to support mass customization ([4], pp. 27-28).

Another problem arises as the planning of the production program can not occur – or only in a very restricted

manner. This stems from the fact that in case of mass customization the products are still unknown at the time when planning normally would occur. The customer determines the kind of the product during the phase of product configuration. Furthermore, the materials planning becomes more difficult, as the bills of materials and the schedules of job operations have normally to be generated ad hoc and individually for each customer order, and in general, the batch sizing can only be done on a very low inventory level. For the same reasons, the rough planning of time limits and capacities is more difficult - or may only be done for parts on a low inventory level. In addition, this complicates the arrangement of valid delivery dates, since it would be necessary to match the results of the rough planning with the demands of the customer order during the generation of offers.

On the part of the suppliers there is a similar problem in connection with the procurement of individualized parts: Basic for the success of mass customization is a strong relationship to the suppliers, who should guaranty a just in time delivery. This supplier network may be used for an automatic synchronization of demands. The negotiations, as part of the synchronization process, require that processing times are estimated first in order to calculate delivery dates.

Table 1: Instances of mass customization

Service customization	Service customization allows customers to add specific services to the product, e. g. technical after-sales services or consulting.
Self customization	The customer himself individualizes the product. For this reason the product has a build in flexibility, e. g. by customizing the software that belongs to the product, or by using build in switches that allow a country specific adjustment.
Splitting of the production process	The production is split into two pieces: a customer neutral, standardized part, and a part, where individualized products are manufactured. The customer is integrated in the individualized part of the production process, e. g. at the customer specific production of utility vehicles.
Speed management	The customer service is improved by shorter delivery times, a higher readiness to deliver, and a better faithfulness to deadlines.
Modularization	Customer specific products are combined using a small number of standardized parts (modules), e. g. personal computers or automobiles.

All problems mentioned so far appear already during the generation of offers. For this reason the early phases of offer generation and negotiation are focussed in order to improve application systems for mass customization.

2.2. E-commerce and mass customization – benefits of integrating both approaches

E-commerce may be defined as “any form of business transaction in which the parties interact electronically rather than by physical exchanges or direct physical contact” ([5], p. 2). The scope of e-commerce reaches from the simple *world wide web* (WWW) presence to shared business processes connecting different companies. E-commerce can be divided into four categories:

- business to business e-commerce,
- business to consumer e-commerce,
- business to administration e-commerce, and
- consumer to administration e-commerce.

From these categories, business to business e-

commerce, which covers all transactions between companies, has been well established. Referring to mass customization, this concerns all transactions between retailers, manufacturers, and suppliers. The business to consumer e-commerce expands with the advance of the WWW. It offers opportunities in the area of tool supported configuration of individual products. Business to administration e-commerce and consumer to administration e-commerce have not yet emerged broadly.

The technology with the highest potential to enable electronic business to business interactions is *electronic data interchange* (EDI) [6]. It standardizes the electronic exchange of structured information, e. g. orders, between companies, thus permitting a direct communication between business application systems. Even though, EDI is reputed to be too complicated, too expensive, and too hard to integrate into existing business applications (cp. e. g. [5], p. 16). Besides, just interconnecting companies pursuing mass customization via the Internet or other electronic media is not enough, since the production of

Table 2: Internal and external conditions for successfully pursuing mass customization

Internal conditions	External conditions
Capable of improvement through e-commerce	Capable of improvement through e-commerce
<ul style="list-style-type: none"> • Long-term investments in advanced manufacturing technologies - • Long-term investments in human resource development - • In-house engineering and manufacturing expertise - • Dividing factories into plants which are focussed on their manufacturing tasks - • Establishing organizational mechanisms to foster interactions among the focussed plants - • Installing a culture that focuses on knowledge creation and improving of manufacturing capabilities - • A marketing group that can interest customers in buying individualized products - 	<ul style="list-style-type: none"> • There is no well entrenched competitor already pursuing mass customization - • The market has to be characterized by an increased product proliferation - • Access to a supplier network in close proximity + • Developing an information network with a group of trained retailers +

highly individualized products has also to be planned and coordinated. Especially in the preliminary phases of information and negotiation complex and hard to standardize data has to be exchanged, converted and processed.

The main problem that a business to business e-commerce solution in case of mass customization should solve is to achieve an efficient, flexible, and responsive coordination between manufacturers and suppliers. This becomes clear by looking in detail on the success factors of mass customization.

