XML-based Available-to-Promise Logic for Small and Medium Sized Enterprises

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Abstract
At the Information Systems Research Network (FORWIN), Nuremberg, Germany we have prototypically implemented a lean and flexible available-to-promise application which is integrated with a framework of software components fulfilling the functions of supply chain management (SCM). This project is to demonstrate that it is possible to implement cost-effective and flexible software tailored to the needs of small businesses which can provide reliable information about product availability. To suit a large variety of companies, the way in which the component influences decisions or automates processes can be adjusted through different parameters, such as timeout, substitution, automatic processing or prioritization of suppliers.

In order to integrate all sorts of existing MRP or legacy systems along the supply chain the information flow is organized through a transaction-based exchange of standardized XML documents via the Internet.

1 Introduction
In order to provide customers with reliable information about product availability it is necessary to combine sophisticated calculation methods with fast and accurate information sharing along the whole supply chain (SC). One of the most essential features of supply chain management (SCM) is an available-to-promise (ATP) check [1]. The vendors of SCM standard software packages like i2 Technologies, Manugistics, or SAP have included ATP functionality in their products. Unfortunately, these applications are not really suitable for smaller businesses since they are very complex and expensive [2]. Due to their very restricted financial resources, small and medium sized enterprises (SME) have specific demands on business information systems. They need cost-effective and scalable solutions which fit their special needs. Rather than having complex software for advanced planning and scheduling, SME require simple tools to improve information flow within the SC and collaboration with their partners.

At the Information Systems Research Network (FORWIN), Nuremberg, Germany we are currently developing a software framework for SCM which is tailored to the needs of SME. In order to keep developing cost low while being adaptive to individual aspects of the user’s company and industry the framework is based upon the componentware [3] approach. The basic idea of componentware is to mask individual functions in components that can work independently, or as part of a larger application. Like a construction set the different functions of SCM are being encapsulated in such modules. They can then be arranged and combined flexibly in order to implement only the functionality the user really needs [4]. In prior projects a prototype of a manufacturing resource planning (MRP II) system called CW-PPS (Componentware – Production Planning and Scheduling, see [5] and [6]) using the componentware approach was developed and implemented for several SME in different industries [7]. The success of this concept led us to the idea to extend the focus from MRP II to SCM, and to work on a prototype of CW-SCM (Componentware – Supply Chain Management). In autumn 2000, we published a report explaining the general architecture and defining first core components of CW-SCM [8]. Single prototypes of these modules are being developed one of which is the ATP component.

In the following we discuss the concept of ATP. Then, the software framework of CW-SCM and the information exchange between participating companies are described. Subsequently, the prototype of the ATP software is explained and an exemplary usage scenario given. Before terminating with an outlook for perspective developments of CW-SCM, the technologies used for implementation are discussed.
2 Available-to-Promise

A possible and often referred to definition of ATP can be found in the APICS dictionary. It defines ATP as “… the uncommitted portion of a company’s inventory and planned production, maintained in the master schedule to support customer order promising. The ATP quantity is the uncommitted inventory balance in the first period and is normally calculated for each period in which a master production schedule (MPS) receipt is scheduled. In the first period, ATP includes on-hand inventory less customer orders that are due and overdue” [9]. This rather narrow definition reduces ATP to a calculable quantity. Nevertheless, the aim of ATP is to determine if an incoming order can be promised for a specific delivery date. Since the volume of units available depends on the method of calculation used, the three basic ways of finding the right ATP are described in the following (see [10]).

2.1.1 Discrete ATP

The main step in calculating the discrete ATP quantity is to subtract promised deliveries for the period the ATP is calculated for, and for all following periods for which no master production quantity has been scheduled from the MPS. The MPS, thereby, specifies the items the company anticipates manufacturing each period. In addition to this step, two exceptions have to be considered. In the first period calculated, a possible beginning inventory has to be added to the ATP. The other exception occurs if no MPS is planned for a period. In this case the ATP is always zero. By computing the discrete ATP no forecast data is taken into account.

