A New Perspective of Trust through Multi-Attribute Auctions

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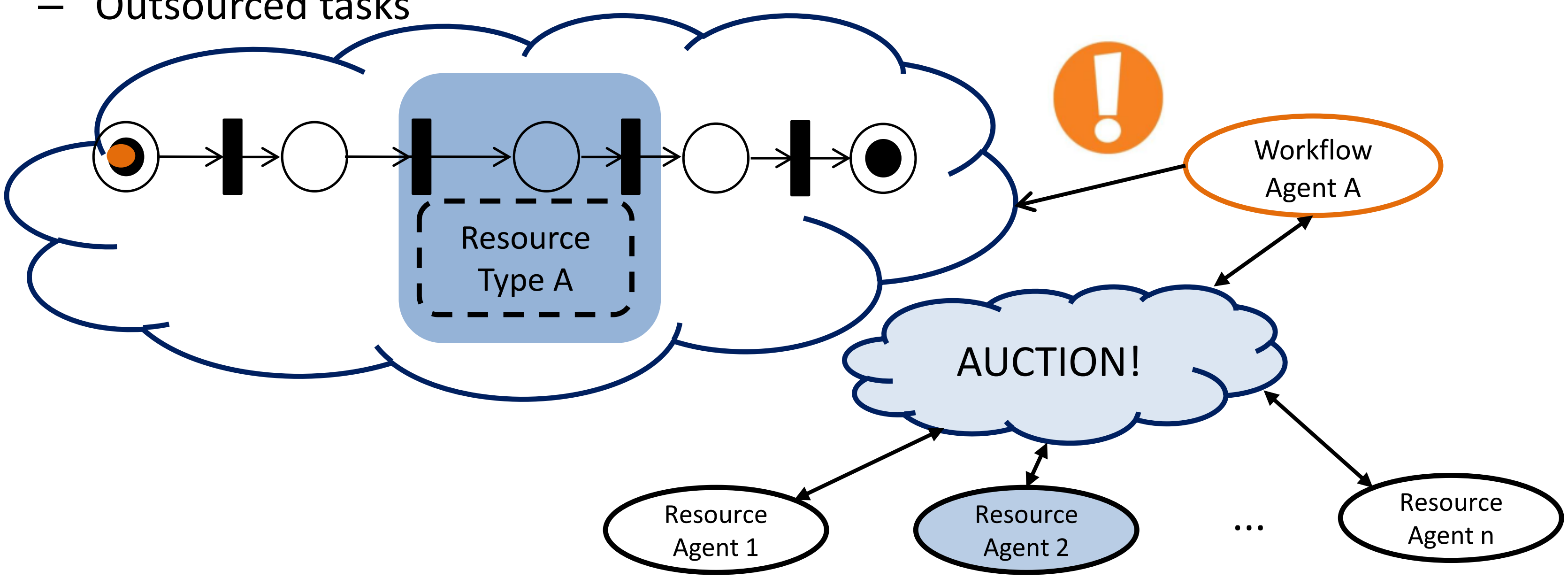
Auctions in workflow management systems

- Auctions allow an optimal allocation for just-in-time
- Competitive market
- Special domains:
  - Production under demand / Supply chain under demand
  - Handling unexpected tasks (provoked by faults)
  - Unknown resource status
  - Outsourced tasks



Multi-dimensional allocation problem

- Production process managers are not only concerned by costs
- Workflow managers are concerned about multiple attributes:
  - Economic costs
  - Product quality
  - Delivery times
  - Environmental footprint
  - Licenses / ISO standardizations
  - …

Multi-dimensional allocation problem

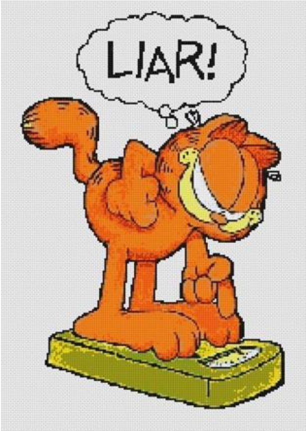
Multi-criteria allocation problem → **Multi-attribute auctions**

Trust motivation

- Misdelivered tasks involve:

