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Online Marketplaces

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Even before the advent of the world-wide web, it was widely recognized that emerging global communication networks offered the potential to revolutionize trading and commerce [Schmid, 1993]. The web explosion of the late 1990s was thus accompanied immediately by a frenzy of effort attempting to translate existing markets and introduce new ones to the Internet medium. Although many of these early marketplaces did not survive, quite a few important ones did, and there are many examples where the Internet has enabled fundamental change in the conduct of trade. Although we are still in early days, automating commerce via online markets has in many sectors already led to dramatic efficiency gains through reduction of transaction costs, improved matching of buyers and sellers, and broadening the scope of trading relationships.

Of course, we could not hope to cover in this space the full range of interesting ways in which the Internet contributes to the automation of market activities. Instead, this chapter addresses a particular slice of electronic commerce, in which the Internet provides a new medium for marketplaces. Since the population of online marketplaces is in great flux, we focus on general concepts and organizing principles, illustrated by a few examples rather than attempting an exhaustive survey.

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1.1 What is an Online Marketplace?

"Marketplace" is not a technical term of art, so unfortunately, there exists no precise and well-established definition clearly distinguising what is and is not an online marketplace. However, we can attempt to delimit its meaning with respect to this chapter. To begin, what do we mean by a "market"? This term too lacks a technical definition, but for present purposes, we consider a market to be an interaction mechanism where the participants establish deals (trades) to exchange goods and services for monetary payments (i.e., quantities of standard currency).

Scoping the "place" in "marketplace" can be difficult, especially given the online context. Some would say that the web itself is a marketplace (or many marketplaces), as it provides a medium for buyers and sellers to find each other and transact in a variety of ways and circumstances. However, for this chapter we adopt a narrower conception, limiting attention to sites and services attempting to provide a well-scoped environment for a particular class of (potential) exchanges.

Many pre-existing marketplaces are now online simply because the Internet has provided an additional interface to existing protocols. For example, online brokerages have enabled any trader to route orders (with some indirection) to financial exchanges and electronic crossing networks (e.g., Island or REDIBook). Although such examples certainly qualify as online marketplaces, the plethora of different interfaces, and usually nontransparent indirections, do make them less pure instances of online marketplaces. For high-liquidity marketplaces like equity exchanges, these impurities may not substantially impede vibrant trade. For newer and more completely online marketplaces, directness and transparency are hallmarks of the value they provide in facilitating exchange.

Perhaps the most well-known and popularly used online marketplace is eBay [Cohen, 2002], an auction site with over 12 million items (in hundreds of categories and subcategories) available for bid every day. eBay is the canonical "person-to-person" marketplace, with upwards of 69 million registered users.[1] Whereas many eBay sellers (and some buyers) earn their livelihood trading on the site (which is why the "consumer-to-consumer" label would be inaccurate), participation requires only a lightweight registration process, and most aspects of the transaction (e.g., shipping, payment) are the ultimate responsibility of the respective parties to arrange. Note the contrast with the brokered trading model employed in financial markets, where securities are generally exchanged between broker-dealers on behalf of clients.

Many online marketplaces define commerce domains specific to an industry or trading group. One of the most prominent of these is Covisint, formed in 2000 by a consortium of major automobile manufacturers (Ford, General Motors, DaimlerChrysler, and Renault-Nissan, later joined by Peugeot Citroen) to coordinate trading processes with a large universe of suppliers.[2] Covisint provides electronic catalog tools, operates online procurement auctions, and supports a variety of document management and information services for its trading community.

Although many of the online marketplaces launched by industry consortia in the late 1990s have since failed, as of 2002 there were still dozens of such exchanges, with projections for renewed (albeit slower) growth [Woods, 2002]. Similarly, the number of person-to-person sites had reached into the hundreds during the speculative Internet boom. eBay clearly dominates the field, but many niche auctions remain as well.

The examples of person-to-person auctions (eBay), industry-specific supplier networks (Covisint), and online brokerages illustrate the diversity of online marketplaces that have emerged on the Internet over the past decade. Another category of major new markets are the exchanges in electric power and other commodities corresponding to recently (partially) deregulated industries. Many of these are hidden from view, running over private (or virtually private) networks, but these too constitute online marketplaces, and play an increasingly significant role in the overall economy.

