RESEARCH

Abstract
Interactive pricing, the subset of dynamic pricing where buyers and sellers enter a computer mediated price-negotiation process, has stimulated academic interest ever since the introduction of Internet-related B2C and B2B applications. However, this has not yet led to the widespread use of standardized interactive pricing mechanisms within industrial applications. A recent study suggests that applicants expect the integration of interactive pricing mechanisms into existing IT infrastructure to be very costly due to high customization efforts. The standardization of interactive pricing should thus be a first step towards enabling a wider use of these mechanisms. Building on the classification of the range of dynamic pricing methods, we analyze existing business standards that should be capable of describing interactive pricing mechanisms. Our analysis reveals the shortcomings of recent business standards which therefore require the development of an enhanced model for interactive pricing applications. Addressing this issue we propose a model that integrates a price communication language with a process description format for the customization of interactive pricing mechanisms. The paper concludes with three case studies illustrating the use of our model.

Keywords: interactive pricing, dynamic pricing, electronic business, procurement, XML standards

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INTRODUCTION
Interactive pricing is one of the most crucial economic activities where sellers and buyers engage in bargaining about the exchange of services and goods at a price level that both buyers and sellers accept (Bakos 1998). Due to the rise of the Internet and computer-aided trading processes, this activity has undergone drastic changes over the past few years. Reduction of processing costs associated with price differentiation, lower menu costs and new possible methods of interacting with trading partners online have enabled a plethora of dynamic pricing mechanisms.

In the context of this paper we define interactive pricing as the subset of dynamic pricing where buyers can actively influence the final price of a product or service by exchanging messages (i.e. bids) with a seller. Since interactive pricing is able to charge different buyers different prices for identical products, it allows sellers to price-discriminate, which could result in higher returns for the sellers (Varian 1996). Yet buyers can profit from interactive pricing, too. Priced-out of the market in a static price scenario, some buyer segments could be served at lower prices by interactive pricing (Bakos 1998). However, interactive pricing is not easy to implement due to the high intensity of communication required. As it gives rise to additional administrative costs, the necessity of enabling communication between negotiation partners could reduce the benefits of such pricing methods (Reinartz 2001).

The use of interactive pricing mechanisms is a common feature on multiple online marketplaces such as eBay (http://www.ebay.com) or Amazon (http://www.amazon.com/auctions). Despite the sales and revenue potential of
interactive pricing, static prices remain the most established pricing model in business and industry, as a large-scale survey among German companies reveals. While many companies acknowledge its potential, costly integration into existing IT and organizational infrastructure remains a persistent obstacle to the large-scale use of interactive pricing functionality (Sackmann and Strüker 2005).

The literature considers standardization a key driver for the development of new functionality since it is able to crucially reduce process and integration costs, especially for small and medium-sized companies (Beck and Weitzel 2005, Stockheim et al. 2006b). In order to describe interactive pricing mechanisms a standardized language is helpful for different reasons: First, a standard can help one to design interactive pricing mechanisms by offering a toolset of standardized processes and design variables. Further, the initiator (usually a seller, but in the case of a reverse auction also possibly a buyer) may design e.g. an auction with different design variables and store it for later use. A standardized description could then be handed over to an intermediary (e.g., an electronic marketplace) with the mandate to conduct the auction in the intended way. Finally, a standardized description could be communicated to potential bidders, announcing the rules for the interactive pricing mechanism. This could prevent misinterpretations and make a computer-aided protocol possible, thereby dramatically reducing the administrative costs of interactive pricing.

Considering both the advantages of interactive pricing mechanisms and the need for standardization in order to enable their wider use even for small and medium-sized companies, the aim of our paper is twofold: First, we identify the gap between findings in academia and the e-Business standards used by practitioners. Second, we provide a model based on the work of Wurman et al. (2002) for the standardization of interactive pricing mechanisms in e-Business to overcome these shortcomings. Compared to alternative approaches that categorize electronic negotiation and pricing processes, like the ‘Montreal Taxonomy’ of Bichler et al. (2003) and Ströbel and Weinhardt (2003), our model is closer to the technical implementation level. It is especially targeted for a direct translation into XML and thus makes standardized use in different XML-frameworks possible. In fact our model does not provide such a wide definition of attributes and aspects of negotiation mechanisms as the ‘Montreal Taxonomy’ does; however this is not relevant for the industrial application of interactive pricing, because we only omit attributes that can hardly be represented in an automated negotiation process, like e.g. social norms or cultural differences. Compared to Wurman et al.’s model (2002) however, our model supports a wide range of interactive pricing mechanisms that have not yet been standardized. Additionally, we leave the model open to further extensions to foster an advancement of the system in practice.

The remainder of this paper is organized as follows: We first motivate this work by synthesizing efforts made by academia to categorize pricing and negotiating processes in line with the aims of e-Business standards. As we detect that existing e-Business standards are inadequate, we then develop a model that closes the gap between research and business practice. As proof of our concept we apply the model and demonstrate its use in three complex interactive pricing mechanisms: reverse pricing, combinatorial auctions and the second-price auction Google AdWords. The final section concludes the paper with remarks and suggestions for further elaboration of our model in the context of industrial standardization efforts.

