

# TRADING-PROCESS CHARACTERISTICS OF ELECTRONIC AUCTIONS

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## ABSTRACT

Auctions are consolidated market institutions with formal process rules. They determine the range of processes that traders are allowed to conduct and need to be specified during electronic auction construction.

This paper claims that trading process specifications do not need to start from scratch when a new auction system is built or an existing one is adapted to changed traders' needs. Trading process specification can rather start from templates of process rules so that rules just have to be selected and configured in order to specify the required auction type.

This paper outlines that idea for a small family of auction types - the Closed, Japanese, Open, and Double Auction. It provides a common rule set for these types, specifies each type through a selection of rules and relates types to each other in an auction taxonomy in order to show the common process characteristics they have.

## MOTIVATION

Auctions have formal rules for market access, trader interaction, price determination and trade generation. They are consolidated market institutions (Friedman 1993) which are traditionally not only applied for the exchange of numerous kinds of commodities like raw materials, securities or cargo capacities, but also for determination of prices for individual objects including pieces of fine art, buildings or large vessels.

However, the face of auctions is changing dramatically. Information technology is the main driver for innovations. Advances in information technology have made electronic auctions technically realizable, lower costs of computing and communi-

cation have changed their construction and operation to become economically feasible. Today, new variants of auction trading are invented and information systems are the medium for a growing number of traders who interact in auctions on an quasi ad-hoc base. Auction design and construction is changing to an engineering task and has to respond to traders' needs with an auction system that allows them to conduct the range of trading processes they demand.

A trading process specification is crucial in this respect. Through a collection of rules it defines how traders can interact. More technically spoken, it determines the

- ◆ set of message sequences that traders may exchange and
- ◆ the transformation of message sequences into one or multiple trades.

The following paper contributes to the systematic trading process specification of electronic auctions. We claim that trading process specification need not start from scratch, but can be based on pre-defined rule sets. We outline that idea for a family of auctions - the Closed Auction, Japanese Auction, Open Auction, and Double Auction - and show that their trading processes can be defined on a common rule set. For each type a trading process specification based on that rule set will be provided, and we arrange the specification of auction types gained in a taxonomy to illustrate common process characteristics among the different auction types.

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## BASIC TERMS

We will use the term 'trader' to refer to an agent to whom a specific asset is allocated and who is searching for the opportunity to exchange it for an other asset. 'Exchange' denotes any non-coercive process through which at least two traders alter the allocation of assets (Friedman 1993). Exchange leaves the total quantity of assets constant. We assume that two categories of assets exist. One is called 'good' the other is called 'money'. We call a trader who is willing to exchange a specific good for money a 'seller'. The term 'buyer' in turn refers to a trader willing to exchange money for a specific good.

A trader places an 'order' or reacts on an order through indication of an 'accept'. An order is either a 'bid' or an 'offer'. A 'bid' denotes the commitment of a trader to buy a specific good under the conditions the bid indicates, 'offer' in turn refers to the commitment of a trader to sell a specific good at conditions the offer specifies. The term 'accept' is used here to refer to the consent of a trader to buy or sell an asset at the conditions specified in a offer or bid to which he is referencing.

The term 'trade' is defined as the contractual agreement between a buyer and a seller on the conditions of an exchange. 'Price' denotes the trade condition which specifies the amount of money the buyer pays to the seller for each unit of an asset received.

The term 'trading' denotes all interaction processes that traders carry out through the exchange of messages, specifically bids, offers and accepts, to effect trades. We also call such an interaction process a 'trading process'.

We subdivide a trading process into six parts:

- ◆ order placement,
- ◆ order information,
- ◆ trade generation,
- ◆ trade information,
- ◆ trade confirmation, and
- ◆ trade processing.

For the purpose of this paper we concentrate on the first four steps.

'Order placement' denotes a trader's activity of making an order available to the rest of the market. Once placed it represents the trader's commitment to buy or sell a good at conditions the order indicates and grants a trading option to other traders. Although, the market can not react on an order until it has been published.

The notion 'order information' refers to the generation and dissemination of information on determinants of orders placed. The completeness of available information about an order's determinants, the immediacy of information dissemination, and the degree of equality of order information available among traders determines the 'pre-trade-transparency' of a market.