Mass customization can be introduced more successful if specific internal and external conditions are fulfilled. Table 2 lists internal and external conditions (cp. [7], pp. 447-449) and depicts where the meeting of conditions may be improved through the use of e-commerce. First of all long-term investments in advanced manufacturing technologies are necessary. This encompasses in particular to invest in a sophisticated information technology. A special section will address this important aspect later on. However, a sophisticated technology is necessary, but not sufficient. The companies as well have to develop their human resources in order to achieve the flexibility and responsiveness that is critical to mass customization. The access to in-house engineering and manufacturing expertise and capabilities is necessary, because mass customization may entail enormous logistical and manufacturing problems. Firms that do mass customization as well as mass production should divide their factories into plants according to their manufacturing focus: mass production or mass customization. These identification of *focussed plants* avoids conflicting objectives (e. g. to minimize cost

and to increase flexibility) and makes it more easy to meet competitive priorities. The fundamental thesis behind this approach is that factories that are more focussed (that are divided into focussed plants) outperform those factories that try to fulfil a lot of competitive targets. To support the creation of new knowledge and to gain higher flexibility organizational mechanisms to foster interactions among the focussed plants should be installed, e. g. worker rotation or centralization of engineering personnel. Furthermore, a culture focussing on knowledge creation and improving of manufacturing capabilities is required as well as a marketing group that can interest customers in buying individualized products. Appropriate pricing and intensive communication with the customer, for instance, are means to create a customer demand for individualized products.

The external conditions for a successful mass customization refer to the market situation in general and to the relations to the suppliers. Being the first in implementing mass customization in a specific market can be important, because the market growth may be less than expected. Moreover, competitors may not be able to catch up on a learning curve advantage. In addition, the market has to be characterized by an increased product proliferation. Speed and costs are both critical success factors for pursuing mass customization. Building and maintaining a supplier network in close proximity allows to achieve the speed required to satisfy customer orders and to avoid the cost of carrying large inventories.

Besides, conditions concerning the use of specific information technology have to be met and appropriate tools

Table 3: Information technology related conditions for successfully pursuing mass customization

	Capable of improvement through e-commerce
• Configuration and ordering of customized products	+
• Customized engineering	-
• Linking to suppliers	+
• Real-time scheduling	-
• Multi-plant coordination	+
• Shop floor flexibility and coordination	-
• Demand-driven logistics	-

have to be available. Table 3 gives an overview on these conditions (according to [8], p. 35; [4], p. 26), and shows in which areas the use of e-commerce may lead to an improvement. First, customers need a way to describe what exactly they want to purchase. Among time limits and quantities this encompasses product characteristics as colors, performance or geometry. That information has to be translated into terms that can be understood by the production planning, the manufacturing, and the engineering. This task can be supported by configuration tools which are based on *electronic product catalogues*. Configuration tools display all available components and permitted changes of the characteristics of the product. Some are already applicable online (cp. e. g. [9]). If an order forces an engineering change, software for *product data management* (PDM) allows quick changes of the design data. PDM-systems may be integrated with systems for *enterprise resource planning* (ERP). As already stated above building and maintaining a supplier network is a critical success factor for pursuing mass customization. Internet based electronic yellow pages help to build a supplier network where manufactures and suppliers can locate one another. Using EDI makes the links between

manufactures and suppliers more responsive, because manual interfaces can be omitted. Another means to increase the responsiveness on the customer's side is to do real-time scheduling. Real-time scheduling allows to assure valid time limits to the customer. Paired with a *supply chain management* approach [10], even optimized manufacturing schedules may be calculated. Being dependent on its suppliers, a company doing mass customization should extend its supply chain management approach to a multi-plant coordination that especially comprises the capacity planning of its most important suppliers. This can be done by using an agent technology ([11], pp. 2-4) that allows automatic negotiations which are limited by basic agreements. Real-time scheduling is often combined with modular product design and small flexible assembly teams. *Manufacturing execution systems* coordinate these assembly teams in order to achieve a high shop floor flexibility. To shorten the production-to-ship time, special software is used that holds customer-specific profiles.