**INTERACTIVE PRICING – THEORY AND PRACTICE**

Pricing mechanisms can mainly be classified into static pricing (i.e. prices can only be changed by the seller in the long-term following market fluctuations), and dynamic prices (prices are changed in the short-term). In our context, dynamic pricing denotes a flexible price setting process with respect to market dynamics (supply and demand fluctuations), sectoral price discrimination according to the willingness-to-pay (W2P) of the individual consumer (consumer group), inter-temporal price discrimination as well as the capacity and inventory conditions of the sellers’ facilities. Dynamic pricing results either from an interactive pricing process (interactive pricing) or a short term price setting process triggered by sellers depending on observed consumer behaviour (dynamic posted pricing) (Kauffman and Wang 2001). Interactive pricing can thus be regarded as a special case of dynamic pricing (Elmaghraby and Keskinocak 2003).

Over the past few years dynamic pricing has become increasingly important. Elmaghraby and Keskinocak (2003) provide three reasons for this phenomenon:

- the increased availability of demand data;
- the case of changing prices due to new technologies; and
- the availability of decision support tools for analyzing demand data for dynamic pricing.

Interactive pricing in particular has recently become important as a subset of dynamic pricing. Due to the reduction of processing costs associated with price differentiation and new methods of interaction with trading partners, a steadily increasing number of negotiated prices can be seen in Electronic Commerce (Stroebel 2000). The growing use of online auctions as the most widely used form of interactive pricing mechanisms (Bichler 2000) manifests this trend. Table I outlines the different types of dynamic pricing.
<table>
<thead>
<tr>
<th>Criteria</th>
<th>Seller-buyer interaction</th>
<th>Description of the pricing mechanism</th>
<th>Response to market, processing time and cost</th>
<th>Allocation and pricing efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic Pricing Mechanism</td>
<td>Negotiation-Based Pricing (NBP)</td>
<td>1 : 1 (1 : n) (n : 1) Bilateral negotiations lead to exchange of contracts based on individually bargained prices. Multiple parties can be involved with alternating partners.</td>
<td>Dynamics depend on repetition frequency and possibility of renegotiation. Processing time and pricing costs are usually high.</td>
<td>Efficiency corresponds to parties’ negotiation talent and bargaining position of the parties.</td>
</tr>
<tr>
<td>Reverse Pricing (RP)</td>
<td>1 : 1 Consumer places a bid (typically below his W2P). Seller accepts bid if threshold price is outbid. Threshold price is unknown to buyers.</td>
<td>Dynamics depend on the threshold price setting and the consumers’ reaction. Low processing time and cost due to simplicity.</td>
<td>Exploits the individual W2P of the consumers. Due to the invisibility of the threshold price, inequality is not perceived.</td>
<td></td>
</tr>
<tr>
<td>Auctions</td>
<td>1 : n n : 1 n : n Interactively determines the price and allocation of goods and services based on bids according to predefined rules.</td>
<td>Dynamics depend on the iteration rate and are low for continuous auctions. Pricing time and costs are up to the auction setup.</td>
<td>Allocation and pricing efficiency vary with mechanism design. Mechanism design literature discusses this topic in detail.</td>
<td></td>
</tr>
<tr>
<td>Dynamic Posted Pricing (DPP)</td>
<td>1 : 1 Differentiates prices according to a classification of the buyers according to their W2P.</td>
<td>Dynamics depend on the sellers’ learning rate for the consumers’ reaction function. Low pricing time if ANPs are used.</td>
<td>Exploits individual W2P leading to higher returns. Perceived inequality can cause consumer disaffection.</td>
<td></td>
</tr>
<tr>
<td>Yield Management (YM)</td>
<td>1 : n YM price differentiation follows a fixed scheme. YM uses consumer self-selection related to service level and timing conditions</td>
<td>Dynamics strongly relate to the W2P learning rate and the quality of the YM model. Costs are in mid-range due to mature YMs.</td>
<td>Targets high revenues and achieves satisfying allocation if pricing classes and contingents are appropriate.</td>
<td></td>
</tr>
</tbody>
</table>
Since the approaches we have found in the research suffer from several shortcomings, we want to address this with our model for interactive pricing. Taxonomies like the ‘Montreal Taxonomy’ focus on a broad abstract categorization of negotiation processes including exogenous rules, but do not allow translation directly into an XML vocabulary. At the same time, descriptive models for interactive pricing in the literature focus solely on common auction mechanisms. Wurman et al. (2001, 2002) are the first to present a parameterization of the Auction Design Space for the AuctionBot and show that this parameterization can easily be translated into XML by providing an adequate XSD. Lochner and Wellman (2004) present an advance on the AuctionBot parameterization that is capable of dynamically reacting to events in the course of the auction process by using the rule-based language AB3D.

The Descriptive Auction Language (DAL) proposed by Rolli et al. (2006) also takes on the direction of a dynamic language while extending the parameterization space of the aforementioned approaches. DAL follows the notions of a separate Auction Reference Model (ARM) that provides the foundations for structuring auction mechanisms (Rolli and Eberhart 2005).