2.1.2 Cumulative ATP without lookahead

The cumulative ATP without lookahead is calculated as the sum of the ATP quantity of the preceding period and the MPS, minus the promised deliveries for the period under consideration. The difference between this method and the discrete ATP method is that the ATP can include quantities already included in the ATP of other periods.

2.1.3 Cumulative ATP with lookahead

The cumulative ATP with lookahead overcomes the drawback of the cumulative ATP without lookahead where items produced in one period, but promised for delivery in a future period are excluded from the ATP quantities of other periods. Therefore, the algorithm to compute the cumulative ATP with lookahead can be described as follows [10]:

\[
\text{ATP}_j = \text{ATP}_{j-1} + \text{MPS}_j - B_j - \sum (B_j - \text{MPS}_j) \\
\text{until } \sum \text{MPS}_j > \sum B_j, \text{ where } j > 1
\]

In this equation Bi,j describe promised, but yet to be shipped orders from customers. Table 1 illustrates the three discussed methods for calculating the ATP.

<table>
<thead>
<tr>
<th>Period</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beginning Inventory</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MPS</td>
<td>169</td>
<td>169</td>
<td>22</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>110</td>
<td>80</td>
<td>5</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Discrete ATP</td>
<td>10</td>
<td>69</td>
<td>89</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Cumulative ATP without looka-</td>
<td>10</td>
<td>69</td>
<td>158</td>
<td>175</td>
<td>160</td>
</tr>
<tr>
<td>Cumulative ATP with looka-</td>
<td>10</td>
<td>69</td>
<td>158</td>
<td>160</td>
<td>160</td>
</tr>
</tbody>
</table>

Table 1. Calculation methods for ATP [10]

In the course of the development of SCM practices throughout the last years it seems reasonable to broaden the definition of ATP from being a strictly numerical value. In our comprehension ATP is not limited to the computation of available quantities. It also includes the ability to provide information about possible delivery dates at any time, as well as the fast communication of possible delays during production or shipment. Therefore, an event driven technology is required, which considers all partners along the SC with the ability to provide information about delivery dates, bottlenecks, or shipments virtually in real time. In this respect Buxmann and Koenig describe ATP as a “… functionality for multi-level checks of the resource and product availability, which permits an integrated, up-to-date availability test along a SC. The ATP can be used to determine a delivery date or the effects of a desired date while making use of company internal and external areas and at the same time taking account of costs, such as additional transport costs” [11].

3 CW-SCM a framework for SCM

3.1 Preliminary considerations

In designing a suitable framework to enable information sharing throughout the SC, several different aspects must be considered. First of all, we decided that the framework should follow a distributed approach in contrast to the commonly used central approach of standard software for SCM [12]. The central and the distributed approaches represent two different ways in which information among partners of a SC can be shared and calculations can be done. The difference between those two lies in the location of data storage and how calculations take place. The basic concept of the central approach is to extract all relevant data from the enterprise resource plan-
ning (ERP) systems of connected companies. This data is then stored in a central database, or even kept in memory, and the SCM software does all the calculations. SAP’s and i2’s SCM products are examples that utilize this approach. While this concept allows very fast calculations, especially through the use of technologies like SAP’s ‘liveCache’ [13], and of sophisticated planning methods, it is not really suitable for SME. The central approach does not only imply the use of powerful and therefore expensive hardware and software, but it also requires the participating companies to set up and maintain a common database. In the distributed approach, however, every company uses its own ERP system to perform calculations and planning tasks. A server coordinates the communication between the partners of the SC and acts as a central hub. Figure 1 illustrates these two basic concepts.

