September 2001

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In: Buhl, Hans Ulrich, u.a. (Hg.) 2001. *Information Age Economy*; 5. Internationale Tagung Wirtschaftsinformatik 2001. Heidelberg: Physica-Verlag

ISBN: 3-7908-1427-X

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Abstract: Recent years have seen an enormous increase in the role of information technology in markets. During the past few years, economists, game theorists, and computer scientists have started to take a direct role by designing various kinds of market mechanisms for electronic markets in various industries. What is so special about "electronic" market design is the fact that a designer has many more possibilities in designing a mechanism than one would have for physical markets. Multi-attribute reverse auctions are such a new market mechanism, which would hardly be feasible without the use of information technology. In this paper we describe a first application of a multi-attribute auction market in the tourism industry.

Keywords: Electronic Market, Multi-Attribute Auction, Dynamic Pricing

1 Introduction

Hundreds of auction sites and online exchanges have sprung up in the past couple of years in business-to-business (B2B) as well as business-to-consumer (B2C) markets, but the market mechanisms used do not always work well. In conventional auction markets, there is usually competition only in a single dimension: price. But in most markets, price is only one of many dimensions in which suppliers compete. Most procurement markets for goods and services in fact have imperfect competition and suppliers compete with similar but slightly differentiated products. Conventional procurement or reverse auctions are not a good solution in these situations, since they only compare prices.

Tourism is a good example and a particularly intersting application domain. The products and services offered in this industry are not homogeneous. For example, the offerings a tourist gets nowadays from an online reservation system differ in numerous attributes such as location, time, board, amenities and price. Therefore, conventional procurement auctions, where accommodation providers bid on price alone, would lead to inefficient outcomes in these situations. New dynamic pricing mechanisms have a high potential impact in this field. This is particularly inter-

esting, since tourism is the biggest and fastest growing industry in electronic commerce [ETM00].

In this paper we focus on the design of a multidimensional auction market for the tourism industry. The core of our approach are multi-attribute reverse auctions [BiKl00; Bich00]. These new market mechanisms allow automating negotiations with multiple suppliers on multiple attributes. In other words, they enable customers to select the "best" bids based on their preferences. The approach is based on methods from economics, decision analysis and computer science and enables support for complex negotiations on electronic tourism markets.

In the next section we describe a number of phenomena that can be observed on electronic markets, namely the trend towards dynamic pricing concepts and support for complex negotiations. Based on this, we introduce multi-attribute auctions in section 3. Section 4 provides an overview of relevant data about the tourism industry and the industry participants, and section 5 describes the implementation of a multi-attribute auction market for the tourism industry. To our knowledge, this is the first real-world implementation of this kind. Finally, section 6 provides conclusions and an outlook on future research.

2 Dynamic Pricing of Complex Goods

The following sections will describe two basic phenomenas that can be observed on electronic marketplaces. The first trend is the move to dynamic pricing, where prices and resource allocation are determined based on the bids of market participants. This can be seen on most electronic markets nowadays, which utilize conventional auction mechanisms in order to automate price negotiations. The second trend is relatively new, but inevitable when it comes to trading complex goods, namely support for multi-attribute negotiations.

2.1 Towards Dynamic Pricing

Up until now, most electronic commerce has involved fixed price transactions. For stable markets or for day-to-day, low-involvement purchases where the stakes are small, the predictability and low transaction costs associated with fixed pricing are more compelling for the consumer. Two trends in electronic commerce are causing a shift from fixed to dynamic pricing for both business-to-consumer and business-to-business electronic commerce. First, price uncertainty and volatility have risen and the Internet has increased the number of customers, competitors and the amount and timeliness of information. Some empirical evidence for this hypothesis can be found in Brynjolfsson and Smith [BrSm99]. Businesses are finding that using a single fixed price in these volatile Internet markets is often ineffective and

inefficient. Second, the Internet has reduced the transaction costs associated with dynamic pricing by eliminating the need for people to be physically present in time and space to participate in a market [Stro00]. The conclusion is that more negotiations can be expected to take place in electronic markets than in traditional markets. Certainly, fixed pricing will never disappear, but the Internet is changing the balance in favour of dynamic pricing.