Trust motivation

- Misdelivered tasks are due:
  - Cheating behaviors

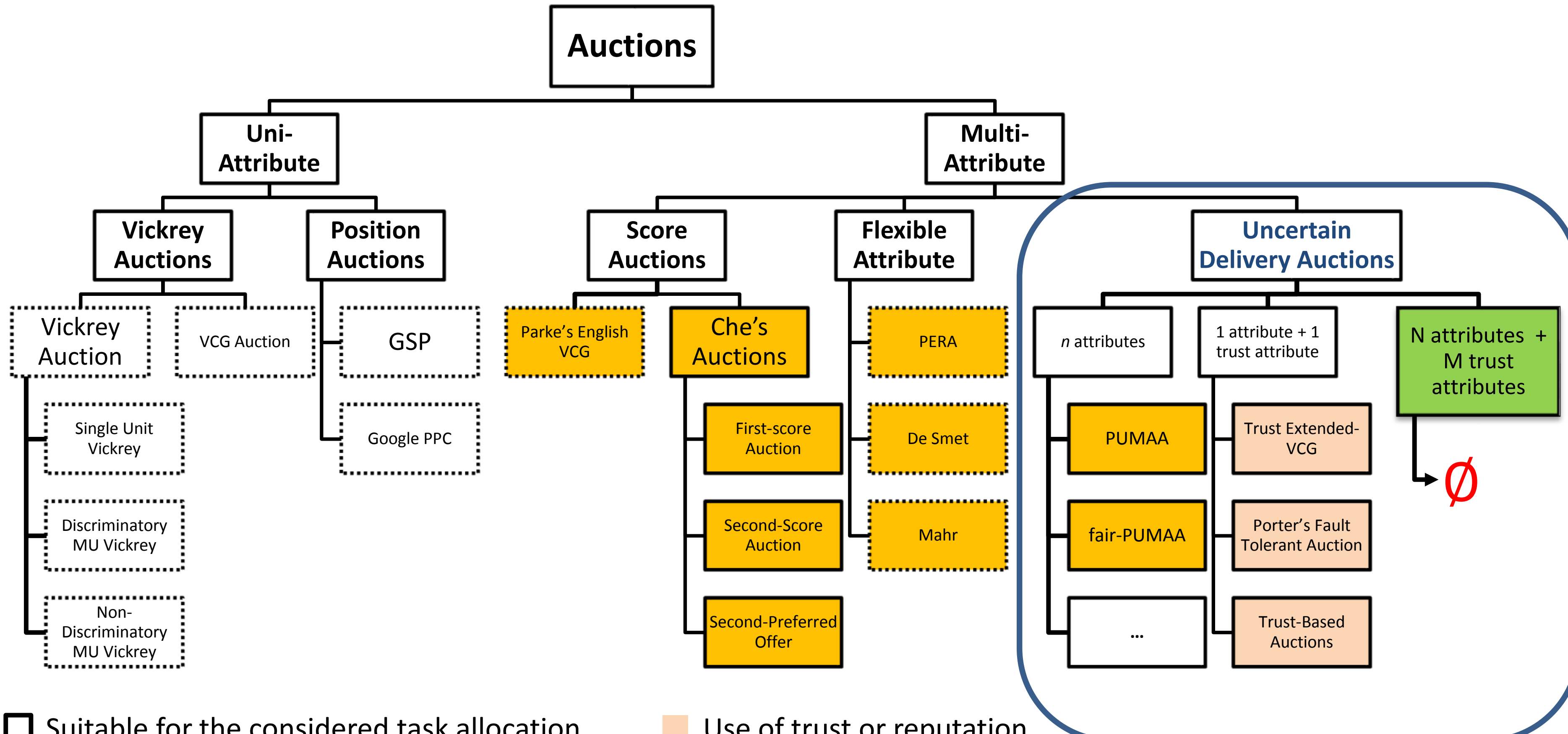


  - Involuntary errors
    - Bidders may not be able to accurately estimate their abilities

Trust motivation

- Cheating agents:
  - Incentive Compatible Mechanism
    - Vickrey Based Auction (VCG Payment rule)
    - …
- Involuntary errors and misestimating the abilities
  - Trust & Reputation based auctions
    - Porter's auction (uni-attribute)
    - Ramchurn's auction (uni-attribute)
    - …
- **No solution integrating Incentive compatibility, trust & multi-attribute**