![Figure 1. Central versus distributed approach](image)

Naturally, the results of the distributed approach can not equal the ones of the centralized approach. In a way they are even contradictory to the goal of SCM of finding a global optimum for all partners since the participating companies still aim for their local optima. Yet, the companies will have higher profits than before because the information their local systems calculate with is more up-to-date and precise. The use of the distributed approach also has several advantages over the central approach. First, it is not necessary to buy and maintain the respective hardware and software for a complex SCM system or to set up a common database for the SC. It is also favorable that each company uses its own ERP system to perform calculations because they then only have to share the results of calculations and therefore do not need to disclose sensitive, internal information. Companies can thus control the amount of data they divulge. For these reasons, the CW-SCM framework relies on a distributed architecture.

The time horizon in which information is exchanged between different applications has also a major impact on the architecture. Three different concepts can be distinguished: real-time, fixed interval updating, and transaction-based. Real-time systems always perform calculations using the most recent data. This is without doubt the preferable solution, as it provides the fastest and most accurate results. Unfortunately, it is not feasible for SME because of the expensive hardware and software that is required. Another approach would be to exchange information only at fixed intervals, e.g. every two hours or once a day. While a daily exchange of information might be sufficient for certain applications, it is not suitable for availability checks. Neither the required accuracy of data, nor the goal of providing fast answers can be accomplished with this concept. The best compromise in respect of costs and speed can be seen in the transaction-based approach. Every time an ATP check needs to be performed, the necessary information is exchanged and the calculation takes place. Therefore our framework is transaction-based.

The integration of different information systems such as MRP II, ERP or legacy systems along the SC is the third key issue in forming a suitable framework for SME. Granted that individual enterprises often apply diverse information systems it is essential to create an environment which is open to any of them. Therefore CW-SCM shares information between the business partners through messages. These rely on the extensible Markup Language (XML) [14]. XML is platform-independent and offers the opportunity to exchange data in well-structured documents which are readable for any recipient regardless of the software he uses (see also section 5.2).

The architecture of CW-SCM is based on a client/server concept. CW-SCM consists of a server and several clients installed with each participant. The clients operate as the system’s frontend. They send the necessary information to the server. The services provided by the CW-SCM server include authentication, sending, and receiving of information, storing, and routing of documents. For a reliable connection between the clients and the server, which is independent of the location, the transmission control protocol / Internet protocol (TCP/IP) is used. The CW-SCM client/server software provides the necessary framework for the components of CW-SCM. Its main purpose is to enable communication throughout the SC. The CW-SCM server can be seen as a central hub. Each registered partner of the SC connects through the CW-SCM client to the server. Each time a successful connection to the server is established, the client identifies itself with a username and password. Once a client is authenticated, the server software and the connected clients can start to send and receive information. To ensure a uniform and flexible format of the information, XML is used to structure the data. After the server receives an XML document, it stores it and routes it to one or several clients. The CW-SCM clients receive and store these documents and hand them to the appropriate component for further processing. The CW-SCM clients therefore act as an interface between the installed components of the CW-SCM.
system, e.g. the ATP component, and the server. Figure 2 illustrates this concept.

![Diagram of CW-SCM architecture]

**Figure 2. Overview of the CW-SCM architecture**

The database shown in Figure 2 is used in several ways. Beyond the purpose of authentication, it holds general data, like the name or address of each registered partner of the SC used for the routing process. The database also stores component specific data. For the ATP component, for example, these are tables that allow the correlation of products with vendors.

### 3.2 Information exchange via XML documents

#### 3.2.1 General parts of CW-SCM XML documents

To ensure the processing of XML documents from different components without failure, certain tags are required for all documents regardless of the component they originate from. This not only ensures the integrity of the documents, but also allows the routing of documents to their associated components and the storage according to their types.

```xml
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<DOCTYPE CW_SCM SYSTEM "http://localhost:8080/inquiry.dtd">

<CW_SCM>
  <COMPONENT>ATP</COMPONENT>
  <DOC_TYPE>inquiry</DOC_TYPE>
  <SENDER>
    <ID>123456</ID>
    <NAMING>Company ABC</NAMING>
    <CONTACT>Mr. Miller</CONTACT>
    <DATE_SENT>2024-01-01</DATE_SENT>
  </SENDER>
  <RECIPIENT/>
  ...
</CW_SCM>
```

**Figure 3. General parts of CW-SCM documents**

Figure 3 shows an example of the general parts of an XML document for CW-SCM.

