

BestBasket, an Application for Efficient Indirect e-Procurement in Small and Mid-size Businesses

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Abstract: The Internet opens up new markets for businesses and can thus allow for a significant improvement in procurement. However, this will only apply if the customers are able to handle this huge market. In this paper we show that finding optimal suppliers in B2B marketing is a complex combinatorial problem and present a solution to it. The BestBasket system of Mercateo.com helps customers to handle the problem and to easily manage their procurement in an optimal way. The system is used by 1100 customers each day and 35% of them accept the optimized supplier-portfolio computed by the system. This makes up an overall relevant market of € 150 billion per year in Germany.

1 Background, Indirect Procurement and Purchasing in SMB

Procurement is a central business process for almost all companies today. It includes finding suppliers, negotiating prices, logistics, several other complex business tasks and finally purchasing. Large companies have departments for this task and employ experts who arrange for their best possible purchasing of raw materials, capital goods and maintainance, repair and operation supplies (MRO). For small and mid-size businesses (SMB) such a department would in most cases not pay. The direct procurement (i.e. of raw materials and production goods) is often done by the general management and the overall expenditures of the indirect procurement (i.e. of MRO and capital goods) is far too low to make in-house professional procurement profitable. The potential of savings would be smaller than the cost for the procurement staff.

Indirect procurement, in particular the procurement of MRO is a very frequent task in many SMB. New office supplies, furniture, computers and many other things are needed for instance. In order to make this task manageable several companies offer catalogues of a wide variety of goods for business customers only. In contrast to catalogues for private purchasers, these suppliers are much more flexible in the shipment conditions. Prices depend on the amount ordered, delivery time, insurance conditions and several other factors. This makes the purchasing of MRO a complicated task. SMBs have to select suppliers for all their needs such that their individual overall objectives are optimized. These objectives can be the overall cost, but also delivery time or other factors. For an ideal portfolio of suppliers, the SMB would often have to split their orders.

2 The Optimization Potential

Today, millions of private consumers use the advantages of purchasing goods in the web. They use marketplaces to compare the prices of many suppliers for millions of products every day. When we want to buy a particular DVD-player, we can go to a marketplace and will see at least 10 different offers made by different internet-shops. We select the cheapest or the supplier we like best and order.

This new possibility is brought to us by the Internet. We are able to collect information from all over the world in very short time with very low effort and cost. This allows also for the SMB to shop in a country-wide or sometimes even world-wide market. It extends their choice of suppliers considerably, provided this large amount of information is prepared in a usable way (e.g. in a marketplace). Furthermore, it increases competition and results in better prices in the web. There are suppliers who offer their assortment of goods in the web for cheaper prices than in their paper catalogues.

The difference of private purchasing and procurement in SMB results from the complicated shipping conditions we have in B2B-marketing. This makes the selection of suppliers for particular goods on their shopping list a complex combinatorial problem. Consider for instance the situation in table 1. An SMB wants to order 50 binders and 4 keyboards. There are three suppliers (A,B and C) who all offer both articles. The prices differ and the shipping costs differ. When we want to optimize our purchase what should we order from which supplier?

product	supplier A	supplier B	supplier C	items needed
binder	€ 10/item € 8/item when purchasing more than 30	€ 9/item	€ 10/item	50
keyboard	€ 70/item	€ 55/item	€ 45/item	4
shipping	€ 10 € 5 for order value > € 500 0 value > € 1000	€ 5 0 value > € 500	€ 10 0 value > € 250	

Table 1: example of purchasing options

If our objective is to get only one package we need to select either of the suppliers. In this situation B would be the best choice delivering at a total cost of € 670 (A would cost 685 and B 750). However, if we accept multiple suppliers and reduce the cost as far as possible, we should order 43 binders at A and 7 binders at C together with the four keyboards. Thus we would get the cheapest possible overall price of € 594.