[1] Source: `http://pages.ebay.com/community/aboutebay` and `internetnews.com`, May 2003.
[2] 76,000 members as of January 2003. Source `http://www.covisint.com/about/history`.

1.2 Market Services

What does a marketplace do? In order to facilitate conduct of trade, a marketplace may support any or all phases in the lifecycle of a transaction. I find it useful to organize commerce activities into three stages, representing the fundamental steps that parties must go through in order to conduct a transaction.

1. The **Connection**: searching for and *discovering* the opportunity to engage in a commercial interaction.

2. The **Deal**: *negotiating* and agreeing to terms.

3. The **Exchange**: *executing* a transaction.

These steps are illustrated in Figure 1.1. Of course, the boundaries between steps are not sharp, and these activities may be repeated, partially completed, retracted, or interleaved along the way to a complete commercial transaction. Nevertheless, keeping in mind the three steps is useful as a way to categorize particular marketplace services, which tend to focus on one or the other.

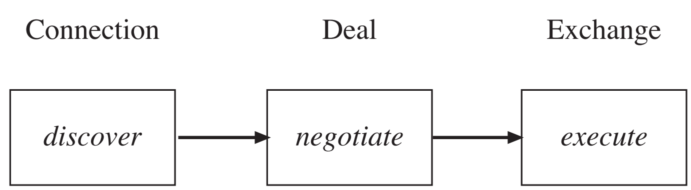

Figure 1.1: The fundamental steps of a commerce interaction.

In this chapter, we focus on the negotiation phase, not because it is necessarily the most important, but because it often represents the core functionality of an online marketplace. Discovery and exchange are relatively open-ended problems, with services often provided by third parties outside the scope of a particular marketplace, as well as within the marketplace itself. Moreover, several aspects of these services are covered by other chapters of this Handbook. Nevertheless, a brief overview of some discovery and transaction facilities is helpful to illustrate some of the opportunities provided by the online medium, as well as requirements for operating a successful marketplace.

1.2.1 Discovery Services

At a bare minimum, marketplaces must support discovery to the extent of enabling users to navigate the opportunities available at a site. More powerful discovery services might include electronic catalogs, keyword-based or hierarchical search facilities, and the like. The world-wide web has precipitated a resurgence in the application of information retrieval techniques [Belew, 2000], especially those based on keyword queries over large textual corpora.

Going beyond generic search, a plethora of standards have been proposed for describing and accessing goods and services across organizations (UDDI [Ariba Inc. et al., 2000], SOAP, a variety of XML extensions), all of which support discovering connections between parties to a potential deal. For the most part these are designed to support search using standard query-processing techniques. Some recent proposals have suggested using *semantic web* [Berners-Lee et al., 2001] techniques to provide matchmaking services based on inference over richer representations of goods and services offered and demanded [Di Noia et al., 2003; Li and Horrocks, 2003].

The task of discovering commerce opportunities has inspired several innovative approaches that go beyond matching of descriptions to gather and disseminate information relevant to comparing and evaluating commerce opportunities. Here we merely enumerate some of the important service categories:

- Recommendation [Resnick and Varian, 1997; Schafer et al., 2001]. Automatic recommender systems suggest commerce opportunities (typically products and services to consumers) based on prior user actions and a model of user preferences. Often this model is derived from cross-similarities among activity profiles across a collection of users, in which case it is termed *collaborative filtering* [Riedl and Konstan, 2002]. A familiar example of collaborative filtering is Amazon.com's "customers who bought" feature.

- Reputation. When unfamiliar parties consider a transaction with each other, third-party information bearing on their reliability can be instrumental in establishing sufficient trust to proceed. In particular, for person-to-person marketplaces, the majority of exchanges represent one-time interactions between a particular buyer and seller. *Reputation systems* [Dellarocas, 2003; Resnick et al., 2002] fill this need by aggregating and disseminating subjective reports on transaction results across a trading community. One of the most prominent examples of a reputation system is eBay's "Feedback Forum" [Cohen, 2002; Resnick and Zeckhauser, 2002], which some credit significantly for eBay's ability to achieve a critical-mass network of traders.

