A Parametrization of the Auction Design Space

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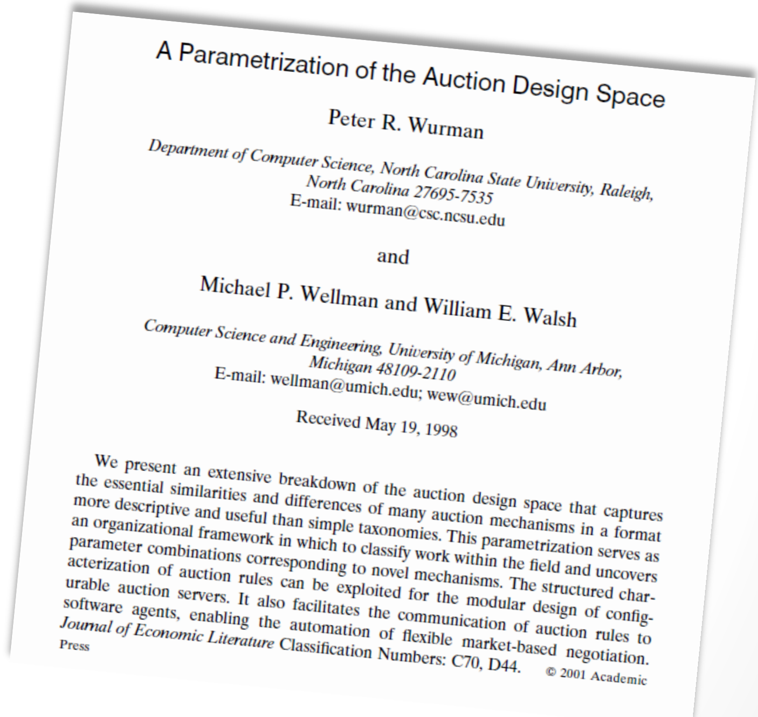
2/18/2013

The Paper

P. Wurman, M. Wellman, and W. Walsh. A parameterization of the auction design space. *Games and Economic Behavior*, 35:304.338, 2001.



A Parametrization of the Auction Design Space

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Received May 19, 1998

We present an extensive breakdown of the auction design space that captures the essential similarities and differences of many auction mechanisms in a format more descriptive and useful than simple taxonomies. This parametrization serves as an organizational framework in which to classify work within the field and uncovers parameter combinations corresponding to novel mechanisms. The structured characterization of auction rules can be exploited for the modular design of configurable auction servers. It also facilitates the communication of auction rules to software agents, enabling the automation of flexible market-based negotiation. *Journal of Economic Literature* Classification Numbers: C70, D44.

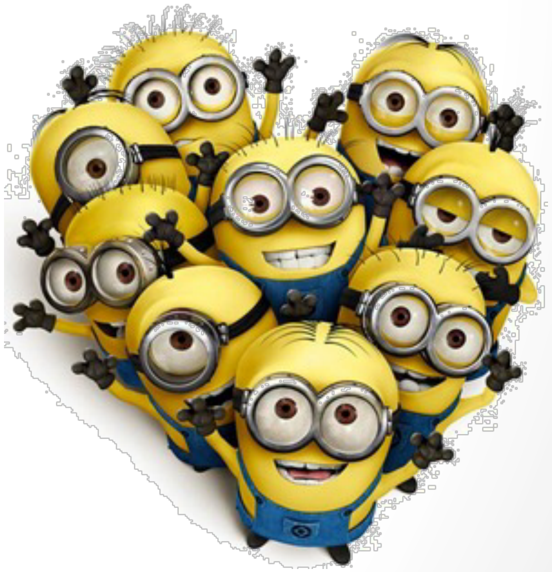
Outline

- Introduction
- Auction Activities
- Auction Rules
- Conclusions
- Praises
- Critiques
- Implications
- Q & A