The following chapter discusses an approach to support mass customization by e-commerce techniques. On the basis of an example business process, it is shown where

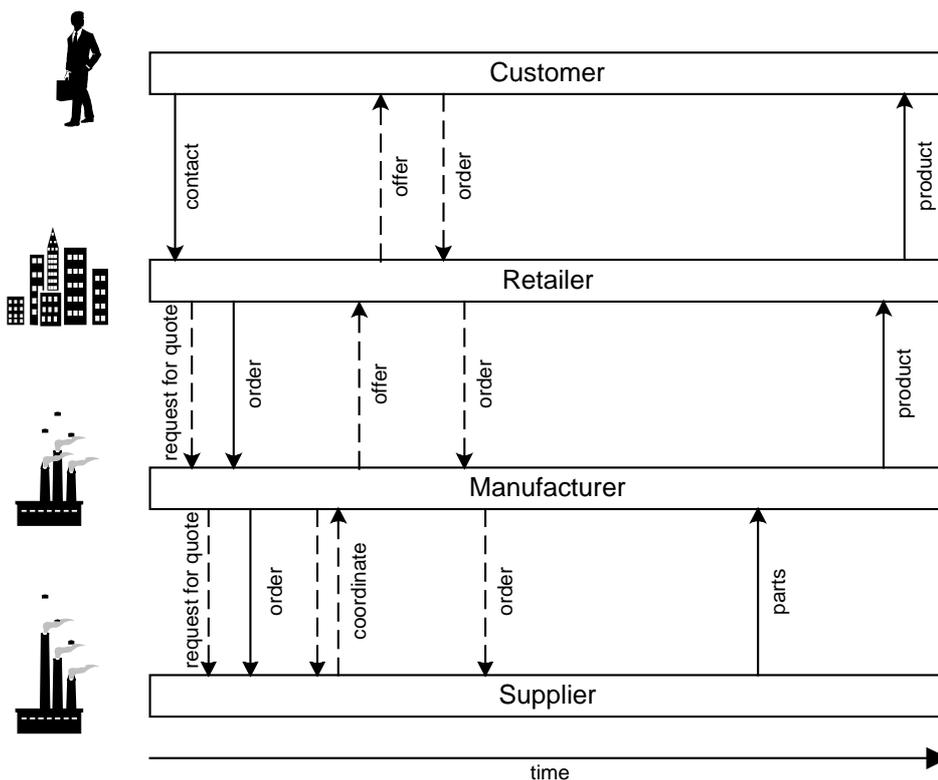


Figure 1: Exemplary interactions necessary for sale, production, and distribution of individualized products

3.2. Combining efficient data exchange with fast multi-plant planning and coordination

Looking at the information flow diagram in figure 2, it is conspicuous that there is no direct need for a retailer. In fact, the retailer may be omitted if not needed as an intermediary expert. The customer may use a WWW-based product catalogue or product configuration tool himself, maybe together with an expert system, which gives explanations and which helps in the case of problems. Since the emphasis is put on business to business interactions, it is assumed that the data describing the individualized product is somehow transferred into the PPC application of the manufacturer.

First it is shown, how the data exchange between manufacturer and supplier can be handled efficiently. This is done by using XML/EDI [12] instead of "pure" EDI. XML/EDI is based on the fusion of five technologies ([13], pp. 2-12): *extensible markup language* (XML), EDI, templates, agents, and repositories. The whole application is based on XML, which is an extension of the *hypertext markup language* (HTML). XML enlarges HTML by allowing the creation of custom tokens and custom document structures. Every XML document and each element of a XML document is an object with own properties. This features allow to express existing EDI mechanisms using the XML syntax, and further, new and

more flexible methods may thereby be created. To define custom tokens and custom document structures *document type definitions* (DTD) are used, which belong to XML. DTD serve as templates that explain the syntax and the content of a document that is based on a specific DTD. An example how DTD together with XML may be used to code an order form *and* to generate a corresponding *electronic data interchange for administration, commerce, and transport* (EDIFACT) message is given in [14].

The approach to take documents and elements of documents as objects with own properties, offers an efficient way to match data from within application systems to interchange formats, and vice versa. This task is performed by *software agents* that are coded in Java. Besides, the software agents coordinate the business process - especially in the early phase of order processing and offer generation - (cp. figure 2) and are a means to support the management of the supply chain, which will be discussed later.