- Comparison shopping. The ability to obtain deal information from a particular marketplaces suggests an opportunity to collect and compare offerings across multiple marketplaces. The emergence on the web of *price comparison services* followed soon on the heels of the proliferation of searchable retail web sites. One early example was BargainFinder [Krulwich, 1996], which compared prices for music CDs available across nine retail web sites. The University of Washington ShopBot [Doorenbos et al., 1997] demonstrated the ability to automatically learn how to search various sites, exploiting known information about products and regularity of retail site organization. Techniques for rapidly adding sites and product information have continued to improve, and are employed in the many comparison-shopping services active on the web today.

- Auction aggregation. The usefulness of comparison shopping for fixed-price offerings suggested that similar techniques might be applicable to auction sites. Such information services might be even more valuable in a dynamically priced setting, as there is typically greater inherent uncertainty about the prevailing terms. The problem is also more challenging, however, as auction listings are often idiosyncratic, thus making it difficult to recognize all correspondences. Nevertheless, several auction aggregation services (BidFind, AuctionRover, and others) launched in the late 1990s. Concentration in the online auction industry combined with the difficulty of delivering reliable information has limited the usefulness of such services, however, and relatively few are operating today.

1.2.2 Transaction Services

Once a deal is negotiated, it remains for the parties to execute the agreed-upon exchange. Many online marketplaces support transaction services to some extent, recognizing that integrating "back-end" functions—such as logistics, fulfillment, and settlement—can reduce overall transaction costs and enhance the overall value of a marketplace [Woods, 2002].

A critical component of market-based exchange, of course, is *payment*, the actual transfer of money as part of an overall transaction. The online medium enables the automation of payment in new ways, and indeed, the 1990s saw the introduction of many novel *electronic payment mechanisms* [O'Mahony et al., 1997], offering a variety of interesting features [MacKie-Mason and White, 1997], including many not available in conventional financial clearing systems. For example, some of the schemes supported anonymity [Chaum, 1992], micropayments [Manasse, 1995], or atomic exchange of digital goods with payment [Sirbu and Tygar, 1995].

As it turned out, none of the innovative electronic payment mechanisms really caught on. There are several plausible explanations [Crocker, 1999], including inconvenience of special-purpose software, network effects (i.e., the need to achieve a critical mass of buyers and sellers), the rise of advertising-supported Internet content, and decreases in credit-card processing fees. Nevertheless, some new payment services have proved complementary with marketplace functions, and have thrived. The most well-known example is PayPal, which became extremely popular among buyers and sellers in person-to-person auctions, who benefited greatly from simple third-party payment services. PayPal's rapid ascension was in large part due to an effective "viral marketing" launch strategy, in which one could send money to any individual, who would then be enticed to open an account.

1.3 Auctions

Until a few years ago, if one said the word "auction", most hearers would conjure images of hushed rooms with well-dressed art buyers bidding silently while a distinguished-looking individual leads the proceeding from a podium with a gavel. Or, they might have envisioned a more rowdy crowd watching livestock while yelling out their bids to the slick auctioneer speaking with unintelligible rapidity. Another common picture may have been the auctioneer at the fishing dock lowering the price until somebody agrees to haul away that day's catch. Today, one is just as likely to suggest a vision (based on direct experience) of an auction happening online. Thus is the extent to which online auctions have emerged as a familiar mode of commercial interaction.

Speculations abound regarding the source of the popularity of online auctions. For some, it is a marketing gimmick—enticing customers by making a game of the buying process. Indeed, participating in auctions can be fun, and this factor undoubtedly plays a significant role. More fundamentally, however, auctions support dynamic formation of prices, thereby enabling exchanges in situations where a fixed price—unless it happened to be set exactly right—would not support as many deals. Dynamic market pricing can improve the equality of trades to the extent there is significant value uncertainty, such as for sparsely traded goods, high demand variability, or rapid product obsolescence. Distribution of information is, of course, the rationale for auctions in offline contexts as well. The online environment is particularly conducive to auctions, due to at least two important properties of the electronic medium.

First, the network supports inexpensive, wide-area, dynamic communication. Although the primitive communication protocol is point-to-point, a mediating server (i.e., the auction) can easily manage a protocol involving thousands of participants. Moreover, the information revelation process can be carefully controlled. Unlike the human auctioneer orchestrating a room of shouting traders, a network auction mediator can dictate exactly which participants receive which information and when, according to auction rules.