Our interactive pricing model is based directly on the idea of Wurman et al. (2001, 2002) but incorporates a wider range of pricing mechanisms at the cost of omitting those exogenous rules suggested by the ‘Montreal Taxonomy’ that can not be described in an XML vocabulary as already mentioned above. Since the primary goal is to provide a standardized set of rules for interactive pricing in the first stage of our model proposal, we do not introduce dynamics into our language. Figure 1 depicts the differences between our model and the academic approaches already discussed. The x-axis depicts the increasing complexity and level of abstraction of the different interactive pricing frameworks in multi-attribute aspects of negotiations. Our model provides a high level of standardization (y-axis) like the ‘Auction Design Space’ of Wurman et al. and supports a plurality of pricing mechanisms (z-axis) which is also addressed by the ‘Montreal Taxonomy’.

Although more and more products are sold through interactive pricing, standardization seems unable to keep pace with this fast development. In the following section we examine widely used e-Business standards in terms of their ability to model interactive pricing. This evaluation is mandatory to determine the gap between needs and potential of e-Business standards.

In the late nineties various initiatives to identify common workflows in the area of B2B and to work out semantics to describe these workflows were started. Some of these initiatives focus on a particular target group, whereas others are suitable for a broader audience. Therefore, the standards are not only substitutes but can be used complementarily (e.g. as is the case for the ebXML Framework and the Universal Business Language). Due to their diverse focus, the standards can be broken down into three major categories: Frameworks, functions and verticals.

Frameworks provide specifications for structuring XML messages between parties for exchange within and among industries and probably receive the most public attention (Kotok 2000). They are not restricted to semantic declarations, but provide methods for the entire communication process, enabling intersectoral document exchange flow. An impressive number of frameworks have emerged, some of which are BizTalk, eCo, Open Applications Group (OAGIS), Electronic Business XML (ebXML), Commerce XML (cXML) and RosettaNet.

Functions can be used as a pattern for a specific business process that crosses industry boundaries. The class of functions includes the Common Business Library (xCBL), Guideline XML (gXML), Information and Content Exchange (ICE) Protocol, Universal Business Language (UBL) and XML/EDI Repositories.

Verticals are used for standardization within an industry or within a holistic value chain. Many industries have created their own standard covering their specific needs which has led to a plethora of conflicting or overlapping specifications.

Since it has the nature of a business vocabulary, the process of interactive pricing should be encapsulated in a function or vertical. However, some of the frameworks also include more detailed descriptions of business processes. For example RosettaNet’s latest version 2.0 of PIP3A2 (Rosetta.org 2007) considers dynamic posted prices, while interactive pricing has not yet been specified. Normally, frameworks like the BizTalk Framework are purely specifications for document exchange flow and thus focus on very basic information structuring and on transmission mechanisms. The description of superordinate business transactions is usually omitted by frameworks.

Figure 1. The model for interactive pricing in contrast to related frameworks.
The eCo Framework project started by CommerceNet in 1998 with Commerce One as primary corporate sponsor can be split up into an architectural specification and a semantic specification. The architectural specification separates different functions like market, interaction and services into layers. In contrast, the semantic specification provides a sample set of business documents that can be used in the eCo Framework. The recommendation (eCo 2007) only makes use of static prices. Similarly, cXML (commerce eXtensible Markup Language) developed by leading e-Business-companies like Ariba and Sterling Commerce, is a plain XML standard aiming to cover a wide range of business processes. Therefore, the degree of detail is rather low. Prices are defined as price per unit on a product level and can be summed up on a higher level (cXML.org 2007).

The United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT) as expert for standardization and the Organization for the Advancement of Structured Information Standards (OASIS) as expert for XML-specifications started the standardization project ebXML (Electronic Business XML) in 1999, aimed to create a single global electronic market (OASIS 2007a). The aim of ebXML is to model processes, describe the exchange of documents and specify the basic components of business documents. The pricing model has not yet been determined but examples make use of very simple pricing models (OASIS 2002). OASIS has recently started to promote the function vocabulary UBL to extend ebXML with XML documents describing common business transactions.

Although UBL can be used within the ebXML Framework, it can be applied uncoupled from ebXML and, vice versa, ebXML does not rely on the vocabulary of UBL. The function vocabulary has been created as an exchange format for distinct e-Business-Frameworks, since vertical industries have created their own XML standard. UBL contains a sophisticated pricing model so as to implement a high level of inherent flexibility. Nevertheless, this function vocabulary assumes what is called a BasePrice and does not make it possible to describe the price as result of an interactive process (OASIS 2007b).

The latest version of xCBL (XML Common Business Library) (4.0) offers attributes for describing the pricing scheme, thus allowing prices to be differentiated based on time or transaction currency. Furthermore, different types of prices can be specified, such as StandardPrice, PromotionalPrice, DiscountPrice, and prices depending on quantity scales (xCBL.org 2007).

Our survey reveals that all these e-Business standards are based on static prices and that some of the more sophisticated standards allow one to describe dynamic posted prices. Prices can then be modified using multipliers depending on order amount, sales channel or billing currency. Hence, second and third degree price discrimination can be modelled.