Multi-attribute resource/task allocation



Suitable for the considered task allocation

Not suitable for the considered task allocation

Use of trust or reputation

Multi-attribute (excluding trust)

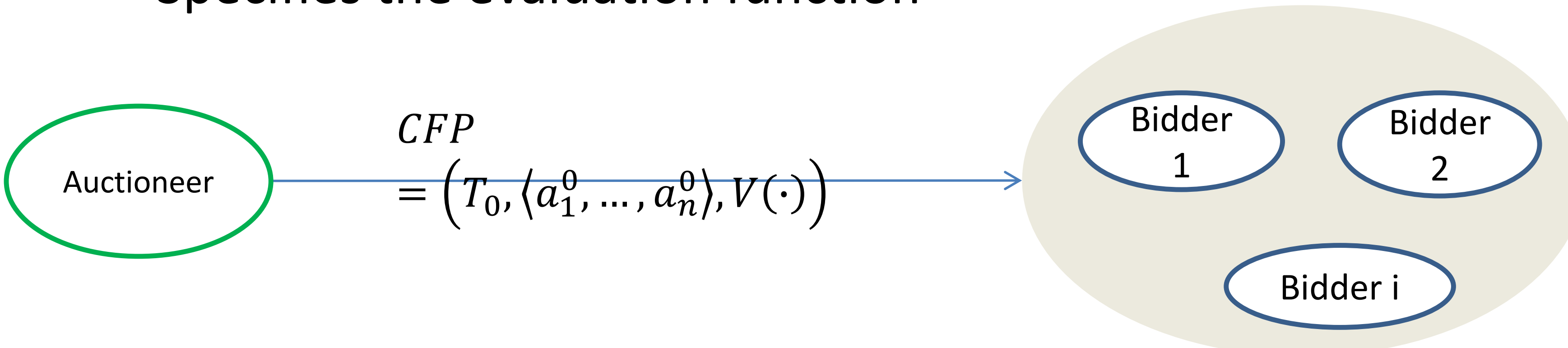
Methodology

1. Call for proposals (CFP)
2. Bidding
3. Winner determination problem (WDP)
4. Payment
5. Trust learning

1. Call for proposals

- An auctioneer A_0 needs to allocate a task T_0 with a set of attributes $a_1, \dots, a_n$

- It Sends a call for proposals (CFP) to all the bidders
  - Specifies the task
  - Specifies the attribute to evaluate
  - Specifies the evaluation function