Second, to the extent that auction-mediated negotiation is tedious, it can be automated. Not only the auctioneer, but also the participating traders, may be represented by computational processes. For example, many sellers employ listing software tools to post large collections of goods for sale over time. To date, trading automation appears to be only minimally exploited by buyers in popular Internet auctions, for example, via "sniping" services that submit bids automatically at designated times, thus freeing the bidder from the necessity of manual monitoring.

1.3.1 Auction Types

Despite the variety in imagery of the auction scenarios above, most people would recognize all of them as auctions, with items for sale, competing buyers and a progression of tentative prices, or bids, until the final price, or clearing price, is reached. How the initial price is chosen, whether the tentative prices are announced by the auctioneer or the traders (i.e., bidders) themselves, or even whether the prices go up or down toward the result, are defining details of the particular type of auction being executed. Although the specific rules may differ, what makes all of these auctions is that they are organized according to well-defined rules, and at the end of the process, these rules will dictate what deal, if any, is struck as a consequence of the bidding activity by the auction participants.

Many obvious variants on the above scenarios will clearly qualify as auctions as well. For example, there might be several items for sale instead of one, or the bidders might compete to sell, rather than buy, the good or goods in question.

Once we consider how auction rules can vary, we see that auctions naturally group themselves into *types*, where auctions of a given type share some distinctive feature. For example, the scenarios described above are all instances of *open outcry* auctions, which share the property that all status information (e.g., the tentative prices) is conveyed immediately and globally to all participants.

Another form of open outcry auction is the familiar "trading pit" of a commodities or securities exchange. Although this might not always be viewed as an auction in common parlance, it shares with the examples above some essential features. Even the seemingly chaotic trading pit operates according to rules governing who is allowed to shout what and when, and what the shouts entail in terms of offers of exchange.

The most immediately distinguishing feature of the trading pit is that it is *two-sided*: both buyers and sellers play bidders in this protocol. In contrast, the art, livestock, and fish auctions alluded to above are *one-sided*: a single seller offers an item to multiple bidding buyers.

The inverse one-sided auction—where a single buyer receives bids from multiple competing sellers—is sometimes called a *reverse auction*, and is often employed by businesses in procurement, where it is often called a *request for quotations*, or RFQ.

Unlike open outcry events, in *sealed-bid auctions* the participants do not learn the status of the auction until the end, if then, or until some other explicit action by the auctioneer. Familiar examples of sealed-bid auctions include government sales of leases for offshore oil drilling and procedures by which real-estate developers let construction contracts. Note that the latter is an example of a procurement auction, as it is the sellers of construction services doing the bidding.

Sealed-bid auctions may be one-shot, or may involve complex iterations over multiple rounds, as in the prominent US FCC spectrum auctions held in recent years [McAfee and McMillan, 1996]. Like open outcry auctions, sealed-bid auctions may also come in one-sided or two-sided varieties.

Internet auctions, like their offline counterparts, also come in a range of types and variations. Today, almost all consumer-oriented auctions are one-sided (i.e., they allow buy bids only), run by the sellers themselves or by third parties. The prevailing format can be viewed as an attempt to mimic the familiar open outcry auctions, posting the current high bid and the bidders identity. The very familiarity of these mechanisms is an advantage, and may be the reason they have proliferated on the Internet.

1.3.2 Auction Configuration and Market Design

Auctions operated in business-to-business marketplaces are also predominantly one-sided (typically procurement or reverse auctions), though some two-sided auctions (often called *exchanges*) persist. Familiarity is also a factor in designing business-oriented auctions, though we should expect less of a tendency for a one-size-fits-all approach, for several reasons.

- Industry trade groups may have preexisting prevailing conventions and practices, which will be important to accommodate in market designs.

- Participants earn their livelihood by trading, and so are more willing to invest in learning market-specific trading rules. Adopting more complex rules may be worthwhile if they enable more efficient trading over time.

- Transactions will involve higher stakes on average, and so even small proportional gains to customization may be justified.

The Michigan Internet AuctionBot [Wurman et al., 1998] was an early attempt to support general configurability in auction operation. Although the ability to customize auction rules proved not to be very useful for consumer-oriented marketplaces, for reasons above this capability provides potentially greater value for specialized commercial trade. The AuctionBot provided a model for the auction platform now distributed as Ariba Sourcing™, which underlies several business-to-business marketplaces.