In the example we can see, that selecting a supplier for every single item we order is the choice we have to make in order to compose an optimal order. In the real scenario we have for many articles up to 25 suppliers and very frequently orders of far over 100 items. The

overall search space has an exponentail size of $|suppliers|^{|items|}$. Therefore we need a smart algorithm to actually find the best possible offer.

3 A Successful Implementation

Mercateo.com is a B2B-Marketplace in Germany with almost 400.000 customers. The Marketplace offers more than 3.700.000 articles from more than 300 suppliers/ catalogues. Users can use the BestBasket-System to optimize their shopping basket. To our knowledge, it is the only marketplace worldwide which offers this option to its customers.

The project was implemented by the author in cooperation with Mercateo. It was funded exclusively by Mercateo AG. The author implemented a prototype system. The core of this systems was integrated in the now used life system. For the implementation expert knowledge on Constraint Programming was used which is the actual contribution of the author to the system.

Usage. The BestBasket-system is an optional step for the customers to take when proceeding to the checkout with their shopping basket (see Figure 1). Around 1100 customers make this additional step every day. When entering the shopping basket optimization, the user can select her most important optimization criterion. Options are currently price, number of suppliers and delivery time. The system defines the criterion to break ties between purchases of the same quality. In an additional expert mode the user can define a priority-order of objectives herself. The system will then create an optimized basket whith the same content as before, but possibly other suppliers. The user can accept this basket or resume to her own. After that the basket is checked out in a traditional way.



Figure 1: Usage of BestBasket

Architecture. The BestBasket System is a thin client solution to optimization. The filled shopping basket is uploaded to a server, where first, alternative suppliers are found and second the optimization is performed. For the latter, the shopping basket is entered as a constraint optimization problem into an off-the-shelf Constraint Programming solver[oCS01]. The solution is then delivered to the client. Currently only 3 servers are used to perform the optimization. Since very short response times are required for usability reasons, optimization may be interrupted by a timeout. Thus, heavy-tailed search efforts are eliminated and the computing power of the used machines is sufficient.

Technology. An important prerequisite to allow for the optimization is to maintain a list of products that are offered in more than one catalogue and to keep track of the identity of items from different offers. This is an easy, but very time-consuming task which is performed by Mercateo. For this a table in the database of articles is maintained which links the primary keys of same products in different catalogues together. With this we can retrieve for each item in a shopping basket all potential suppliers.

This is used to define decision variables and domains of an optimization problem. For each item we have a variable and its domain is the list of possible suppliers. The constraints are derived from the shipping conditions of the different suppliers. We thus implement a declarative model of the application domain. We did not implement any algorithms but use the constraint solver as a re-used component with its sufficient general problem solving capabilities. With this we can constrain variables that represent three objective functions:

- overall cost: the sum over the price to pay to each selected supplier. The cost per supplier is computed by element-constraints that relate prices for certain items to suppliers. The shipping costs are defined with propositional constraints.
- number of suppliers: the sum of different values in all the decision variables
- delivery time: the maximum of the delivery times of the suppliers which are given in tables.

Thus we can create a Constraint Satisfaction/Optimization Problem (CSOP) from the shopping basket and the database.

This model together with the selected optimization criterion is then passed to a constraint solver. The used solver implements efficient optimization for each of the objective functions. We used out of the box optimization algorithms of SICStus Prolog [oCS01]. The performance was sufficient for this application such that there was no need of further customization or implementation of algorithms for search. The solver computes an optimal solution wrt. the selected criterion (ties are broken by price) or times out. In the latter case it may still provide an improved solution due to the anytime properties of constraint solving [WF96]. This means, we do not have to wait until the complete search for an optimal solution is finished. As soon as one solution is found we are able to provide a valid shopping basket to the user. This solution is an instantiation of the variables (i.e. items) with suppliers (i.e. where to order). All shopping baskets are valid solutions in our model such that any assignment can be considered a (sub-optimal) solution. The result is prepared on an HTML-file which is then passed to the customer.