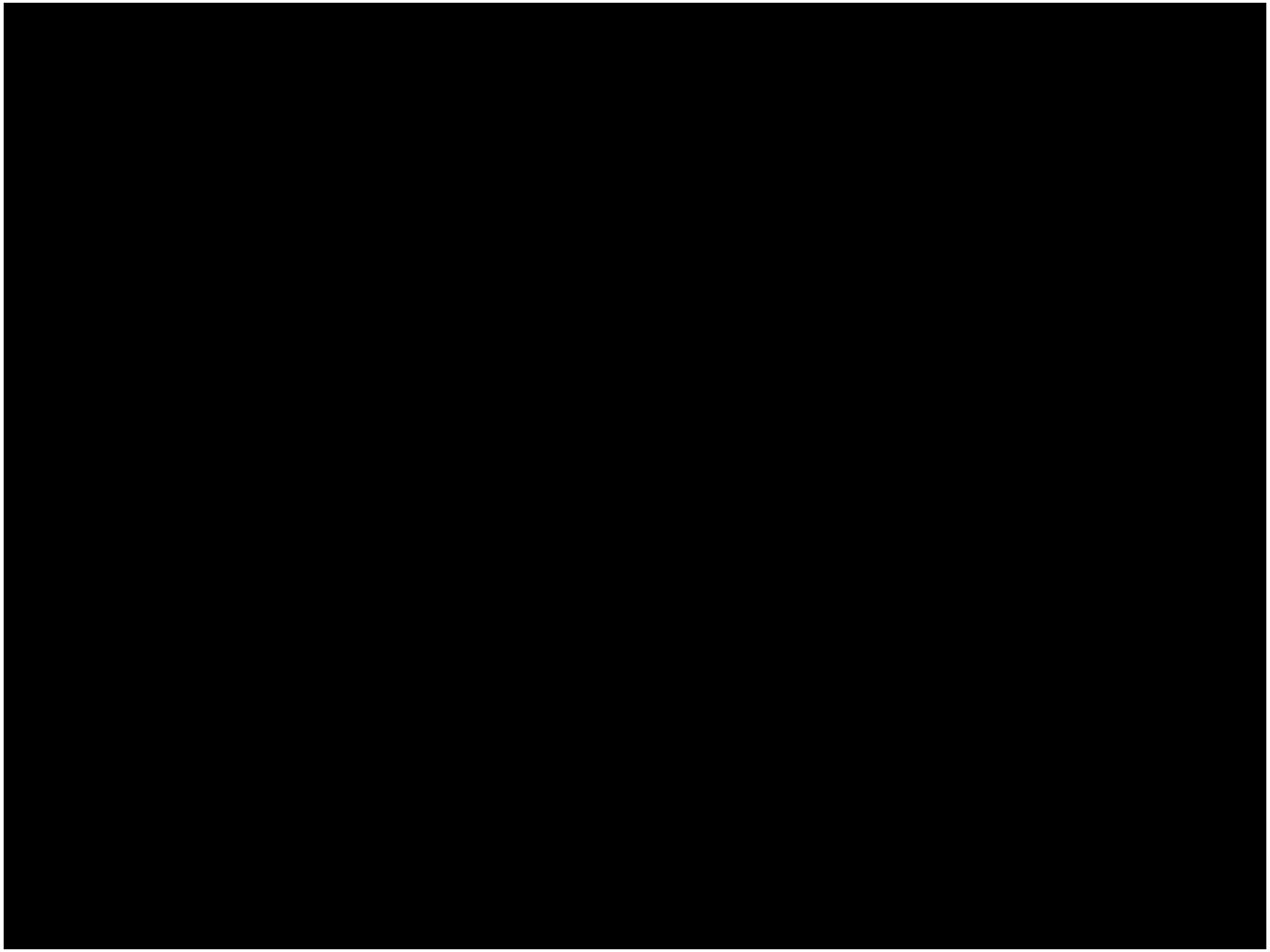
Auction & Multi-agent System

- An Auction market is ***naturally*** a Multi-agent system
  - Buyer agent
  - Seller agent
  - Auctioneer agent