Table 2 presents the pricing capabilities of the business standards examined, based on the following criteria:

- Relative: Relative price changes by multiplication or division.
- Conditional: Dynamic posted prices driven by segmentation, e.g. transaction currency, country, order amount, sales channel, or validity period.
- Interactive: Specification of interactive pricing mechanisms.

Kelkar et al. (2002) give a more detailed insight into pricing models in different catalogue standards and provide a generalized model which does not include interactive pricing. For a more detailed comparison of frameworks see Dogac and Cingil (2001). Meanwhile, most frameworks have been improved but have not usually undergone a significant change in focus. Nevertheless, nowadays neither the frameworks nor the functions support interactive pricing, which suggests that standardization has failed to include this important feature for contemporary trading processes. The large-scale use of interactive pricing mechanisms is therefore not yet encouraged by existing business standards.

Table 2. Evaluation of business standards based on pricing capabilities

<table>
<thead>
<tr>
<th>Business Standard</th>
<th>Initiator</th>
<th>Version</th>
<th>Relative</th>
<th>Conditional</th>
<th>Interactive</th>
</tr>
</thead>
<tbody>
<tr>
<td>cXML</td>
<td>Ariba and others</td>
<td>1.2</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>ebXML</td>
<td>OASIS</td>
<td>2.0</td>
<td>not def.</td>
<td>not def.</td>
<td>–</td>
</tr>
<tr>
<td>RosettaNet</td>
<td>RosettaNet</td>
<td>modular</td>
<td>+</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>eCo</td>
<td>CommerceNet</td>
<td>modular</td>
<td>+</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>xCBL</td>
<td>Commerce One, SAP and others</td>
<td>4.0</td>
<td>–</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>UBL</td>
<td>OASIS</td>
<td>2.0</td>
<td>+</td>
<td>+</td>
<td>–</td>
</tr>
</tbody>
</table>
A MODEL FOR INTERACTIVE PRICING

This section provides an overview of the properties that define an interactive pricing mechanism. Due to our focus on electronic pricing, we only consider automated systems based on Internet technology. One field related to such a classification is mechanism design, where an enormous amount of research has been conducted for many years (Bajari and Hortacsu 2004, Bichler et al. 2003, Kannan and Kopalle 2001, Pinker et al. 2003, Stroebel and Weinhardt 2003). However, insights gained in academia are rarely used in applied e-Commerce or e-Business since practitioners often focus on simplicity when designing pricing mechanisms.

To compare different mechanisms, a systematic classification using their attributes is mandatory (Bichler et al. 2003). Figure 2 provides an overview of attributes and categories of attributes that are relevant for interactive pricing mechanisms. Besides the primary objective of classification, it can also be used within a modelling tool or as a framework for a description language, e.g. XML. The ‘Montreal Taxonomy’, which tries to accomplish similar objectives to those of the approach presented, distinguishes between exogenous and endogenous, as well as explicit and implicit classification criteria (Ströbel and Weinhardt 2003: 149) and focuses on the explicit endogenous rules of the mechanisms. Our model, presented in Figure 2, combines attributes from the ‘Montreal Taxonomy’ as well as the work of Wurman et al. (2001, 2002) and focuses on the explicit, endogenous criteria. Four basic feature groups are identified: participation, bidding, clearing, and information policy. These policies contain the rules that define the mechanism. While dashed lines

Figure 2. Interactive pricing design space
indicate optional categories in Figure 2, the rules of most categories can be combined. The contents of the categories and subcategories are detailed in the next subsections.

Participation policy

The participation policy restricts which roles are given to how many participants in an interactive pricing process. The first two categories are buyer cardinality and seller cardinality, which classify the number of participants on the demand and the supply side. The simplest form is a cardinality of one, which occurs in one-to-one price negotiations on both sides and in classical auctions on the one side, e.g. in the English Auction on the seller side. If the admission of participants is restricted to a specific group of persons or organizations, the setting is labelled as closed. By contrast, if in general each agent is allowed to participate in the auction or negotiation, it is open with respect to buyers and/or sellers. A classical English Auction would therefore be called one-to-many (open) or one-to-many (closed) depending on whether the group of participants is restricted or not. Moreover, in exchanges (or double-auctions) that usually have a many-to-many cardinality participants may be restricted to being disjoint, i.e. either a seller or a buyer.

In addition to the direct implication of possible bidder-fluctuations in the negotiation process, the cardinality of buyers and sellers reveals whether the supply or demand is fixed or not, i.e. when participating in a one-to-many auction the bidder knows the available items ex-ante. Furthermore, the effort to monitor the market’s participants, which increases the chance of successful participation, increases with the number of participants.

Most of these systems require the existence of an intermediary or, more technically, a server to ensure that the process is in compliance with rules arranged ex-ante. If the pricing mechanism is an auction, the intermediary has the role of the auctioneer and sends imperative messages to the bidders. Furthermore, an intermediary can act as a trusted third party and suggest solutions to the price negotiating agents. A complete decentralization of such an interactive pricing process is possible, i.e. up to a degree where no more central instances are required.