The XML and document type definition (DTD) declarations, as well as the root element are mandatory parts to ensure that the document is well formed and valid. The COMPONENT and DOC_TYPE elements are also required. While the COMPONENT element specifies the CW-SCM component that the document is associated with, the DOC_TYPE tag specifies the purpose of the document within this component. The elements between the SENDER tags identify the generating company and also hold information about the date and time the document was sent. The information about the recipient of the document plays a special role, since it may or may not be empty. If data about a certain recipient is provided, the server simply routes the document to the specified company. An empty element tag indicates that the document is meant for one or more addressees. The handling of this instance is described in the next section.

#### 3.2.2 Routing of CW-SCM XML documents

The CW-SCM server accomplishes the routing of the documents. Therefore, it is necessary that the server keeps track of the connected companies and the IP addresses associated with them. Since all SME are not necessarily assigned a static IP address, e.g. in the case of a dial-up connection, this cannot be achieved with a static table. In fact, the server dynamically stores the IP address of each company only for the time it is connected. As described in the previous section there are two possible scenarios. In the first case, in which information about a recipient is provided in the document, the server can look up the IP address of the company and send the document to it. The other scenario can, for example, occur during an inquiry for an ATP check. Consider the case in which several suppliers are producing the same product for a customer. Rather than sending the same document with different recipients from the CW-SCM client to the server, the server queries the database to find all the companies that sell the specified product and subsequently sends the document to them. This method helps to reduce the traffic and allows the flexible integration of other companies, as only a single database needs to be maintained.

#### 3.2.3 Storage of the XML documents

The documents sent and received are stored on both the client and the server side. The storage on the side of the clients is necessary for further processing, while the server stores the documents to enable a later delivery in case a company is not connected and for archival purposes. The possibility to specify a certain amount of time after which documents on the server get deleted is conceivable. The logic of the storage process for the clients and the server is similar. Each installed component has a designated folder.
under each of the three main directories: sent, received, and unprocessed. Furthermore, every component can maintain several sub-directories in its folders to reflect different document types. A received document is first stored in the unprocessed folder. After the task it is associated with is accomplished, the document is moved to the received folder. Therefore, the unprocessed folders are temporary storage spaces and should not contain files over a longer period of time. One difference between the directory structure of the clients and the server is that the server can generate and maintain this structure for every member of the SC. In addition, the server can generate an unconnected directory for each client and component to temporarily store received documents if a client is not connected at that time. Clients check these folders each time they connect to the server.

Figure 4 illustrates the directory structure generated by the CW-SCM server. The described directory structure and the unique filename for each document ensure the integrity of the data.

4 The ATP component of CW-SCM

As one of the first modules for CW-SCM, a prototype of an ATP component is being developed. Because of the chosen architecture of the underlying framework an optimization of the ATP check, in the sense of an improvement of the ATP result, heavily depends on the used ERP software. Nevertheless, the component helps the planner to simplify and speed up the decision-making process. Therefore, the developed ATP component could also be seen as a decision-support tool. To suit a wide variety of companies, the way in which the component influences decisions or automates processes can be adjusted by different parameters.

4.1 Main window

Figure 5 shows the main window of the ATP component. The table in the middle of the window contains all received, but not yet processed documents. To display these documents, the component checks its unprocessed folder each time it is started, or after the CW-SCM client informs it that a new document has been received. Depending on the type of the document, the user can display or answer it, as well as move it to a different folder, or even delete it. After the user has answered an unprocessed document, it is automatically moved to the appropriate directory in the received folder. Other menus give the user the possibility of displaying the sent and received documents instead of the unprocessed view, to configure the parameters of the ATP component, or to create and send a new document.