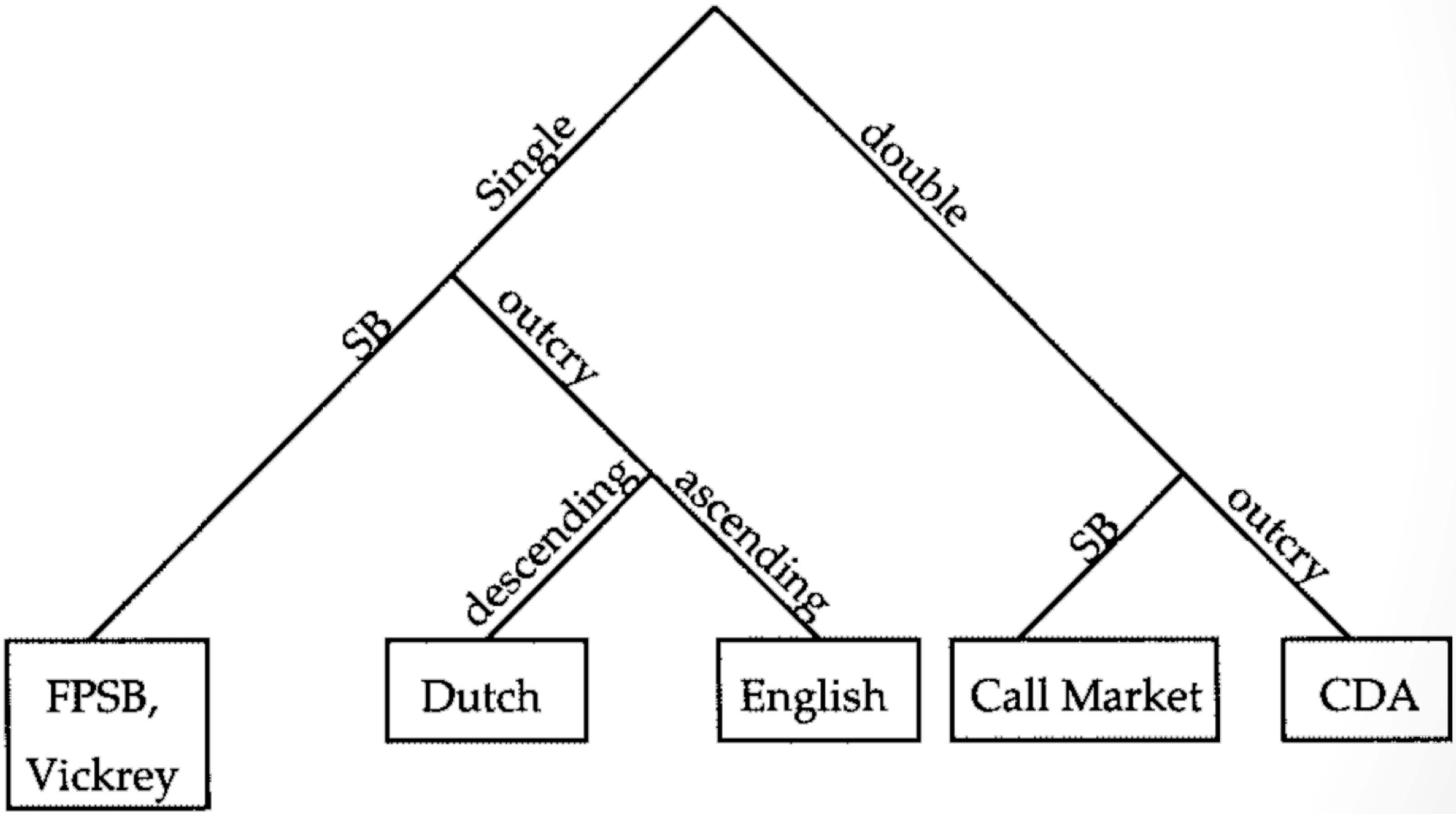
- Therefore, studying Auction markets can provide valuable insights into Multi-agent systems
  - Resource allocation
  - System coordination



CBOT Soybean Auction



Classic Auction Types



Activities & Rules of an Auction

Activities

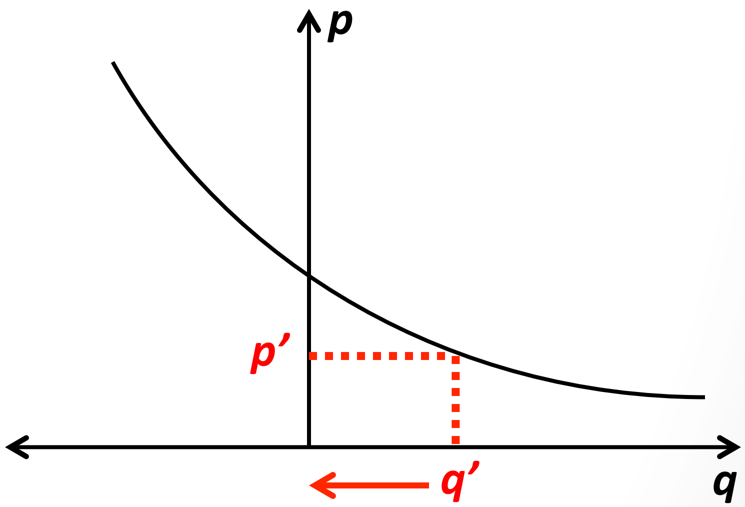
- Bids
- Clear
- Reveal intermediate information