'Trade generation' refers to the transformation of orders into trades. Basically, two ways of order generation exist - order execution and order acceptance. The term 'order acceptance' refers to a trader's reaction on an order placed. He indicates an accept and causes a trade to occur having conditions derived from the determinants of the order accepted. Once accepted the order is no longer available.

'Order execution' denotes a rule based mechanism for the generation of trades out of orders placed. The mechanism checks bids and offers for execution, determines those to be executed, finds and fixes the trade conditions, matches the orders to be executed, withdraws them from the market and forms one or several trades. Both principles, order execution and order acceptance, can be combined to form an order execution mechanism.

'Trade information' refers to the process of producing and carrying information about trades generated to all or some traders. The completeness of information about a trade's conditions, the immediacy of information dissemination, and the degree

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of equality of trade information available to traders determines the 'trade transparency' of a market.

The term 'trading system' denotes an infrastructure that enables traders to conduct trading. For that purpose it comprises

- ◆ facilities for traders to interact, including the specification, placement, and acceptance of orders, retrieval of market information, and receiving of trade confirmations,
- ◆ mechanisms for the organization of orders,
- ◆ mechanisms for the translation of orders into trades, and
- ◆ links to systems for payment and delivery.

'Electronic trading system' denotes an information system having the functionality to serve as a trading system. In other words: traders use it as an electronic medium for trading. For that purpose it offers interface functions for order specification and order placement. Pre- and post trade information streams need to be accessed via the system's interface as well. Orders and trades are represented and managed electronically, order execution is automated. The system constitutes a formal codification of trading process rules. Its behaviour restricts the set of message sequences that traders may exchange and determines the trading outcome. Thus, it completely defines the range of trading processes which traders may conduct.

We apply the term 'market institution' (cf. McCabe, et al. 1992) to refer to the specification of the set of admissible messages (i.e., traders' actions, usually price and/or quantity offers), and the final commodity allocation given any combination of messages chosen by the traders and any initial allocation.

In that sense, an electronic trading systems constitutes a particular market institution. We call market institutions that

- ◆ provide equal information on trading opportunities,

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- ◆ preclude simultaneous transactions at different prices, and
  - ◆ which give higher priority in transactions to better orders (higher bids, lower asks)
- an 'auction' (Friedman 1993).

We use the term 'electronic auction' to refer to an electronic trading system that constitutes an auction market institution.

### AUCTION TYPES

#### CLOSED-BIDS AND CLOSED-OFFERS AUCTION

In a Closed-Bids Auction ('CBA') bids are made privately with no special order during a pre-defined time interval. Traders respond to an offer initially posted and published. A Closed-Offers Auction ('COA') exhibits the same behaviour with a bid submitted and published first. Privately posted offers follow. In a Closed-Bids Auctions the bids are opened and published at a certain point of time, then the highest bidder wins. If there are multiple bids at the highest price then the bid submitted first wins. The same procedure holds for a Closed-Offers Auction with the lowest offer to win. (Cassady 1967)

#### OPEN-BIDS AND OPEN-OFFERS AUCTION

Bids are made publicly in an Open-Bids Auction ('OBA'). They follow an offer which was posted and published at the auction's start. Only a limited time interval for the placement of bids is available. A bid is required to have a higher price than the one posted before. When the time interval for the placement of bids ends, the bid with the highest price wins. In an Open-Offers Auction ('OOA') the trading process starts with a bid which is published and continues with offers at decreasing prices. (Cassady 1967)

#### JAPANESE-BIDS AND JAPANESE-OFFERS AUCTION

In a Japanese-Bids Auction ('JBA') the bidding starts as soon as a signal is given. Like in an Open-Bids Auction, are bids made publicly so that other bidders can adjust their own. Although, bids are not

required to follow an ascending price scheme as in the Open-Bids Auction. Bidders make their adjustments very quickly since only a relatively short period is allowed for bidding. At a certain moment the seller spots the highest bid and accepts it. This moment is difficult to foresee, in most cases he is looking for a particular bid that he will take as soon as it is indicated (Cassady 1967). We will refer to the symmetrical auction institution as a 'Japanese-Offer Auction' ('JOA'). In that type offers are posted and one is finally taken by the buyer.

#### DOUBLE-AUCTION

Buyers and sellers make bids and offers for the exchange of a single item at a time in a Double Auction ('DA'). New bids and offers entered are required to improve conditions provided by the best standing bid (the highest bid to buy the current item) resp. offer (the lowest offer to sell the unit). A trade results if a buyer accepts the standing offer or if a seller accepts the standing bid.