This shift from fixed pricing to dynamic pricing is expected to be most evident in the business-to-business electronic commerce. Forrester Research predicts that business-to-business Internet auctions will grow to US $52.6 billion by 2002, while analyst Vernon Keenan [Keen00] forecasts that in the same period dynamically priced business-to-business transactions will rise to US $88 billion, representing 27% of the value of all business-to-business electronic commerce transactions.

2.2 Classic Single-Sided Auction Formats

Auctions are the most widely used form of dynamic pricing mechanism. They have been defined as "a market institution with an explicit set of rules determining resource allocation and prices on the basis of bids from the market participants" [McMc87]. The competitive process serves to aggregate the scattered information about bidder's valuations and to dynamically set a price. In an auction a bid taker offers an object to two or more potential bidders who send bids indicating willingness to pay for the object [MiWe82].

Four basic types of auctions are widely used and analyzed: the ascending-bid auction (also called the open, oral, or English auction), the descending-bid auction (or Dutch auction), the first-price sealed-bid auction, and the second-price sealed-bid auction (also called the Vickrey auction). Oral or open-cry auctions reveal price quotes and require public and adjustable bids. After a certain elapse time the auction clears, meaning it matches buyers and sellers and determines the price. Sealed-bid auctions do not reveal price quotes and require private, committed bids which are opened simultaneously. The highest bidder acquires the object and pays the seller her own bid price in a *first-price sealed-bid auction*, and pays the second highest bid price in a *second-price* or *Vickrey auction*. (see [Wolf96] for a more detailed review).

2.3 Support for Complex Negotiations

Auctions are particularly robust forms of negotiation protocols. In cases where no one person knows the true value and each individuals estimate may be highly imperfect, the clearing price is still an accurate value estimate. The competitive process serves to consolidate the scattered information about bidder's valuations. The classic single-sided auction formats are primarily a means to negotiate prices. The

products in question are pre-specified in all their qualitative attributes at the outset. This has already lead to a tough price competition amongst suppliers in many markets.

These developments have caused many suppliers to differentiate their products and services and to look for profitable niches in a way that defies comparison shopping by price alone [Vari96]. Nowadays, many goods are wrapped up in service. For instance, when buying a car customers get free servicing, insurance and perhaps only temporary leasing, etc. In addition to this, as Internet commerce matures beyond books, software and CDs towards higher valued items such as financial services and business services, price becomes less important and negotiation on multiple attributes becomes necessary. Of course, conventional procurement auctions are far from optimal in these situations, as the customer will be comparing increasingly differentiated products. Therefore, many marketplaces require the design of completely new negotiation protocols.

During the past few years, several research labs and start up companies have proposed new mechanisms to automate negotiations on heterogeneous goods. Many approaches focus on support for *bilateral negotiations*. For example, TradeAccess (http://www.tradeaccess.com) provides a commercial negotiation support system for strategic bilateral procurement negotiations. Haggleware (http://www.haggleware.com) offers a one-to-one negotiation solution with an electronic salesperson, which, based on current product supply and demand, negotiates on behalf of the seller with a buyer, factoring in buyers' bid history, product interest, negotiation skill and buying credibility. Besides, there are numerous approaches from academia for so called “negotiation support systems” [Kers98].

In our previous work we have focused on *multi-attribute reverse auctions* (see [Bich01; Bich00; BiKl00] for details). Multi-attribute reverse auctions are an approach to supporting multilateral procurement negotiations on multiple attributes of a deal. Compared to bilateral negotiation support tools multi-attribute auctions leverage the power of competition in order to achieve efficient results.

3 Multi-attribute Auctions

Several authors have analyzed tenders and procurement auctions (see [Vick61] or [DaSp89]). These auctions are mostly deployed in governmental or corporate procurement where a bid taker auctions off goods or services she wants to buy. Those studies have generally assumed that the qualitative attributes are fixed prior to competitive source selection - hence bidding competition is restricted to the price dimension.

Purchasing managers have their own preferences for product quality, price, terms of payment and delivery and they are looking for the offer that best satisfies these

preferences. The overall utility of a deal for the buyer contains not only the price of the item but a combination of the different attributes. In contrast to sales or forward auctions the bids submitted in tenders often comprise heterogeneous goods or services and the bid taker has the burden to select the "best" bid.