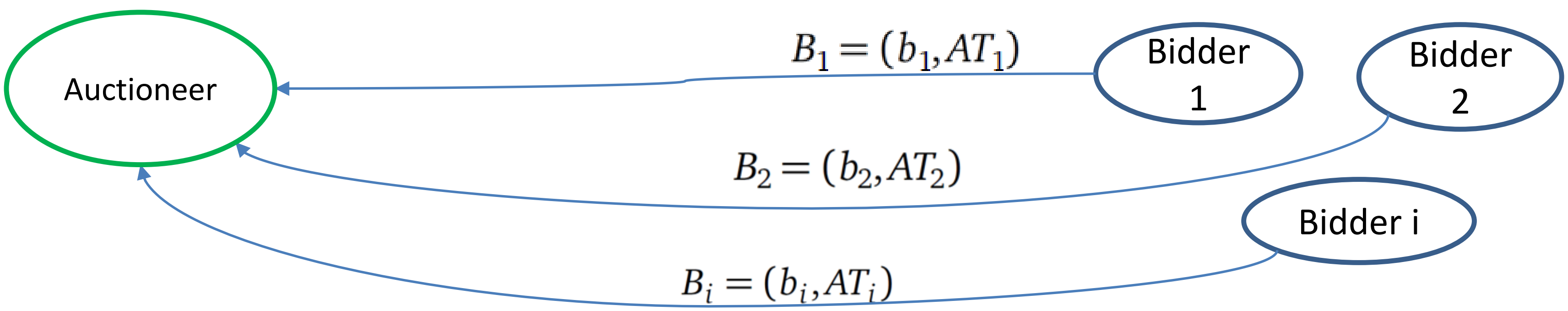


2. Bidding

- Bidders evaluate the CFP and submit the bids with the corresponding attributes

$$B_i = \langle b_i, t_i, e_i \rangle$$

- Each bidder submits the bid that is expected to maximize its utility



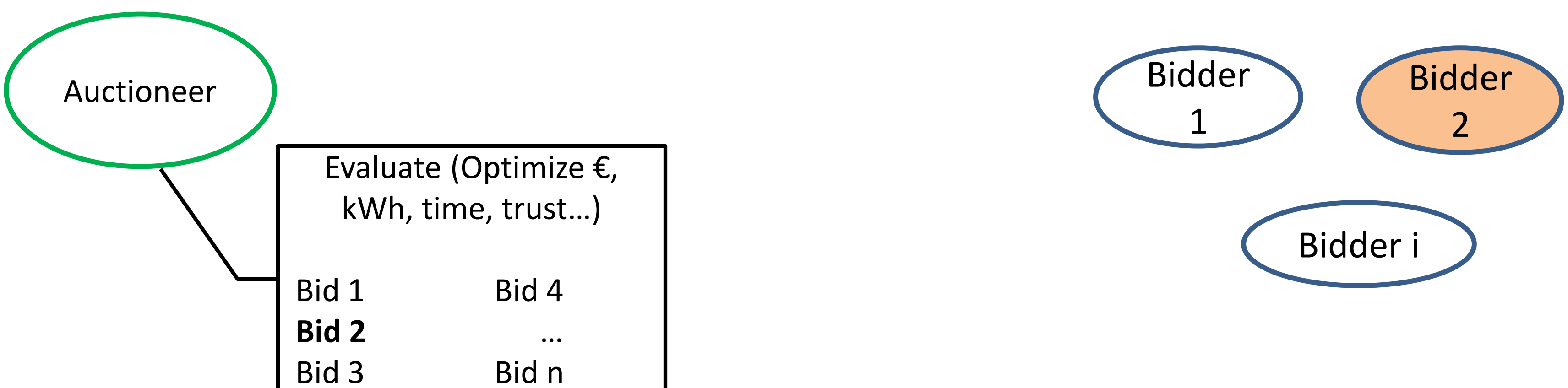
3. Winner determination problem

- Inclusion of trust in the valuation of the bid
  - One trust attribute per checkable attribute

$$\bar{u}(T_0, b_i, t_i, e_i, \tau_{i,r}^t, \tau_{i,r}^e) = v(T_0) - V\left(b_i, \frac{t_i}{\tau_{i,r}^t}, \frac{e_i}{\tau_{i,r}^e}\right)$$

- WDP consists of finding the bid that minimizes the evaluation function

$$\min_i \left\{ V\left(b_i, \frac{t_i}{\tau_{i,r}^t}, \frac{e_i}{\tau_{i,r}^e}\right) \right\}$$