### TRADING-PROCESS CHARACTERISTICS

#### MESSAGES

Messages are the basic elements out of which trading processes are built. Sequences of messages represent a particular process run. Trading process rules determine the allowed message sequences for a particular market institution and define how a given sequence of messages transforms into a re-allocation of assets.

We base our descriptions on a small set of messages that apply for the auction institutions considered. We use bid.b to denote the placement of a bid b. Parameter b should include information on the trader who places that order and a price which indicates the sum the trader is willing to pay for the item offered. Message offer.f denotes the placement of an offer f with the same parameters like a bid. We assume that bids and offers are for one piece of an item. Principally, the concept presented here would support any further type of parameter.

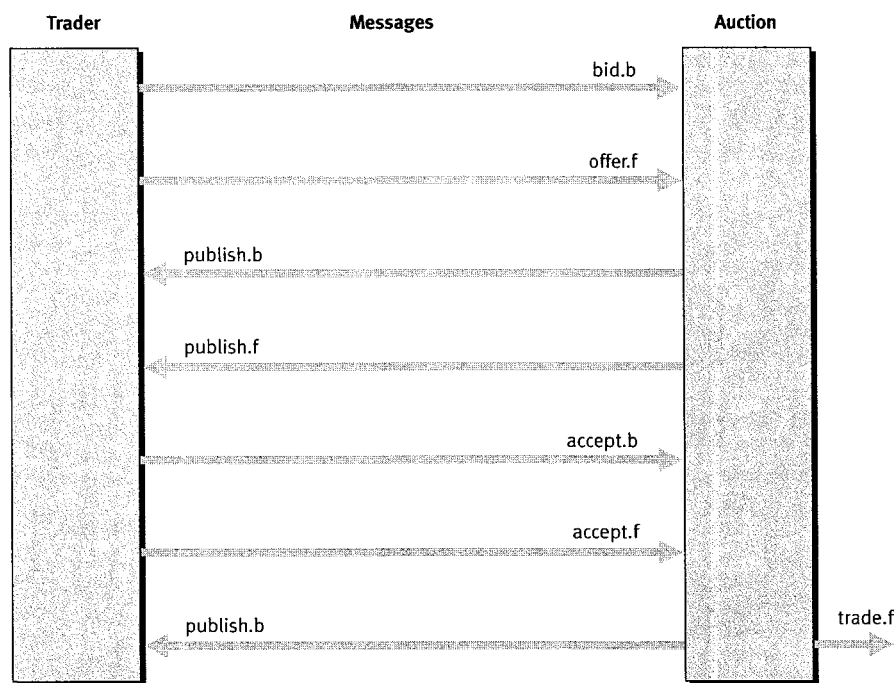


Figure 1. Type and direction of auction messages

Message publish.b conveys the information which a bid b carries to all market participants. Publish.f informs the market about an offer placed in the same way. With a message hit.b does a trader indicate that he is willing to accept the conditions of bid b which has been placed and published immediately before. A trader expresses his wish to accept an offer f by sending the message take.f to the market.

One or multiple trades may result out of an exchange of the messages mentioned above, it is denoted by trade.d and its occurrence is published by publish.d. In this case, parameter d carries information on the price at which the asset traded is exchanged as well as a reference to the buyer and seller engaged.

Figure 1 above illustrates the flow of possible messages between an individual trader and the auction centre. We assume message trade.d to be generated there and to be input for trade settlement which follows the actual auction trading process for regulating the agreement(s) found in the auction process before.

TRADING-PROCESS RULES

The following section presents sets of rules which are applied to characterize the selection of auctions considered. Rules refer to the start of auctions and determine the placement of bids and offers. They prescribe how bids and offers placed are published and which conditions hold for hitting bids and taking offers. They determine the timing of order placement as well as the details of trade occurrence and formation. Trades that result from an auction run carry prices as constituent parts so that special rules need to be specified to explain price determination for orders submitted. Finally, some restrictions are imposed on the number of occurrence of particular messages.