3.1 Description of the Mechanism

The negotiation situations we investigate describe heterogeneous monopsonies with a single buyer and multiple sellers where the traded goods have several negotiable attributes and the buyer has certain preferences about these attributes. It is important in these situtations to give a bidder explicit instructions on how to improve or optimize her bids. If a bid taker does not provide these instructions, this will lead to unguided bidding and potentially inefficient results. In our approach, called "multi-attribute auctions", we assume that the buyer reveals a scoring function to the bidders based on her utility function. That is, a buyer first has to define her preferences for a certain product in the form of a private utility function. This might not be feasible or desirable in all cases (e.g. if preferences are highly confidential), but it is a good way to guide bidders towards an efficient solution and to automate the bidding procedure. After soliciting bids from the various suppliers, the mechanism designates the contract to the supplier who maximizes the buyer's utility, i.e. who provides the highest overall utility score for the buyer.

We next introduce some terminology and notation. A buyer solicits bids from m firms. Each bid specifies an offer of price and multiple quality dimensions, at which a fixed quantity of products with the offered quality levels is delivered. A bid received by the buyer can then be described as an n-dimensional vector Q of relevant attributes indexed by i. The attributes may be any combination of monetary and non-monetary attributes. We have a set B of bids and index the m bids by j. A bid by firm i is denoted by a vector $\mathbf{x}_j = (x^1_j \ldots x^n_j)$ where x^i_j is the level of attribute i. In the case of an additive scoring function $S(\mathbf{x}_j)$ the buyer evaluates each relevant attribute x^i_j through a scoring function $S_i(x^i_j)$. An individual scoring function, $S: Q \rightarrow R$, translates the value of an attribute into "utility scores". The overall utility $S(\mathbf{x}_j)$ for a bid $\mathbf{x}_j$ is given by the sum of all individual scorings of the attributes. It is convenient to scale S and each of the single-attribute utility functions S_i from zero to one, by weighting the individual attributes. That is, for a bid $\mathbf{x}_j$ that has values $x^1_j \ldots x^n_j$ and a scoring function that has weights $w_1 \ldots w_n$ on the n relevant attributes, the overall utility for a bid is given by

$$S(\mathrm{x}_j) = \sum_{i=1}^{n} w_i S_i(x^i_j) \;\; and \;\; \sum_{i=1}^{n} w_1 = 1 \qquad (1)$$

The problem a buyer faces is to determine appropriate S_i functions and w_i weights. An optimal auction is allocating the deal to the suppliers in a way that maximizes

the utility for the buyer, i.e. to the supplier providing the bid with the highest overall utility score for the buyer. The function $max\ S(\boldsymbol{x}_j)$ (with $1 \leq j \leq m$) gives us the utility score of the winning bid and can be determined through various auction schemes.

3.2 Multi-Attribute Auction Formats

Similar to classic auction theory, we consider open-cry and sealed-bid auctions. In a *first-score sealed-bid auction* the winner gets a contract awarded containing the attributes $\boldsymbol{x}_j$ of the winning bid. Alternatives with the same overall utility are indifferent and the first of those bids is the winning bid. The *multi-attribute English auction* (also first-score open-cry auction) works in the same way, but all bids are made available to the participants during an auction period. In a *second-score sealed-bid auction* we take the overall utility achieved by the second highest bid S_{max-1} and transform the gap to the highest overall utility $(S_{max} - S_{max-1})$ into a higher price. Consequently, the winning bidder can charge a higher price. In the first-score and second-score sealed-bid schemes the auction closes after a certain pre-announced deadline. In a multi-attribute English auction bids are made public and the auction closes after a certain time elapse in which nobody submits a bid. We do not consider a generalization of the Dutch auction, as this procedure is more difficult to realize in the multi-attribute case.

In our previous work we dealt with many of these practical issues of multi-attribute auctions. Bichler et al. [BiKa99] describe a prototypical implementation of an electronic brokerage system where we utilized conventional MAUT in order to determine a buyers' utility function. The implementation leads to a good understanding of the problems involved with a real-world deployment of the mechanism. Based on these experiences we conducted a set of laboratory experiments in order to learn about the applicability of multi-attribute auctions in the context of trading with non-standardized financial derivatives [Bich00]. In these laboratory experiments we could show that multi-attribute auctions achieved a significantly higher utility score than conventional single-attribute auctions. We could also show that the efficiency of multi-attribute auctions was comparable to single-attribute auctions. In a a simulation model we showed that in general multi-attribute auctions achieve better results than conventional single-attribute auctions, if there are multiple attributes that are relevant to the buyer [Bikl00]. In this paper we will focus on the application of multi-attribute auctions and our experiences in a particular field – the travel and tourism industry.