One task of the agents is to transform documents in a format that is supported by the recipient. A repository provides the DTD which are needed for this task. The agents connect themselves to the repository in order to get the right DTD. As there are often many different suppliers using different application systems, the DTD may be company specific and are provided by the respective company. However, there may also exist standardized

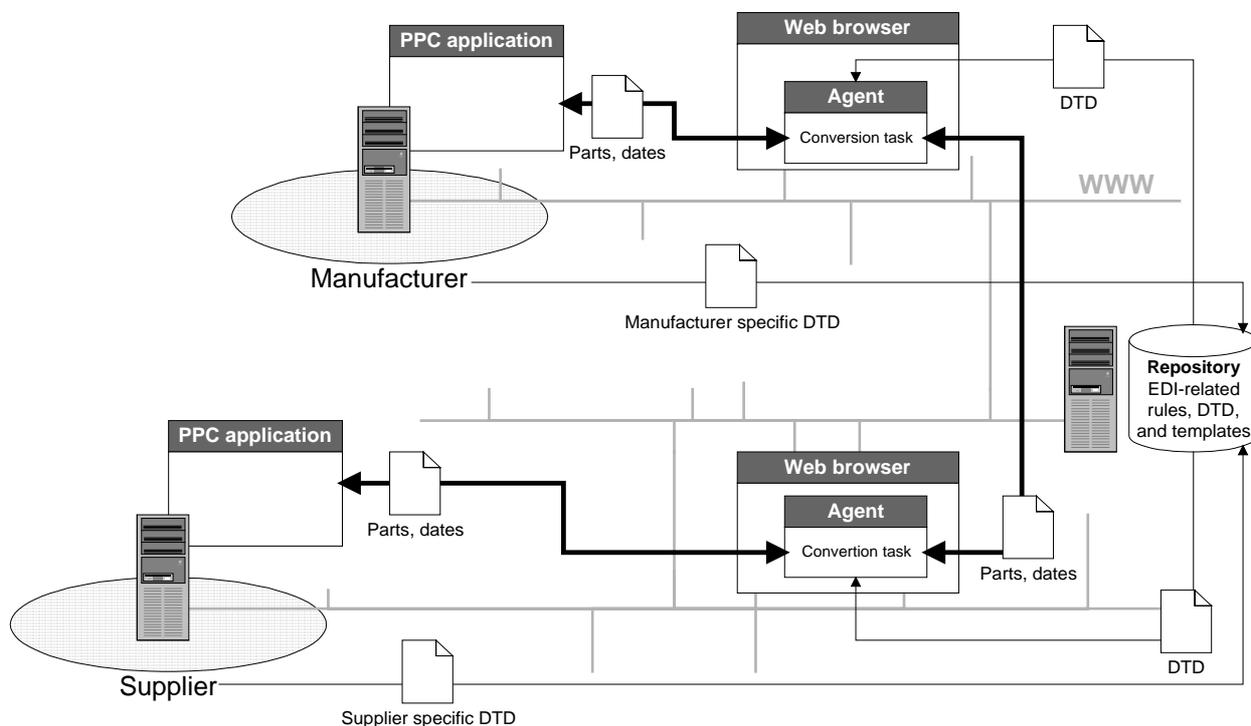


Figure 3: Agents using DTD from a repository to fulfill the conversion task

DTD which are used simultaneously by different companies, and that make it easier to use this technique for small companies. Since the elements of the documents that have to be exchanged are objects with own properties, software agents can cross-reference these objects between different formats by using the DTD, e. g. from legacy systems to a manufacturer specific DTD, or from a manufacturer specific DTD to a supplier specific DTD (cp. figure 3).

At this point, it becomes clear, that the product configuration tool may also use XML/EDI encoded documents, but has not to do so. Product catalogues and product configuration tools are highly specialized products, which are often designed to work together with a specific PPC-system, and it may not be short-term cost-effective to change these products.

The second part of the approach focuses on the use of software agents to coordinate the production of individualized products in the early phases of negotiation between manufacturer and suppliers. It will be shown how a multi-plant planning can be done currently in order to achieve short response times.

In addition to the software agents that convert the transferred information, *negotiation agents* are used to make the PPC-systems from manufacturer and suppliers negotiate with each other (figure 4).

Objects of the negotiation process are parts that have to be produced in order to assemble a customer individual

product. The negotiation agents do not need to know much about these objects. As depicted in figure 5 a negotiation agent only gets an identification and certain constraints, e. g. due dates or quantities. This information is created by the conversion agent based on the data that the conversion agents initially receive from the PPC-systems of the suppliers or from the PPC-system of the manufacturer. The corresponding negotiation agents produce offers or results as an output. (Accepted offers become results.) Offers are passed on to negotiation agents of other negotiating parties. The routing and the necessary conversion is done by the conversion agents. If the negotiation is completed, the results are passed on to the negotiating parties.