Usability. Usability is a crucial issue for the success of such a system. The SMBs ordering at Mercateo want to prevent time-consuming procurement and get the optimal offer with as little effort as possible. Currently around 68% of the customers use BestBasket, which can be considered a big success from a usability point of view. The complex topic of optimization is actually handled by so many customers. We don't know, how many of them are first-time users and will never use BestBasket again, but it is unlikely that a majority of the 1100 users per day are new, since only registered customers are allowed to use the system and we have far fewer new registrations per day. As can be expected, the

expert mode is not very frequently used. In this mode the user is to some extent expected to understand what optimization with multiple criteria means. It seems that this is not practical from a usability perspective. Mercateo currently even considers to allow for omitting the selection of the one optimization criterion. The plan is to pre-combining different objectives, for instance "for each reduction of the number of suppliers we are willing to pay 3 Euros more" and thus make the optimization criterion even more transparent to the users.

4 Related Work

We are not aware of any other systems in the web providing a tool for optimizing procurement in an automated way. A reason for this could be that not every marketplace may be willing to pass cheaper prices they get due to good procurement through to its customers. Furthermore, the optimization potential only arises in B2B-marketing, because only here we find the complicated shipping conditions which make the problem a combinatorial problem.

In the literature, optimizing procurement is usually considered a management task see e.g. [Nee01]. However, frequently the commercial relevance of e-procurement is impressively outlined. Our work is an implementation of a part of the general idea of e-procurement in the special setting we found at mercateo.com. Certainly it can be generalized to settings, where not all suppliers are known in advance but are dynamically found in the web.

This aspect is considered in recent work on e-catalogs. E-catalogs are a central step towards the automatization of e-procurement [BSADB00]. This research proposes ways to allow for finding suppliers of certain MRO-goods on the fly in the web. In our setting, we know the suppliers in advance. However, given e-catalogs provide their shipping conditions in a uniform way, we could integrate that work with ours. This could lead to a system for optimized e-procurement on the basis of e-catalogs.

5 Evaluation

We consider this application a big success for different reasons. First of all it has a very wide acceptance and is probably one of the most used constraint-based systems in the world. Every day, 1100 customers use the system. That is 68% of the customers of Mercateo. The changed shopping baskets proposed by the system are accepted by 35% of these customers. This means every day, more than 380 people experience the advantage of computer-based optimization. They manage the highly complex problem of optimal procurement in the World Wide Web.

We do not know, which optimization criteria are selected most. However, price is in all cases (except when in expert mode) the first or second most important criterion since the user can choose it explicitly or the system breaks ties by this criterion. The average savings

are 0.78 % of the total order. This makes a relevant overall market in Germany of 150 billion Euros per year. But not only the money is important. We consider the marketing aspect of providing a “button to save money” as a great advantage for the marketplace. However, we are not able to quantify this. A rising number of customers may have its reason among others in this unique feature.

Finally the technology used allows for a very effective implementation from a software-engineering point of view. It is easy to add or modify objective functions because of the general approach to model a shopping basket as a CSOP. New objective functions or combinations of the existing criteria can be integrated. The declarative model of the application domain allows for new variables to be integrated and connected to the existing model by new constraints. Such new variables serve as new optimization criteria which can be passed to the optimization implemented in the used solver. For instance customer satisfaction of suppliers is to be implemented by providing a mapping of suppliers to quality-values in the system. For each shopping basket the average of these values expresses the expected satisfaction of a user with the selected supplier portfolio. This variable could be selected as an optimization criterion and maximized by the solver.

6 Conclusions

The scientific contribution of the paper is to identify the optimization potential in e-procurement. Given this we can extend recent work on e-catalogs with the new feature of optimizing shopping baskets.

The contribution as an application paper is to show the relevance of Constraint-Programming to real-world applications and how this field of Computing Science can actually improve our everyday life. We thus tried to make the declarative methodology of CP more interesting to other communities in computing and economy research as recently proposed by J Hooker[Hoo07].

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