1.3.2.1 Dimensions of Market Design

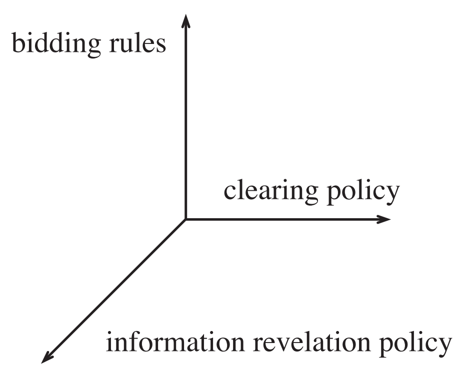

Figure 1.2: Three dimensions of market design.

Flexible market infrastructure supports a variety of market rules, covering all aspects of operating a market. The infrastructure is *configurable* if the designer can mix and match operating rules across the various categories of market activity. We have found it particularly useful to organize market design around three fundamental dimensions (Figure 1.2), which correspond to three core activities performed by the market.

1. **Bidding rules**. Traders express offers to the market in messages called *bids*, describing deals in which they are willing to engage. The market's bidding policy defines the form of bids, and dictates what bids are admissible when, and by whom, as a function of bids already received.

2. **Clearing policy**. The object of the market is to determine exchanges, or deals, by identifying compatible bids and *clearing* them as trades. The clearing policy dictates how and when bids are matched and formed into trades, including determining the terms of the deals in cases where there exist many consistent possibilities.

3. **Information revelation policy**. Markets typically post intermediate information about the status of bidding, prior to the determination of final trades. Determining what information is available to whom, when, and in what form, is the subject of information revelation policy.

1.3.2.2 Bidding Rules

To illustrate the specification of market rules across these dimensions, let us consider some of the possible range of bidding rules an auction can impose. The outline below is far from exhaustive—even for the bidding dimension alone. I include it merely to illustrate the great variety of separately definable auction features. A more comprehensive and technically precise exposition of auction design space is presented by Wurman et al. [2001].

We generally assume that any trader can always submit a bid to an auction. The bidding rules determine whether it will be *admitted* to the auction. Admitted bids are entered into the auction's *order book*, which stores the bids considered currently active.

Most bidding rules can be defined to hold for everyone, or specialized to hold for particular classes of traders. In general, a bidding rule may consider the current order book, previous bids by this trader or, for that matter, any aspect of the auction's history. However, it is helpful to focus the examples on forms of bidding rules corresponding to particularly useful categories.

- **Allowable bid modifications**. These rules regulate when a bid revision is permitted, as a function of the previous pattern of bids by this trader or others.
  - *Withdraw/replace allowed*: Whether or when a new bid may be submitted to supersede a previous one.
  - *Bid frequency restrictions*: Set over the entire course of the auction or for designated periods. For example, an auction might define a notion of stage, or round, and allow each trader to bid once per round.
- **Static restrictions on bid content**. Content rules define what bids are admissible, based on the specifics of the offer. A content rule is static if it can be defined independently of other bids that have been submitted by this trader or others.
  - *One- versus two-sided*: Competitive bidding on both the buy and sell sides, or just one or the other. As discussed above, in a one-sided auction, only one distinguished trader is allowed to sell (buy); all others can submit only buy (sell) bids.
  - *Bid quantities*: Offers can be for single or multiple units, and if multi-unit, the allowable offer patterns. For example, a multi-unit offer may be limited to a single price point, or arbitrary *price-quantity schedules* may be allowed. Similarly, quantity bidding rules control such issues as whether or not indivisible ("all-or-none") bids are allowed.
- **Dynamic restrictions on bid content**. A content rule is *dynamic* if it depends on previous bids by this trader, or the current order book.
  - *Beat-the-quote*: A new bid must be "better" than some designated benchmark, such as the best offer received so far. These rules can be used to implement an ascending (or descending) auction, where prices progress in a given direction until the final price is reached.
  - *Bid dominance*: In a manner analogous to beat-the-quote, we can require that a new bid improves the trader's own bid. There are various versions of this rule, based on different criteria for comparing bids.
  - *Eligibility*: Defines the conditions under which a trader is eligible to submit bids, or the prices or quantities allowed in those bids. Eligibility is typically based on trader qualifications (e.g., credit ratings), or prior bidding history. For example, *activity rules* define eligibility based on the extent of current bids—the stronger the current bids, the greater the trader's eligibility for subsequent bidding.
- **Payments**. Sometimes, restrictions such as those above can be waived on agreement to pay a fixed or variable fee. For example, an initial bid may require an entry fee (refundable or not), or withdrawals may be allowed on payment of a decommitment penalty.