If the initially received constraints are violated, the functionality of the attached PPC-systems is used to evaluate the practicability of the offers or results generated by the corresponding negotiation agents. This is done by generating orders, which are temporarily scheduled by the PPC-systems. The due-dates and float times calculated by the PPC-systems are in the following passed on to the corresponding negotiation agent.

The described approach uses *multi-agent systems* to plan and coordinate production processes and is based on the *contract net* paradigm. (For an introduction to the related agent technology and its application in the area of PPC cp. e. g. [15].) In particular, a simple man-

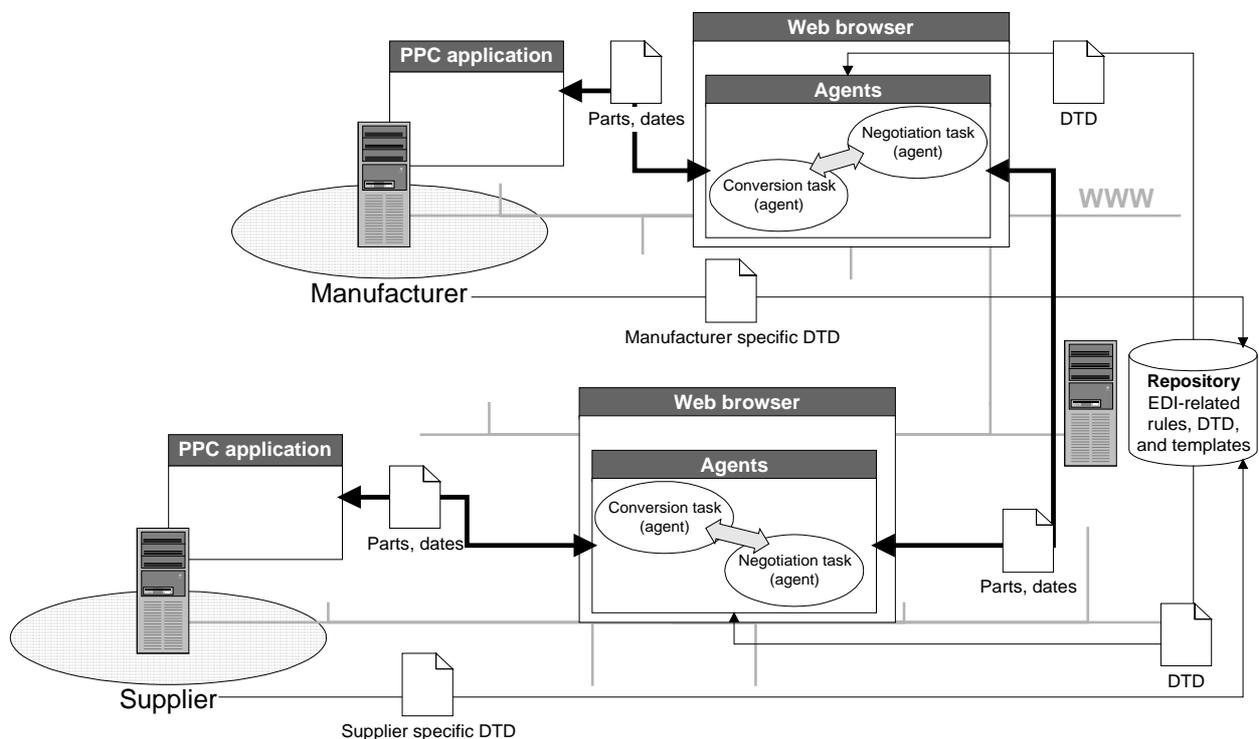


Figure 4: Negotiating agents facilitate multi-plant planning

ager/contractor architecture is employed. All participants in a manager/contractor architecture are represented by an agent. The agent that represents the manager asks for a specific output by sending messages directly to the contractor agents. The contractor agents respond by sending offers. Finally the manager agent informs each contractor agent whether he accepts his offer.

By applying the manager/contractor architecture to the negotiation task in case of mass customization, the negotiation agent of the manufacturer acts as a manager agent and the negotiation agents of the suppliers act as contractor agents. Precisely, conversion agents together with negotiation agents act as manager or contractor agents.

In general, manager or contractor agents are made of three parts: a knowledge base, a problem solving component, and a communication component. The problem solving component and the knowledge base are part of the negotiation agent. The communication component is part of the conversion agent. All these agents are implemented in Java and use a web browser as runtime environment. The number of negotiation and conversion agents is not limited. For each new negotiating party that joins the negotiation process a new set of agents is created.

