INCREASING NEGOTIATION PERFORMANCE AT THE EDGEOF THE NETWORK

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Support low-power agents negotiating at the edge of bandwidth-constrained networks

- Learning a shared model
- Wireless spectrum allocation
- Distributed and autonomous surveillance system using UAVs

Background

- Ω: negotiation space of allowable proposals. $\Omega = \prod_{i=0}^{N} \Lambda_i$ with $|\Lambda_i| = M_i$ that means that the negotiation consists of N issues, each of which consists of M_i values
- Bilateral negotiations. Each agent X has:
  - $u_X : \Omega \rightarrow \mathbb{R}$ utility function, and hence a total preorder $\succeq_X$ over Ω. This must be linearly additive, i.e. $\forall \omega \in \Omega : u(\omega) = \sum_{i=1}^{n} w_i e_i(\omega_i)$, with $\sum_{i=0}^{N} w_i = 1$ and $\forall i \in \{1, \ldots, N\} : w_i \in [0, 1]$. Here the w_i represents the relative importance of the ith issue.
  - ρ_X: reservation value, i.e. minimum utility an offer must have to an agent to be acceptable
- Alternating Offers Protocol (AOP). Each agent can: (1) make a proposal; (2) accept the previous proposal; or (3) terminate the interaction without coming to an agreement. ω^t denotes the offer made at time-step t. t is discrete.
- Strategy:
  - Zero intelligence, or random sampling
  - Concession: each agent enumerates the offers in the negotiation space in descending order of preference

Drawbacks of AOP when used at the edge of the network

Resource intensive and in particular bandwidth intensive due to the number of messages that need to be exchanged before an outcome can be determined.

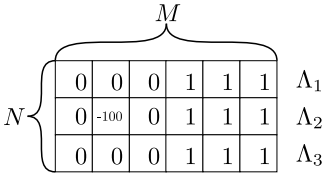
Particularly wasteful when considering autonomous agents at the edge of the network, which have limited bandwidth resources.

Edge agents usually run on low-power devices, hence they cannot be equipped with extremely complex reasoning capabilities able to learn and predict other agents' behaviour.

Contribution: Alternating Constrained Offers Protocol

- Agents have the opportunity to express a constraint (red line) to the opponent when they propose a counter offer
- Cooperative agents could express all their constraints as fast as possible to give the opponent more information to come up with efficient proposals.
  Conservative agents can express constraints only as they become relevant, which might lead to expose fewer information in the case the negotiation terminates with an agreement.
- In this work we focus on the use of atomic constraints. These are constraints that express which one of single particular issue value assignments is unacceptable.

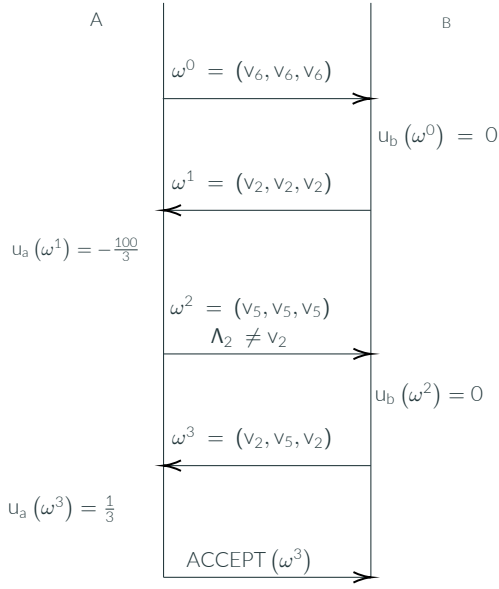
Example



u_A

1	1	1	0	0	0	Λ_1
1	1	1	0	0	0	Λ_2
1	1	1	0	0	0	Λ_3
v_1	v_2	v_3	v_4	v_5	v_6	

u_B



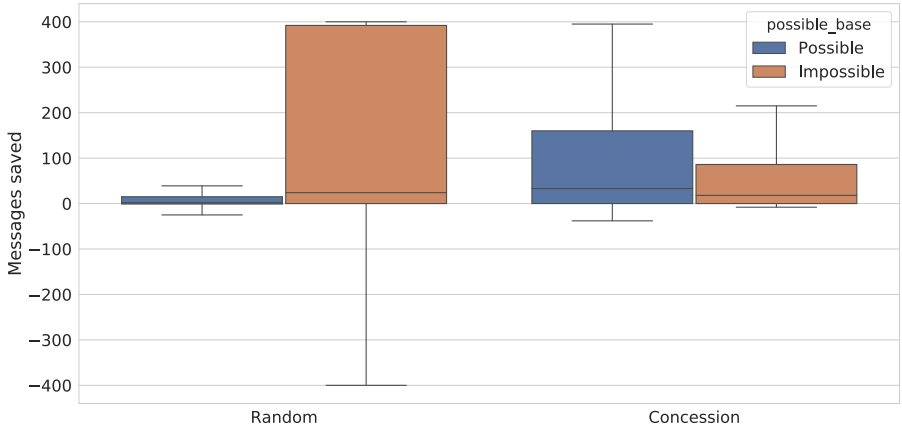
Reservation value (both) $\frac{1}{3}$

Research hypotheses

Q1 Do negotiations operating under ACOP exchange fewer messages than negotiations operating under AOP in similar scenarios?

Q2 Does adopting ACOP negatively impact the outcome of negotiations when compared to negotiations using AOP?

Impact of adopting ACOP on negotiation length



Effect on the utility

Strategy	ACOP compared to AOP	% of negotiations
Random	Utility at least 10% greater	3.40
	Utility at most 10% greater	27.83
	Equal	38.44
	Utility at most 10% lower	27.62
	Utility at least 10% lower	2.70
Concession	Utility at least 10% higher	9.06
	Utility at most 10% higher	5.88
	Equal	81.68
	Utility at most 10% lower	2.82
	Utility at least 10% lower	0.55

Conclusion

- We proposed the Alternating Constrained Offers Protocol, a novel extension to the Alternating Offers Protocol. This allows agents to express constraints to the adversary along with offering counter proposals.
- ACOP allows agents to terminate negotiations faster without consistently negatively impacting the utility of the outcome, allowing them to save bandwidth without the need to equip them with sophisticated reasoning capabilities.
- We demonstrated it in an extensive experimental analysis that took into consideration also two different strategies for exploring the negotiation space.

Future work

- Non-linear utility functions
- More sophisticated strategies and opponent models
- Use soft constraints rather than hard ones.
- More articulated comparison with other leading approaches in literature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