Messages	CBA	OBA	JBA	COA	OOA	JOA	DA
bid.b	♦	♦	♦	♦	♦		♦
offer.f	♦	♦		♦	♦	♦	♦
publish.b		♦	♦	♦	♦		♦
publish.f	♦	♦			♦	♦	♦
hit.b			♦				♦
take.f						♦	♦
trade.d	♦	♦	♦	♦	♦	♦	♦
publish.d	♦	♦	♦	♦	♦	♦	♦

Table 1. Messages and Auction Types

Rules	CBA	OBA	JBA	COA	OOA	JOA	DA
Start 1 start with offer	♦	♦					
Start 2 start with bid				♦	♦		
Start 3 start with signal for bidding			♦				
Start 4 start with signal for offers						♦	
Start 1 or Start 2 start with bid or offer							♦

Table 2. Rules for Auction Start

Rules	CBA	OBA	JBA	COA	OOA	JOA	DA
Post 1 publish offer before any bid is placed	♦	♦					
Post 2 publish bid before any offer is placed				♦	♦		
Post 3 bid prices ascending		♦					♦
Post 4 offer prices descending					♦		♦

Table 3. Rules for Posting bids and offers

Auction Start

Some auctions either start with the placement of a bid (Closed-Offers, and Open-Offers Auction), or start with the placement of an offer (Closed-Bids, and Open-Bids Auction). For the Double Auction both messages are allowed at the beginning.

Posting Bids and Offers

The placement of bids may depend on the previous submission of an offer as in a Closed-Bids or Open-Bids Auction, or vice versa – the submission of a bid – as for a Closed-Offers and Open-Offers Auction. In an Open-Bids Auction the prices of sequential bids are strictly ascending, for the Open-Offers Auction we demand offer prices to descend. A Double-Auction fulfils both requirements.

	Rules	CBA	OBA	JBA	COA	OOA	JOA	DA
Pub 1	immediate publ. of bids		♦	♦	♦	♦		♦
Pub 2	immediate publ. of offers	♦	♦			♦	♦	♦

Table 4. Rules for Publishing Orders

	Rules	CBA	OBA	JBA	COA	OOA	JOA	DA
Hit	no hit unless bid placed before			♦				♦
Take	no take unless offer placed before						♦	♦

Table 5. Rules for Hitting bids and Taking Offers

	Rules	CBA	OBA	JBA	COA	OOA	JOA	DA
Time 1	bids to be placed in time interval	♦	♦					
Time 2	offers to be placed in time interval				♦	♦		

Table 6. Rules for Auction Timing

	Rules	CBA	OBA	JBA	COA	OOA	JOA	DA
Trade 1	no trade unless bid placed	♦	♦	♦	♦	♦		
Trade 2	no trade unless offer placed	♦	♦		♦	♦	♦	
Trade 1 or Trade 2	no trade unless bid or offer placed							♦
Trade 3	trade requires hitting a bid			♦				
Trade 4	trade requires taking offer						♦	
Trade 3 or Trade 4	trade requires hitting bid or taking offer							♦
Trade 5	trade follows hit			♦				♦
Trade 6	trade follows take						♦	♦
Trade 7	no action other than trade publ. after trade	♦	♦	♦	♦	♦	♦	♦

Table 7. Rules for the Occurrence and Publishing of Trades

*Publishing Bids and Offers*

Immediate publishing of posted orders instantaneously provides complete information of the prevailing order situation to all market participants. That property holds for the Open-Bids and Open-Offers Auction, the Japanese-Bids, and Japanese-Offers Auction as well as the Double-Auction institution.

*Hitting Bids and Taking Offers*

The placement of a bid is the precondition for a hit to occur in a Japanese-Bids Auction. In a Japanese-Offers Auction offer placement is the precondition for a take-message. Both conditions are met by the Double Auction which applies both concepts - hit and take.

*Auction Timing*

Only a limited time interval is available for the placement of bids and offers in a Closed-Bids, Closed-Offers, Open-Bids, and Open-Offers Auction.

*The Occurrence and Publishing of Trades*

For some auctions no trade can occur unless a bid (offer) has been posted. For the Double-Auction at least one offer or one bid has to be submitted so that a trade can result. Some auctions generate a trade only if a bid is hit (Japanese-Bids), or an offer is taken (Japanese-Offers). Hitting a bid and taking an offer in Japanese Auctions as well as the Double Auction result in a trade which triggers the next message. As all auctions considered here generate only a single trade, no other actions than trade publishing may follow each trade.