Bidding policy

The bidding policy defines the bidders’ and sellers’ space for bargaining actions with respect to the pricing process. Expressiveness defines the bidding language. The aim of the bidding language is to express a function of the bidders’ W2P in a structured way (Nisan 2006). In the most simple form, these are unit prices (for a quantity of one item), which can then be summarized under the class of price-quantity schedules. A price-quantity schedule is a stepwise specification of various quantities, and according to the level of prices a bidder offers to buy or sell. Alternatively, the bidders’ W2P could be expressed by continuous price functions, which can simplify the bid structure in contrast to price-quantity schedules. In the case of infinitely divisible goods, e.g. fluids or bidding on using resources within continuous time windows, continuous price functions may be obligatory. Combinatorial expressions are a powerful means to express causalities in bids, whereas the impact of combinatorial bids (or bundle bids) on the complexity of the mechanism depends on the number of dependencies that exist between the items (usually expressed as super- or subadditivity – see Case 2). The trade-off between the expressive power of the bids and the resulting computational complexity of the allocation problem can be reduced by allowing additional bid constraints, e.g. capacity limitations in transportation scenarios or providing a list of prices to choose from rather than letting bidders freely decide upon a price they want to bid. Ströbel and Weinhardt (2003) present an overview of possible parameters that might be used to reduce the complexity of bids. However, a complete enumeration of possible restrictions is impossible.

To enforce certain properties of the message flow within the mechanism, additional rules are often added to a negotiation scheme. The following list gives typical examples of rules that further limit the bidders’ choices.

- Some auctions utilize the characteristics of sessions and rounds. In this case a rule based bidding policy is used (round-based rules). Often this is used to reduce strategic behaviour, e.g. by forcing a participant to bid or get out of the auction.
- Rules that restrict a new bid based on previously placed bids are called dominance rules. Generally, there are two kinds of such rules: ascending rules require that new bids are higher while descending rules require new bids to be lower than previous bids. This statement increases in complexity when quantity-price tuples or multi-dimensional auctions (including combinatorial auctions) are considered. The bid that is replaced could be the highest actual bid (English auction) or the bidder’s active bid. Moreover, such rules allow the enforcement of minimal bid increments (or decrements) in interactive pricing schemes.
- While dominance rules refer to previous bids, some auction schemes require a bidder to increase the price above a certain minimum (possibly composed of atomic item prices). Following Wurman et al. (2002) a classification named beat-the-quote is introduced to represent such a condition. In the context of multi-dimensional auctions the calculation of atomic prices surpasses the optimal allocation problem in terms of
complexity, i.e. it could be impossible. To overcome this obstacle, shadow prices of the underlying problem are often used as price quotes for the bids’ components and provide an indication of the prices the bidders have to beat (Stockheim et al. 2006a).

- **Activity rules** allow the reduction of strategic bidding in multi-item auctions. Activity rules describe rules defining when a bidder can be active and submit new bids or change bids. The rules can be used by the auctioneer to control strategic bidding behaviour (Kwasnica et al. 2005). They are applicable to most kinds of interactive pricing mechanisms.

- A similar strategic behaviour could be systematic overbidding and withdrawal of bids. To avoid such patterns **withdrawal rules** can be used. An alternative to withdrawal is scheduled expiration of bids. The time of expiration typically has to be specified at bid time. This category comprises indicative offers like those mentioned in the ‘Montreal Taxonomy’ (Ströbel and Weinhardt 2003).

### Clearing policy

The clearing **policy** describes when and how an exchange of goods, services and money is initialized. The deals resulting from the clearing process are determined by the **matching function**. Immediately after the clearing no mutually profitable exchanges should be possible among the remaining bids. Moreover, it is often required that the allocation be locally efficient, meaning that it maximizes welfare as represented by the bids. The matching function depends on various external factors and is closely related to the bidding rules of the negotiation. Focusing on the observable properties of these mechanisms, we propose the following categorization of this category:

- Deals resulting from matching are coupled to prices. The simplest form of **pricing** in an auction is *pay-as-you-bid*, i.e. in an exchange the buyer pays the amount of money specified in the winning bid. Other forms of pricing like *second-price* are also commonly applied. This kind of pricing belongs to the **individual pricing** category, where identical items can have different prices (even to the same bidder). Whereas if items or bundles with identical properties have identical prices, this pricing is called *anonymous pricing*. For such cases quantity discounts are still feasible. Finally, *linear pricing* represents a simpler type with prices calculated for atomic items. With this attribute set each item is sold at the same price.

- Matching functions may include **side payments** to increase bidders’ incentive to express their W2P, to decrease the bidders’ incentive to cheat, to form coalitions or to implement some idea of ‘fairness’ in the mechanism. The calculation of side payments is usually communicated to participants prior to the actual negotiations. Clarke Tax is a prominent example of such a mechanism (Clarke 1971). Due to the possible variety of rules for side payments they are depicted as a category in Figure 2.

- **Tie breaking** may occur when different allocations which result in the same (cumulated) outcome for the seller/buyer or more general in the same allocation quality are possible. Three common methods of solving such ties in one-dimensional auctions are: breaking the goods arbitrarily, favouring earlier bids (first come first served) or favouring bids for larger quantities. In multi-dimensional settings the problem rarely occurs (then the first solution is typically used – implicitly at random).