Figure 5. Main window of the ATP component

The functionality of the component depends on whether a company sends or receives a document and on the specific type of the document. The following sections describe and classify the different possible documents for the ATP component and their functions.

4.2 XML documents for ATP

At present, there are eight XML documents available to cover the different aspects and stages of an ATP check.

<table>
<thead>
<tr>
<th>Doc_Type</th>
<th>From</th>
<th>To</th>
<th>Doc_Type Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inquiry</td>
<td>Customer</td>
<td>Supplier(s)</td>
<td>Answer Inquiry</td>
</tr>
<tr>
<td>Answer Inquiry</td>
<td>Supplier(s)</td>
<td>Customer</td>
<td>New Inquiry, Order, -</td>
</tr>
<tr>
<td>Order</td>
<td>Customer</td>
<td>Supplier</td>
<td>Answ. Confirmation</td>
</tr>
<tr>
<td>Confirmation</td>
<td>Supplier</td>
<td>Customer</td>
<td>-</td>
</tr>
<tr>
<td>On Time</td>
<td>Customer</td>
<td>Supplier</td>
<td>Answer On Time</td>
</tr>
<tr>
<td>Answer On Time</td>
<td>Supplier</td>
<td>Customer</td>
<td>-</td>
</tr>
<tr>
<td>Shipping</td>
<td>Supplier</td>
<td>Customer</td>
<td>-</td>
</tr>
<tr>
<td>Delay</td>
<td>Supplier</td>
<td>Customer</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 2. ATP documents within CW-SCM

The type of document thereby specifies the function of the sending and receiving company and also whether an answer might be expected or not. Table 2 gives an overview of the existing documents for the ATP component
and classifies them according to the relationship between the involved partners of the SC.

4.2.1 Inquiry
With the inquiry document, a potential buyer has the possibility to initiate an availability check and to request information about order terms and conditions. The customer specifies the desired product and quantity, as well as the price the company is willing to pay, the currency, and the desired delivery date. The customer can also omit information about the supplier. In this case the CW-SCM server looks up suppliers that sell the desired product and routes the inquiry document to them. Once a company has received the inquiry, it can perform an ATP check accordingly and generate an answer inquiry document.

4.2.2 Answer inquiry
The answer inquiry document contains information about the results of an ATP check. It specifies the conditions under which a supplier is willing to accept an order. The provided information can differ from the data of the inquiry document. The supplier is able to offer a substitute, change the available quantity, specify another possible delivery date, or change the requested price. Furthermore, the document contains the shipping costs and the total offer. To avoid misunderstandings among the partners of the SC, the involved companies have to agree upon the terms of delivery before they use the CW-SCM system, for example upon the transfer of perils. This is often accomplished by the use of Incoterms [15], such as free on board, or delivered ex ship, even if the shipment is not international.

4.2.3 Order
This document is used to place a new order. It is assumed that all conditions, like delivery date, available quantity, or costs were already negotiated between the involved companies. An order document contains the product number and description, the costs for the product and shipment, the currency, and the desired delivery date.

4.2.4 Confirmation
The confirmation document is used to verify and confirm the information of an arrived order. The document repeats the details of the order and must contain an order number that the supplier assigns. This not only makes it possible for the customer to ensure that the order was transmitted and received correctly, but also enables both companies to use the order number for further reference.

4.2.5 On time
The on time document provides customers with the capability of requesting a status report about an order already placed. Thereby, enabling the customer to initiate a check rather than waiting for a delay notice from the supplier. The only necessary information is the order number, but the customer can also provide the ordered quantity, and the desired delivery date.