Rules

- Bidding rules
- Clearing policy
- Quote policy

Bids

- Semantics
  - Seller: a bid is a message that states the agent's willingness to exchange goods or services for money (aka ask)
  - Buyer: the bid is a reflection of the agent's demand for the resource in terms of a price
- General Characteristics
  - Monotone
  - Divisible



Bidding Rules

Bidding rules determine under what conditions bids may be introduced, modified, or withdrawn, as a function of agent identity, current bid status, or the entire auction history

- Agent Identity
  - one buyer : many seller
  - many buyer : one seller
  - many buyer : many seller (double auction)

Bidding Rules Cont.

- Expressiveness
  - Price-quantity schedules

    A bid schedule is a stepwise specification of offers to buy or sell various quantities at discrete price point

    - Single units: an agent can express a single-unit offer as a price and a sign indicating whether the offer is to buy or to sell
    - Single price points: this option restricts offers to a fixed number of units (buy or sell) at a single, per-unit price
  - Continuous

    A bid may specify offers that are continuous function of prices

Bidding Rules Cont.

- Dominance

  Bid dominance rules restrict the relationship of an agent's new offer to the bid it replaced and in general

  - Buyer-side: ascending rule (new bids > old bids)
  - Seller-side: descending rule (new bids < old bids)

- Beat-the-Quote

  The purpose of beat-the-quote rules is to ensure a progression of prices, directing the process to a steady state or an equilibrium

  - E.g. a new bid must beat the highest bid so far (by a specified increment) in an English outcry auction

Bidding Rules Cont.

- Withdraw and Expiration Rules
  - E.g. withdraws are permitted only in conjunction with a clearing operation
  - Expiration: a planned withdraw, typically specified at bid time

- Activity Rules

  In many complex domains, agents can benefit from a strategy in which they withhold information while others reveal information

    - E.g. waiting in the background while others bid and when the market seems about to converge, the agents step in and "steal the deal"

Clear

The central purpose of an auction is to clear the market, determining resource exchanges and corresponding payments between buyers and sellers

Clearing Policy

- Matching Function

  Determining which agents will trade and the exact terms of each exchange

  - Trade $surplus = P \downarrow buyer - P \downarrow seller$,
    - Trade is mutually beneficial if surplus > 0
    - Match is locally efficient if max (Σ surplus)
    - Market is cleared if no surplus exists among the remaining bids

Case 1 is better

Whoever (buyer or seller) values the good the most should end up with the good

In the second case Agent 2 values the unit 3rd highest so it should not get the unit

An Example with 4 Bids

Agent	Bids
Agent 1	sell 1 unit at $1
Agent 2	buy 1 unit at $2
Agent 3	sell 1 unit at $3
Agent 4	buy 1 unit at $4

Case 1 (surplus $3)
Agent 1 -> Agent 4

Case 2 (surplus $2)
Agent 1 -> Agent 2
Agent 3 -> Agent 4

Clearing Policy Cont.

- Matching Function Cont.
  - Uniform-Price
    - Transaction price is the same among all trades
    - In k-double auction $p = k \cdot \bar{p} + (1-k) \cdot p$, $k \in [0,1]$

Sell Offers	Bid #	1		
		⋮		
	Bid #	M	$\bar{p}$: upper bound	
Buy Offers	Bid #	M + 1	p : lower bound	
		⋮		
	Bid #	M + N		

Increasing price ↓

Special case M = 1, Vickrey auction where p is the second price

Clearing Policy Cont.