The **clear timing** defines the schedule of time points when the **matching function** is executed. A simple but unusual possibility is **random clearing**, meaning that the matching function is arbitrarily executed. Traditional auction mechanisms mostly trigger the clearing mechanism only once as the last step of the mechanism (on **closing**). A third possibility is **activity-based** triggers, e.g. whenever an agent makes a bid, the clearing of mechanisms that finish when no agent increases its bid within a given interval of time is classified by the clear timing attribute ‘on **closing**’. The **closing condition** is used to end the auction depending on the activities of the bidders or a pre-defined timing. In many cases the closing condition also triggers the clearing mechanism. For example, the well-known eBay auction would thus be classified as on **closing** with a fixed time as closing condition. More possible closing conditions follow in the next paragraph. Frequently used timing options are the **inactivity-based** trigger that clears the negotiation when no agent changes its bid and the **fixed-time-points** trigger, which invokes the clearing process repetitively (e.g. every minute). Combinations of the clearing time attributes are possible.

To classify a trading mechanism it is necessary to specify the event or point in time that terminates the negotiation. This trigger is called the **closing condition**. If a trading mechanism runs constantly with no predefined temporal ending, the closing condition is **never**. However, frequently used triggers close at a **fixed-time** or **fixed-round** or on **inactivity** of the bidders. For negotiations that try to reach an equilibrium price (defined by equal supply and demand at the given prices) the corresponding condition is on **match**. This category also specifies a closing that appears when a specific, externally given condition matches, e.g. a bid surpasses a threshold price.

The last part of the category **clearing policy** is the **auctioneer fees**. Although such fees are important to the user of an auction, they do not necessarily classify an auction mechanism. Nevertheless, fees that are intended to change the consumers’ bidding behaviour constitute a
part of the mechanism and should be considered in the classification. It is even possible that payments are made in the opposite direction, e.g. to unsuccessful bidders to achieve certain incentives. To cover such cases, auctioneer fees are provided in the classification. Figure 3 depicts three standard types of auctioneer fees: bid-, transaction- and entrance-fees. Splitting rules can be used to distribute fees between different parties, e.g. the seller and the auctioneer.

Information policy

Information policy defines the kind of information revealed to bidders. The information provided could influence the bidding behaviour and thus have a crucial impact on the outcome of the pricing process.

- According to Ströbel and Weinhardt (2003) electronic negotiation is anonymous if an assignment of participants to their offers is not possible and their identities are not revealed. Information regarding the identity of agents or the human/company the agent represents belongs to this category of information.
- A price quote informs a bidder of the price range of the accepted offers if the auction clears at the time the quote is issued. In other words, the price quote is a hypothetical clearing. An accurate price quote is not always available. In complex auction settings such as combinatorial auctions, the computation of the optimal allocation requires considerable amounts of time. Furthermore, it is not always possible to calculate accurate prices (Stockheim et al. 2006a).
- The quote timing can have properties identical to those of the clear timing. Additionally, in some auctions, especially online auctions, the actual quotes are always available (‘on request’).

- An order book shows the currently active bids. The auctioneer can make all bids available or choose to disclose information selectively. The usual choices are all or nothing, i.e. either publishing the complete order book or no information on previous bids at all.
- Most iterative negotiation or auction mechanisms publish historical clearing prices. These transaction histories may include prices, quantities or even the identities of the successful bidders.
- Various forms of incentive mechanisms constitute primarily information regarding the mechanism characteristics. Besides legally necessary information about fees and side payments, incentives may be increased by bonus systems. However, mechanism properties are not restricted to financial effects – the collection of status-related bonus points plays an increasingly important role in on- and offline mechanisms.

APPLICATION OF THE MODEL

The capabilities of our model will be demonstrated in the following section by explaining its functionality with three very different cases of interactive pricing: The description of a reverse pricing scenario in a B2C environment, the very prominent case of the Google AdWords-auction and a combinatorial auction for transportation logistics. Table 3 displays the properties of these mechanisms:

Case 1: Reverse pricing

Reverse pricing was first established by Priceline.com in 1998. Besides Priceline.com, several other companies like Expedia.com and Germanwings apply this new
mechanism using different design variants. Priceline allows for a single bid within seven days for one and the same product only, whereas bidders are allowed to bid repeatedly and increase their initial bid price if it has not surpassed the seller’s threshold in a multiple bidding case. Such a mechanism has recently been introduced by eBay where buyers can place up to three offers which a seller may accept or reject (see http://pages.ebay.com/bestoffer for more information). In order to reduce incremental bidding behaviour when bidders – starting at the lowest bid – increment their bids by minimum increments only, Bernhardt (2004) suggests the use of cost constraints (e.g. a fee for the option to place additional bids) or time constraints (e.g. a waiting-time between two consecutive bids), many of which have been successfully applied in practice.

Combining the descriptive approach of Bernhardt (2004) and the previously proposed model, we derive the following matching: First, reverse pricing is a negotiation between one seller and one buyer. Therefore, the cardinality is one-to-one. Bidding is done solely by stating a bid for a product and bids can be placed under certain constraints, e.g. waiting time, bidding costs. These variables are part of the expressiveness defining the bidding language. Additional rules are not necessary; however, a reasonable policy might be to require new bids always to beat the bidder’s own bids that have been previously rejected.