4.2.6 Answer on time
This document represents the answer to an on time document and gives information about the status of an order. The document contains the order number and the details of the order, such as the original quantity and delivery date. Furthermore, it states the estimated delivery date and the estimated quantity for that date. In the event of a partial delivery, the document contains the estimated delivery dates and quantities for every planned shipment. While the order number would be sufficient to provide the answer, the repetition of the order details enable the ATP component to simply compare the data in the document rather than searching and loading the associated on time document.

4.2.7 Shipping
The XML document with the DOC_TYPE shipping can be used to inform a customer that its order has been shipped. It provides data about the quantity ordered and shipped. It also contains the desired delivery date and the actual shipping date, as well as a tracking number.

4.2.8 Delay
The delay document informs a customer about an unexpected delay during the processing of the order, i.e. a backlog. The document contains information about the initial number of units the customer wanted. It can also hold information about the data and quantity of a possible partial delivery. Furthermore, it contains a new estimated delivery date for the rest of the order.

4.3 Possible parameters for the ATP component
Besides the already discussed documents, covering the different aspects and stages of an ATP check, the planner can specify some parameters to adjust the software according to the needs and policy of each company. The ATP component thereby offers the possibility to set parameters either globally or locally. The global parameters can be specified from the main window of the component in the configuration menu (see (4) in Figure 5). Normally, these parameters are valid for every transaction within the ATP component, but the software also offers the possibility of adjusting the parameters for each document. These local parameters overwrite the global settings only for a single transaction. This gives the user the opportunity to adjust the parameters to fit most transactions, while still allowing the company to adapt to exceptions.
4.3.1 Timeout

The timeout parameter influences the time needed to find a result of the ATP check. The basic idea of this parameter is that the user can specify a certain time for transactions.

The functionality thereby depends on the type of document. For inquiry documents, the timeout specifies the time range in which the sender accepts answers. After a company has sent a new inquiry document to the server, the ATP component accepts answers until the specified timeout is reached. Answers received after the deadline will not be taken into account. Suppliers use the timeout parameter for the answer inquiry documents. It gives companies the possibility to limit the duration of reservations. After the specified timeout is reached, the company can free products and resources reserved for a potential order, so that they are available for other ATP checks.

4.3.2 Substitution

The CW-SCM ATP component offers two different parameters regarding a possible product substitution. First, the company can specify whether the system should accept answers to inquiry documents in situations where a supplier offers a substitute. The second set of parameters defines the way in which the software reacts if the suppliers cannot satisfy an initial inquiry.

The user can specify possible substitutes for each product. The ATP component then automatically generates and sends new inquiry documents for all possible substitutes. The software thereby automatically disables the processing of A, B, or C parts (see next section), since it is possible that the suppliers offer several different substitutes for a potential order. For specific products, where a substitution is not possible, the software can start a new inquiry process to find out a possible delivery date.

4.3.3 Processing of A, B, and C parts

To simplify the order process, the ATP component offers functions to classify the different products according to their value. While category A reflects the most expensive parts or products, category C represents the least expensive items, e.g. screws or small plastic parts. Category B contains products with prices between the two other categories [16]. The user has the possibility of assigning each product to one of these categories, and to define processing rules for them. If the parameter for a category is set to automated processing, the ATP component generates and sends orders for products of this category automatically, provided the price, date, and volume of the offer match the initial inquiry. Where price and date match and the desired quantity can be reached by combining several offers, the software also generates an order automatically. Otherwise the ATP component generates and displays a suggestion and waits for a decision by the user. When a new document is created, the software shows the defined parameters to enable the user to change the global values for specific transactions.

4.3.4 Prioritization of suppliers

Under certain circumstances it may be desirable for a company to express a preference of one supplier over another, even if it appears to be the more expensive solution. This may be the case if a customer has agreed to buy a certain quantity of products from a supplier over the year. The user can therefore specify a chain of suppliers for each product and defines a threshold for each of them. It is a percentage value and indicates how much higher the price per unit for a product compared to other offers may be, until the prioritization for a certain transaction is dismissed. The user can also temporarily disable the prioritization when creating a new inquiry document.