- Matching Function Cont.
  - Discriminatory-Price
    - Pay buyer's / seller's bid
    - Chronological pricing (earlier / later bid)

Agent 1 -> Agent 9
Agent 4 -> Agent 2
Total Surplus = $ 6

An Example with 5 Bids

Time	Agent	Bids
t_1	Agent 1	sell at \$5
t_2	Agent 2	buy at \$8
t_3	Agent 3	buy at \$7
t_4	Agent 4	sell at \$6
t_5	Agent 5	buy at \$9

Transactions

	1 sells to 5	4 sells to 2
Seller's price	\$5	\$6
Buyer's price	\$9	\$8
Earlier bid	\$5	\$8
Later bid	\$9	\$6

Clearing Policy Cont.

- Matching Function Cont.
  - With indivisible bids
    - The surplus maximization problem is NP-hard
      reducible to 0-1 knapsack problem
    - Greedy algorithms

$$\max \sum_i \sum_z z w_i^{-1}(z)\,\delta^{iz}$$ Total trade surplus

$$\text{s.t.} \quad \sum_i \sum_z z\,\delta^{iz} \le 0$$ We don't allocate more than we have

$$\sum_z \delta^{iz} \le 1 \qquad \forall i$$ No agent wins more than one quantity level

$$\delta^{iz} \in \{0, 1\},$$ $\delta \uparrow iz$ = 1 means that i's offer for z units is part of the solution

Clearing Policy Cont.

- Clear Timing
  - Scheduled

    clears occur at a specified set of times
  - Random
    - clears are determined according to some random distribution
    - can deter agents from applying time-dependent strategies
  - Bidder activity
    - clears occur whenever a new bid is admitted
    - default timing policy of continual auctions (i.e. CDA)
    - variant: synchronized auctions where clears happen when a new bid has been received from each participant or when a fixed number of bids has been received
  - Bidder inactivity

    the auction clears when no bid has been received for a specified period

Clearing Policy Cont.

- Closing Conditions
  - The closing conditions are logical tests that determine whether a clear should be the final clear
  - Auctions can close at a schedule / random time, after a period of inactivity, when bid of designated agents are matched (e.g. the seller) or when an external signal is received

- Tie Breaking
  - In favor of the earlier bids
  - In favor of the bids for larger quantities
  - Or break ties arbitrarily

Clearing Policy Cont.

- Auctioneer Fees
  - Entrance fee

    A fixed fee for the agent's first bid
  - Bid fee
    - A fixed fee with every bid
    - Can provide disincentive to price manipulation (McCabe et al, 1993)
  - Ad valorem / Non-linear

    A percentage / non-linear function of the exchange price

Intermediate Information

Auctions commonly supply agents with some form of intermediate status information (quotes), typically in the form of hypothetical results were the auction to clear at that moment

Quote Policy

- Price Quotes

  A price quote informs an agent of the range of offers that would have been in the exchange set (B_{in} and S_{in}) had the auction cleared at the time the quote was issued

  - In many cases, the quote function can be viewed as a hypothetical matching function
  - The bid quote $\underline{p}$ is the price an agent would have to bid under in order to place a winning sell bid
  - The ask quote $\bar{p}$ is the price an agent would to bid over to place a winning buy bid

Quote Policy Cont.

- Quote Timing
  - No price quotes

    Auctions that reveals no information (sealed-bid auctions)
  - Scheduled

    Quotes are generated according to a specified schedule
  - Random

    Price quotes are generated according to some stochastic process
  - Bidder activity

    Price quotes are generated with each new bid admitted
  - Bidder inactivity

    Price quotes are generated when no bid has been admitted for a specified time

Quote Policy Cont.

- Order Book
  - The order book keeps track of current set of active bids
  - The auctioneer may make some or all the information in the order book public or choose to keep the book closed
- Transaction History
  - Auctions may publicize selected information about past exchanges (price, quantities or even identities of the agents)
  - Publicly revealing past transactions helps to avoid information asymmetry

Conclusions

- This paper presents a comprehensive survey of the auction design space
- The auction activities and auction rules discussed in the paper captures the essential similarities and differences of many auction mechanisms

