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# An Ascending Protocol for SLA Negotiation with Multiple Providers

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# Outline

1. The research problem
2. Approach
3. QEA implementation
4. Experimental results
5. Conclusions

# 1. The research problem (1/2)

- Service Level Agreement (SLA)
  - contractual obligation between a provider and a consumer
  - expectations on Quality of Service (QoS)
- Critical issues
  - efficient resource allocation
  - different goals and policies for the involved parties
  - lack of automated negotiation mechanisms



# 1. The research problem (2/2)

- Proposed solution
  - virtual environment with several service providers and a consumer
  - an ascending protocol from the consumer's point of view
  - concurrent SLA negotiations with these goals:
    - maximizing consumer's satisfaction
    - fair utility results for the winning provider



- Practical characteristics
  - the consumer avoiding publicly revealing his preference profile
  - induce incentives for providers participation



## 2. Approach (1 / 2)

- The negotiation setup
  - follows the WS-Agreement Negotiation standard
  - reversed auction: one buyer, many sellers
  - multi-issues setup:  $x = (x_1, x_2, \dots, x_n)$
  - additive utility function for each auction participant:
$$U(v) = \sum_{k=1}^n w_k^{sc} U_k(v_k), \quad \text{with} \quad \sum_{k=1}^n w_k^{sc} = 1$$
  - qualitative environment
    - non-transferable utilities – no established currency
    - bids are expressed as vectors of issue values



## 2. Approach (2/2)

- English auction  
(direct)
  - center announces increasing prices
  - player's dominant strategy: to bid actively until the announced price reaches the value of the object to the player
  - winner: player with the highest price bid
- Qualitative English auction  
(reversed)
  - players bid with service alternatives
  - player's dominant strategy: to offer the highest alternative in his preference order -> the best bid is preferred by the buyer
  - winner: player with the highest ranked bid in the buyer's preferences

# 3. QEA implementation (1/3)



- Theoretical QEA

## Buyer side

2. buyer announces his preferences

3. while number of sellers  $> 1$  or is any seller willing to raise buyer's utility

## Sellers side

1. seller agents join the negotiation process

3.1 sellers submit offers with higher utilities for the buyer than Max Utility(previous offers)

3.2 withdraw decision with no re-enter possibility: reservation value achieved

□ winner selection: the last remaining seller



## 3. QEA implementation (2/3)

- Practical QEA

### Buyer side

2. ~~buyer announces his preferences~~

3. while each seller's reservation value is not reached and his bid provides higher utility in a given time frame

3.2 offer selection : Max Utility (sellers' offers)

3.3 buyer announces the selected offer publicly

### Sellers side

1. seller agents join the negotiation process

2. buyer's profile is blank for the sellers

3.1 sellers submit offers with higher utilities than the winning offer from the last round

3.4 sellers update their buyer's profile with the announced bid's utility

3.5 withdraw decision with no re-enter possibility: reservation value achieved or time frame elapsed

□ winner selection: the last remaining seller

## 3. QEA implementation (3/3)



- Protocol properties
  - an ascending protocol with increasing utilities
  - does not require the buyer to make his profile public
  - the buyer gains access to resources in a certain amount of time
  - can simulate non-private value setup – sellers are able to learn competitors preferences

## 4. Experimental results (1/2)



- Experimental setup

### Simulator

- adapted GENIUS simulator
- seller side agent -> adapted Bayesian agent
- withdraws when no further possible bids are available or the time limit is reached

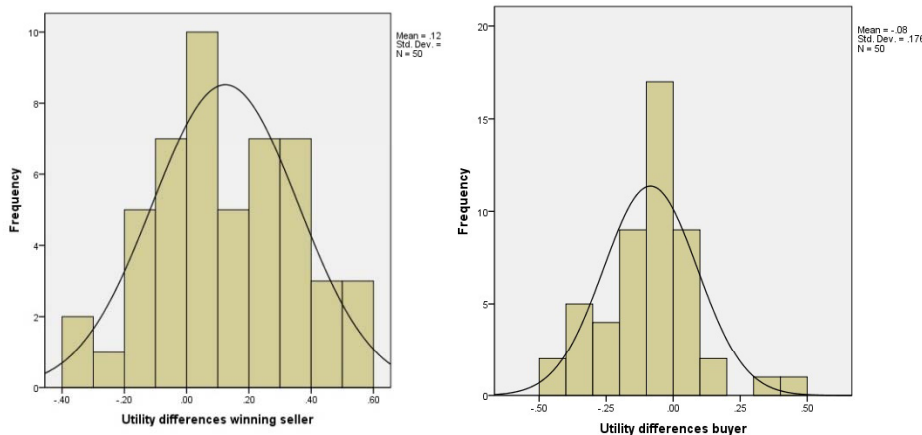
### Test domain

- service oriented negotiation
- 4 issues: delivery time, quality, duration, penalty
- each issue has 30 possible values

### Simulations

- 1 buyer and 5 sellers, 7 minutes deadline/round
- 12 preferences profiles with various reservation values and weights
- a sample of size 50 negotiation simulations

# 4. Experimental results (2/2)



Figures: Utility differences between the theoretical and practical QEA for the winning seller (left) and the buyer (right)

|             | Mean    | Std. dev. | 95% conf. int. |         | Skewness | Kurtosis |
|-------------|---------|-----------|----------------|---------|----------|----------|
|             |         |           | lower          | upper   |          |          |
| Diff buyer  | -0.0846 | 0.17553   | -0.1345        | -0.0347 | 0.327    | 1.515    |
| Diff seller | 0.1242  | 0.23411   | 0.0577         | 0.1907  | -0.003   | -0.640   |

- Slight left asymmetry for the winning seller and mean of 0.1242
  - ⇒ in the practical protocol the winning seller reached a higher utility than in the theoretical one
- Slight right asymmetry for the buyer
  - ⇒ the practical protocol offer has a bit lower utility for the buyer than the theoretical one
    - reason: cost for the limited period of time in which the buyer wants to gain resources
  - ⇒ The loss of the buyer transfers as gain for the winning seller offering incentives for further participation

# 5. Conclusions

## Designed protocol

- practically implements the qualitative English auction
- learning agents play the providers' roles for fully automated setups

## Negotiation outcomes

- the buyer obtains resources in a reasonable limited time
- the winning sellers are offered an incentive for future participation

## Future development

- sellers should be equipped with different intelligence
- run real-life simulations with sellers' profiles based on cloud instances characteristics





Thank you for your attention!  
Questions?