1.3.2.3 Criteria for Auction Design

Given the wide range of possible ways to run an auction, how is the designer to choose the policies for a particular market? The first step is to define one's objectives. There are many characteristics of a market we may care about. These may be categorized roughly into *process-* and *outcome*-oriented features.

Process-oriented features bear on the operation of the market, and the participation effort required of traders or other interested parties. For example, we generally prefer that market rules be as simple and familiar as possible, all else equal, as this promotes ease of learning and participation. Markets may also differ on how much time they impose for bid preparation and monitoring, or how much information they require the traders to reveal. Some market structures might be considered more transparent than others, or otherwise present perceived differences in fairness. All of these may be important issues for marketplace designers.

Outcome-oriented features represent properties of the results that would be reasonably expected form the market. Natural measures include expected revenue from a seller-run auction, or expected expenditures in a procurement auction. Often we care most directly about overall *efficiency*, that is, how well the market allocates resources to their most valuable uses. A natural index of efficiency is *total surplus*, the aggregate gain (measured in currency units) from trade summed over all participants. Other considerations include the resistance of the mechanism to market manipulation, collusion, or various forms of cheating.

To take such issues into account, of course the designer needs some way to relate the market rules to these desired characteristics. Fortunately, there exists a substantial body of theory surrounding auctions [Klemperer, 1999; Krishna, 2002], starting from the seminal (Nobel-prize-winning) work of Vickrey [1961]. Auction theory tends to focus on outcome-oriented features, analyzing markets as games of incomplete information [Fudenberg and Tirole, 1991]. One of the key results of the field of *mechanism design* is the impossibility of guaranteeing efficiency through a mechanism where rational agents are free to participate or not, without providing some subsidy [Myerson and Satterthwaite, 1983]. It follows that auction design inevitably requires tradeoffs among desirable features. In recent years, the field has accumulated much experience from designing markets for privatization [Milgrom, 2003], yielding many lessons about market process as well as performance characteristics.

1.3.3 Complex Auctions

The discussion of market types above focused attention on "simple" auctions, where a single type of good (one or more units) is to be exchanged, and the negotiation addresses only price and quantity. In a *multidimensional* auction, bids may refer to multiple goods or features of a good. Although such complex auctions are not yet prevalent, automation has only recently made them feasible, and they are likely to grow in importance in online marketplaces.

A *combinatorial* auction [de Vries and Vohra, 2003] allows indivisible bids for bundles of goods. This enables the bidder to indicate a willingness to obtain goods if and only if the combination is available. Such a capability is particularly important when the goods are *complementary*, that is, the value of obtaining some is increased when the others are obtained as well. For example, a bicycle assembler needs both wheels and frames—neither is capable of producing a bicycle without the other. Bidding rules for combinatorial auctions dictate what bundles are expressible, and clearing policy defines the method for calculating overall allocations and payments.

A *multiattribute* auction [Bichler, 2001] allows bids that refer to multiple features of a single good. For example, a shipment of automobile tires might be defined by wheel diameter, tread life, warranty, delivery date, and performance characteristics (anti-skid, puncture resistance), as well as the usual price and quantity. Multiattribute bids may specify the value of particular feature vectors, or express a correspondence of values over extended regions of the attribute space. The form of such bids are defined by the bidding rules, and the clearing policy dictates the method of matching such multiattribute offers.

Multidimensional negotiation constitutes an area of great potential for online marketplaces—enabling a form of trading automation not previously possible. Ultimately, combinatorial and multiattribute negotiation could in principle support the negotiation of general contracts [Reeves et al., 2002]. Before that vision becomes reality, however, numerous technical issues in multidimensional negotiation must be addressed, including such problems as:

- What are the best forms for expressing combinatorial and multiattribute bids?
- What intermediate information should be revealed as these auctions proceed?
- How can we reduce the complexity of participating in multidimensional negotiations?
- What strategies should we expect from combinatorial and multiattribute bidders?
- What is the appropriate scope of a market? Combining related goods in a single negotiation avoids market coordination failures, but imposes synchronization delays, and other potential costs in computation, communication, and organization.