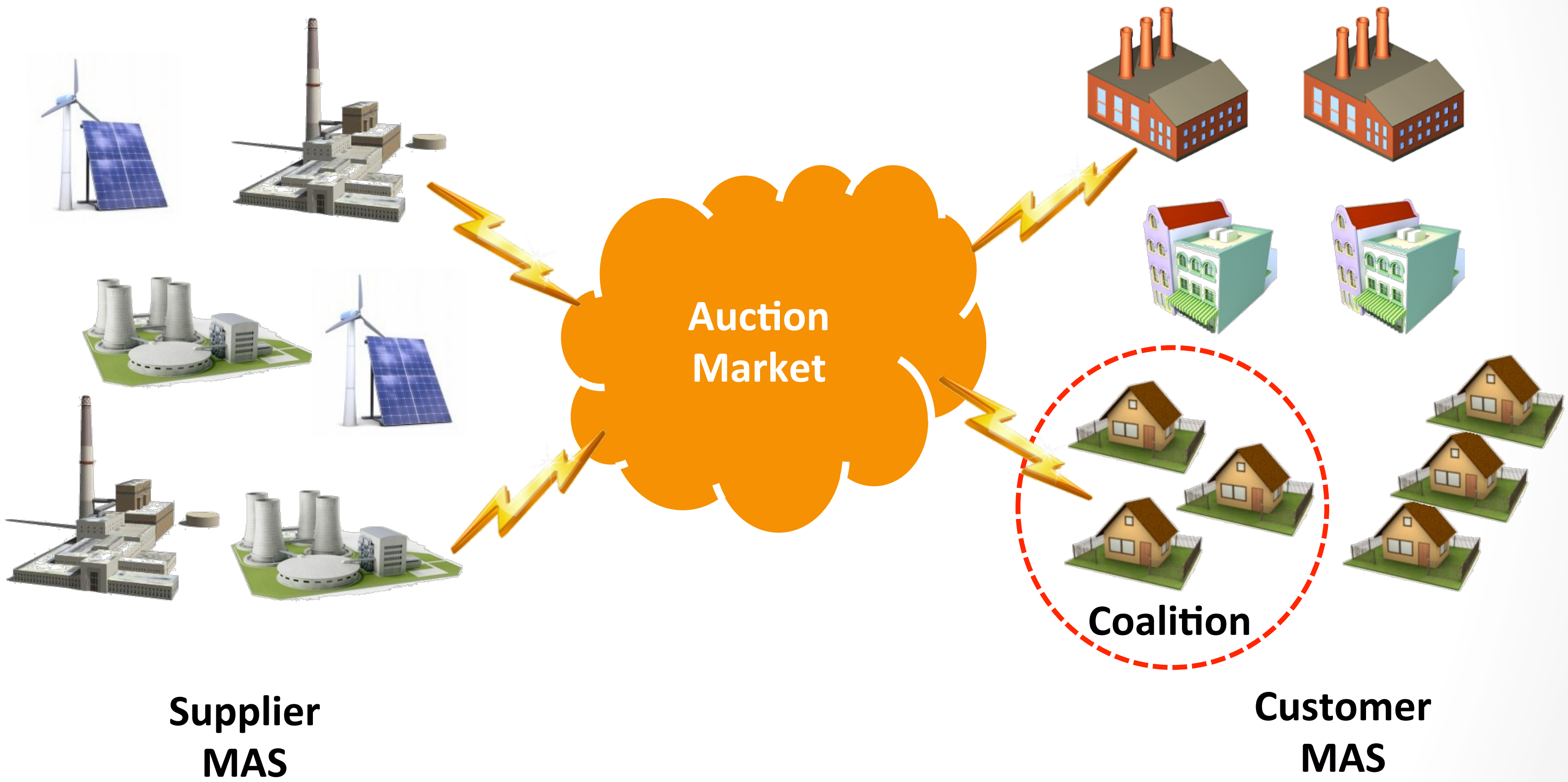
Praises

- The parametrization introduced by the authors provides a more descriptive and useful perspective than the traditional taxonomic approach
- The parametrization can serve as an organizational framework to classify research in auction analysis and to uncover new, potentially useful mechanisms
- The parametrization facilitates the design and development of software auction agents

Critiques

- The paper mentions activity rules, which are particularly useful to study the interactions among bidding agents, however they are not in sufficient detail
- Some examples discussed in the paper are over-simplified. More realistic instances could be used instead
- The authors could study the effects of different configurations of auction parameters

Implications on Smart Grid MAS




Q
A