	Rules	CBA	OBA	JBA	COA	OOA	JOA	DA
Form 1	highest bid constitutes trade	♦	♦	♦				
Form 2	lowest offer constitutes trade				♦	♦	♦	
Form 1 or Form 2	highest bid or lowest offer forms trade							♦
Form 3	time priority	♦			♦			
Form 4	traded bid and offer match	♦	♦	♦	♦	♦	♦	♦

Table 8. Rules for Trade Formation

	Rules	CBA	OBA	JBA	COA	OOA	JOA	DA
Price 1	price of highest bid sets trade price	♦	♦	♦				
Price 2	price of lowest offer sets trade price				♦	♦	♦	
Price 1 or Price 2	price of highest bid or lowest offer sets trade price							♦

Table 9. Rules for Price Determination

	Rules	CBA	OBA	JBA	COA	OOA	JOA	DA
Count 1	at most one offer	♦	♦					
Count 2	at most one bid				♦	♦		
Count 3	at most one hit			♦				♦
Count 4	at most one take						♦	♦
Count 5	at most one trade	♦	♦	♦	♦	♦	♦	♦

Table 10. Rules for Number of Messages

*Trade Formation*

In a Closed-Bids, Open-Bids and Japanese-Bids Auction (Closed-Offers, Open-Offers and Japanese-Offers Auction) is the highest bid (lowest offer) a constituent part of a trade. Time priority holds as a secondary criterion for multiple bids (multiple offers) having the best price in a Closed-Bids (Closed-Offers) institution. In a Double Auction either the highest bid or the lowest offer forms the trade depending on which of the two orders is accepted first.

*Price Determination*

In auctions which comprise multiple competing bids (Closed-Bids, Open-Bids, Japanese-Bids Auction) the highest bid sets the trade price. For a Closed-Offer, Open-Offer and Japanese-Offer Auction it is the lowest offer. Consequently, the order accepted in a Double-Auction determines the trade price in that auction type.

*Number of Messages*

At most one offer (bid) can be placed in the Closed-Bids (Closed-Offers) and Open-Bids (Offers) Auction. Traders can send at most one hit of a bid (take of an offer) to a Japanese-Bids Auction (Japanese-Offers Auction). A Double-Auction allows one hit or take to occur in one auction run. The number of trades in these auctions is limited to one.

**FORMATION OF AN AUCTION**

**TAXONOMY**

We use the rule set presented in the previous section to establish a graphical representation for a taxonomy of the auction types we consider here. Figure 2 shows for each auction, the Closed-Bids, Open-Bids, Japanese-Bids, Japanese-Offers, Open-Offers, Closed-Offers and the Double Auction, its specification using the common rule set.

Let us take the Japanese-Offers Auction as an example to show how its characterization is encoded here. We have to trace back all paths that lead to the grey box named 'JOA' and collect all rules that