Although several existing proposals and models address these questions in part, multidimensional negotiation remains an active research topic in market design.

1.4 Establishing a Marketplace

To build an effective online marketplace, one needs to identify unfulfilled trading opportunities, design a suitable negotiation mechanism, and provide (directly or through ancillary parties) well-integrated discovery and transaction services. This is of course quite a tall order, and the specifics are dauntingly open ended. Nevertheless, assembling all these functions still is not sufficient to ensure marketplace success.

Unfortunately, despite several useful sources of advice on establishing an online marketplace [Kambil and van Heck, 2002; Woods, 2002], much of the prevailing wisdom is based on anecdotal experience—accrued within a dynamic technological and economic environment, and continues to evolve rapidly. In this section, I briefly note some of the additional technical and organizational issues that can prove instrumental in making an online marketplace really work. As the field matures, we can expect that some of these will become routinely addressed by common infrastructure, and others will become more precisely understood through accumulation and analysis of experience.

1.4.1 Technical Issues

The section on auctions above discusses economic as well as technical issues in the design and deployment of negotiation mechanisms, focusing on the “logic” of market procedures. To underpin the market logic, we require a robust computational infrastructure to ensure its proper operation under a range of conditions, loads, and extraordinary events. By their very nature, online marketplaces operate over distributed networks, typically accessed by a heterogeneous collection of traders and observer nodes. For example, one user might submit a simple bid through a web page accessed via telephone modem, whereas another might automatically submit large arrays of trades through a programmatic interface from a fast workstation connected through a high-bandwidth network. Access is generally asynchronous, and conducted over public networks.

In many respects, the processing issues faced by a marketplace are identical to those in other transaction processing applications. We naturally care to a great extent about general system reliability and availability, and transparency of operation. It is important that transactions be atomic (i.e., an operation either completes or has no effect), and that state is recoverable in case of an outage, system crash, or other fault event.

There may also be some additional issues particular salient for market applications. For example, maintaining *temporal integrity* can be critically important for correct and fair implementation of market rules. In the market context, temporal integrity means that the outcome of a negotiation is a function of the sequence of communications received from traders, independent of delays in computation and communication internal to the market. One simple consequence of temporal integrity is that bids be processed in order received, despite any backlog that may exist. (Bid processing may in general require a complex computation on the order book, and it would be most undesirable to block incoming messages while this computation takes place.) Another example involves synchronization with market events. If the market is scheduled to clear at time t, then this clear should reflect all bids received before t, even if they are not all completely processed by this time. One way to enforce this kind of temporal integrity is to maintain a *market logical time*, which may differ (i.e., lag somewhat behind) the actual clock time [Wellman and Wurman, 1998]. Given this approach, any information revealed by the market can be associated with a logical time, thus indicating the correct state based on bids actually received by this logical time.

Despite its apparent importance, strikingly few online markets provide any meaningful guarantees of temporal integrity, or even indications relating information revealed to the times of the states they reflect. For example, in a typical online brokerage, one is never sure about the exact market time corresponding to the posted price quotes. This makes it difficult for a trader (or even a regulator!) to audit the stream of bids to ensure that all deals were properly determined. The likely explanation is that these systems evolved on top of semi-manual legacy systems, for which such fine-grained accounting was not feasible. As a result, to detect improper behavior it is often necessary to resort to pattern-matching and other statistical techniques [Kirkland et al., 1999]. With increased automation, a much higher standard of temporal integrity and accountability should be possible to achieve normally, and this should be the goal of new market designers.

Finally, one cannot deploy a marketplace without serious attention to issues of privacy and security. We cannot do justice to such concerns here, hence will just note that simply by virtue of their financial nature, markets represent an obvious security risk. In consequence, the system must carefully authenticate and authorize all market interactions (e.g., both bidding and access of revealed market information). Moreover, online marketplaces are often quite vulnerable to denial-of-service and other resource-oriented attacks. Because negotiation necessarily discloses sensitive information (as do other market activities, such as search and evaluation), it is an essential matter of privacy to ensure that the market reveals no information beyond that dictated by the stated revelation policy.