To connect legacy (PPC-)systems to the web-based multi-agent system, an interface is needed. The programming of this interface may be simplified by using a *web interface definition language* (IDL) as proposed by [16]. However, there is no need to change the existing application system itself. By means of an appropriate DTD the data can be imported and exported easily.

With a view to the supplier side, the proposed approach may be compared with a call center. A *call center* is a combination of technologies to deal with customer

(phone) calls in an efficient and responsive way. In case of mass customization the supplier has to deal with the manufacturer's requests. The responsiveness needed is achieved through software agents which convert the incoming request and negotiate with the customer – both tasks are originally done by a call center. Since both tasks are done automatically by means of software agents, the call center is virtual.

4. Outlook and conclusion

E-commerce is a means of enabling organizational changes that support pursuing mass customization. It enables companies to be more flexible and efficient while processing customer orders, and to be more responsive to the customers needs. By blurring and lowering the barriers between companies, manufacturers and suppliers can work together more closely. This simplifies electronic procurement and supports shared business processes, which includes multiple companies.

The approach to use software agents together with XML/EDI for data exchange as well as for the coordination of manufacturers pursuing mass customization and their suppliers, leads to various advantages: It allows the exchange of data which is hard to standardize with an approach that is flexible and based on existing industry standards. The legacy systems do not have to be changed, as the task of converting data is encapsulated in a Java environment with an interface, that might easily be adapted to an existing application. By using the same interface and the same agent technology which is used for data interchange, the coordination of the production process can occur. This leads to an automatic multi-plant plan-

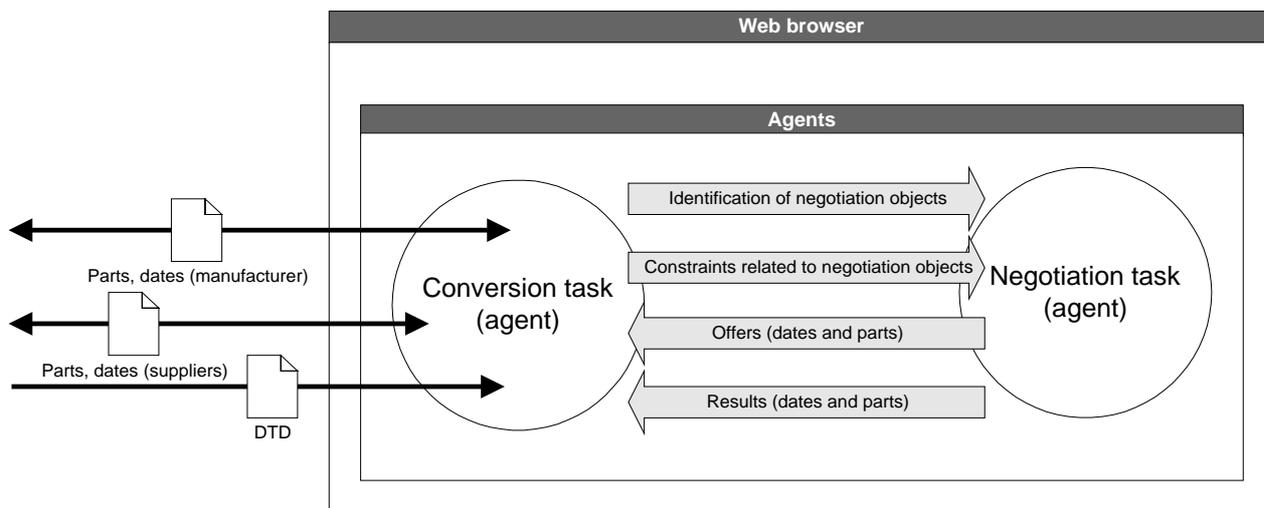


Figure 5: Interaction between negotiating and converting agents

ning between manufacturers and suppliers, and improves the response times for the customers.

Since an early coordination between manufacturers and suppliers is critical for the success of mass customization, a preliminary coordination which is based on the use of fuzzy approaches may further improve the negotiation results of the software agents ([17], pp. 1777-1778). This may be done by using fuzzy instead of crisp constraints, e. g. "approximately five parts needed" instead of "five parts needed", or by using a fuzzy rule-bases for the negotiation task. A kernel that supports the use of fuzzy approaches in a Java environment does already exist [18], and can be used to extent the negotiating Java-based software agents.

Another improvement to the presented approach might be the use of more market-related agent-based coordination mechanisms as proposed in [19], as certain disadvantages of the manager/contractor architecture could be avoided.

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