4.4 Example

To clarify the functionality of the CW-SCM ATP component and the influence of the described parameters, an example is illustrated in Figure 6. The documents shown here only contain a small portion of the information that could be found in the actual XML documents. In this scenario customer A creates a new inquiry (1) for 400 units of product 48F5. The company needs the supply on or before 2001-06-04 and is willing to pay 24.00 USD per unit. As mentioned earlier, the company can set the different parameters for this specific document only. Otherwise, the software assumes the globally defined values for the parameters.

The document created is then send to the CW-SCM server (2) and the timeout starts. Since the inquiry document does not contain data about a certain receiver, the server looks up the possible suppliers of the desired product in its database (3). After gathering the necessary information the server sends copies of the inquiry document to the three possible suppliers B, C, and D (4). At the supplier’s side, the CW-SCM clients receive the documents and hand them to the ATP components, which display the inquiry document in the unprocessed table view. The suppliers then feed the provided information into their local ERP systems to perform an ATP check (5). At this stage of development of the ATP prototype, the process of putting the data from the inquiry document into the local planning system and the triggering of the ATP check are performed personally.

After the local ERP systems returned their results, the planners generate the answer inquiry documents (6). In this example, supplier B is able to deliver 300 units of the desired product for the specified price. Supplier D can beat the price and meet the date customer A asked for, but the company is only able to deliver 280 units. As shown in
Figure 10, supplier C does not provide an answer. This can have several reasons. Maybe the supplier is not interested in the potential order. It is also possible that supplier C is just not able to deliver the desired product before the given date or that the supplier is not connected to the CW-SCM system at the time. In the next step the suppliers send their answer inquiry documents back to the server (7). It forwards them to the CW-SCM client of customer A (8). After the timeout is reached, the ATP component checks whether and how many answers to the initial inquiry were received. In our case, the ATP component finds the answers of supplier B and D. In a first step the ATP component now checks whether one of the received answers meets all criteria. As this is not the case, the software tries to combine the answers from the suppliers in the next step to match the initial inquiry. Under the assumption that customer A has not specified any prioritizations, the ATP component would suggest an order of 280 units from company D and the remaining 120 units from company B, since this is the least expensive solution. In the final step, the component generates new order documents for suppliers B (9) and D (10). If the component is configured for automated processing, the software sends the documents to the server. Otherwise, the ATP component waits for the decision of the user.

4.5 Further extensions

4.5.1 Automated execution

The transfer of data from the ATP component into the local planning systems of the SC partners and vice versa is, at the moment, done personally. Not only is this a possible source of error, but it is also a drawback in regard to the time it takes to perform an availability check. The implementation of interfaces for the ATP module and different MRP systems has therefore a high priority in the next stage of development. These adapters should offer the functionality to automate the process of transferring the necessary data between the ATP component and the planning systems and to trigger the appropriate functions, to obviate human intervention.

4.5.2 Connection to external marketplaces

In order to stay abreast of changes in the development of virtual marketplaces and private exchanges, another possible extension to the CW-SCM system would be the possibility to connect the software to these trading platforms. In doing so, the companies of the SC, which use the CW-SCM application can appear as a virtual enterprise (see e.g. [17]). This gives them the opportunity to present their products to a broader audience. Therefore, the implementation of interfaces, which extract and convert the data and coordinate the information flows between CW-SCM and external marketplaces would be necessary. Existing tools can simplify the mapping of required information between the CW-SCM format and the format of other systems. SAP offers for example the so-called SAP Business Connector. This software provides functionality for automatic conversion of data from an XML based format into SAP format and vice versa [18].