4 Electronic Markets and Tourism

The following section provides some statistical data about the latest developments in the tourism industry and discusses the main stakeholders and their roles. This should not only motivate the application domain, but describe the problem and the relevant factors in this industry.

4.1 The Tourism Industry

According to a 1997 study of the World Travel and Tourism Council [WTTC96], the travel and tourism industry is the world's largest industry in terms of the GDP. The study also shows that the relative importance of tourism will grow to approximately 11% of the GDP in the year 2007 and will be one of the leading industries in this century, besides IT and telecommunication. A WTO study concludes that there will be no slowdown in the pace of growth of international tourism, reaching more than 1 billion in 2010 and 1.6 billions in the year 2020 [WTO97]. This number corresponds to 7% of the worldwide potential population that travels, leaving still some potential for further growth. Europe will continue to be the most visited tourism destination in the world with a projected total of 717 million tourists for the year 2020, that is 382 million more tourists than in 1995, although its growth rate is assessed below world average with 3.1% per year.

According to the European Travel Monitor [ETM00] 13 million bookings have been conducted online in 1999 and tourism therefore is the biggest online business in Europe in terms of turnover. Jupiter Communications states that online travel booking will be worth 25.2 billion by 2003 (http://www.nua.net/surveys/). That is, online booking of tourist services has become the most popular and revenue generating transaction in the digital economy.

4.2 Industry Participants

The travel and tourism industry can be seen as an umbrella industry, containing a set of interrelated businesses, involving travel companies, accommodation facilities, catering enterprises, tour operators, travel agents, providers of recreation and leisure facilities. We distinguish between suppliers, consumer and intermediaries. On the supplier side we find primary suppliers and airlines. Among the intermediaries one can find a large variety of services including tour operators, travel agents, and computerized reservation systems (CRS) (see [WeKl99] for a more detailed description).

The *primary suppliers* produce the basic tourism products such as accommodation, catering, or entertainment. Accommodation facilities are the largest group of these. In 1995 12.3 million rooms existed worldwide, including those in hotel

chains. The enterprises are mostly small and medium sized. For example, within the European Union in the "HoReCa" sector (covering hotels and other accommodation, restaurants, canteens and catering) 95.5% of the enterprises are very small (1-9 employees). Travel agents act as a distributor, broker or retailer on behalf of the suppliers, their main contact with the supply side is the tour operator.

CRS have been developed in the 1960's, acting today as the main electronic interface on the travel and tourism market. They act as a switch between suppliers and intermediaries on one side and travel agents on the other side. As the result of a permanent concentration process four major systems, namely Amadeus, Galileo, Sabre and Worldspan have evolved. CRS focus on large hotel chains, which are in fact only a small proportion of the overall number of accommodation facilities. The Internet offers new opportunities for intermediaries. Several Internet-based online reservation systems provide access to services of existing CRS. Others build new databases with small- and medium-sized accommodation providers which have not been part of established CRS so far.

The offerings that can be found nowadays in online reservation systems comprise fixed prices. Although the suggested consumer benefit of lower prices on the Internet may seem intuitively realistic, it is becoming increasingly evident that getting a good travel deal on the Internet is by no means an easy task. The results of two studies done by Anckar and Walden [AnWa00a; AnWa00b] indicated (i) huge variations in price in self-bookings even among highly experienced Internet users; and (ii) online bookers being unlikely to compete on price with physical travel agents. Hence, it seems to be the case that people using the web are not always getting the best deal partly because special fares with restrictions are not always advertised online, and partly because this would require some basic knowledge about the pricing principles of the travel industry and the strategies travel agents use to get a low fare. Therefore, if a tourist contacts them directly hoteliers and accommodation providers are often willing to go way below their list prices, simply to generate additional revenue. Multi-attribute auctions can be one possibility to enable more dynamic ways of pricing goods and services in this industry.