Rules  
Form 4, Count 5 and  
Trade 7 hold for all  
auctions

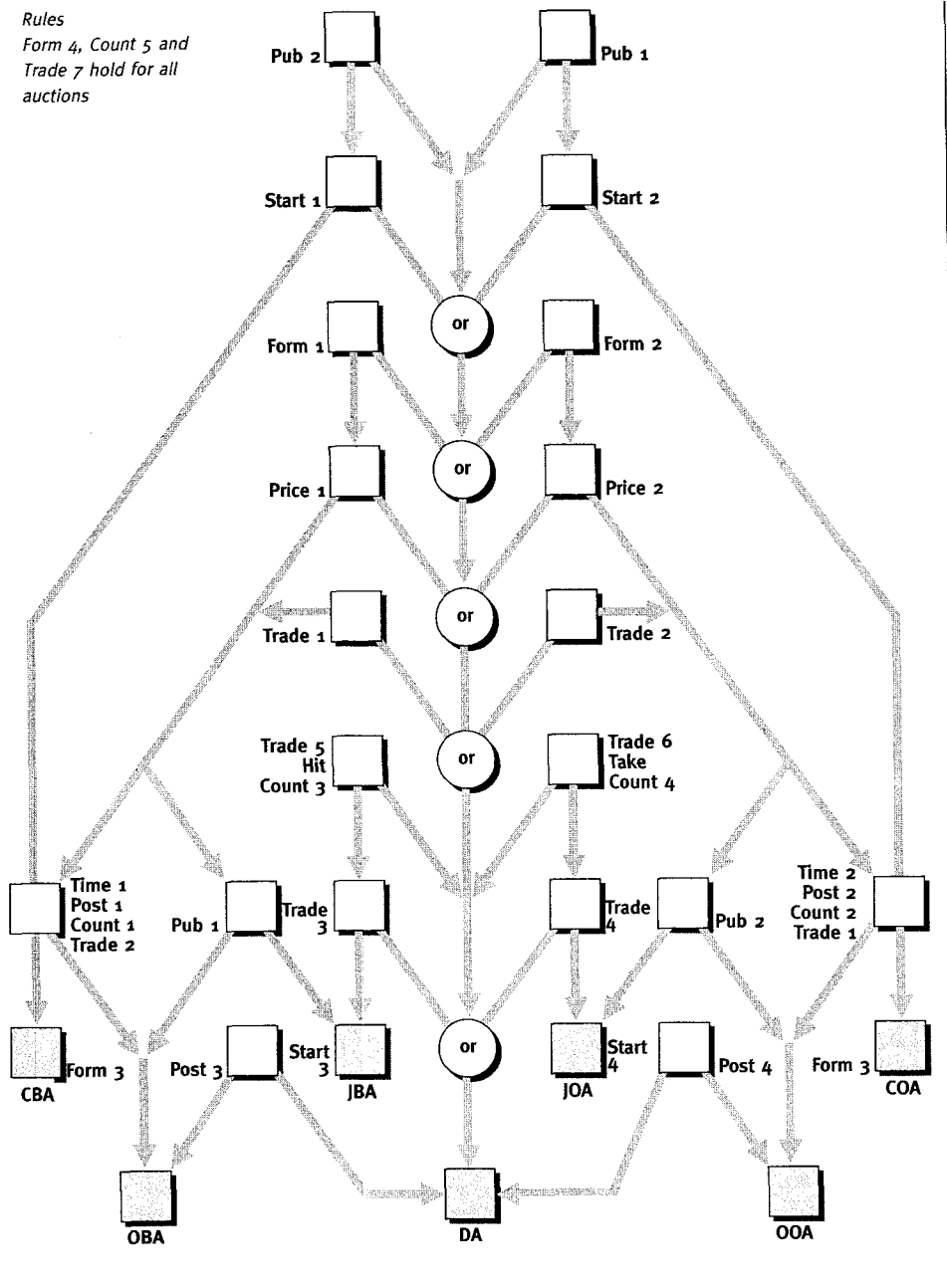


Figure 2 Auction Taxonomy

annotate those paths. For the Japanese-Offers Auction we get: Start 4, Trade 2, Trade 4 and Trade 6, Take, Count 4 as well as Pub 2, Price 2, and Form 2.

The graphical representation shows common properties of auction processes as well as differences between them. The Open-Offer Auction - 'OOA' - for instance, has all rules on the paths that lead to Pub 2 in common with the Japanese-Offers Auction. In addition, rules Post 4, Time 2, Post 2, Count 2 and Trade 1 as well as Pub 1 and Start 2 hold.

The symmetrical form of figure 2 represents the symmetrical characteristics of the auctions as mentioned in sections above. Furthermore, the figure illustrates how the Double Auction 'inherits' process characteristics from both sides of the auction taxonomy.

**CONCLUSION**

Obviously, it is possible to specify the trading processes of a group of auctions by using a common set of process rules. Furthermore, the specifications which result can be used as input for a taxonomy of auctions. It indicates common and specific process characteristics of the auctions taken into consideration.

It appears worthwhile to further explore and define rule systems for auction processes in order to provide a uniform base for the specification of electronic auctions. Such systems could ease and accelerate system construction in an early phase since they might serve as references for auction process specifications. (cf. Malone, et al. 1997 and Wyner & Lee 1995 for organizational processes).

The specifications given here are natural-language descriptions. They can be taken as input for formal specifications of process rules. Trace specifications as proposed in (Broy, et al. 1993) appear to be suited to capture the process requirements for auctions (Reck 1997). Trace specifications of auction processes allow to formally prove auction properties (for sequential models of organizational processes also see Pentland 1995). Furthermore, they provide a sound methodological base for further development steps during electronic auction construction (Reck 1993).