In the case of reverse pricing, the clearing policy is composed of the following rules: Pricing is done on an individual level and the process ends when a fixed number of rounds (number of bids possible) is reached or when a certain condition is fulfilled (on-match): in this case, when the bid surpasses the secret threshold. The clearing is invoked on closing. It is also possible to use the auctioneer fees to settle the bidding costs generated and split them up using a splitting policy specified beforehand. Finally, the information policy consists of the rule that the price quote equals the buyer’s bid (= pay-as-you-bid) and this quote is ‘calculated’ on-closing. An order book is irrelevant in the case of reverse pricing, whereas the transaction history consists of the bidder’s previously rejected bids. Identities and price quotes are never published since reverse pricing is based on intransparency.

The classification depicted in Figure 3 can be easily translated into XML. As proof-of-concept, we implemented a Web Service allowing the automated insertion of new offers using the specified XML dialect on an existing reverse pricing platform.

Figure 3 illustrates a Windows application that invokes this Web Service which sends the XML document containing product data and the interactive pricing information based on our model. The Web Service decomposes these two parts and creates an offer which is displayed on the offer list. As can be seen in the right side of Figure 3, the product is then ready to be purchased by bidders who place bids in conformance with the constraints defined by the XML document on the marketplace. The ellipse marks the bid constraints in the XML document and the corresponding information that is presented to bidders on the marketplace.

**Case 2: Google AdWords-auction**

Search engine marketing (SEM) with expenditures of 710 million € in Germany in 2006 is one of the fastest
growing services in online marketing. SEM is also called paid search and works as follows: A consumer types a keyword, e.g. ‘laptop’, into a search engine and receives two types of results: One part with unsponsored search results which a search algorithm determines and the second part with sponsored search results. Clicking on one of the sponsored search results leads the consumer to the advertising company’s landing page, which provides further information and an opportunity to buy or register. At the same time the search engine charges the advertiser for the click. The price per click is a result of a keyword auction, by which search engine providers sell their advertising space. The bids in such auctions determine not only the price per click but also the rank (or position) of the ads in the sponsored links area (Kitts and Leblanc 2004; Varian 2006). Higher bids result in more attractive positions in the sponsored links area. However, the position of the ad in the sponsored links area is also determined by so-called quality scores.

The specific calculations for such scores are kept secret, but are essentially determined by the keyword’s historical click through rate. Additionally, Google uses some stochastic elements to change the position of the ad dynamically making it hard to evaluate precisely the influence of the price on the final position of the ad.

However, we focus on the Google AdWords-auction and not on the exact algorithm for the position. The auction is an auction with one seller (Google) selling ad spaces to many buyers (advertising companies), so the cardinality is one-to-many. Google is selling as well as conducting the auction, and so the results of the auction are clearly imperative.

There are some bid constraints in Google’s bidding policy, e.g. there is a minimum price. The auction is never closing and winners are dynamically determined after activity, i.e. a new bid has been received. The price of the second winner determines the price that has to been paid for a click-through by the winner, so the pricing is set to second price. The rules for tie-breaking have not been publicly reported yet and are hard to determine due to the stochastic element in the positioning.

Google pursues a very restrictive strategy in terms of information: Identities of the bidders stay unrevealed and price quotes are never published, though the identities of other bidders can be the subject of speculations.

We use the case of the Google AdWords-auction to demonstrate how our framework can be used to structure a prominent case of interactive pricing. However, we do not claim that Google used our framework. Cases 1 and 3 though made use of our concept and developed a detailed XML dialect based on the framework presented.

Case 3: Combinatorial auctions

Combinatorial auctions (CAs) allow bidders to formulate bids that comprise combinations of services or goods. Bidders can express their W2P for each bundle by placing a bid on an available combination of single items. The valuation of the bundle can be subadditive, indicating that the bidder’s valuation for the bundle items is lower than the sum of the valuation of the single items in the bundle. In contrast, a superadditive valuation describes a bundle valuation that is higher than the sum of the valuation of the items in the bundle (de Vries and Vohra 2001). The return-maximizing combinatorial allocation process performed by the auctioneer, the bidders’ ability to formulate bundles and the nonlinear valuation of the bids all constitute the increased efficiency of the CA (Crampton et al. 2006).

The use of CAs is an especially interesting method for dynamic pricing, if a combination of goods and services is a necessary input factor for the value creation process. This is the case in domains like supply chain management scheduling, procurement or logistics (Schwind 2005). One application of CAs in the sector of logistics is to use them for the exchange of transportation capacities while taking the synergies that are generated by the appropriate allocation of bundles of transportation tasks to different carriers into consideration (Gujo et al. 2007, Gujo and Schwind 2007).

Figure 4 shows the GUI of a Web-based system for the combinatorial auctioning of transportation routes between logistic service providers in an intra-enterprise exchange of logistic services in an enterprise that is related to the food sector and organized in a profit centre structure. In the intra-enterprise exchange process, each profit centre can release delivery contracts for outsourcing if the geographic location of a consumer allows a reduced-cost delivery by another profit centre in the neighbourhood. The cost calculation is based on the results of an integrated routing system, while the in- and out-sourcing process is managed by using the auction mechanism ComEx (Gujo and Schwind 2007). In the following we describe the characteristics of the underlying auction process according to the interactive pricing scheme presented in Figure 2.