5 The BidTaker Auction Market

Together with TIScover (http://www.tiscover.com), a leading European online reservation and destination management system, the Information Systems department of the Vienna University of Economics and Business Administration has designed and implemented BidTaker, a prototypical multi-attribute auction market for the tourism industry. To our knowledge, BidTaker is the first real-world implementation of multi-attribute auctions. Multi-attribute reverse auctions allow tourists to define their preferences on all relevant attributes. Then accommodation

providers submit their bids, which will be ranked according to the customer's preferences. This solution has advantages for both, customers and suppliers:

- For customers it leads to time-savings. In the traditional model they have to call numerous suppliers in order to find out whether the offers correspond to their preferences. This means they have to communicate their preferences over and over again. On the BidTaker marketplace customers define their preferences once and a few days later they can choose form a ranked list of tailor-made bids.
- For accommodation providers a multi-attribute auction marketplace allows to customise offerings to the individual needs of a certain customer. The anonoymity of the marketplace enables them to differentiate among customers based on their actual capacity.

In the following, we will provide a brief overview of the prototype.

5.1 Software Implementation

BidTaker is a web application [Kass00] implemented entirely in Java based on an Oracle 8i database. The software supports multiple languages and currencies and is highly flexible, in that it can easily be customized for different application domains.

The BidTaker solution utilises a combination of flexible applications designed to support the process of finding the right accommodation. In a first step, accommodation providers have to register with BidTaker over the web. Then the tourist specifies her preferences in a multi-step web form. A tourist's reservation for a certain accommodation is a complex decision involving multiple attributes such as

- check in dates,
- destination,
- accommodation,
- amenities, and
- price.

For all of these attributes a customer can choose or determine acceptable values and determine her preferences for these values (see for example how customers can define multiple acceptable check in dates in Figure 1).

In a final step, the customer determines, how important the individual attributes are to him. Then the BidTaker application selects a number of matching accommodation providers from the database who satisfy the basic requirements and informs them via e-mail about the new request for bids. Now accommodation providers can select from a list of requests and submit appropriate bids. The bidders

see the preferences of the buyers and improve their bids in multiple attributes, namely dates, board and price. All other attributes such as area, or type of accommodation can be taken from their profile in the database. Bidders can also determine the score, a certain bid would achieve based on the preferences of a certain tourist (see Figure 2).