4.5.3 Security

Another important aspect of possible extensions for the prototype is the security of the software and the data. Since the partners in the SC transmit critical information via CW-SCM, it is important that this data is secure, not only from a possible loss, but also from the eyes of others, especially from competitors. At present the application uses unsecured Internet connections to send and receive the various documents. To overcome this vulnerability, the software should utilize secure and encrypted communication channels. This can be realized by implementing the Java secure socket extension (JSSE) package. It includes classes and methods to implement Java versions of the secure sockets layer (SSL) and transport layer security (TLS) protocols, as well as for data encryption and client authentication [19].

![Figure 6. Example scenario](image-url)
4.6 System requirements

Since one goal of the CW-SCM project is to develop a prototype that fits into the heterogeneous infrastructure and the limited IT resources of SME, there are no special hardware requirements for the system. The computer running the CW-SCM server needs a permanent connection to the Internet. As already mentioned, the server offers the functionality of temporarily storage for documents of clients that are not connected for a later delivery. For fast response, a constant Internet connection is however recommended for all clients, but it is not necessary for the system to work properly.

5 Technologies used

5.1 Java

For the implementation of the prototype, the Java programming language was used. The most important advantage Java offers over opponents, like C++, is its platform independence. The necessary software to run the CW-SCM application includes the Java 2 runtime environment (JRE), Standard Edition, in version 1.3.0, the Java API for XML processing (JAXP) package in version 1.0.1, and the Xalan XSLT processor version 1.2. All these programs are available for most operating systems and can be freely downloaded from the Internet.

5.2 XML

Instead of sending information between the partners of the SC in plain text format, the software utilizes the XML standard. The structuring of information with the help of tags may seem excessive, since the documents contain a redundant overhead of data, but the use of XML offers several advantages, which legitimize this procedure. First of all, it is simple for the software to control if a document contains all necessary data. Not only is the application able to check whether a document is well formed, by using a DTD, the software can also test the validity of a document. Another advantage of XML can be seen in the fact that data is separated from format instructions. With a cascading style sheet (CSS) or extensible style sheet language transformations (XSLT), a document can be transformed into and represented in a wide variety of formats, e.g. hypertext markup language (HTML) or portable document format (PDF), without the need of recoding. Finally, XML adopted Unicode, a character encoding standard that supports most languages, by providing a unique number for every character [20]. This, and the fact that XML is a very strict standard, ensures a platform and software independent way to communicate, no matter the language.

5.3 Databases

Microsoft Access 2000 is used to store information about the companies of the SC and their products, on both the client and the server side. The software developed executes common structured query language (SQL) statements to communicate with the databases. The connections are thereby established using the Java database connectivity - open database connectivity (JDBC-ODBC) bridge, a driver, which translates Java calls into ODBC conform calls [21]. This ensures platform and software independence, since the users can install any ODBC compliant database, without the need to change the code and recompile the software.

6 Conclusion

In this article we have shown that it is possible to design lean and flexible software solutions tailored to the special needs of SME. This can be achieved by implementing the componentware approach. The ATP component, one of the first modules of CW-SCM, has been developed to make availability checks for SME possible and to simplify and shorten the process of inquiring and ordering. The goal of this component is to present a cost-
effective alternative with limited functionality to highly sophisticated and expensive existing solutions. Yet the above mentioned extensions especially the integration of CW-SCM with different ERP systems must soon be approached in order to obtain a competitive ATP logic.

In order to prove the practical relevance of our approach we are negotiating with several pilot enterprises willing to use CW-SCM in day-to-day business. Only by implementing CW-SCM in different industries we can find out if it provides satisfying results and is able to compete with the products of other software vendors.

Regarding the progress of developing more components for the CW-SCM framework, we are working on further prototypes simultaneously. Next to ATP a module for vendor-managed inventory (VMI) (see [22]) has also been developed which allows the users of CW-SCM to intensify their relationships with customers and suppliers. Other components for monitoring and controlling, e-procurement and the configuration of an SC are currently being promoted.

7 References