According to Figure 2 the first point in the negotiation model describes the participation policy by specifying the number of buyers/sellers involved in the auction process. It determines the type of the CA by discriminating between procurement or seller auctions and a combinatorial exchange as used in ComEx. Our application case has a many-to-many cardinality due to the bilateral role of the profit centres operating both as sellers of delivery contracts in the out-sourcing case and buyers of transportation tasks in the in-sourcing case. The intermediary is imperative in the ComEx setting because of its role as an auctioneer. The second main category of the scheme in Figure 2 is the bidding policy and includes the branch expressiveness, which in our case is combinatorial. The combinatorial property is required to enable the ComEx system to give the bidders
the opportunity to submit and bid for alternative combinations of delivery contracts or tasks that are geographically close to each other. The bidding process is coupled with the route planning process in the ComEx system and uses an exclusive-or (XOR) notation for the combinatorial bids. An important complement to the bidding rules are constraints on the formulation of the bids, e.g. the maximum transportation capacity that can be attributed to a single bidder. The bidding rules can also be used to impose constraints on the allocation process. The clearing policy is another major issue in the definition of the combinatorial transportation services exchange. Closing condition is set to a fixed time in this case, due to the fact that the auction is a single round auction. The tag clear timing denotes the beginning of a transaction and comes together with the on-closing signal of the ComEx auction. The tag marks the end of the bid acceptance phase and the beginning of the winner determination process performed by the auctioneer. The matching function then describes the winner determination process used by the auctioneer and is coupled to the pricing function determining the amount of money that finally has to be spent for the intra-enterprise transportation service in the ComEx system. In our logistics scenario the price quotes are a pay-as-you-bid function. The introduction of side payments between bidders is useful for incentive compatibility reasons (Gujo et al. 2007) but not implemented in the current version of ComEx. In the case of two bids with the same W2P for identical services, a tie-breaking-rule has to be introduced to decide which of the two bids wins. A very simple way to resolve the tie-breaking problem is to randomly select a winner in such a case. The tie-breaking-rule can be set to random, because equality of W2P is very unlikely while using combinatorial bids and the overall result of the CA will not be perceptibly affected by this decision rule. Another important issue while using auctions is how information feedback provided to the bidders by the auctioneer is covered by the information policy. ComEx only provides information about the acceptance of a bid at the end of the auction. The revelation of the bid prices, called quote timing is done on-closing after the winner determination process has taken place. Neither order book nor transaction-history exist in the ComEx system. Auctioneer fees are not charged in the current version of ComEx and the identity of the bidders is revealed due to its intra-enterprise character.

CONCLUSIONS

In our survey of common e-Business standards we reveal that they do not have the capability to support new forms of pricing mechanisms. While the possibilities of dynamic posted pricing are foreseen, interactive pricing functionality is not yet supported by existing e-Business standards. This confirms the findings of a large-scale survey among German companies conducted by Sackmann and Strüker (2005). The lack of standardization might be an obstacle to the broader application of interactive pricing which can increase allocation efficiency and thus welfare. As yet, business has not exploited the full potential of price differentiation, although many studies have shown that interactive pricing is well accepted among both consumers and business partners.

For the sake of unification we therefore present a universal model that allows the explicit description of a broad range of interactive pricing mechanisms with respect to their informational and economic requirements. The model can easily be translated into XML and might thus be a guideline for industrial standardization efforts. As all e-Business standards have their own nature, we do not elaborate the XML structure in detail. However, as proof of concept, we illustrate the application of our model for two different cases of interactive pricing scenarios.
The resulting XML structure can be used to describe interactive pricing mechanisms, store them for later use or can be handed to an intermediary such as an electronic marketplace to conduct the pricing process in the way described. Since many sellers offer their products on different sales channels like eBay, Overstock.com and their own online shop to target different market segments, such a standard could reduce processing costs dramatically.

However, our approach would additionally profit from the following extensions: Dynamics could be introduced in the generation of our XML language to enable it to respond to changing negotiation situations during the interactive pricing process. Our approach can handle a large number of language specifications. Thus a versioning system and sub-classes for the particular interactive pricing methods could be introduced into our model. Nevertheless, our model represents an initial approach to closing the gap between models developed in academia and e-Business standards that are frequently used in business practice. We do this by focusing on the endogenous variables that can be actively changed by the party initiating the price finding process. Following our call for standardization in the domain of interactive pricing mechanisms, a larger number of application classes will enable users of interactive pricing methods to easily create new variants of pricing. We expect different standardization approaches in the near future which will solve individual problems in the area of interactive pricing, but encourage a broad solution for this domain. This could significantly drive the development of e-Commerce and e-Business and lead to a business environment connected even more closely online.

ACKNOWLEDGEMENTS

This paper originates from research conducted within the framework of the ‘Internetökonomie’ project funded by the German Federal Ministry of Science and Education (BMBF). We would like to thank the participating organizations, consortia members, partners and our dear colleagues for their support.

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