- Conditional Vickrey-based payment
  - Good delivery: VCG playment rule

$$V_0(p_1, AT_1) = V_0(b_2, AT_2)$$
$$p_1 = V_0^{-1}(V_0(b_2, AT_2), AT_1)$$

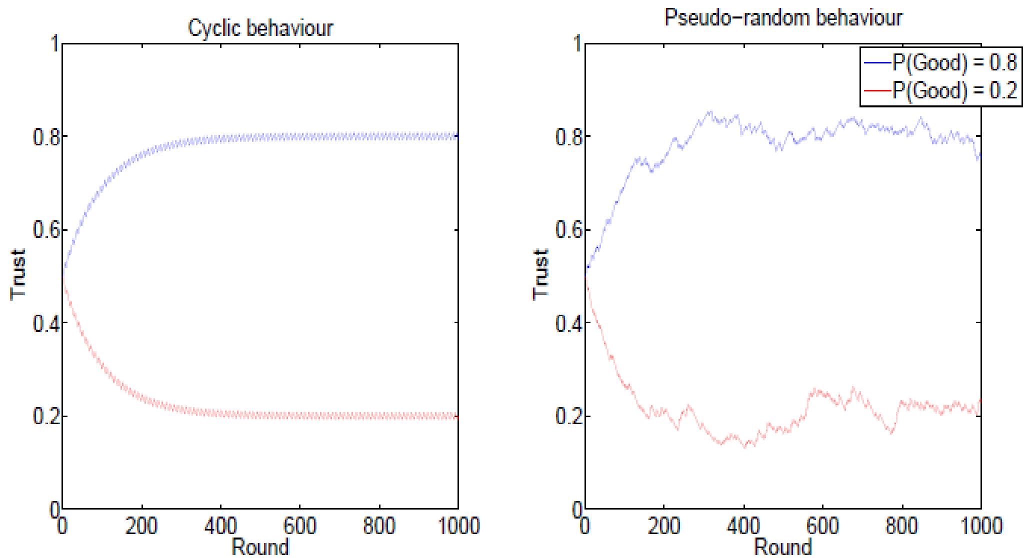
  - Bad delivery

$$V_0(p_1, AT_1') = V_0(b_1, AT_1)$$
$$p_1 = V_0^{-1}(V_0(b_1, AT_1), AT')$$

5. Trust learning

$$\tau^t_{j,r+1} = \begin{cases} \tau^t_{j,r} + \alpha_t(1-\tau^t_{j,r}) & \text{if } t'_{i,j,k} \leq t_{i,j,k} \\ \tau^t_{i,r} - \beta_t \tau^t_{i,r} & \text{otherwise} \end{cases}$$

$$\tau^e_{j,r+1} = \begin{cases} \tau^e_{j,r} + \alpha_t(1-\tau^e_{j,r}) & \text{if } e'_{i,j,k} \leq e_{i,j,k} \\ \tau^e_{i,r} - \beta_t \tau^e_{i,r} & \text{otherwise} \end{cases}$$



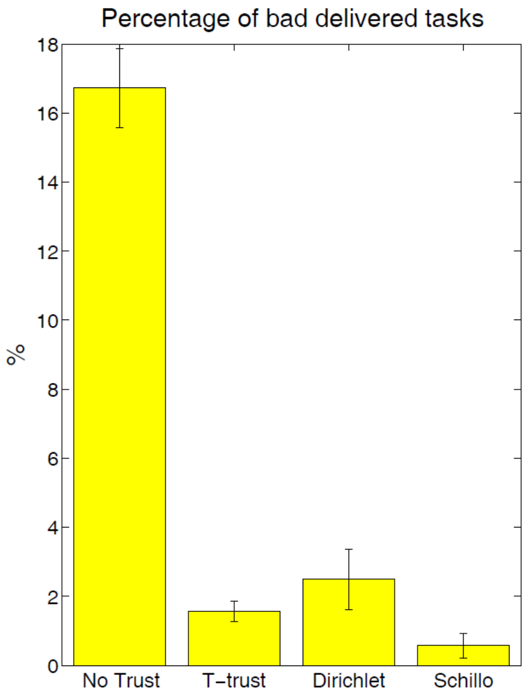
$$\alpha = \beta = 0.01$$

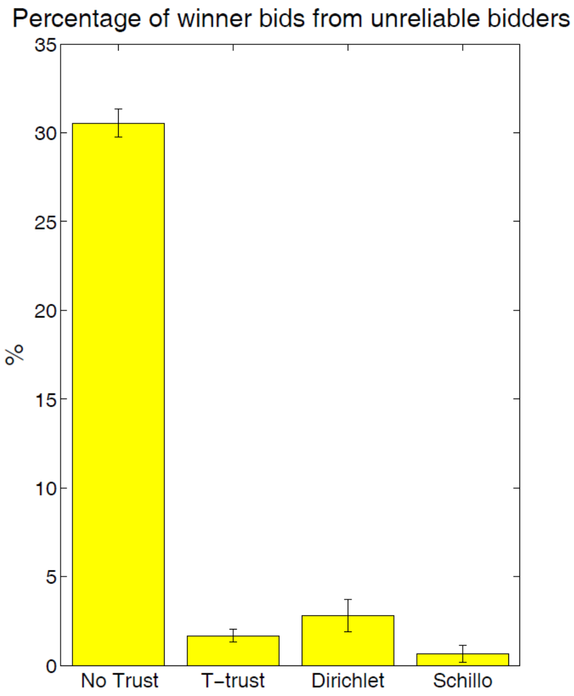
Experiments

- Experiments based on a real business process
  - One auctioneer outsources tasks to external agents
  - Consideration of economic cost + delivery time + energy consumption
  - Greedy bidders
  - Execution times and energy consumptions based on real agents probability distributions
- 6 accurate bidders + 6 inaccurate bidders
- Each accurate bidder has its own inaccurate twin bidder
  - Same abilities
  - Same time and energy distributions