1.4.2 Achieving Critical Mass

If we build an electronic marketplace for a compelling domain, with rich supporting services, sound economic design, and technically solid in all respects . . . will the traders come? Alas, it (still) depends.

Trading in markets is a *network* activity, in the sense that the benefit of participating depends on the participation of others. Naturally, it is a waste of effort searching for deals in a market where the attractive counterparties are scarce. To overcome these *network effects* [Shapiro and Varian, 1998; Shy, 2001], it is often necessary to invest up front to develop a critical mass of traders that can sustain itself and attract additional traders. In effect, the marketplace may need to subsidize the early entrants, helping them overcome the initial fixed cost of entry, until there are sufficient participants such that gains from trading itself outweigh the costs. Note that enticing entrants by promising or suggesting some advantage in the market itself is generally counterproductive, as it inhibits the traders on the "other side" who will ultimately render the market profitable overall.

It is commonplace to observe in this context that the key to a successful marketplace is achieving sufficient *liquidity*. A market is liquid to the extent it is readily possible to make a trade at the "prevailing" price, at any time. In a *thin market*, in contrast, it is often the case that one can execute a transaction only at a disadvantageous price, due to frequent temporary imbalances caused by the sparseness of traders. For example, markets in equities listed on major stock exchanges are famously liquid, due to large volume as well as the active participation of *market makers* or specialists with express obligations (incurred in return for their privileged status in the market) to facilitate liquidity by trading on their own account when necessary.

It is perhaps unfortunate that the financial markets have provided the most salient example of a functionally liquid market. It appears that many of the first generation of online marketplaces have attempted to achieve liquidity by emulation of these markets, quite often hiring key personnel with primary experience as traders in organized equity or commodity exchanges. For example, traditional financial securities markets employ variants of the *continuous double auction* [Friedman and Rust, 1993], which matches buy and sell orders instantaneously whenever compatible offers appear on the market. However, many eminently tradeable goods inherently lack the volume potential of financial securities, and for such markets instantaneous matching might be reasonably sacrificed for more designs likely to produce more robust and stable prices. In principle, new marketplaces provide an opportunity for introducing customized market designs. In practice, however, familiarity and other factors introduce a bias toward "legacy" trading processes.

1.5 The Future of Online Marketplaces

Anyone contemplating a prediction of the course of online marketplaces will be cautioned by the memory of prevailing late-1990s forecasts that proved to be wildly optimistic. Though many online marketplaces came and went during the Bubble, the persistence of some through the pessimistic Aftermath is surely evidence that online marketplaces can provide real value. Even the failed attempts have left us with cautionary tales and other learning experiences [Woods, 2002], and in some instances, useful technologies. So without offering any specific prognostications with exponential growth curves, I end this chapter with a generally positive outlook plus a few suggestions about what we might see in the next generation of online marketplaces.

First, while specific marketplaces will come and go, the practice of online trading will remain, and likely stabilize over time through recognition of successful models and standardization of interfaces. Decisions about joining marketplaces or starting new ones should perhaps be driven less by strategic concerns (e.g., the "land grab" mentality that fueled the Bubble), and more by the objective of supporting trading activities that improve industry efficiency and productivity.

Second, as discussed above, there is currently a large amount of research attention, as well as some commercial development, devoted to the area of multidimensional negotiation. Combinatorial and multiattribute auctions support richer expressions of offers, accounting for multiple facets of a deal, and interactions between parts of a deal. Whereas multidimensional negotation is not a panacea (presenting additional costs and complications, and unresolved issues), it does offer the potential to get beyond some of the rigidities inhibiting trade in online marketplaces.

Finally, trading is a labor-intensive activity. Whereas online marketplaces can provide services to assist discovery and monitoring of trading opportunities, it may nevertheless present too many plausible options for a person to reasonably attend. Ultimately, therefore, it is reasonable to expect the trading function itself to be automated, and for online marketplaces to become primarily the province of programmed traders. Software agents can potentially monitor and engage in many more simultaneous market activities than could any human. A recently inaugurated annual trading agent competition [Wellman et al., 2003] presents one vision of a future of online markets driven by autonomous trading agents.

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