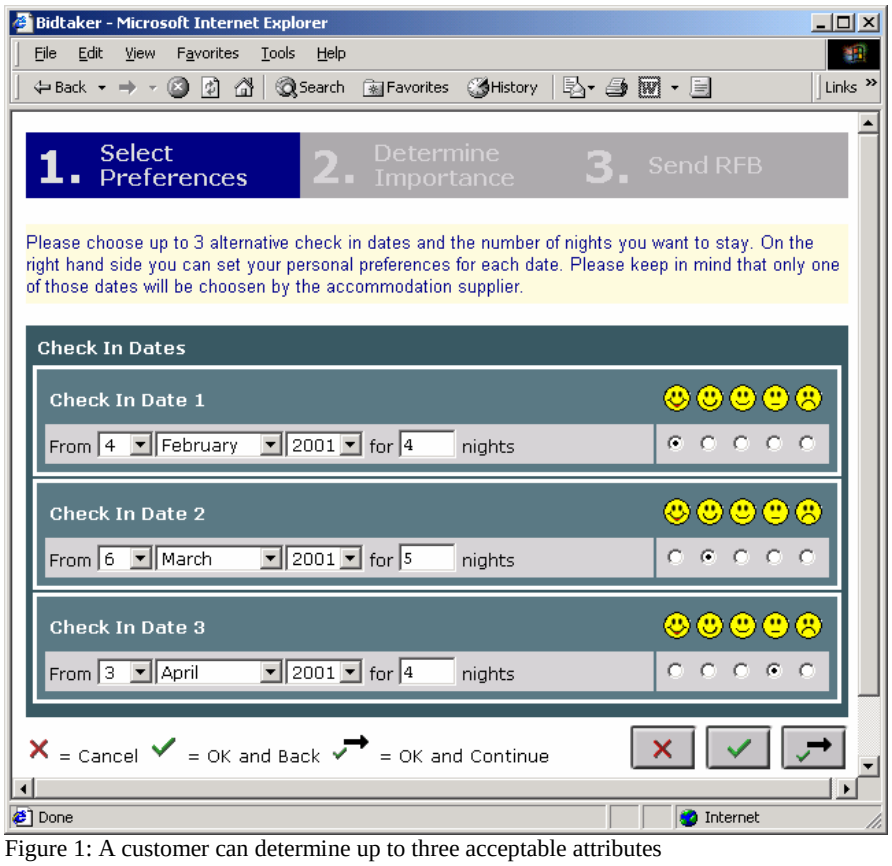

Figure 1: A customer can determine up to three acceptable attributes

Currently there are two modes of bidding – an open-cry format where the bidders know the highest score and a sealed-bid format, where no information about other bidders' bids is revealed.

After the auction expires, the customers get an e-mail and can access a list of bids ordered by score. Customers can get additional information by looking at the pictures provided or clicking on the individual homepages and book immediately (see Figure 3).

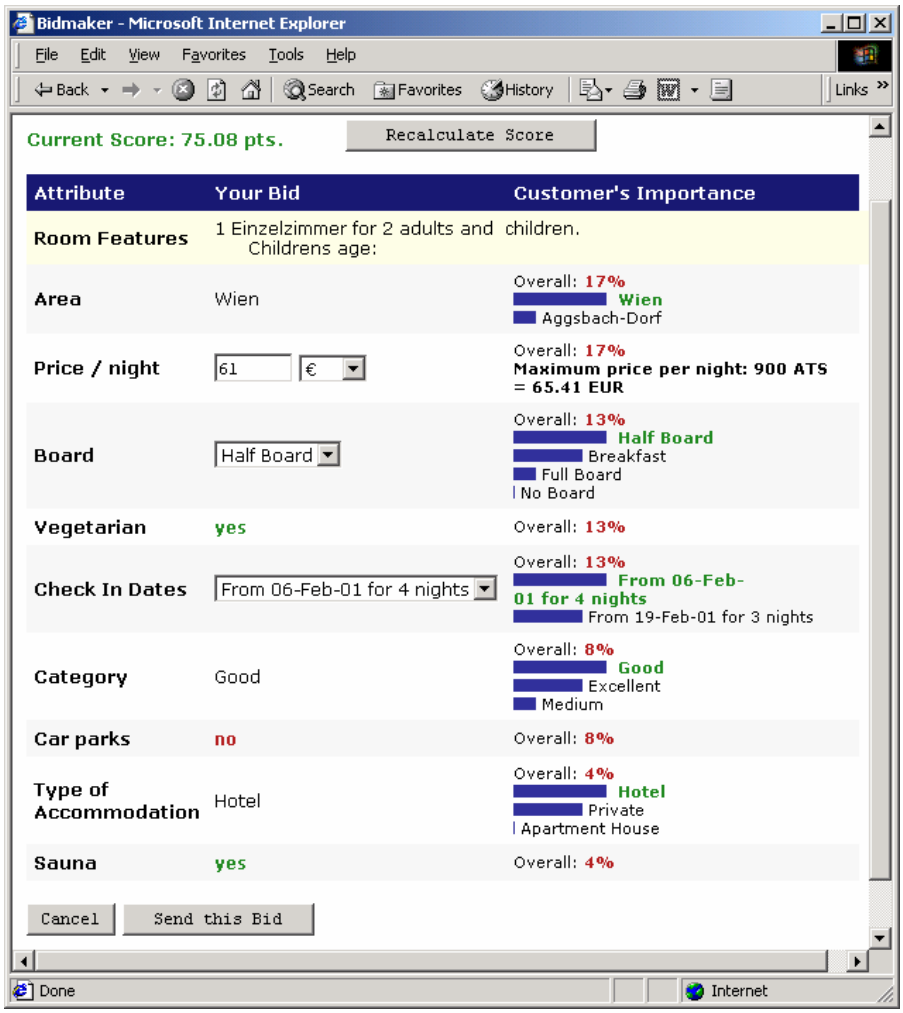

Figure 2: Accommodation providers can bid on multiple attributes

The tourism domain has a number of particularities a system designer needs to consider. As already mentioned, not all relevant attributes can be considered in the scoring function. The look and feel of the hotel or the hotel rooms might be very relevant to the decision of a buyer, but it is not considered in the scoring function. Therefore, we provide links to the individual homepages in the final list of bids.