Results

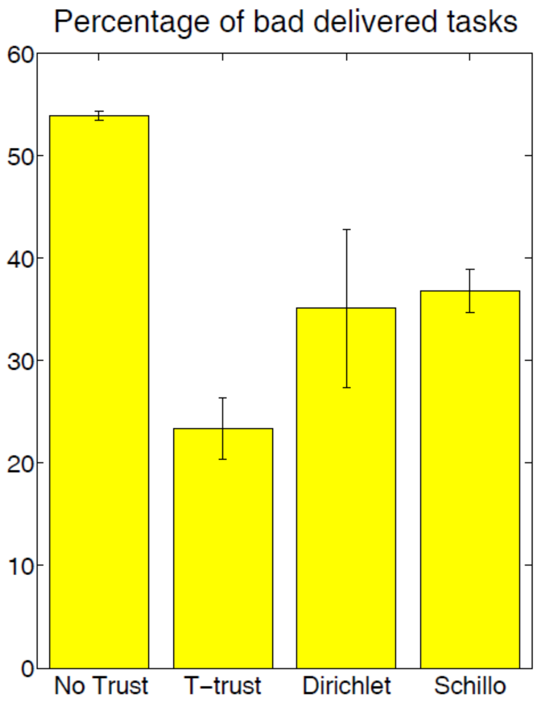
- The use of trust highly reduces the amount of bad delivered tasks
- With agents that always behave equal, Schillo model outperforms the others

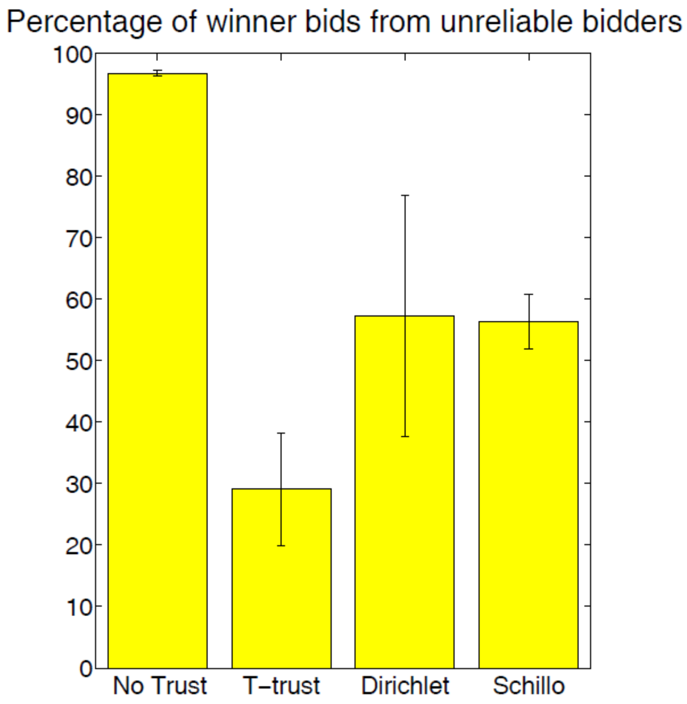




Results

- All bidders misestimate the attributes but good bidders add a security margin ($1.5 \times \sigma$)





Conclusions

- ✓ Merge of trust with multi-attribute auctions
- ✓ Inclusion of trust in the valuation function. This affects:
  - The winner determination problem
  - The payment
- ✓ Flexibility of trust regarding each checkable attribute
- ✓ Proposal of a trust learning model
  - ✓ Easy to parametrize and adjust the learning curve
  - ✓ It does not present rigidity when faces agents' behavior changes
  - ✓ Robust against initialization and random misdeliveries

THANKS!!