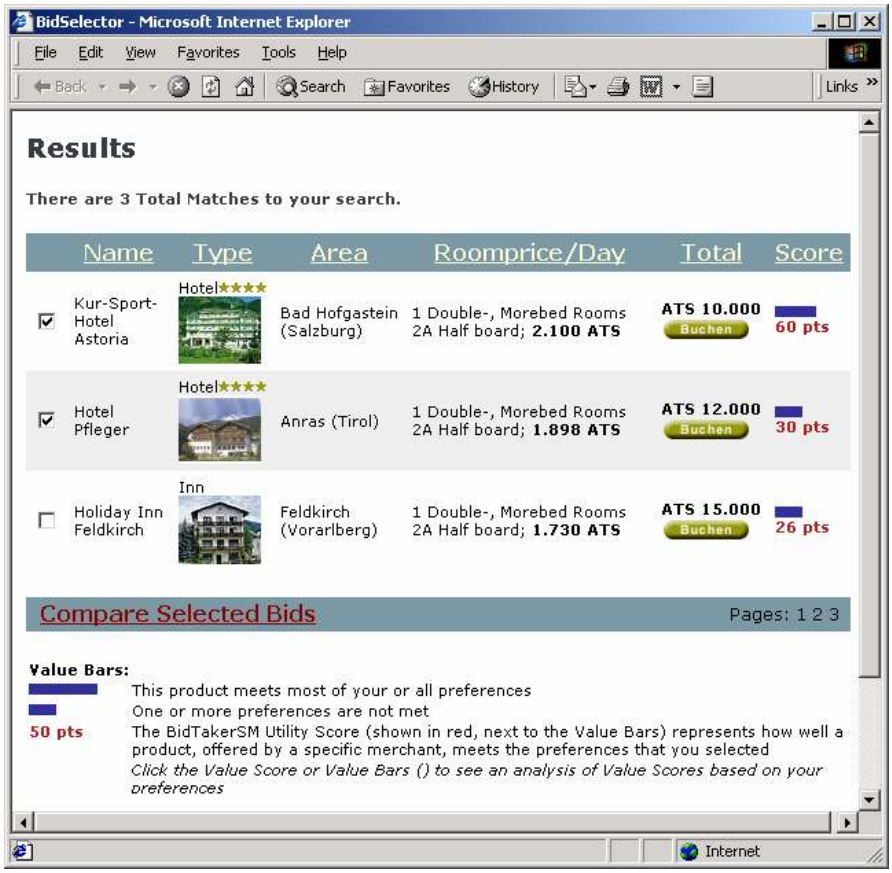

Figure 3: Selection of bids by the customer

Nevertheless, the ranking according to the customers' preferences for check in date, area, type of accommodation, amenities, and price is a good decision aid for the tourist. It also needs to be analyzed, how well customers know their preferences. Currently, we provide a tool for them to re-adjust the weights after the bidding if they do not feel comfortable with the ranking of bids. We plan to investigate this issue in more detail in the future.

6 Conclusions and Future Research

The design of electronic markets is a challenging task as it has the potential to change existing business models. In our previous research we have analyzed multi-attribute auctions in general using laboratory experiments and computer

simulations. In this paper we have described the application of multi-attribute auction mechanisms in a tourism marketplace.

We think, that multi-attribute auctions can be an important contribution in this industry. The process of bilateral negotiations with several accommodation providers is time-consuming and cumbersome. Multi-attribute auctions release the customer from having to communicate her preferences several times. Moreover, it provides a tool to automatically evaluate the bids. Most important, the customer can have the accommodation providers compete against each other in an open-cry manner. Accommodation providers in this market on the other hand do not have to compete on the price alone. They can bring in their strengths (e.g. location, type of accommodation, amenities) and have a better grasp of what their customers really want. In general this can lead to more transparency in the market.

During the next few months we plan to collect and evaluate transaction data from this tourism marketplace. Methods from econometrics will play a pivotal role in determining and fine-tuning relevant parameters such as the optimal length of an auction period or the optimal number of items in a multi-unit auction. This will be highly valuable for a further understanding of multi-attribute auctions.

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